Joint symposium on maize and peanut. Held in Suriname on behalf of the 75th Anniversary of The Agricultural Experiment Station of Paramaribo.

November 13 – 18, 1978

Proceedings of the Caribbean Food Crops Society. Vol. XV, 1978

CONTRIBUTORS

Antigua	Miss E.D. Metcalf	Department of Agriculture Dunbay British Development Division
	C.J. Walker	Cardi, P.O. Box 766 St. John's
Barbados	M.M Alam	: Cardi, Sugar Technology Research Unit, Edgehill, St Thomas
	A. Brewer	: Cardi, University of the West Indies P.O. Box 64 Bridgetown
	J.P Jeffers	: Ministry of Agriculture, P.O. Box 505 Crumpton
	E B Lauckner	: Cardi, University of the West Indies, P.O. Box 64 Bridgetown
	V.A.L. Sargeant	: Cardi, P.O. Box 64, Bridgetown
	D. Walmsey	: Cardi, University of the West Indies, Campus, P O Box 64, Bridgetown
	E.B. Whyte	: Bayer Caribbean Ltd., Lowland Christ Church,
	H A Williams	: Ministry of Agriculture, P.O. Box 505, Crumpton
Belize	J.L. Hammerton	: O.D.M c/o Ministry of Agriculture, Belmopan.
	P.G Lee	: O D M c/o Ministry of Agriculture, Belmopan.
Curacao	R.A. Van Aerde	: Dienst LVV, Kleine Kwartier 33
	R.F. Van de Veer	: Dienst LVV, Kleine Kwartier 33
Dominica	C.J. Baptiste	: P.O. Box 32, Rosean
	C.J.L. Dupigny	: P.O. Box 32, Rosean
Dominican Republic	F.M. Gonzalez	: Mencia No. 9 Los Cacicaggo
	J. Hernandez	: Calle B No. 15 VRB Apolo
	S. Hilario	: Aruba No 92
	A M Pinchinat	: P.O. Box 711
	H Stagno	: Anacyona II – Edificio 8 Apt. 201
French Guyana	M. Remrlett	: Orstom, BP 165, 97301 Cayenne
Guadeloupe	L M. Degras	: I N R A –Guadeloupe, Domain Duclos Craag 97170 Petit - Bourg
	A. Miglıori	I N R A –Guadeloupe. Domanie Duclos Craag 97170 Petit – Bourg.
Guyana	L.E Daisley	: Cardi, 64 Middlestreet Georgetown
	J. Dumett	: Caricom, Corn & Soyabean Co. P.O. Box 355, Georgetown
	G.J. Muller	: Guyana Sugar Corporation 166 Waterloo street North Cummingsburg, Georgetown
	R E Pierre	: I.I.C.A. 88 Brickdom, P.O. Box 823, Georgetown
Haiti	C. Grand Pierre	: Vallee du silence No. 6 Boroton, Port au Prince
Jamaica	K I Ittyeipe	: Banana Board, P.O Box 602, Kingston
	P. Miller	: Ministery of Agriculture, Kingston

May the new findings and attainments in the field of maize and peanut cultivation, soil management, disease control and marketting, as written down in this book, broaden the way to fruitful exchanges of know how amongst the caribbean countries.

The more so, since most of our scientists are working along the same lines to solve the same or similar problems.

Thanks to all participants of the joint symposium for their presented papers and contributions to the discussions

Thanks are due also to Mr. I.E. Soe Agnie for his soil scientifical remarks.

The editor,

Ferdinand E. Klas

September 24, 1979

PREFACE

On the 4th of December 1978 the Suriname Agricultural Experiment Station in Paramaribo commemorated its 75th anniversary. Related to this memorable date several activities were planned and carried out. Besides activities with a local and social bias, the need was felt to organize an event with an international, scientific character

During the same year the Caribbean Food Crops Society held its 15th meeting. Therefore it was worthwhile to combine our efforts in a joint meeting.

Eventually there was chosen for a Symposium with maize and peanuts as main topics. Maize is a commodity of international importance and in particular for Suriname with a developing animal husbandry. The same is true for peanut, while in the near future export possibilities also must be taken into consideration. Besides these two crops other items were covered in the miscellaneous group.

The Symposium was held from 13 till 18 November. Besides the different papers that were presented, two field trips were organized, while the technical part of the Symposium ended with a workshop.

The preparation and the organization of this Symposium attended by 80 participants of which 45 from foreign countries took quite some time. However, due to the enthusiasm and efficient approach of the members of the different organizing committees the Symposium went off very well.

Besides to the above mentioned members I want to express my sincere thanks to all the other groups, firms or institutes which contributed in one way or an other to help to make this Symposium possible.

The Director,
of the Agricultural
Experiment Station,

F.W. van Amson

COMMITTEES

Organizing Committee:

Chairmen	.	F W van Amson, F.A. del Prado
Secretaries	:	R. Dumas, R. Huiswoud
Members	·	E Soe Agnie
		P Segeren
		A.H. van Dijk

Housing and Transport Committee:

Chairman	:	A. Tjong A Hung
Members	·	Mrs. G S. Lata
		C. Dos Ramos
		Ch. Gopal/Dalidjan

Reception and Departure Committee:

Chairman	.	A. Tjong A Hung
Member	.	Mrs. G.S. Lata

Secretarial and Special Services:

Chairmen	.	Mrs T.L. Nanden-Amattaram, Mrs. C. Seales-Meye
Reception	·	Mrs. S. Jankie-Raktoe
Information		Mrs. E Somaroo-de Miranda
Members	,	Miss I Nelson
		Mrs R. Welas-Dunker
		Mrs. H. Renfrum-Abendanon
		Mrs. C. Heymans Dorwart
		Mrs L. Soekardie-Dipowirono
		Mrs. M. Lo Fo Sang-Teixeira
		Miss L.C. James
		R. Markiet
		W. Poniran
		I Jalink

Publicity Committee:

Chairman : F. E. Klas
Members : E. Soe Agnie
A.N. Jubithana
R. Markiet

Coordinators at the Coebiti Fieldstation and the Tijgerkreek-West Fieldstation:

A. Roelofsen
D. Wessels

Guides:

Chairman : R. Mansour
Members : A. San A Jong
J. Nanhoe
Mrs. R. Segeren – van den Oever
D. Wessels

Ladies Committee:

Mrs. O. van Amson Lachmising
Mrs. Y. Tjong A Hung-Karamat Ali
Mrs. I. Wessels-Guman

	H. Payne	: University of the West Indies Faculty of Agriculture-Mona
	A.H. Wahab	: I.I.C.A., P.O. Box 349 Kingston 6
	C.C. Weir	: University of the West Indies, Faculty of Agriculture – Mona
St. Kitts	K.U. Buckmire	: Cardi, c/o Ministry of Agriculture Basselene
Martinique	G. Rimbaud	: 10 klm Route de Balata 97200 Fort – de France
	J.F. Turenne	: Orstom Martinique B.P. 81 97201 Fort – de – France Cedex
Mexico	S.K. Vasal	: Cimmyt, Apdo Postal 6-641 Mexico 6, D.F.
The Netherlands	G.M. van Marrewijk	: Agricultural University – Wageningen. Instituut voor plantenveredeling. Lawickse Allee 166, Wageningen
Puerto Rico	G. Jackson	: Romanach 306, Borinquen Gardens San Juan
	M.A. Lugo-Lopez	: P.O. Box 506, Isabella, Puerto Rico 00662
Suriname	R.P.S. Ahlawat	: Agricultural Experiment Station, Paramaribo, P.O. Box 160
	F.W. van Amson	: Agricultural Experiment Station, Paramaribo, P.O. Box 160
	S. Ausan	: Agricultural Experiment Station, Paramaribo, P.O. Box 160
	W.R. Caldeira	: Ministry of Agriculture, Animal Husbandry and Fisheries. 12 cultuurtuinlaan, Paramaribo
	R. Druiventak	: Agricultural Experiment Station, Paramaribo P.O. Box 160
	R. Dumas	: Agricultural Experiment Station, Paramaribo P.O. Box 160
	E.W. Fung Kon Sang	: Agricultural Experiment Station, Paramaribo P.O. Box 160
	A.W. Graanoogst	: Ministry of Agriculture Animal Husbandry and Fisheries. 12 cultuurtuinlaan, Paramaribo.
	R. Huiswoud	: Agricultural Experiment Station, Paramaribo P.O. Box 160
	A.N. Jubithana	: Agricultural Experiment Station, Paramaribo P.O. Box 160
	F.E. Klas	: Agricultural Experiment Station, Paramaribo P.O. Box 160
	J. Kromodimedjo	: Agricultural Experiment Station, Paramaribo P.O. Box 160
	Mrs. G.S. Lata	: Agricultural Experiment Station, Paramaribo P.O. Box 160
	K.M. Manniesing	: Ministry of Agriculture Animal Husbandry and Fisheries 12 cultuurtuinlaan, Paramaribo
	R. Mansour	: Agricultural Experiment Station, Paramaribo P.O. Box 160

	F.A. del Prado	: Ministry of Agriculture Animal Husbandry and Fisheries. Plant Protection Service Kankantriestreet, Paramaribo
	P.D. Rellum	: Soil Survey Department Suriname. 79-81 Rust en Vrede Street, Paramaribo.
	A. Roelofsen	: Agricultural Experiment Station Paramaribo P.O. Box 160
	R. Samlal	: Agricultural Experiment Station Paramaribo P.O. Box 160
	P. Segeren	: Agricultural Experiment Station Paramaribo P.O. Box 160
	Mrs. Segeren-v.d. Oever	: Agricultural Experiment Station Paramaribo P.O. Box 160
	R.S. Sharma	: Agricultural Experiment Station Paramaribo P.O. Box 160
	E. Soe Agnie	: Agricultural Experiment Station Paramaribo P.O. Box 160
	F.W. Soerodimedjo	: Agricultural Experiment Station Paramaribo P.O. Box 160
	A. Tjon A Hung	: Agricultural Experiment Station Paramaribo P.O. Box 160
	H. Veldkamp	: Agricultural Experiment Station Paramaribo P.O. Box 160
	J. Veltkamp	: Agricultural Experiment Station Paramaribo P.O. Box 160
	D. Wessels	: Agricultural Experiment Station, Paramaribo P.O. Box 160
	J.F. Wienk	: Centre for Agricultural Research c/o Leysweg, P.O. Box 1914
Trinidad & Tobago	N. Ahmad	: University of the West Indies St. Augustine
	L.A. Baptiste	: 17 Orange Grove Rd. Trincity
	C.A. Philips	: Texaco Trinidad Inc. Pointe – a – Pierre
	M. Yaseen	: CIBC, 1 Gordonstr. Curepe
U.S.A.	J.F. Mc Gill	: University of Georgia, P.O. Box 1209 Tifton Georgia

MINUTES OF THE BUSINESS SESSION
NOVEMBER 15, 1978

The Business meeting was called to order by the President, Mr. Frank A. del Prado at 2:00 p.m. at the Torarica Hotel, Paramaribo, Suriname.

The minutes of the previous meeting in Guadeloupe-Martinique in 1977 was read and approved.

Old Business

The Secretary delivered a report covering his participation as CFCS representative at the DARNDR/IICA Meeting on Research Systems in Agriculture, held November 28 through December 2, 1977 at Port-au-Prince, Haiti. This report titled "Contributions of the Caribbean Food Crops Society to Agricultural Research in the Antilles Zone" was approved.

New Business

1. Mr. Francisco Miguel Gonzalez presented a letter from His Excellency, the Secretary of the Agriculture of the Dominican Republic, the Honourable R. Hipolito Mejia D. presenting the Dominican Republic as the proposed site of the 16th Meeting of the CFCS in 1979.

2. The Nominating Committee presented their recommendations for the officers for 1979-80. They were as follows:

President of the Board	Mr. F.A. del Prado	Suriname
Board Member	Mr. L.M. Degras	Guadeloupe
Board Member	Mr. C. Grand-Pierre	Haiti
Board Member	Mr. J.P.C. Jeffers	Barbados
Board Member	Dr. A.M. Pinchinat	Dominican Republic
Board Member	Dr. A.H. Wahab	Jamaica
Board Member	Dr. M. Yaseen	Trinidad
President	Mr. R. Hipolito Mejia D.	Dominican Republic
Vice-President	Dr. F.M. Gonzalez	Dominican Republic
Secretary	Mr. G.C. Jackson	Puerto Rico
Treasurer	Dr. M.A. Lugo-López	Puerto Rico

The report was received and all proposed officers were elected unanimously.

3. Mr. Jackson pointed out that the 1971 Proceedings have still not been issued. He asked that Dr. M.A. Lugo-López be authorized to visit Guyana on his return trip from this meeting, in order to determine reasons for the delay. Permission was approved.

4. Mr. Jeffers proposed that CFCS offers membership to Agricultural Engineers in the Caribbean. The reason being that there is no forum for this group of professionals to associate with. This proposal was accepted and approved.

5. Dr. Wahab was nominated as special collection agent for the CFCS in Jamaica. This nomination was accepted and approved.

6. Dr. Pierre was nominated as special collection agent for the CFCS in Guyana. This nomination was accepted and approved.

7. Mr. Gonzalez took the floor to thank the membership for electing Mr. Mejia president and him as vice president. He announced that the meeting would be held in Santo Domingo, Dominican Republic, probably in July or August of 1979, and that the meeting theme will be announced long before the meeting date.

8. Mr. Payne asked that the secretary record a vote of thanks by the membership to the organizing committee in Suriname for their excellent work.

There being no further business, the meeting was adjourned.

CONTENTS

CONTENTS

PEANUT

Soil management

Cultivation and Production

Pests, diseases and weeds

Economic aspects

MISCELLANEOUS

Soil management

Cultivation and production

Pests, diseases and weeds

Economic aspects

INTRODUCTION

WELCOME ADDRESS OF THE ACTING DIRECTOR OF THE MINISTRY OF AGRICULTURE AND ANIMAL HUSBANDRY

(J. A. Drielsma)

Your Excellency, President of the Republic of Suriname
Mr. Prime Minister
Mr. Minister of Agriculture
Distinguished guests
Ladies and Gentlemen

It is a great honour for me to welcome you on behalf of the Department of Agriculture to this occasion.

If I say that this is an honour for me, I do not only refer to the fact that so many distinguished persons are gathered here, but also to the fact that we are here to commemorate the 75th anniversary of our Agricultural Experiment Station, or as we refer to it THE EXPERIMENT STATION.

This of course implies a certain pride, and with reason are we proud of our Experiment Station, not only because it is one of the oldest Agricultural research institutes of our region, but because of the important work it has done in the past and is still doing. That its path has not always gone over roses, does not have to be stated here. Suriname is not a very large Country, but in proportion to its population it covers a huge area. It is logical that we are faced with the same range of problems of a large Country with a large population.

Research in itself being expensive, this is the more so in Suriname, with its small population and limited financial resources. Moreover, Suriname is a Country in development and since development implies change, this also has a marked effect on our Agriculture. The old colonial system of Plantation Agriculture is disappearing and gradually being replaced by Commercial Agricultural enterprises.

But this is not our main headache, since the big boys can for a good deal take care for themselves. Our problem lies mainly in the peasant farming, where we are now in a transition fase from the traditional peasant (subsistance) agriculture to a form of modern semi mechanized agriculture.

This has affected our Agricultural research fundamentally. This is logical, since you can only have sound development if the changes are taking place on the basis of concrete results of research.

As I have already mentioned our limited financial resources, becomes now significant, since we are not able to tackle all the problems that arise as the consequence of our development. So priorities had to be set forth. The choice was also need to the fact that we have to counterbalance the monocrop position of rice. In our Symposium at the 70th anniversary of the Agricultural Experiment Station, rice was the topic.

Since the development of maize and peanut production is high on our priority list, the choice for this Symposium fell on these crops. So the contribution that the discussions of this week will have to the national economy and more in particular, the Suriname Agriculture will be of very great importance. So it is not out of politeness but with a certain amount of selfishness that I hope that your discussion will be very fruitful.

To the foreign guests I would wish them a very pleasant stay in our country.

WELCOME ADDRESS OF THE PRESIDENT OF THE CARIBBEAN FOOD CROPS SOCIETY

(F.A. del Prado)

Your Excellency President Dr. Ferrier, Honourable Ministers of Cabinet, members of Parliament, distinguished guests, collegues, ladies and gentlemen.

Last year when I was again elected President of this distinguished body of agricultural scientists, I knew that a tremendous task was awaiting us in Suriname to organize this 15th meeting of the Caribbean Food Crops Society, this time a combined meeting with the Suriname Agricultural Experiment Station, het LandbouwProefstation, which next month shall celebrate its 75th anniversity. Those of you that are members of the executive committee, or have been, have experienced the many months of hard work that precedes the official opening which is today.

The previous meeting of the Caribbean Food Crops Society held in Suriname in 1967, our fifth meeting, is remembered by many old timers. It was hard work then, many good papers were presented and the social activities we arranged, were enjoyed by all.

During this week that you are going to be with us you'll be able to see some of our work. We shall not only meethere at the Torarica Hotel, but we are going to be out twice on fieldtrips. I can promise you that it is going to be a week of hard work, but a week in which we can learn a lot from each other.

It is a somewhat other type of meeting, a combined one of the Caribbean Food Crops Society and the Suriname Agricultural Experiment Station. A symposium where the emphasis shall be on maize and peanuts. Of both crops large amounts are imported every year in many of our countries resulting in a drain of foreign currency.

Your Excellency President Dr. Ferrier, distinguished guests, ladies and gentlemen, in this region we have a great many scientists and the knowledge which we can use for the production of more and better food. However, knowledge and the scientists alone, cannot feed our peoples. We have to plant more and harvest more, which shall result in better living standards for our farmers and eventually a better economic structure for our countries.

So much land is available, and so much can, and has to be done, individually, on a country basis and regionally. Let us scientists of this region with the aid of our respective Governments show that we can produce more and better food to feed our hungry world. Too many people are still starving in many countries due to hunger, even on our continent.

At the Fourteenth Regional Meeting of the Food and Agricultural Organization of the United Nations held in Lima, Peru in 1976, we were told that our countries could supply the world with many crops which grow better and show higher yields due to scientific practices.

Let all of us keep this in mind and strive to reach this goal. It is feasible because the potentialities are present. All we need is hard work and more hard work, good management, financial, and political backing.

I know that it is a difficult task that lies ahead of us, but a task which gives satisfaction when done right.

Your Excellency, Honourable Ministers of Cabinet, Mr. President of Parliament, distinguished guests, ladies and gentlemen, as President of the Caribbean Food Crops Society I am wishing you, my friends and colleagues from abroad, a pleasant and fruitful conference in Suriname.

WELCOME TO OUR FRIENDLY NATION!

WELCOME ADDRESS OF THE DIRECTOR OF THE AGRICULTURAL EXPERIMENT STATION

(F.W. Van Amson)

On the 4th of December the Agricultural Experiment Station will commemorate its 75th anniversary.

The history of the last 75 years was especially influenced by two world wars. Increased technological developments, mainly as a result of these wars, resulted in enormous achievements in various fields.

These again had a tremendous impact on the social behaviour of men. Economic values changed rapidly, upsetting certain societies.

All these changes also influenced the different aspects of the Suriname society.

Before 1903 the abolition of slavery had a strong effect on the economy. As a result of this abolition a shortage of laborers occurred and gradually the plantation agriculture became a marginal proposition.

At the turn of the century the witches broom disease in cacao also contributed to a rapid decline of our once flourishing agriculture.

However, it was in particular this disease that stimulated scientific agricultural research in Suriname.

Referring to the last 75 years there are some significant issues, which structured agriculture and agricultural research in Suriname.

One of the consequences of the abolition was the establishment of a group of small holders. Former slaves and contract-laborers were the new farmers who started small scale farming, mainly supplying the local market with their products.

The aversion against the old plantation system was strong resulting in a gradual increase of independent farmers.

The plantations were mainly located on heavy clay soils. A complicated pattern of small beds and trenches was necessary to promote an effective drainage. However, the lay-out was such, that exploitation was only possible with intensive hand labor.

In the past it was thought that cacao was a good alternative, because this crop is easy to grow, to maintain and to harvest.

The before-mentioned witches broom disease however made a careful reconsideration essential.

Attempts to establish plantings with resistant cacao varieties failed; meanwhile, research indicated that citrus was a promising crop for the old plantations.

Between the two world wars the results of rice experiments on the heavy clay soils in the district Nickerie looked hopeful.

These results in combination with breeding studies at the Agricultural Experiment Station formed the fundaments for future research on the mechanization of rice.

In the meantime the small-holders developed into a very functional group in our society. Vegetables, fruit and animal products were produced by this group.

In a way research contributed to a certain extent to the development of this group through the channels of the Agriculture Extension Service.

The economic crisis between the two wars also had negative effects on our agriculture, particularly on our export.

After the second world war funds became available to stimulate agriculture. Again attempts were made to re-activate plantation agriculture.

However, gradually it became clear that this system, because of the demand for manpower, was obsolete Education and training attracted Surinamese to better payed jobs compared to agriculture in its old form.

A confrontation with modern highly sophisticated commodities had a tremendous influence on the behaviour of men. This also resulted in an increase of the aversion for a risky and tiresome form of agriculture.

There was a need to initiate new studies in order to be able to obtain results which could be used as a model suitable to a contemporary way of living in agriculture.

This was a big challenge!

This challenge was accepted in the district of Nickerie and eventually resulted in large scale mechanized rice operations as an alternative to exploit the heavy clay soils.

At the same time this system, more or less adapted, also appealed to people interested in middle- and small scale farming.

From the success of this operation it can be concluded that new and better farming systems in Suriname, must stress the use of machines.

This can be introduced on relative small holdings with an intensive use of the land or on large scale farming systems with heavy equipment. Besides the mechanized rice operations on the clay soils small holdings can be stimulated in the northern part of the country. Particularly on the sand and shell ridges of the Young Coastal Plain, while large scale operations can be introduced on the excessively drained sand to sandy loam soils of the Zanderij formation.

Research is being carried out in both locations and the next step will be an integration of the results into a farming system most suitable for that particular region.

Often the question has been raised on the importance and use of agricultural research in the developing countries.

Agricultural research produces very seldom spectacular results, unless these can be translated in hard financial data.

Large scale agricultural operations after the second world war are: the Foundation of Mechanized Agriculture, the banana Company, both in the Young Coastal Plain. The palm oil estates and the beef cattle activities on the well drained soils of the interior. Years of studies were however required to indicate that a large scale operation was economically feasible.

Not only is research needed to study new crops and new farming systems, but there must always be an organization or institute that is alert to cope with calamities which can treaten certain crops, in a most unexpected way.

A few years ago "moko" disease was observed in an isolated plantain area. Moko is a very nerious disease, that can completely destroy banana plantations in a short time. Alertness resulted in a timely control of the disease.

University of Cornell Georgia and Wageningen

Coconut palms died from an unknown disease called "hartrot". Research carried out in co-operation with experts from the indicated that probably flagellates were the causative agent of the death of the palms. This unic finding attracted international attention and resulted in provisional measurements to check the spread of the disease. However, extended fundamental research is needed to study the disease in order to be able to introduce a permanent control system.

It was not only in the field of plant pathology that research contributed to our agricultural development. After the second world war soil research was stimulated. Soil surveys started and in a second phase studies about the interaction of soil properties and crop production were initiated. In a later stage fertilizer trials with various crops were carried out.

Plant protection and soil studies are centred around a variety of annual and perennial crops while Agro-technological research is adapted to develop technics for processing and conserving certain agricultural products.

Suriname is a country with good potentials for agriculture. However, research will be needed to indicate what farm model has to be used in a particular region.

Given the natural potentials of soils and climate, it will be a "new" farmer who will and can exploit these potentials with a reasonable profit.

A new farmer who will differ completely from the farmer of some decades ago.

Suriname is a large country with a small population. To exploit our soils economically, skilled farmers, who will operate the land with modern techniques, have to be introduced.

Finally I have to indicate some misconceptions which exist in relation to agricultural research. Stimulating agriculture is not only related to research and the type of farmer!

As was mentioned before, research is carried out to study interactions between crops and growth factors or to study specific problems of certain crops.

However, research is only a means to reach a certain goal. This goal is generally a higher and better production to improve the living conditions.

This can only be achieved by necessary steps taken by the government. These steps are not controlled by research, but have a direct influence on the policy of research.

If the results of research are not translated and promoted through other channels, than research becomes more or less sterile and hardly contributes to an increase of agriculture production.

Ladies and gentlemen, I do hope that with this brief sketch I have been able to introduce you into some research aspects which have been carried out and into a vision along which agriculture research has to develop.

It is my sincere wish that this meeting will contribute to stimulate the development of our agriculture in a modern way. I wish you a very fruitfull meeting!

OPENING ADDRESS BY MR. J. SISAL, MINISTER OF AGRICULTURE, ANIMAL HUSBANDRY AND FISHERIES

After the Minister has formally addressed his Excellency the President of the Republic of Suriname and the other distinguished guests, he presents the following statement:

"For the development of the agricultural sector during the coming 10 – 15 years, the Ministry of Agriculture, Animal Husbandry and Fisheries has prepared a multi annual integrated agricultural development plan.

As a contribution to the national goals, the main objectives of the agrarian sector are an increase in production and the creation of full employment with a reasonable minimum income for the producer.

Research is the basis of development, in this case of agricultural development. It is well known however, that research is a very complex, costly and time consuming activity. Developing countries have to consider very carefully therefore which crops to focus their attention on.

For this symposium the topic is maize and peanuts (groundnuts).

These two crops are very important to the economic development of Suriname. We import quite a lot of these products, although it is possible due to our conditions here to cultivate these crops on a commercial basis.

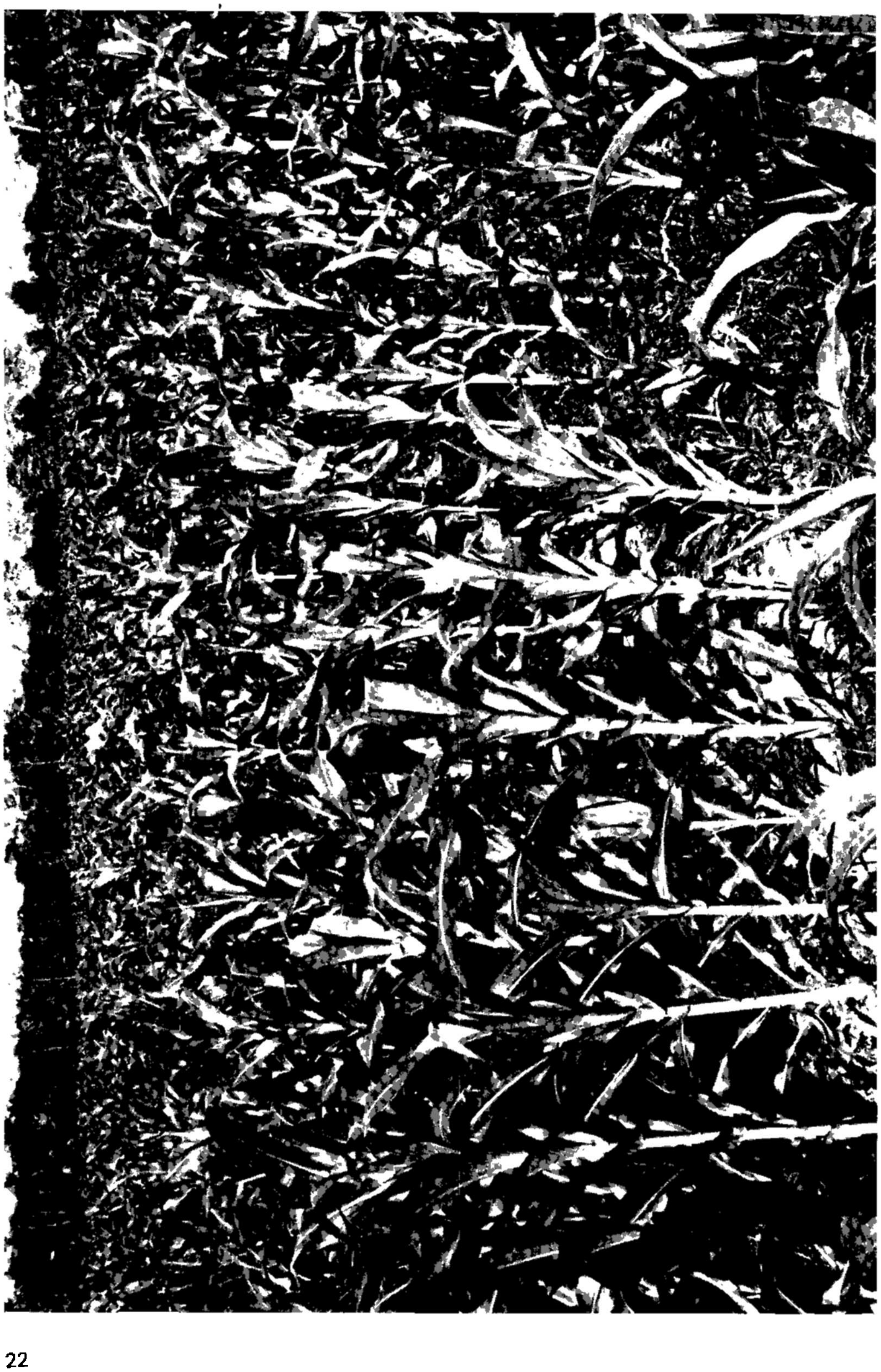
There is a lot of research still needed of course, especially in the field of farm mechanisation, crop protection, selection of varieties etc.

I am convinced however, that we can provide for our own wants with regard to these two crops.

The problems we have here are not typical for Suriname, that's why this international gathering of research people can contribute a lot to help solve these mutual problems.

During the workshops and the field trips, there will be enough time I hope to exchange experience, knowledge and skills with regard to these two crops.

I wish you all a pleasant and very fruitful time during your stay in Suriname".



MAIZE

SOIL MANAGEMENT FOR MAIZE PRODUCTION IN THE CARIBBEAN

N. AHMAD

The University of the West Indies,
St. Augustine, Trinidad

INTRODUCTION

There is little experience in the Caribbean area in the commercial maize production and associated soil management requirements. As with all cereal crops, commercial maize production would involve complete mechanised systems and the problem of soil management would have to be considered with this in mind. Obviously, maize in some form is an old crop in the Caribbean where it is mainly grown in small cultivations, the main use of the crop being for green corn as a vegetable. Very little of this crop presently end up as grain corn used for livestock feed and it is for this purpose that the commercial production of maize is important in the region. Although there must be other examples of cultivation of corn for grain in the region, there are only three outstanding examples.

One of these is in Belize at Spanish Lookout where the Mennonite farmers have been cultivating maize for grain for up to 20 years. The crop is used as livestock feed mainly in their own farming but some of the grain is also sold outside of the settlement. The soil on which the crop is grown is a vertisol, an extremely fine textured soil with high montmorillonite content in the clay fraction. In this case the farmers, under normal conditions, could manage the soil for up to 2500 kg/ha of grain which is not a high yield with 100 kg/ha of a 12:24:12 fertilizer at planting plus 60 kg/ha urea six weeks later. Problems which the farmers have not yet been able to solve include soil fertility maintenance for continuous maize production, what constitute adequate drainage, the layout of the land and soil management for the growing of two maize crops in one year.

Another area where commercial cultivation of maize is being attempted is in Antigua where the Antiqua Agricultural Industries Limited aim at eventually cultivating over 5,000 ha in maize. This enterprise is only about three years old and it presently has a little over 1,000 ha cultivated, and therefore well below its target. The soils used are very fine textured clays rich in montmorillonite not unlike the Spanish Lookout soil of Belize. Fertilizer (20:12:12) at 600 kg/ha is applied at planting. Seedbed preparation for planting is done by discing, harrowing then cultivated with a spring tyne harrow (Widrich cultivator). All operations are mechanically done and there is a yield expectancy of 5,500 kg/ha.

In Guyana, the Caricom Corn/Soya Project has cultivated a fairly large area on free-draining brown, sandy soils with very low fertility and moisture retention properties. The main problems here are fertility maintenance where up to 80 percent of inputs is in fertilizers. Soil erosion is also a serious problem. This activity is several years old.

From the limited attempts at commercial maize cultivation in the region, it may be said that many problems of soil management have emerged and these are seriously affecting the commercial prospects of the crop. It may also be said that in all cases inadequate scientific investigations of potential soil problems were done prior to the launching of these schemes. This has resulted in incorrect field procedures which are proving very costly.

SOIL MANAGEMENT REQUIREMENTS

Soil management requirements for maize is a function of the type of soil and the particular weather characteristics during which the crop is to be grown. Soils of different textures and clay mineralogy would have different management requirements. Also, the particular weather and soil moisture regime in which the crop is to be grown would impose constraints on soil management. The problem will be discussed under the various soil requirements for the maize crop.

(i) Tillage: – Tillage requirements for maize appear to be influenced the world over by what is done in the mid-western U.S., without thinking of the particular conditions of soil, climate and degree of mechanisation which applies there. Thus in Antigua, Belize and Guyana on Vertisols in the first two and on a coarse textured sandy soil in the last case a deep fine seed-bed is prepared in the traditional sense. The purpose of soil tillage is to allow the seed to be inserted into the soil in the first place and to reduce the soil to sufficient fineness so that the roots of the crop could grow easily and maintain contact with the soil. It is also done with the aim of improving the structure of the soil so that the roots of the growing crop could grow more freely into the soil.

Tillage to the extent that is usually practiced in tropical soils particularly clay soils, with the main objective of improving the rooting volume of the soil probably does not fulfil this purpose for many soils. In fact there is some evidence that in clay soils, soil physical conditions In fact there is some evidence that in clay soils, soil physical conditions deteriorate in direct relationship to the extent of tillage (Ahmad and Paul, 1978). Since the structure of tropical soils is determined by special circumstances depending on whether the particular soil is a Vertisol, an Oxisol, an Ultisol etc., it is not surprising that traditional tillage practices may not necessarily improve soil physical conditions and could have different effects.

Excessive tillage, apart from possibly allowing the soil to compact to a greater degree than before the cultivation, is usually associated with accelerated soil erosion and loss of applied fertilizer by surface run-off. There are examples of this occurring in the three examples of commercial maize production in the Caribbean already referred to. It seems important that experiments should be done to determine the optimum tillage requirements for any soil to be used for maize cultivation. This is particularly important since in the Caribbean area as a whole, clay soils with differing soil mineralogy and behaviour are likely to be important maize-growing soils in the future. The effects of minimum tillage, over-tillage and zonal tillage on the soil and crop should be assessed before a cultivation regime for commercial maize production should be decided upon. Data are already available showing considerable soil physical deterioration on Vertisols in Belize following about 20 years of continuous maize cultivation.

The suitability and use of machines and implements in maize cultivation should also receive attention. In the case of Antigua, it would appear that the wrong type of machines was introduced from the inception. The adequacy of the particular machinery and implements should be studied in relation to its role in soil compaction, trafficability in the particular soil and the tillage requirements of the soil.

(ii) Soil drainage:- It is an established fact that maize is unlike many other graminaceous crop plants in being intolerant to poor soil drainage. Consequently, on land of little relief and on fine textured soils, land layout to facilitate drainage is a very important aspect of soil management. A suitable land layout must facilitate the surface drainage of much of the water that falls as rain in the wet season since the natural infiltrability and permeability of such soils is extremely poor.

The cambered bed was introduced in countries such as Guyana and Trinidad for the cultivation of sugar cane. This crop, being a more adaptable crop to poor soil drainage, performs more or less equally in all positions of the bed. Other crops have been tried on such beds but none have been as successful as sugar cane. Especially with maize, there is a very strong "edge" effect in which the rows of plants on the slopes of the bed perform much more poorly than the rows at the crest of the bed. This effect is noticeable almost everywhere maize is grown on cambered beds. In heavy clay soils increasing water- logged conditions in the wet seasons is evident from the crest of the bed to the sides. A cambered bed layout alone could be ruled out as an effective layout of a field in a flat area on clay soils as a means of adequately draining the soil for maize.

In addition to the constraint of the cambered bed on mechanisation this "edge" effect on crop productivity is important. Where differential soil drainage is not the main factor in differences in crop production across the camber, differences in soil fertility caused by piling top soil on the crest of the bed in making the cambered bed is noticeable by differential crop performance.

Alternative methods of soil drainage and land layout would have to be found. Some of these could be as follows:-

(i) Box-drains in association with cambered beds:- In this suggestion, box-drains between the cambered beds is proposed, the width and depth of the drains being variable and dependent on soil texture, amount of rainfall and land relief. In such a system, there must be effect means of collecting the water from these drains and draining it away from the cultivated area. Such drains would have to be graded to allow even and quick flow. The whole system is expensive to instal and a great problem to maintain with mechanised cultivation. The type of seedbed preparation now being practiced would be a problem to achieve, in this layout.

(ii) Mole-drains in association with cambered beds: Mole drains established across the camber have been effective in draining a very fine textured vertisol in the Spanish Lookout area of Belize. In such a layout, the cambered beds could be wider and in Belize, a width of about 20 metres is considered possible. The moles are made during the cultivation operations and it is not an expensive operation. This combination is now being tried in Guyana in sugar cultivation where the cost of making the moles is estimated to be about forty dollars (Guyana) per hectare. Such moles could be made for each planting although it is not now known whether this would be necessary. In clay soils where the subsoil drainage is good as in some of the fresh to brackish water swamp-derived soils of Guyana and Surinam, this layout has real promise. With a wider bed, mechanisation is easier and less of the land area is lost through drainage channels.

(iii) Individual banks:- In this layout, individual ridges are made for each row of maize. At the present time, this layout works well in land of some relief and in areas where the internal soil drainage is good as in some loamy soils of Trinidad. On clay soils and in areas of flat topography it is obvious that it would not work. However, if it is combined with land grading so as to imposed surface drainage in the area, it could well be successful. The layout has been fairly successful for sugar cane on clay soils in Trinidad. Some other advantages are very little land wastage in the form of drains and ease of mechanisation of all operations. Disadvantages are the very high cost of the initial land grading and the differential soil fertility that would be imposed for a crop such as maize. This layout again pre-supposes the establishment of an efficient system of receiving ditches which are well graded to enable even and rapid flow of water from the site.

As an alternative to land grading in association with individual ridges, land layout according to the contour as is done for rice cultivation could be tried. This, however, would impose some problems of making the ridges once the contour bunds have been built. If the right vertical interval is selected, the crop may well be cultivated on the flat without ridges and this would facilitate mechanisation. There is good reason to believe that in the more permeable of the clay soils in Guyana and Surinam, this layout could be successful. Drains would be built on the inside of the contour bund which would receive water from the level above that contour. Once again, an overall drainage system to drain the water collected by these contour ditches would be needed.

(iv) Flat planting:- This field layout, where no particular provision is made for external or internal soil drainage, is possible only on coarse textured soils with rapid internal drainage. In developing the vast areas of brown sands and loams in Guyana and Surinam, this feature is of great importance. Maximum use of the land area for the cultivation of the crop is achieved and the various mechanical operations are facilitated to a maximum degree. It is unsuitable for fine textured soils or soils of poor internal drainage.

(iii) Soil water relations:- It is recognised that maize, like most other cereal crops, has specific demands for water at the crop establishment and pre-tasseling through silking stages. If the soil is at field capacity or close to it just at planting and water can be extracted at low tensions just before tasseling through silking, water would not limit crop productivity. In figure 1, the

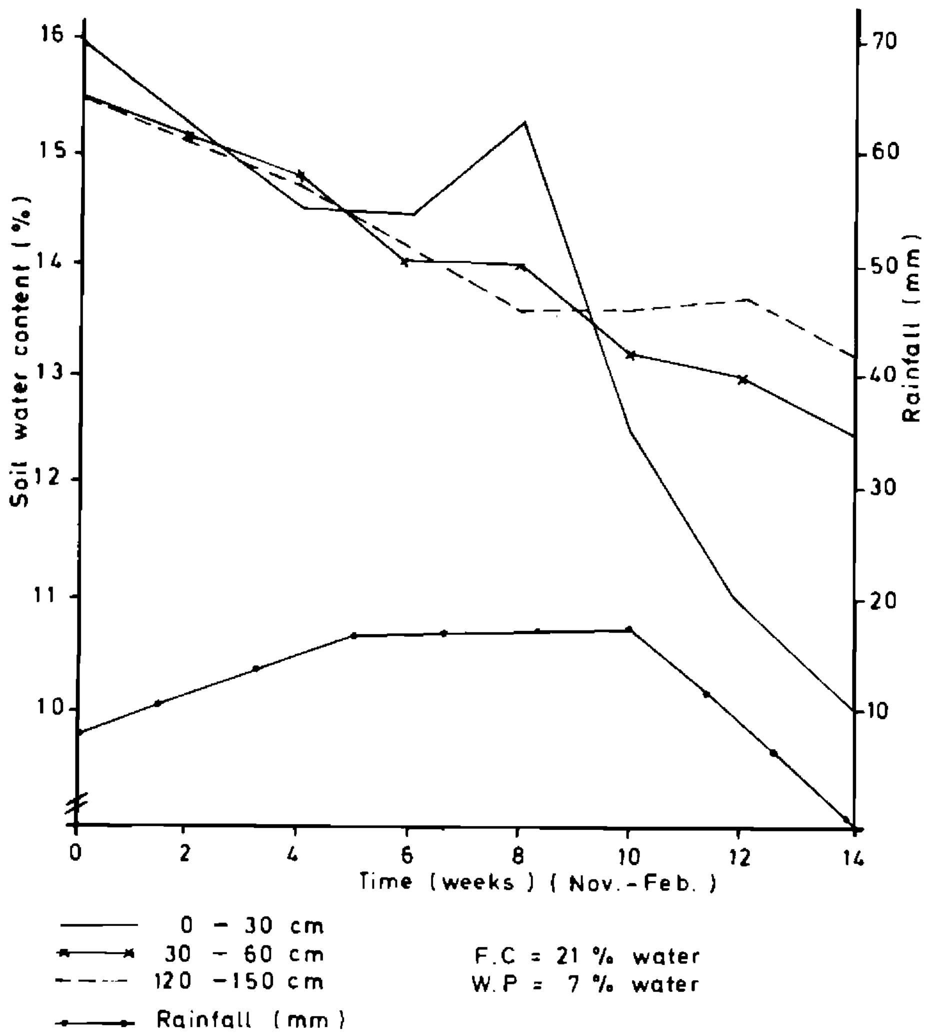


Fig. 1 Variations in soil water content and rainfall during growth of maize crop.

soil water content in maize experimental plots in the Trinidad dry season (1978) is shown. Note that as the dry season advanced, the soil water content of the surface layer approached wilting point but the crop did not suffer from drought effects. In this case, the crop was extracting water from deeper soil layers, the water content of which did not decrease as sharply.

If there is water deficiency at the critical stages of the crop as is obtained in the drier years in Antigua, for example, the yield and quality of the crop is low and particularly there would be no response to fertilizers. This has been observed repeatedly in experiments in the drier areas of the Caribbean.

Unless water is very easily available and readily applied, irrigation is not likely to be an economic practice in maize cultivation. It is better to plan the cultivation of the crop to take advantage of the natural weather pattern or to manage the soil for maximum water use. In a system for continuous maize cultivation involving two crops per year, the second crop which is usually planted towards the end of one wet season and matures into the dry season could suffer from water deficiency. Soil management for maximum water use would involve the encouragement of deep rooting by paying attention to appropriate cultivations, fertilizer placement and application, and placement of ground limestone where this is considered necessary. Effective weed control in water deficient conditions is of particular relevance.

The other extreme of water relations i.e. water-logging, was considered earlier with respect to drainage. Maize is particularly adversely affected by water-logging caused by poor drainage; adequate drainage is an essential pre-condition for cultivation of maize.

The effect of mulching as a management factor in influencing water relations in Trinidad's conditions of maize is summarised in table 1. In the wet season when there is excess soil water

Table 1. Effect of surface mulch on growth and yield of maize (kg/ha)

Duration of Crop	Dry matter production at eight weeks				Yield of grain			
	No nitrogen		Nitrogen (100 kg/haN)		No nitrogen		Nitrogen (100 kg/haN)	
	No mulch	mulch	No mulch	mulch	No mulch	mulch	No mulch	mulch
Wet Season June-August	465	307	504	0	not determined			
Wet to dry season (Nov.-Jan.)	2100	2818	3008	3373	3704	4706	5242	6290
Dry Season March-May	1320	5187	1934	6186	not determined			

if anything, mulching has proved to be detrimental on the soil in the University area in Trinidad. Perhaps the type of mulch used i.e. fresh bagasse, may have been important in creating anaerobic soil conditions in the top layer where the maize roots are concentrated. If a crop is grown at the time of the year when the rainy season is tailing off i.e. November-January, mulching is not of importance in water conservation. However, if a crop is planted in December or January and grows through the dry season, mulching was shown to be essential if a crop is to be expected. The depth of mulch beyond about 2 cm, evenly distributed, does not appear to be of much importance. Other effects of mulching such as soil erosion control, weed control and soil temperature control make this practice of great value in most cases. The great problem is the availability of mulching materials and the cost and problem of applying it to the soil planted with maize.

(iv) Soil fertility:- Maize is one of the most responsive crops to soil fertility and infertility. For this reason, the plant is used extensively as an indicator in nutrient availability and soil fertility studies.

Aspects of soil fertility that are important in the Caribbean context are soil acidity or alkalinity and their related problems, and supply and availability of the various nutrients.

Soil acidity: Soil acidity is a problem in maize production only in some parts of the Caribbean i.e. parts of Guyana, Surinam, Trinidad, Jamaica, Puerto Rico and Belize. It does not seem to be important in the Leeward and Windward Islands. The main effects of soil acidity are indirect, in the form of Al toxicity and P deficiency.

Some of the early studies on the effect of Al on plant growth utilised maize as one of the test plants. There is no specific foliar symptom of Al toxicity; growth depression occurs but it is a nonspecific symptom. Uptake of the element causes root damage. In the early stages the roots become discolored, then the branch roots stop growing and finally the entire root system stops growing (Mc Lean and Gilbert, 1927; Lignon and Pierre, 1932). Evans (1955) described similar symptoms for sugar cane and used the term "coralloid" roots to describe the short, thickened and discolored root systems which result from high Al. Trenel and Alten (1934) concluded that Al was a specific root poison for maize and the poisoned roots were unable to translocate the element to other parts of the corn plant. Thus, the concentration in the roots get higher as the toxic effects become more advanced. In extreme cases, P is precipitated within the roots in Al-bound forms (Wright and Donahue, 1954) and eventually the plants affected display foliar symptoms of P deficiency. The uptake, translocation and metabolism of Ca is also adversely affected, leading to foliar symptoms of Ca deficiency.

Ahmad (1960) working on the frontland clays and pegasse soils of Guyana found that Al and to a lesser extent P, accumulated in the roots of maize plants growing in acid soil. Al was found to be more immobile in the roots of maize than cowpea which was related to an apparent greater tolerance of cowpea to higher Al concentrations in the soil solution. From these studies it was concluded that plants which are able to translocate Al from root to leaves appear to be more resistant to Al toxicity.

Correction of Al toxicity and the induced P deficiency which results is achieved by the use of ground limestone to the extent where the pH was 5 or higher. In Guyana and Surinam where there are no reserves of $CaCO_3$ rock and where the soils require large dressings of lime to achieve the desired pH change, it becomes very expensive. The use of dilute sea water (Evans and Cate, 1962) to achieve partial reclamation is an interesting innovation but the difficulties involved in controlling the use of dilute sea water on land, the availability of large quantities of fresh water for leaching after sea water flooding, and the careful check in changes in soil chemical and physical properties are problems in its wide use.

With current lack of facilities for bulk handling and application of ground limestone throughout the region, and therefore the high cost of treating soils, it is doubtful whether ameliorating acid soils by liming under existing conditions is economical. Where it is to be done, there are no particular precautions that are necessary and it need only be done to the extent that the exchangeable Al content is substantially lowered i.e. about pH 5.

Soil alkalinity: Maize is being grown successfully on soils whose pH is much higher than 7 without any apparent injurious effects. In such cases the continued use of ammonium sulphate obviously plays an important role.

(v) Nitrogen:- Few factors have as great an impact on corn production as the extensive use of nitrogen fertilizers. In the midwestern U.S., it is recognised that up to 150 kg N/ha is needed for a yield expectancy of 6,000 kg/ha grain. In Antigua, in the fertilization regime used there, 120 kg/ha is applied for an average yield of 5,000 kg/ha. About the most efficient use of nitrogen is achieved by the Mennonite farmers in Belize who apply 12 kg/ha at planting in the form of a 12:24 NPK fertilizer at 100 kg/ha for a yield expectancy of 2,000 kg/ha. A side dressing of 25 kg N/ha applied as urea six weeks after planting could raise the yield expectancy to 3,000 kg/ha and it is considered a very worthwhile practice.

The nature of the response to nitrogen as well as phosphorus and potassium in several West Indian soils was studied by the Department of Soil Science and UWI and the results are summarised in figures 2 to 5 (Baynes and Walmsley, 1973 and Forde et al, 1975). It is to be noted that in every case except for Barbados, there was a considerable response to nitrogen fertilizer. The no response in Barbados to all fertilizers is interpreted as due to a partial soil water deficiency and not to adequate levels of the nutrients in the soil.

The kind of nitrogen fertilizers used is of some importance. For example, in the high pH soils of much of the West Indies, sulphate of ammonia could be a good form on account of the acidifying effect. On these soils, this form always produces a bonus effect over the nitrogen which is supplied. In some cases, volatilisation losses could be severe if the fertilizer is applied to the soil surface in high soil pH situations. Also loss from surface run-off could be important. In slightly acid, loam soils, the recovery of added nitrogen by maize could be very good but as the texture becomes more clay, the soil more compact, and the pH higher, the recovery is decreased.

In some situations in Trinidad, side-dressing in the form of anhydrous ammonia injected into the soil could be successful although this method of applying nitrogen to soils has never been tried in the Caribbean.

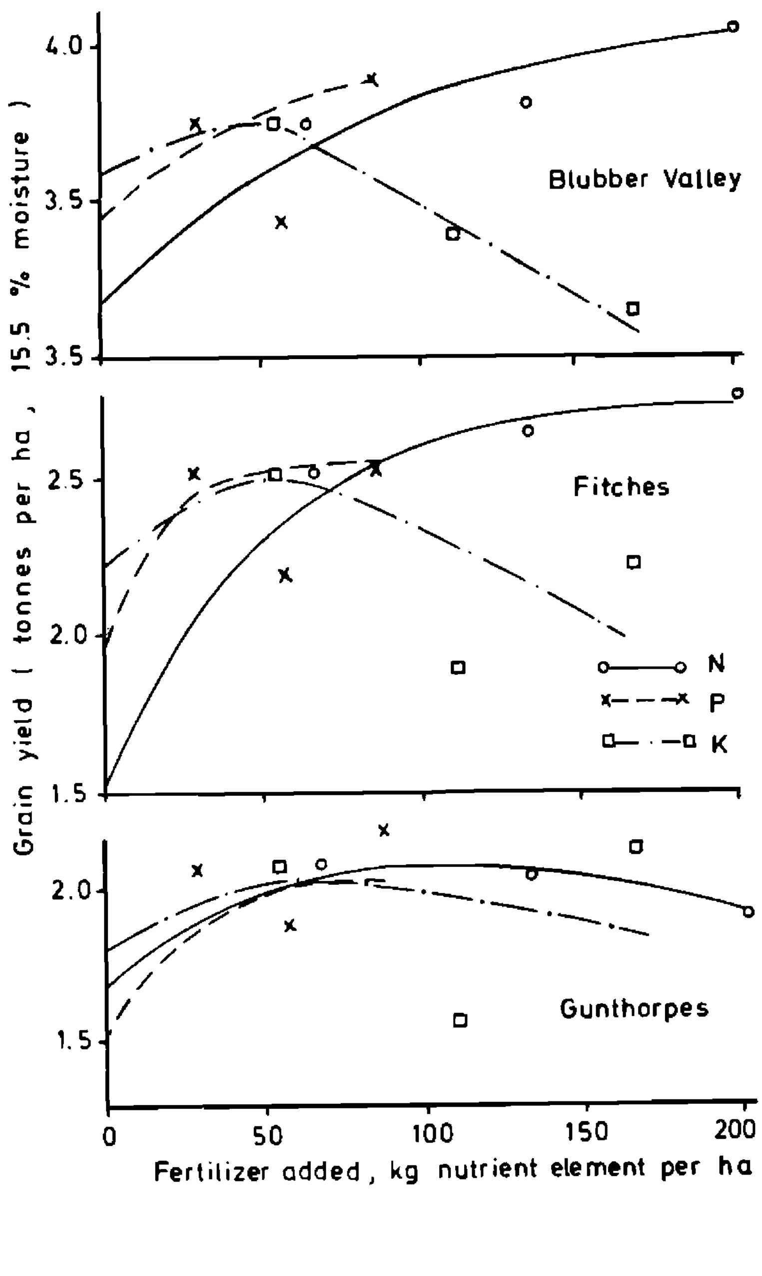


Fig. 2. Influence of different rates of N, P and K fertilizers on mean grain yield of maire in Antigua.

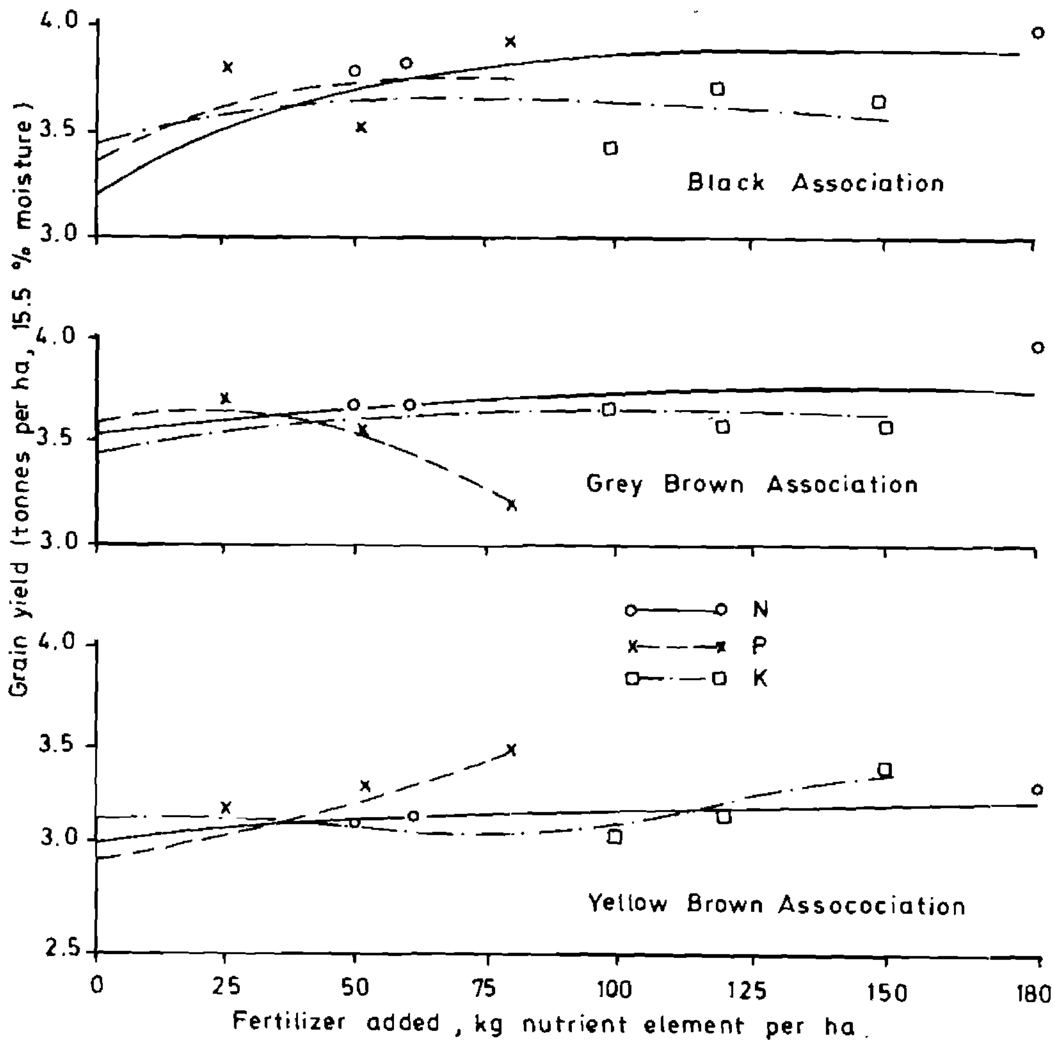


Fig. 3. Influence of different rates of N, P and K fertilizers on mean grain yield of maize in Barbados.

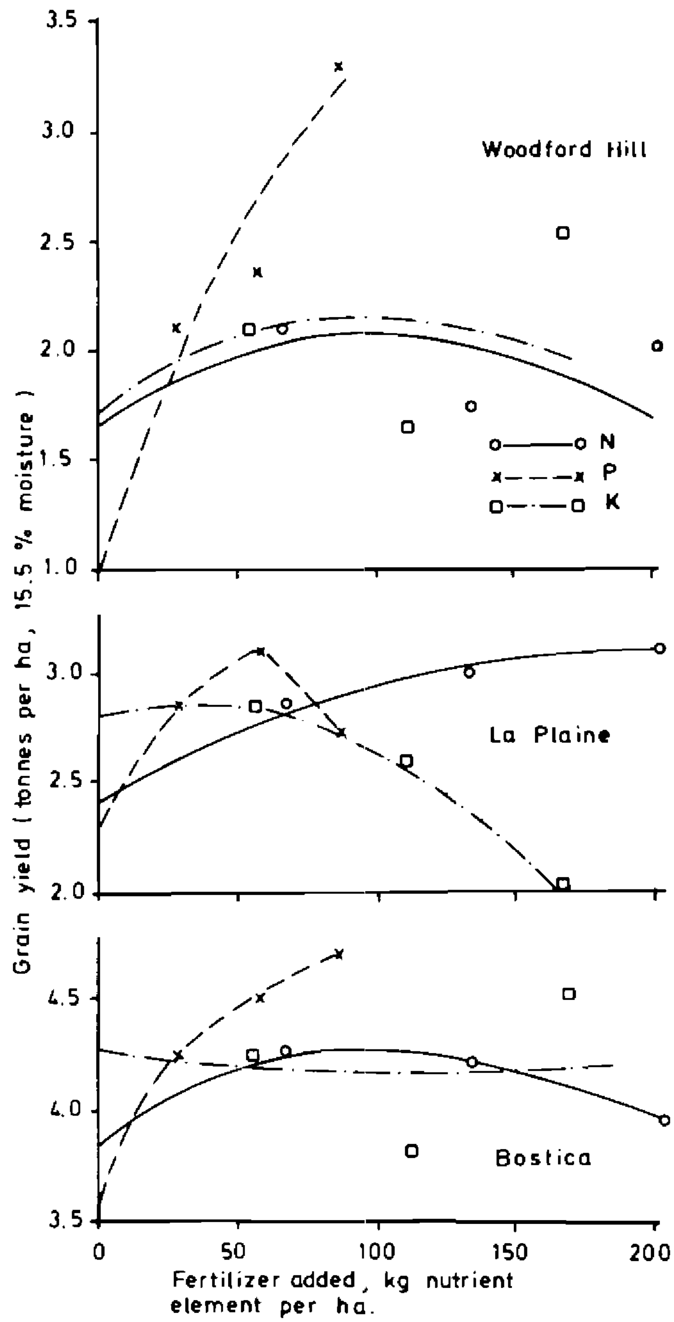


Fig. 4. Influence of different rates of N, P and K fertilizers on mean grain yield of maize in Dominica.

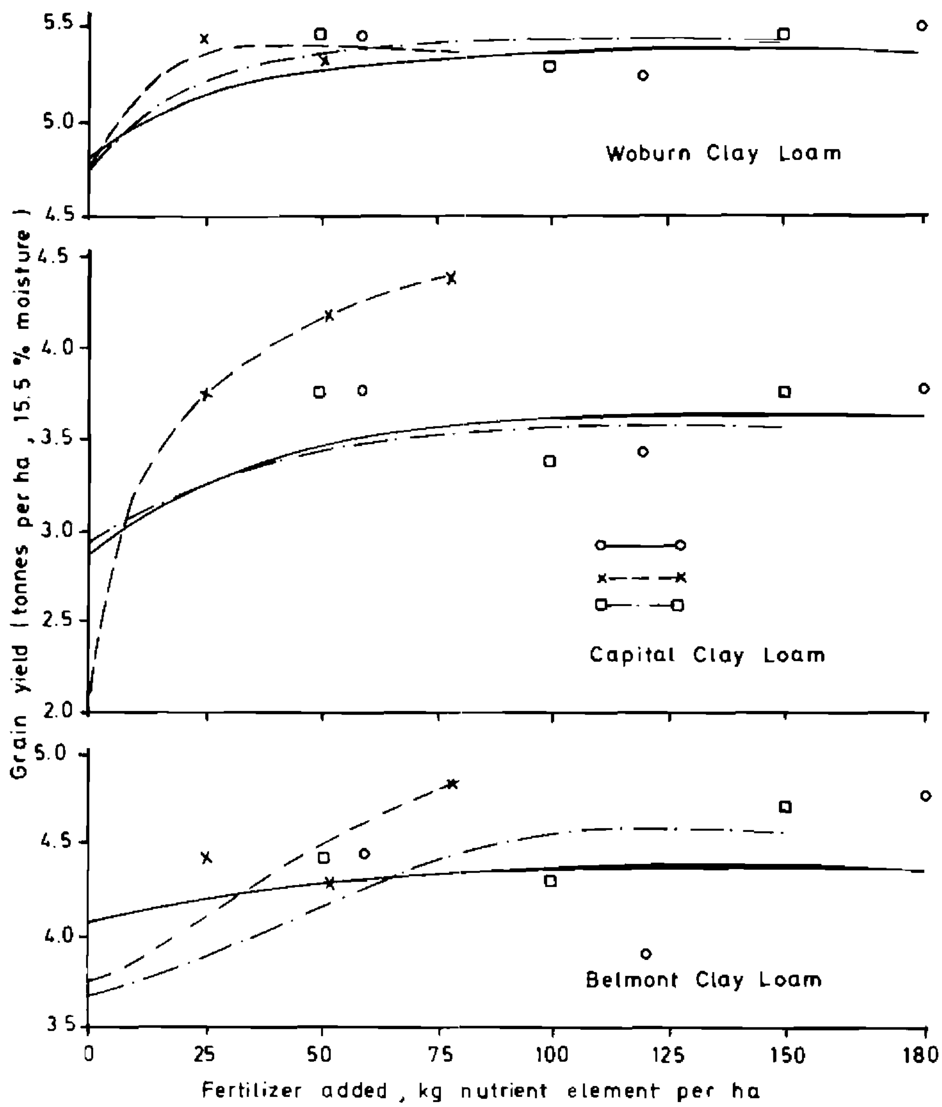


Fig. 5. Influence of different rates of N, P and K fertilizers on mean grain yield of maize in Grenada.

Table 2. Fertilizer recommendations for some of the soils of the Caribbean assuming minimum 3,000 kg/ha grain production

Island and Soil Series	Soil Taxonomy name	Texture	Fertilizer recommendation N	P	K
				kg/ha	
ANTIGUA					
Blubber Valley	Cumulic haplustolls	clay	100	25	50
Fitches	Typic calciustolls	clay	100	25	50
Gunthorpes	Udic chromusterts	clay	50	25	50
BARBADOS					
Black soil	Typic chromusterts	clay	50	–	50
Grey brown	Udic chromusterts	clay	50	–	–
Yellow brown	Vertic tropudult	clay	50	50	–
DOMINICA					
Woodford Hill	Typic tropudults	clay	50	75	50
Espagnol	Typic durustolls	clay	150	25	150
La Plaine	Udic durandepts	clay	100	50	25
Boetica	Entic dystrandepts	clay	50	75	25
GRENADA					
Capitol clay loam	Oxic humitropept	clay	50	50	50
Woburn clay loam	Paralithic vertic	clay	50	25	50
MONTSERRAT					
Grove	Typic ustipsamment	ashy	25	25	25
Amersham	Typic tropudalfs	loam	50	80	25
Riley's	Typic tropudalfs	loam	50	25	50
ST. KITTS					
Shadwell	Mollic vitrandepts	ashy	50	25	50
Golden Rock	Mollic vitrandepts	ashy	25	25	25
Sandy Bay	Mollic vitrandepts	ashy	200	–	–
Mansion	Typic tropudalfs	ashy	50	75	50
ST. LUCIA					
Balembouche	Aquic tropic argiudolls	clay	100	15	25
Raveneau clay	Udic chromusterts	clay	50	25	50
ST. VINCENT					
Akers sandy clay loam	Udic argiustolls	loam	50	25	50
Bellevue sandy clay	Typic eutropept	loam	50	25	50
Soufriere cindery gravelly loamy sand	Typic vitrandept	cindery	150	25	50

(vi) Phosphorus and potassium:- There are many Caribbean soils which are low in P or K or both. In the volcanic islands, low P availability is often a cause of low productivity in maize as seen from experiments carried out in Grenada and Dominica. In general, the vertisols in the Caribbean which are formed from limestone are well supplied with P but may be deficient in K. The exceptions are the Vertisols of Belize derived from calcareous rocks which are quite low in P and those of Antigua on marl which are high in K. Soils derived from sedimentary and recent alluvial materials and those formed on shales or schists tend to be adequately supplied with K but in some cases responses to P may be obtained. The coastal clays of Guyana and Surinam are well supplied with K, and P may also be adequate. However, P and K availability in the brown sands is too low to have much of an impact on crop requirements.

The extent of response and recovery of P and K for any soil for maize should be found by experimentation. In some of the high P fixing soils, non-conventional ways of using P fertilizers for greater efficiency must also be found. Examples of such soils are the bauxitic soils of Jamaica. Except in these special circumstances, P and K fertilizers could be applied at planting, placed in close prominity to the planted seed.

Fertilizer recommendations for several West Indian soils for maize are given in table 2.

(vii) Soil management for erosion control:- Soil erosion is probably the most important soil hazard in commercial maize cultivation.

Under existing procedures for tillage and other cultivation operations for maize, the soil is left in a very erodible condition for long periods of time and as a result, serious examples of soil erosion could be seen where maize is commercially grown in the Caribbean. Surface erosion is the most serious form, although gullying and landslipping could be easily caused particularly with Vertisols on sloping topography. Much can be done in managing the soil to minimise erosion. The extent of tillage which was already discussed is very important in this respect. Minimum tillage and zonal tillage as opposed to fine uniform seedbed preparation should be considered seriously. The substitution of cultivation for weed control by the used of herbicides is also a means to reduce soil erodibility. Where maize is grown on sloping land, the layout of the land should be in accordance with good soil conservation practices.

(viii) Crop rotations:- Few soils in the Caribbean could support indefinitely, continuous cultivations of maize. As an example of soil deterioration, 20 years of continuous maize at Spanish Lookout has resulted in erosion of topsoil, soil compaction and lowering of soil fertility. From observations of the farmers, maize should only be grown continuously for up to 5 years and that this should be rotated with pasture for three years. This rotation is a means of maintaining the soil in reasonable physical condition due to "resting" of the soil for the three years of pasture and to allow fertility to accumulate. In Antigua, continuous maize even for a few years has resulted in marked modification of the natural flora where grasses and other weeds, some introduced, have replaced the naturally prolific legume vegetation.

In normal crop rotations, several variations are possible. For instance, within one year, a maize crop could be rotated with a grain legume crop. Alternatively, maize followed by maize or sorghum could be grown for up to five years and then the soil allowed to recuperate by putting it in pasture for up to three years. A severe disadvantage here is the deterioration, under pasture and grazing, of any drains, ditches or particular land layout which is necessary for growing of maize.

REFERENCES

Ahmad, N. 1960. Aluminium toxicity of certain soils on the coast of British Guyana and problems of their agricultural significance. Trans. 7th Int. Congr. Soil Sci. 2: 161-170.

Ahmad, N. and Paul, C.L. 1978. Effect of sub-soiling on soil physical conditions and sugar cane root distribution in a Trinidad clay soil. In Modification of Soil Structure. Ed. W.W. Emerson, R.D. Bond and A.R. Dexter. J. Wiley & Sons: 419-430.

Baynes, R.A. and Walmsley, D. 1973. Fertility evaluation of some soils in the Eastern Caribbean. Department Report No. 17, Department of Soil Science, UWI, St. Augustine, Trinidad, p. 80.

Evans, H. 1955. Studies in the mineral nutrition of sugar cane in British Guyana. Trop. Agric. (Trin.) 32: 124-133.

Evans, H. and Cate, R.B. 1962. Studies on the improvement of problem soils in British Guyana. World Crops 14: 370-373.

Forde, St. C.M., Payne, H.W. and Walmsley, D. 1975. Fertility assessment of some soils in Antigua, Montserrat, St. Kitts and Dominica from maize (Zea Mays) field trials. Department Report No. 18, Department of Soil Science, UWI, St. Augustine, Trinidad, p. 100.

Lignon, W.S. and Pierre, W.H. 1932. Aluminium studies II. Minimum concentration of aluminium found to be toxic to corn, sorghum and barley in culture solutions. Soil Sci. 34: 307-317.

Mc Clean, F.T. and Gilbert, B.E. 1927. The relative aluminium tolerance of crop plants. Soil Sci. 20: 163-175.

Trenel, M. and Alten, F. 1934. The physiological importance of mineral soil acidity: The toxic action of Al. Anal. Chem. 47: 813-820.

Wright, K.E. and Donahue, B.A. 1954. Aluminium toxicity studies with radio-active phosphorus. Plant Physiol. 28: 674-680.

INFLUENCE OF FERTILIZER N AND LEGUME CROP RESIDUES ON MAIZE YIELDS[1,2]

M. A. Lugo-López, Raúl Pérez-Escolar and T.W. Scott[3]

SUMMARY

Studies to explore the N supplied by legume and nonlegume crop residues through crop rotation experiments on a sandy Oxisol and a clayey Ultisol were conducted. In the initial crop, soybean yields were only fair (1,680 to 1,792 kg/ha). Mungbeans (1,125 to 2,044 kg/ha), winged beans (1,456 to 2,800 kg/ha), and maize yields (4,480 to 6,123 kg/ha) were good. In the second crop (maize at both sites), grain yields were striking as a result of fertilizer N, regardless of the previous crop. On the Ultisol, maize tended to yield more following the legumes than following maize, but differences were not statistically significant. About 80% of the maximum maize yield was attained when maize followed the legumes and no fertilizer N was applied, especially in the Ultisol.

INTRODUCTION

For several years, there has been great concern about N fertilization of food crops under tropical conditions especially in developing countries. This has been so, mainly because of the high cost of N fertilizers and their relative unavailability in those areas. Since 1970, studies in this connection have been underway at Puerto Rico in a cooperative effort with Cornell University, with financial support from the U.S. AID. One of the main objectives of the research work is to find alternate sources of N for food crop production. Preliminary attempts to explore the N supplied by crop residues through crop rotation experiments on Oxisols and Ultisols under conditions in Puerto Rico were reported at the past Caribbean Food Crops Society meeting by Dr Thomas W. Scott and have been recently published (Talleyrand et al, 1977). Substantially higher yields of maize were obtained in a sandy Oxisol and a clayey Ultisol from the first crop of maize following soybeans or maize than following fallow. Although the yield of the second maize crop following soybeans was slightly higher than that of the first, the second maize crop after initial maize and fallow were substantially higher. The effect of fertilizer N at all sites was striking, regardless of the previous crop in the rotation. It was noted that the three continuous maize

[1]Paper presented at the XV Annual Meeting, Caribbean Food Crops Society, Paramaribo, Suriname, November 13-18, 1978.

[2]Joint contribution from the Department of Agronomy, Cornell University, Ithaca, N.Y., and the Agricultural Experiment Station, Mayaguez Campus, University of Puerto Rico, Rio Piedras, P.R. This study was part of the investigations supported by USAID under research contract ta-c-1104.

[3]Professor and Soil Scientist (Ret.), Agricultural Experiment Station, University of Puerto Rico, now Consultant, Cornell University, Soil Scientist, Agricultural Experiment Station, University of Puerto Rico, Mayaguez Campus, Rio Piedras, P.R., and Professor, Cornell University, Ithaca, N.Y., respectively.

crops on a clayey Ultisol, which were harvested over a period of less than 14 months, produced about 18,000 kg/ha of grain with the application of 110 kg/ha of N/crop. It was postulated that this would not be possible unless a substantial amount of N was available from sources other than the fertilizer N, such as mineralization of soil organic matter or root residues.

This initial work led to further studies, which we are reporting today, with other edible legumes, which after harvesting, would have more green matter in the stover.

MATERIALS AND METHODS

Crop rotation experiments were conducted at two different locations: Manati on an Oxisol (Bayamón series), Typic Haplorthox, with high sand content, oxidic, isohyperthermic; and Corozal on an Ultisol (Humatas series), Typic Tropohumults, clayey, kaolinitic, isohyperthermic (Lugo-Lopez & Rivera, 1976). The Bayamón moil occurs at an elevation of 50 to 130 m, fully exposed to the sun, while the Humatas occurs at elevations of 220 to 580 m with northern exposure. Soil samples were taken at both sites at 0-25 and 25-50 cm depths previous to the establishment of the treatment differentials, and were analyzed for pH, organic matter content, cation exchange capacity, and exchangeable Ca, Mg, K, and Al using standard methods (Black, 1965).

The rotation experiments followed a split-plot design with six replications. The main plots were four rotations: Soybeans *(Glycine max)* and maize *(Zea mays L.)*; winged beans *(Psophocarpus tetragonolobus)* and maize; mungbeans *(Phaseolus aureus)* and maize; and maize in monoculture. The subplots included two treatments for the maize crop following the initial crop: 0 and 67 kg/ha of fertilizer N applied as urea, all when the plants were 1 month old. Plots were 4.57 x 9.15 m in size.

For the first crop in the rotation, maize hybrid Pioneer X-306-B, soybean variety Jupiter, winged bean selection 16 (obtained from the Mayaguez Institute of Tropical Agriculture), and an unidentified variety of mungbeans introduced from Trinidad were planted in the corresponding plots on April 1, 1976 and May 17, 1976 at Manati and Corozal, respectively. The legumes and the maize were planted at 61 cm between rows, and 23 cm between plants. Weeds were removed by hand from all plots as necessary. Excellent crop protection from insects and diseases was achieved through the preventive biweekly use of Sevin and Dithane[4]. The plots at both sites were irrigated as necessary using a sprinkler system. The legume crops and the maize received the following application of fertilizer broadcast at planting: 112 kg/ha of P_2O_5 as triple superphosphate, 112 kg/ha of K_2O as sulphate, and 56 kg/ha of Mg as sulphate. The initial maize crop received 110 kg/ha of N, but no N was applied to the soybeans, winged beans, and mungbeans.

At Manatí, mungbeans were harvested as dry pods 90 days after planting; the stover was plowed under with a rotavator. Winged beans, because of the indeterminate nature of the crop, were harvested periodically from about mid-August to the first week of October 1976. Soybeans and maize were harvested during the first week of October at 180 days of age. The legume and maize stover were plowed under on November 5, 1976.

[4]Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of equipment or material by the Agricultural Experiment Station of the University of Puerto Rico or an endorsement over other equipment or materials not mentioned.

At Corozal, mungbeans were harvested at 60 days at the green-pod stage. The border rows were left unharvested to estimate dry-grain yields. The inner rows were planted again without receiving any additional fertilizer. The objective was to obtain a second crop of mungbeans, in view of the relatively quick growth observed in the first crop, while the other legumes and the maize were still immature or not ready for final harvesting. Winged beans were harvested periodically, as in Manatí, from mid-September to the end of October. In addition, the amount of legume stover was determined and analyzed for N by the Kjeldahl technique (Black, 1965). The second maize at both sites, was planted on February 22, 1977, at Manatí, and on April 13, 1977, at Corozal. Rows were 75 cm apart. Half of each plot received fertilizer N at the rate of 67 kg/ha 1 month after planting. The maize crops received broadcast fertilizer applications as follows: 224 kg/ha of P_2O_5 as triple superphosphate; 168 kg/ha of K_2O as sulphate; and 90 kg/ha of Mg as sulphate.

RESULTS AND DISCUSSION

Table 1 gives selected chemical properties of the two soils. The pH of the surface layer at the two sites was slightly over 5.0, decreasing with depth to 4.6 and 4.8 at the Corozal Ultisol

Table 1. Selected chemical properties of the two soils used in the crop residue experiments

Soil	Depth (Cm)	Organic matter (%)	Acidity (pH)	Cation exchange capacity	Exchangeable cations			
					Ca	Mg (Meq)	K	Al
Bayamón sandy	0-25	1.6	5.2	2.5	1.3	0.8	0.1	0.3
Oxisol	25-50	.7	4.8	2.3	1.2	.7	0	.4
Humatas clayey	0-25	3.7	5.1	7.9	6.4	.8	.7	0
Ultisol	25-50	1.2	4.6	12.4	3.0	.8	.2	8.4

and the Manati Oxisol sites, respectively. Organic matter content of the clayey Ultisol was 3.7; in the sandy Oxisol it was less than half that value. CEC was nearly 8 meq in the Ultisol. Ca saturation was over 80% in the Ultisol and 52% in the Oxisol. Al was low in the Oxisol and negligible in the surface layer of the Ultisol, but increased to almost 70% saturation in the 25 to 50 cm layer of the latter. This should not pose any problem except for highly sensitive crops such as sorghum Wahab et al, 1976.

Table 2 gives grain and stover yields of the initial crop of legumes and maize at both sites.

Table 2. Initial grain and stover yields of legumes and maize crops, kg/ha

Crop	Yields in Oxisol		Yields in Ultisol	
	Grain	Stover	Grain	Stover
Maize (Pioneer X-306B)	6,123	7,258	4,480	2,969
Soybeans (Jupiter)	1,680	2,050	1,792	2,173
Winged beans (W.B. 16)	1,456	2,733	2,800[2]	2,240
Mungbeans	1,125[1]	2,710	2,044[1] or 2,800[2]	2,576

[1]Dry-grain weight.

[2]Green-pod weight.

Table 3. The effect of plowed-in legume and maize stover and roots on yield of maize, Pioneer X-306B, kg/ha

Rotation	Fertilizer N applied	Yield on indicated soil	
		Ultisol	Oxisol
Maize, maize	0	2,337	4,716
Maize, maize	67	3,938**	5,191**
Mungbeans, maize	0	3,022	5,382
Mungbeans, maize	67	3,705**	6,157**
Soybeans, maize	0	3,295	4,327
Soybeans, maize	67	4,296**	5,353**
Winged beans, maize	0	3,096	4,658
Winged beans, maize	67	3,747**	5,765**

** Highly significant differences against no N.

The soybean yields were only fair when compared with yields of other experiments at the same sites and at other locations. Yields of about 3,170 kg/ha have been previously obtained in the Bayamón sandy Oxisol and in liming experiments at other sites (Pérez-Escolar, 1977). Yields of winged beans and mungbeans compare favorably with those obtained at locations outside Puerto Rico (Aldwyn & Roop, 1975; National Academy of Sciences, 1975). Maize yields are good especially at the Oxisol site, a reverse situation as compared to previous work at the same locations (Fox et al, 1974).

The grain yields of the maize crop following the initial maize, soybeans, winged beans, and mungbeans are given in table 3 for the two sites. At the Corozal site (Humatas clay), maize with or without fertilizer N (as whole treatments) tended to yield more following soybeans, mungbeans and winged beans than when following the initial maize crop. The differences, however were not significant, even though the initial maize crop received 110 kg/ha of fertilizer, while the legume crops did not receive fertilizer N. This was not the case at the Manatí site (Bayamón sandy loam), except for maize following mungbeans, with or without fertilizer N, in which case maize yields tended to be more than maize following the other legumes or maize, although differences again were not significant.

The effect of fertilizer N applied to the maize crops succeeding the initial crops was again striking at both sites. In four out of eight cases the increased yield attributable to applied fertilizer N surpassed 1,000 kg/ha; in one case at Corozal the increase reached 1,600 kg/ha (maize following maize both crops with 67 kg/ha of applied N).

At both sites, about 80% of the maximum maize grain yields obtained when fertilizer N was applied could be obtained when maize followed the legumes and no N was applied, especially on the clayey Ultisol. At Manatí, as much as 90% of the maximum yields in the second crop were obtained with no N following maize. However, it must be remembered that the original maize crop and the second maize crop received 110 and 67 kg/ha of fertilizer N, respectively.

Table 4. Dry matter plowed under, its N content and yield of maize X-306B on plots where no mineral N was applied, kg/ha

Treatment	Oxisol			Ultisol		
	Stover	N	Maize yield	Stover	N	Maize yield
	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha
Maize	7,258	60	4,716	2,969	14	2,337
Soybeans	2,050	12	4,327	2,173	20	3,022
Winged beans	2,733	30	4,658	2,240	28	3,295
Mungbeans	2,710	33	5,384	2,576	24	3.096

Table 4 shows the amount of stover plowed under and its N content. As in the previous experiment, there was no apparent statistical relationship between the amount of N returned to the soil from these residues and mean yields of the subsequent maize crop.

Total maize yields of 6,817 and 10,840 kg/ha were obtained at Corozal and Manatí, respectively, for the two subsequent maize crops. At Corozal 17,899 kg/ha of grain (both legume + subsequent maize) were obtained without fertilizer N; at Manatí, 18,628 kg/ha. With fertilizer N, the respective yields increased to 20,239 and 21,535 kg/ha. These are sizeable amounts of grain for a period of less than a year. This would not be possible unless a substantial amount of N became available from sources other than the fertilizer, as also observed in a previous experiment (Talleyrand et al, 1977). The mineralization of soil organic matter and root residues may play a significant role in supplying this N.

RESUMEN

Se realizaron experimentos adicionales de rotación de cosechas para constatar las posibilidades del uso de residuos de cosechas — leguminosas y noleguminosas — como fuentes de N en dos localidades: un Oxisol y un Ultisol arcilloso. Los experimentos se diseñaron como parcelas subdivididas. Los tratamientos principales eran las cuatro rotaciones: 1) maíz, maíz; 2) sojas, maíz; 3) habichuelas mung, maíz; 4) habichuelas aladas, maíz. Los subtratamientos consistieron de dos niveles de N: 0 y 67 kg/ha aplicados un mes después de la siembra. En las cosechas iniciales se obtuvieron rendimientos medianamente elevados de sojas, bastante elevados de habichuelas mung y habichuelas aladas (a base de rendimientos informados de áreas productoras de estos cultivos nuevos para Puerto Rico) y buenos rendimientos de maíz, el aumento en los rendimientos que pueda atribuirse a la aplicación de 67 kg/ha de N fue tan drástico como en experimentos anteriores, independientemente de la cosecha anterior. En el Ultisol, se obtuvieron rendimientos de maíz substancialmente más elevados después de la cosecha inicial de las tres leguminosas que cuando se sembró maíz por dos veces consecutivas en el mismo terreno. La situación en el Oxisol fue diferente, a excepción de la rotación habichuelas mung-maíz. Se logró como 80% de los rendimientos máximos de maíz sin necesidad de aplicar N como abono cuando las siembras previas en la rotación fueron leguminosas. En este caso, hay la ventaja adicional de que se pueden sembrar y cosechar leguminosas comestibles. En Manatí se lograron producciones de grano utilizable de la magnitud de 18,628 kg/ha, incluyendo la leguminosa y el maíz en sólo dos cosechas en alrededor de un año; en Corozal, 17,899 kg/ha. Con el uso de N, estas producciones ascendieron a 21,535 y 20,239 kg/ha, respectivamente. Esto no sería posible si no hubiese disponible una cantidad substancial de N de otras fuentes, aparte del abono, y la que quizás pueda atribuirse a la mineralizachión de la materia orgánica del suelo y de los residuos de cosechas anteriores.

REFERENCES

1. Aldwyn, B., and Roop, G., 1975. Mungbean potential for cultivation in Trinidad and Tobago, Min. Agric., Trinidad Tobago.

2. Black, C.A., Ed, 1965. Methods of soil analysis, Am. Soc. Agron., Wisconsin, Monograph No. 9.

3. Fox, R.H., Talleyrand, H., and Boulding, D.R., 1974. Nitrogen fertilization of corn and sorghum grown in Oxisols and Ultisols in Puerto Rico, Agron. J., Vol. 66, July-August.

4. Lugo-López, M.A., and Rivera, L.H., 1976, Taxonomic classification of the soils of Puerto Rico, Esta. Exp. Agric., Univ. P.R., Bol. 245.

5. National Academy of Sciences, 1975. The winged bean, a high-protein crop for the tropics.

6. Pérez-Escolar, R., 1977. Effect of soil pH and related acidity factors on yields of sweet-potatoes and soybeans grown on typical soils of the humid tropics, J. Agric. Univ. P.R. 61 (1): 82-89.

7. Talleyrand, H., Pérez-Escolar, R., Lugo-López, M.A., and Scott, T.W., 1977. Utilization of N from crop residues in Oxisols and Ultisols, J. Agric. Univ. P.R. 61(4):450-455.

8. Wahab, A., Talleyrand, H., and Lugo-López, M.A., 1976. Rooting depth, growth and yield of sorghum as affected by soil water availability in an Ultisol and an Oxisol. J. Agric. Univ. P.R. 60(3):316-378.

EFFECT OF POTASH FERTILIZATION ON THE SALT TOLERANCE OF MAIZE, IRRIGATED WITH SALINE WATER

C.C. WEIR
Faculty of Agriculture
U.W.I., Jamaica.

SUMMARY

The effect of applying high levels of Potash fertilizer, on the salt tolerance of maize, was investigated under greenhouse experimental conditions.

It was found that high levels of applied K significantly reduced the uptake of Na, and resulted in approximately 20% greater dry matter yield compared to the control (K_0) treatments. The K/Na ratio in the maize tops, was shown go be a good index of salt injury. Ratios of K/Na less than 10 were associated with poor yields.

The effect of high salinity and Potash applications on the uptake of other nutrients was also ivestigated. High levels of Potash consistently decreased Magnesium and Nitrogen uptake, but somehow slightly increased Phosphate uptake.

The practical implications of using Potash applications to offset salinity injuries, caused by using saline irrigation water, are discussed, within the context of a nutrient balance for maize.

INTRODUCTION

Plant species differ widely in their tolerance to salinity. Some like mangroves, grow with their roots in sea water which is approximately 0.5 M NaCl, plus other salts, and has an electrical conductivity (EC) reading of about 55 mmhos/cm (35,000 mg/l).

However the yields of the most salt tolerant commercial crops are affected adversely by irrigation waters which exceed 5 to 10 mmhos per cm. The yields of sensitive ones are affected by waters exeeding 1 mmhos/cm. Thus even modest increases in the tolerance of crops, sufficient to permit economic crop production with moderately saline water, would be a tremendous accomplishment. But in looking for plants with high salt tolerance, we must recognize that tolerance is not necessarily a constant plant property, as it can be modified by other environmental conditions.

Many factors can affect the salt tolerance of plants. The stage of growth of the plant and many climatic factors such as atmospheric humidity, light intensity and oxygen tension can affect salt tolerance. Fertilizer application too can also be of importance in salt tolerance.

The fertilizer element of most significance in salt tolerance is Potassium. This investigation is concerned with studying the effect of Potash applications as a means of increasing the salt tolerance of corn, when irrigating with saline water.

MATERIALS AND METHODS

a. Experimental Design

The statistical design of the experiment consisted of a randomized block design with 15 treatments; 5 salt levels x 3 Potash levels; and three replications. The salt levels ranged from non – saline irrigation water to highly saline water, while the 3 Potash levels consisted of zero, moderate and high applications of Potassium Chloride.

b. Soil used in Study – Application of K fertilizer

The soil used in this experiment was a non-saline alluvial soil, classified as Marverly loam – (No. 22) in the Jamaican Soil Classification System. Some chemical and physical properties of this soil are given in table 1.

Table 1. Some Chemical and Physical Properties of Soil used in Study – (Maverly Loam)

Soil depth	pH	% O.M.	p.p.m. availl. (1) P_2O_5	Exchangeable cations (2) K	Mg	Ca	Mechanical Analyses % Sand	% Silt	% Clay
0 – 15 cm	6.5	2.3	35	0.24	1.2	8.1	44	41	15
15 – 30 cm	6.7	1.6	28	0.20	1.0	7.3	46	42	12

(1) Truog's available phosphate
(2) Data in Me/100 gm

The 3 levels of K applied were as follows: (i) None, (ii) 0.3 Milliequivalent K per 100 gm. soil or approx. 200g KCl per hectare, (iii) 0.6 Me K per 100 gm. or approx. 400 kg KCl per hectare, (iii) 0.6 Me K per 100 gm. or approx. 400 kg KCl per hectare. The Potash applications were made before sowing of the maize seeds. Likewise, basal applications of Nitrogen (Ammonium Sulphate) and Phosphate, at rates of 200 and 100 kg, of N and P_2O_5 respectively were given to all pots.

c. Growth of Maize Seedlings

Maize seedlings (cv "Pioneer X-304") were grown in 25 cm plastic pots, containing approx. 10 kg. of a saline alluvial soil. Seedlings were produced by sowing six seeds directly in the pots, at a depth of about 2 cm. After germination, seedlings were progressively thinned out to 2 plants per pot.

d. Preparation of Saline Solutions and Description of Experiment

The saline solution used for irrigating were prepared from stock solutions, which were made by mixing calculated weights of appropriate chemicals. Relevant data on the 5 irrigation waters are given in table 2.

Table 2. Characterization of Saline Solutions used for Irrigation

Classification for Waters	Elec. Cond. Mmhos/cm	Salts P.P.M.	E.S.P.	Rating
1. Non-saline	0.8	480	55	Good
2. Moderately saline	2.1	1260	70	Fair
3. Saline	3.8	2280	82	Doubtful
4. Very saline	5.7	3420	90	Unsuitable
5. Very highly saline	7.7	4620	95	Highly unsuitable

Irrigation with the saline solutions was started one week after germination, and all pots were irrigated with the appropiate solution on alternate days.
In order to keep the salt concentration of the soil solution in the root zone as close to that of the irrigation water as possible, the soil in the pots was prevented from drying out and thus concentrating the salt in the root zone.

e. Harvesting and Tissue Analyses

The tops of the maize plants were harvested after six weeks growth in the greenhouse, and weighed after drying at 80°C for 24 hours.
The dried samples were ground in a micro-hammer mill and then analysed for total Nitrogen, Phoshporus, Potassium, Sodium, Calcium and Magnesium.

Total Nitrogen was determined by a Micro Kjeldahl Procedure. Phosphorus analyses were carried out by the standard Molybdenum Blue method, Sodium and Potassium by flame photometry and Calcium and Magnesium by atomic absorption spectrophotometry.

RESULTS AND DISCUSSION

The yield of maize tops and the major nutrient conteng of the oven dried tissues are given in table 3.

EFFECT OF K AND NA ON YIELDS

The depressing effect of increasing salinity on yields and Potassium uptake are at once evident in table 3.

Table 3. Yield and Nutrient content of Maize tops

Treatmant		Yield of tops (g)	% K	% Na	% N	% P	% Ca	% Mg
1. NS	K_2	68.3	5.3	.068	1.65	0.20	1.0	0.40
2. NS	K_1	70.0	5.0	.069	2.21	0.19	1.2	0.51
3. NS	K_0	62.1	2.0	.055	2.37	0.17	1.2	0.75
4. MS	K_2	63.7	5.0	.21	1.70	0.21	1.0	0.42
5. MS	K_1	60.0	4.7	.22	2.31	0.20	1.0	0.49
6. MS	K_0	53.4	2.0	.26	2.53	0.17	0.9	0.70
7. Sal.	K_2	55.0	4.6	.50	2.25	0.19	0.95	0.31
8. Sal.	K_1	52.2	4.3	.52	2.60	0.20	0.83	0.35
9. Sal.	K_0	44.5	2.1	.63	2.10	0.14	0.83	0.51
10. V.S.	K_2	48.0	4.0	.65	2.25	0.16	0.83	0.33
11. V.S.	K_1	44.3	3.6	.68	2.10	0.14	0.95	0.39
12. V.S.	K_0	34.1	1.8	.79	2.15	0.13	1.0	0.49
13. V.H.S.	K_2	40.7	3.5	.74	2.53	0.14	0.83	0.30
14. V.H.S.	K_1	37.3	3.2	.90	2.53	0.13	0.70	0.35
15. V.H.S.	K_0	31.0	1.3	1.40	2.48	0.11	0.83	0.40
L.S.D. ($P = 0.05$)		± 7.1	ND	ND	ND	ND	ND	ND

NS = Non-saline; MS = Moderately saline; Sal = Saline;
VS very saline; VHS = Very highly saline.

Also obvious is the effect of using very saline irrigation water on the Sodium content of the maize tops.

The effects of Potash applications on (a) increasing yields and (b) reducing Sodium absorption are quite striking. Potash additions at the highest levels (K_2) decreased Sodium uptake over the controls (Ko), from 19 to 47%. Likewise, Potash applications at the highest levels, increased yields over controls, by an average of approx. 15%. Similar results on wheat, were reported by Schleiff (1975) who found that when using irrigation water, made saline with $MgCl_2$, a 20% yield increase was obtained by application of Potash.

K/NA RATIOS

In computing the K/Na ratios, the % values for each element was first converted to milliequivalents per 100 gm plant material as follows:

$$\text{Milliequivalent K or Na/100g} = \frac{\text{K or Na} \times 1000}{\text{Atomic weight}}$$

The following conclusions can be drawn

- above a K/Na ratio of about 15 – 20, there is vertually little or no change in Maize yields.
- below a K/Na ratio of about 10, Maize yields decreased sharply.
- for reasonable growth, the K/Na ratio must be maintained above 10.

It is interesting to compare the yields at a low K supply and 2.1 mmhos irrigation water, with that of 3.8 mmhos water and high K application.
Similar yields of about 76% of maximum were obtained with a lower K supply, when the water was of fair quality; as well as with poor quality water (3.8 mmhos), when the supply of K was high (K_2). Thus the increased use of Potash, was able to eliminate partly the damage caused by salinity.

NITROGEN AND PHOSPHATE CONTENTS OF MAIZE

The effects of the increasing salinity, as well as the K levels, on N and P uptake, was also investigated. Data in table 3, clearly show the depressing effect of salinity on P content of maize tops. On the other hand, Potash applications tend to increase P uptake.

Some workers (Bernstein, 1964; Nieman & Clark, 1976) have also shown that salinity can cause a deficiency of P in crops. However, a few have shown that salinity can sometimes result in an accumulation of P in plant tissues (Bernstein, 1974). But the injurious effects of salinity depends on the concentration of P in the root medium — at low concentration of P, salinity can cause a deficiency in P. These effects on the concentration of Phosphate in plant tissues seem unique, since salinity does not cause comparable changes in concentration of other essential ions (Bernstein, 1974).

Careful study of table 3, will reveal that there is little or no effect of salinity per se on N uptake. The differences in N content are really due to Potassium. At low salinities (NS, MS) there is a definite reduction in N (about 30%), due to K applications.
This trend is not apparent at higher salinities, because of the depressing effect of Na on K content. Thus, because of low K uptake, the N content in the very highly saline treatments were much higher than in the non-saline pots - 2.5% N vs 2.1% N.

SALINITY AND POTASH EFFECTS ON Ca AND Mg UPTAKE

Table 3 shows that neither high salt levels or Potash applications had any significant effect on Calcium uptake. This is not surprising. On the other hand, both salinity and Potash applications had marked depressing effects on Magnesium uptake. On the average, the nonsaline treatments had 40% higher Magnesium content, than the very saline pots. Similarly, the K_2 treatments had approximately 38% higher Magnesium than the K_o treatments. Leaf symptoms of Magnesium deficiency were detected in some of the K_2 and K_1 treatments.

These results are of great importance, as they indicate some of the nutritional problems that will have to be overcome, in any attempt at using high Potash applications to counteract saline conditions, caused by irrigating with saline water.

CONCLUDING REMARKS

The cation content of the leaves of salt tolerant plants, such as Spinach and Beet, often contain as much as 400 - 500 Meq cations per 100 gm, compared to about 100 - 150 Meq for non-tolerant plants. Many salt sensitive plants such as maize are able to absorb K selectively in large amounts. In this investigation, it has been shown that when K is taken up in large amounts, the salt tolerance of maize was increased.
However, it is believed that if higher tissue contents of K were achieved, more salt tolerance

could have been obtained, particularly in the very saline treatments.

In this greenhouse investigation, the criteria used for assessing salt tolerance, was growth and dry matter yield of maize – rather than grain production. It is recognised that salt tolerance is a function of plant growth stage, i.e. the plant may be more sensitive to salt at certain growth stages, and more tolerant at others. Because of this one cannot assume that the various treatments used in this investigation, would have similar effects on grain yields. However, research by the U.S.D.A. Soil Salinity Division (U.S.D.A. Handbook 60, 1953), have shown that using irrigation water of 8 mmhos, resulted in a 50% reduction in grain yield of maize. These results approximate quite closely the values obtained in this investigation.

The possibility of using K application to offset salinity injuries is not without drawbacks. In the first case, increasing uptake of K consistently results in decreased uptake of Mg and N. In addition, there is the accompanying depressing effect of high salinity on Mg, N and P. This means that if high levels of K are used to offset salinity injuries, then additional amounts of N, P and Mg, will be needed to obtain proper nutrient balance. It is quite possible that higher yields would have been obtained in the very saline treatments if extra N, Mg and P were applied. Subsequent research will explore the implications of these observations.

REFERENCES

Bernstein, L. 1964. Plant Anal, Fert. Problems, Vol 4: 25-45

Bernstein, L., 1974. Crop growth salinity; In J. van Schilfgaarde (ed.) Drainage for Agriculture. Agronomy 17:39-45

Nieman, R.H. & R.A. Clark, 1976. Plant Physiol. 57: 157-161

Schleiff, U, 1975. J. App. Scienes, Vol 7:96-104

Saline and Alkali Soils – U.S.D.A. Handbook 60, PP 55-81 (1953).

A REGIONAL PROJECT FOR PRODUCTION OF GRAIN AND LEGUME

J.A. DUMMETT
CARICOM Corn and Soyabean Company

INTRODUCTION

Corn is grown in Guyana by peasant cultivators as part of a two or three crop rotation following land preparation by slash and burn. The areas where this practice is concentrated are generally along the banks of the Berbice and Poneroon Rivers, the North West District and the Rupunini District. The area planted seldom exceeds three to five acres, no equipment is used except simple hand tools and there is generally little or no application of fertilizer and chemicals for pest control. Production reaching the market rarely exceeds three million pounds.
The government of Guyana supported in 1969 the formation of a farming operation with the same basic objectives as our Company. This operation was sited near to the site of Caricom Corn and Soyabean Company. It has shown a staggered performance while under the control of one then another Government agency and was closed early in 1978.
As part of the same type slash and burn system some cowpea is grown generally of an indeterminate type.
Soyabean is not a traditional crop of Guyana.

Formation of the Company.

Caricom Corn and Soyabean Company is possible through the realization of two important moves in the English speaking Caribbean; the coming into being of CARICOM and the expressed desire of the territories to make a start towards replacing part of the imported foods by production from within the territories. The program for production is evolving and being expressed through the Caribbean Food Plan. This plan is to be given substance by the Caribbean Food Corporation. Caricom Corn and Soyabean Co. is the first regional company and as such is a bit of an anomaly as the subsidary was formed before the holding company.
Policy of the Company rests with a non-executive Board of eight directors.
The Governments of Guyana and Trinidad and Tobago nominate three each, St. Kitts/Nevis one and Caribbean Development Bank one.
All staff come under the control of the General Manager. Early in 1976 the three territories of St. Kitts/Nevis, Guyana and Trinidad and Tobago agreed to finance a company in Guyana to produce grain and legumes. The Company has an authorized share capital of G$ 30 million of which just over G$ 2 million is subscribed. The Company also received loan finance from the Caribbean Development Bank. The C.D.B. prepared the feasibility report for the venture in 1975.

Project site

The Project is located in what is refered to in Guyana as the Intermediate Savannah. This area is inland, by road approximately 130 miles from Georgetown, and can be reached also by travelling up the Berbice river. The river at the point of the Project is navigable to ships of between 500 - 700 tons.

Symposium on maize and peanut, Paramaribo,
Nov. 13 - 18, 1978

Rainfall follows the pattern of a long season (May to August) and a short season (December to January). Temperatures range around 80 to 85°F (26 – 28°C). The topography is rolling with hills 200 - 300 feet with slopes in some areas exceeding 10°. Soils that are being put under cultivation are of the „Brown Sands" which range between loamy sand and sandy loam and are under grass and shrub in the natural state. These soils are characterized as acid, average pH 4, high aluminum, low organic matter, very low nutrient status lacking in all nutrients needed for the plants the Company cultivates.
Production assumes applications of lime and high levels of complete fertilization applied in split applications.

Before moving from the description of the Project site, I must mention that the area to be developed was uninhabited and the Company had had to start from a position of first arrivals.
A total infrastructure has to be created. The construction of bridges, roads, houses, bonds and the like, are being carried out and financed by the Company. There was no community from which workers and staff could commute to the site during this phase. All concerned lived in tents and in fact development of fields and land preparation for the first crop, was carried out simultaneously with the development of infrastructure.

Type of production

The main objective of the Company is to produce food on a large scale at acceptable prices. The Project is, therfore capital intensive and success is dependent on high levels of management and labour efficiency. Since two crops per year are programmed there is little time between harvest of a crop and the planting of the following crop. Land preparation operations are beased on a time allowance of only 4 to 5 weeks in the long dry season (following the long wet) and 3 to 4 weeks in the short dry. The rate at which an operation can be carried out obviously is dependent on the machine capability available but this in turn is dictated by financial considerations.
Since the original feasibility study all costs have escalated. The amoung of finance has not increased as yet and although prices of products are increasing there is the inevitable time lag.

Our task then can be seen as relating several compounds:

- The set of technical data required for the optimum performance of the crop.
- The performance of machinery under local conditions.
- Standards of performance expected from the workers.

From this we must work out systems of management that will make it possible to produce three or four crops on the scale envisaged and the mix must be such that the overall Project is financially viable. To arrive at a program for any aspect of the production sequence, multiple factors have to be considered. Even though there may be a mathematical solution, values will have to be attributed to the factors which we don't have at present. We are at the stage now, where these programs are largely based on intuition. Harvesting is offered as an example, and the following factors are offered as important:

- the minium and maximum percentage moisture acceptable without affecting market quality and/or seed.
- the number of days required for field preparation for the following crop.
- the capital and running cost of employing greater combine capacity.
- the cost of fuel and the dryer capacity.

- the degree of combine loses acceptable at harvest due to level of moisture in the grain.
- capacity of movers to haul grain from the field to dryer or storage.
- capacity of on site storage.

These and other factors are constantly shifting as related costs are mostly influenced by external circumstances and political considerations.

Material handling

As already mentioned the Project is sited in an area where there is no community nearby which can serve as a source of seasonal labour. This situation coupled with the fact that the Company imports directly and stocks all the heavy and bulky inputs makes material handling an important consideration. There is a tendency in project design to pay scant attention to these vital activities which turn out to be the most important constraints to timely operations. For example, even at the present relatively small scale of operation we use 2 to 2½ tons of blended fertilizer per hour of planting and there are many steps in handling fertilizer between picking up a bag in storage and applying the fertilizer to the soul through the planter.

Risk for weather conditions.

Crop production is based entirely on rainfall.
The short rainy season is not of sufficient duration to support the Jupiter variety of soyabeans. There is also some risk to cover during this season. At present we do not think the risk to cover is sufficiently high to not plant corn.
With further experience the planting of corn may be limited to the long rainy season.

There is generally sufficient rain in the long rainy season to carry all crops.

Cowpea (Black eye) is considered to have a fair degree of risk from useasonal weather.
A marketable crop is highly depended on accurate timing of rainfall. If the rains cease too early the result is stunted plants that are low in yield and very difficult to harvest. Extended rainfall promotes fungus which causes severe discolouration in black eye.

Pigeon pea has been grown succesfully in both seasons and we are now evaluating it as a dry pea. This crop promises to have a strong market demand and offers other cultural advantages.

Production costs

As an indication of cost and for compartion purposes approximate figures for corn are offered in the table below. These are a first pull out from the last crop (planted May '78) and must be accepted as tentative.

Table 1. Cost per acre corn given in G$

	Labour		Machine		Material
	Hrs	$	Hrs	$	$
Land preparation	0.40	0.70	0.40	12.00	
Harrowing (preplant)	0.09	0.16	0.10	4.68	
Herbicide	0.87	1.30	0.70	15.50	14.00
Blending	3.40	3.32	0.19	1.90	
Planting (incl. fertilizing)	1.02	1.53	0.41	16.82	293.00
Fertilizing (side dressing only)	4.93	7.39	1.45	40.05	
Spraying (pest control)	0.86	1.29	0.68	15.36	21.00
Harvesting	2.26	4.44	4.44	15.54	
Drying	1.25	11.25	1.56	3.12	

Tot. operational cost $ 484.35

APPENDIX

SEED

Corn

Pioneer 306 B standard use. 1st planting May 1977 Currently evaluating Toxapeno Ministery of Agriculture Guyana selection)

Cowpea

Black-California No 5-1st planting May 1977 (both imported and Guyana selections currently producing own requirements)

Soyabean

Jupiter — 1st planting May 1978. Seed from Chagaramas Development Authority, Trinidad and Tobago.

Pigeon pea

VWI 17-st planting Feb. 1978 — seed from V.W.I.

VWI 26-1st planting June 1978 — St. Augustin T.T.

INSECTICIDES/FUNGICIDES

Corn

Tried a whole range. Min of Agri-Guyana recommends
Monocrotophos 60% active ingredient 20 ml per are major pest at all stages of growth.

Soya
Minor infestation so far. Dipterex effective.

Black-eye Sevin Dipterex
Dithane M 45 usually applied as one or two sprays before beans start to dry.

WEEDICIDES

Corn
Atrazine — no serious problem as yet. Only spot applications.

Soyabeans
Planavin. Will evaluate Trifuralin

Black eye
No serious problem as yet

FERTILIZERS

Nitrogen
Corn from Diammonium Phosphate & urea
Soyabean from Diammonium Phosphate & sulphate of ammonia
Blackeye from Diammonium Phosphate & sulphate of ammonia

Phosphorus
Corn from Diammonium Phosphate & triple super phosphate
Soyabean from Diammonium Phosphate & triple super phosphate
Blackeye from Diammonium Phosphate & triple super phosphate

Potash
Corn from Muriate of Potash & Potasium Magnesium Sulphate
Soyabean from Muriate of Potash & Potasium Magnesium Sulphate
Black-eye " " " " " " "

Magnesium
Corn Potassium Magnesium Sulphate
Soyabean Potassium Magnesium Sulphate
Black-eye " " "

Trace minerals
Corn Fritted trace elements
Soyabean Fritted trace elements
Black-eye ,, ,, ,,

Lime
Ground limestone
Standard practice apply initially 1 ton/acre
Further application rates yet to be finalized

Inoculum for legumes prepared by Ministery of Agriculture, Guyana

Standard field practices
(May be varied by weeds, untimely rain & other factors)

Natural state

1. Clearing & leveling with light buldozer -- to remove scrub, the odd tree; level termite hills.

2. Plough with heavy harrow

3. Distribute lime

4. Harrow to incorporate lime

5. Harrow (once or twice) for seed bed preparation

6. Plant with fertilizer

7. Spray insecticide/fungicide — high clearance ground sprayer, will move to aircraft by next crop.

8. Side dress fertilizer (one or two applications)

9. Harvest

10. Corn stalks left after harvest slashed with rotary slashes.

If herbicide used applied before (6)
If weeds evident interrow cultivate.

NAME OF PAPER: A regional project production of grain and legumes
(J.A. Dumett)

Question by: Errol B. Whyte
Country: Barbados

QUESTION: What is the current average production of maize-tonnes/ha (tons/acre)?

ANSWER: Yield to date inconclusive.
Much depends on the number of crops previously planted.
Experience indicate so far:

1. As a first crop planted for first time on virgin fields.
   Yield very variable from approximately 0.25 to 0.75 short tons/acre.
2. As a second or third crop approx. 1.0 to 1.5 tons/acre.

Question by: R. Parsan
Country: Suriname

QUESTION: What is* the time between clearing and leaving and planting?

ANSWER: Clearing and leveling considered one operation.
Depending on season liming can be carried out and worked in.
Planting is carried out between two and three months after liming.

POPULATION IMPROVEMENT AND VARIETAL DEVELOPMENT IN CIMMYT'S MAIZE PROGRAM

S.K. Vasal, A. Ortega and S. Pandey

INTRODUCTION

Maize plant lends itself to genetic improvement both by inbreeding and cross-breeding procedures. This provides alternatives to maize breeders to develop maize types that will fall in two broad categories. (1) Hybrid forms including single crosses, three-way crosses, double crosses, double top crosses and varietal hybrids; (2) Open-pollinated populations in the form of local or improved varieties belonging to particular races, broadbased composites, synthetics and advanced generation varietal crosses. Development and improvement of the above types of materials, however, involve different breeding approaches. In many developed countries of the world where private hybrid seed industry is well developed, hybrids are most commonly grown and these cover a large part of the total maize acreage. It is, therefore, implicit that in such countries the major research effort is geared towards the development of hybrid maize. Very little, if any, effort is going into population improvement. In contrast the situation in most developing countries is quite different. The private seed industry is either non-existent or so poorly developed that it can hardly do an effective job of seed production and distribution. Also, the spirit of cooperation between private and public sectors is lacking with the result that both are working in competition rather than for each other. A situation like this is not in the overall interest of the country. Difficulties in seed production and distribution have prevented these countries from taking up time consuming and expensive hybrid maize breeding programs. Breeding and improvement schemes designed to improve open-pollinated varieties and composites, therefore, seem to be the most logical approach for such countries at the moment. If such types are released the seed distribution will not be easy but will be greatly facilitated by seed movement from farmer to farmer. It is important to mention that such countries need not stick to this approach only. Any time enough competence and facilities are developed, the switch over to hybrid maize program can be made as quickly as possible.

It may seem important to point out that population improvement in maize is not completely divorced from hybrid maize development. Improvements made in maize population through various intra-population schemes can be profitably exploited in deriving new superior lines. As the genetic base of the material is continually improved, one would expect that the opportunities to extract new and better lines also become greater with every cycle of improvement. It is, therefore, desirable that even in those countries interested in hybrids, population improvement programs are basic to hybrid development to continue obtaining consistent gains in the long run. This is, however, not to argue or to present a case that better hybrids have not been developed in the past. On the contrary, it is very obvious that remarkable progress coupled with consistent gains over the years has taken place even without the use of classical population improvement schemes (Duvick, 1977). It is reported that much of the gains in the presently grown hybrids have been obtained from the improvement of established inbred lines through pedigree method of inbred improvement. Several other methods of inbred improvement have also been used and these are reviewed in a recent paper by Bauman (1977). Another interesting result reported in Duvick's study is that the gains from recurrent selection schemes in some synthetics from Iowa have also the same rate of genetic gain as obtained in resultant hybrids developed from inbred lines improved by the pedigree method.

Since I am going to talk on population improvement, I should probably re-emphasize that population improvement in maize, irrespective of objectives, is a must and it can play a dual role. Improvements made in populations through intra-population schemes not only improve the value of the population for direct and immediate use but also enhances its usefulness in giving rise to new lines as potential parents of hybrids. There is enough data already available to convince that population improvement should increase the expected performance of hybrids to a great extent rather than repeated sampling of the same base population in the classical inbreeding and hybridization approach. Many breeders are aware of the developments in recent years and hopefully there will be an increasing realization over time that a good balanced corn improvement program should place emphasis on the development and improvement of maize population or source germplasms in addition to development and improvement of inbred lines.

PAST ACCOMPLISHMENTS IN THE DEVELOPMENT OF POPULATION IMPROVEMENT METHODS IN MAIZE.

The development and improvement of maize populations has received considerable interest over the last two decades. Though earlier attempts to improve maize materials have been futile, the situation has changed considerably today. There is better understanding that failure to realize significant progress from earlier studies on mass selection could be due to insufficcient genetic control and field plot techniques.

Interest in quantitative genetics started developing in the 1940's. Since then voluminous data has been accumulated presenting accomplishments, both in theory and experimental results. Much of the renewed interest in improving populations has resulted from quantitative genetic studies in maize. The results of several empirical studies have indicated that there is a preponnderance of additive genetic variance for grain yield and other traits in heterozygous maize populations. Such results will suggest that various forms of intra-population schemes should be effective in improving the performance of maize populations. The developments in quantitative genetics have also helped maize breeders in understanding the types of gene action involved in the expression of different characters in maize that are under polygenic control. This type of information is of considerable importance for the breeder in making a choice among alternative breeding schemes. Another area where the quantitative geneticist has helped the breeder is in predicting reasonably well genetic gains from various types of selection schemes. Several studies have been conducted using different selection schemes and in most cases a good agreement has been found between predicted and realized gains. The results in such areas have been reviewed by Gardner (1976) and Eberhart (1976).

Regarding developments in population improvement methods, I plan to present only a cursary review. One of the simplest and oldest methods still being used in many experimental stations is the mass selection method. It exploits aditive gene effects and epistatic interactions involving only additive genetic effects. Several research workers have reported success with this method (Johnson 1963, Gardner 1961, 1973, 1976). Mass selection can be very effective for those characters that are highly heritable and which can be identified before flowering (*Helminthosporium turcicum,* Thrips, Fall armyworm, plant height, flowering, leaf angle and prolificacy). Effectiveness of mass selection in changing ear number (Paterniani, 1978) and leaf angle (Ariyanayagam et al 1974) has also been reported. An improvement over simple mass selection can be made by planting in grids as suggested by Gardner (1961).

Modified ear-to-row selection scheme suggested by Lonnquist (1964) has been used quite widely and effectively in many programs with great success. Several research workers have found interesting results with this scheme (Webel and Lonnquist, 1967, Paterniani, 1967). This selection scheme involves selection among rows based on yield trial data followed by selection within selected rows in the crossing block. This scheme permits completion of one cycle of selection in one year. A modification of this scheme has also been suggested. It uses two seasons instead of one. In the first season only half-sib progenies are yield evaluated. In the second season selected half-sibs using remnant seed are recombined in a crossing block. For male rows only bulk of selected half-sib families is used. The prediction equation for estimating gains for this modified scheme has been given by Compton and Comstock (1976). Two generations per cycle are required to complete this scheme and may result in genetic gains of about one and one-half times as much as the one generation per cycle scheme. An obvious advantage of this scheme involves planting of less number of rows. This would allow larger samples of each family to be grown thus resulting in an increase in the within-row selection intensity. The gains from within family selection can thus be increased.

Several recurrent selection schemes have been suggested as a result of quantitative genetic studies. These include recurrent selection for general combining ability (Jenkins, 1940) recurrent selection for specific combining ability (Hull, 1945) and reciprocal recurrent selection for both general and specific combining ability (Comstock et al. 1949). These recurrent selection schemes differ in the type of tester and the ultimate goal for which the developed material will be used. The critical differences in the schemes are also based on the nature of gene action involved in the populations under selection. These schemes are, however, similar in having successive cycles of selection and the recombination of the selected portion of the population. Especially where the aim is to improve populations, the use of above mentioned recurrent selection schemes may not be highly efficient. It is probable that much of the yield increases that have been reported with these methods are primarily results of additive effects (Sprague 1967). If this is so, it would appear more appropriate to exploit additive genetic effects through phenotypic recurrent selection or through various forms of family selection schemes without the use of the tester.

Various types of mating designs have been suggested by Comstock and Robinson (1952). The three genetic designs suggested by them are useful in estimating additive, dominance and average degree of dominance. Design I is particularly useful for maize and has been used quite frequently not only to work out genetic variances but also to identify best families for recombination and further improvement in a practical maize breeding program. There are several ways one can use this scheme in an on-going population improvement program.

Several family selection schemes have become quite popular in the last one decade. These include full-sib, half-sib and S_1 selection schemes. A combination of S_1 and half-sib systems can also be used for improvement of some traits but cannot be suggested as a general breeding method.

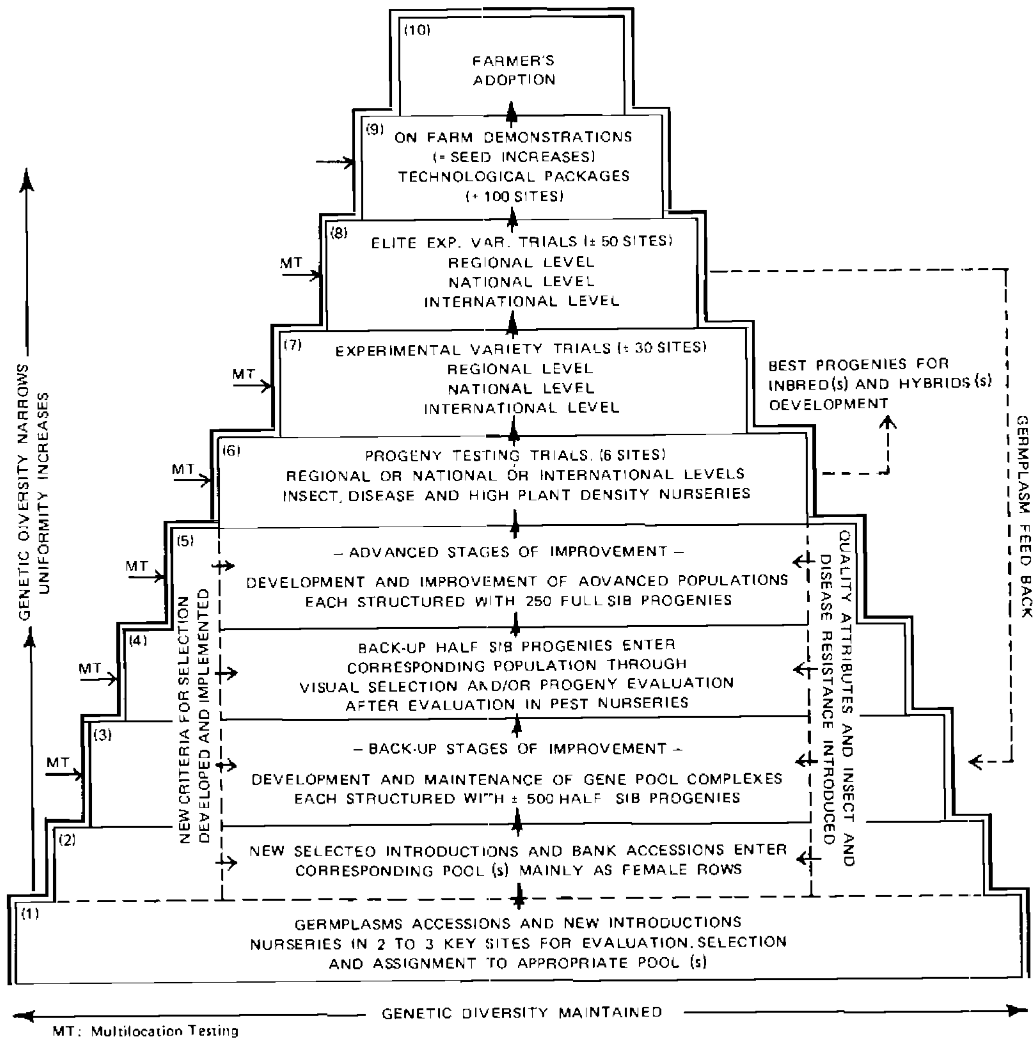
CIMMYT'S MAIZE IMPORVEMENT PROGRAM WITH GENE POOLS AND POPULATIONS

With the foregoing background I plan to devote the rest of the time in describing CIMMYT's maize program with particular emphasis on improvement of populations and development of experimental varieties both in normal and quality protein materials. I shall also touch very briefly on other aspects such as breeding for earliness, insect resistance, collaborative research, and quality protein that are receiving major emphasis in CIMMYT's maize improvement program.

CIMMYT's maize improvement program is a kind of multi-stage program with a continuous step-by-step flow of germplasm. The program believes very strongly in multi-disciplinary approach so that scientists from various disciplines can interact closely with each other on the improvement of various traits but within the same materials. The maize pyramid (fig. 1) illustrates management of maize germplasm at different stages of maize improvement until it reaches the hands of the farmers. CIMMYT's maize improvement program comprises of two main units namely the "Back-up" unit and "Advanced Unit" to handle research functions more appropriate to each unit. Quality protein versions of most materials are being developed through a side-car approach. Special projects have the responsibility of exploring and testing new research hypothesis before the information can be superimposed on the main research activities of the program.

It should be evident from fig. 1 that the back-up unit is a sort of supporting unit to provide superior genotypes or families to the advanced unit on a continuous basis so that improvements in advanced unit materials can be obtained from cycle to cycle. In this way, loss of genetic variability in advanced unit materials can be prevented. A similar type of approach was suggested by Harrison (1967). He suggested having back-up composites to support the composite undergoing population improvement with a high selection intensity. Suggestion was also made to use only mild selection intensity in back-up composites.

In the following section, the research functions within each unit are detailed.


(10)
FARMER'S ADOPTION
(9)
ON FARM DEMONSTRATIONS
(+ SEED INCREASES)
TECHNOLOGICAL PACKAGES
(+ 100 SITES)
(8)
ELITE EXP. VAR. TRIALS (± 50 SITES)
REGIONAL LEVEL
NATIONAL LEVEL
INTERNATIONAL LEVEL
(7)
EXPERIMENTAL VARIETY TRIALS (± 30 SITES)
REGIONAL LEVEL
NATIONAL LEVEL
INTERNATIONAL LEVEL
BEST PROGENIES FOR INBRED(s) AND HYBRIDS (s) DEVELOPMENT
(6)
PROGENY TESTING TRIALS. (6 SITES)
REGIONAL OR NATIONAL OR INTERNATIONAL LEVELS
INSECT, DISEASE AND HIGH PLANT DENSITY NURSERIES
(5)
– ADVANCED STAGES OF IMPROVEMENT –
DEVELOPMENT AND IMPROVEMENT OF ADVANCED POPULATIONS
EACH STRUCTURED WITH 250 FULL SIB PROGENIES
(4)
BACK-UP HALF SIB PROGENIES ENTER
CORRESPONDING POPULATION THROUGH
VISUAL SELECTION AND/OR PROGENY EVALUATION
AFTER EVALUATION IN PEST NURSERIES
(3)
– BACK-UP STAGES OF IMPROVEMENT –
DEVELOPMENT AND MAINTENANCE OF GENE POOL COMPLEXES
EACH STRUCTURED WITH ± 500 HALF SIB PROGENIES
(2)
NEW SELECTED INTRODUCTIONS AND BANK ACCESSIONS ENTER
CORRESPONDING POOL (s) MAINLY AS FEMALE ROWS
(1)
GERMPLASMS ACCESSIONS AND NEW INTRODUCTIONS
NURSERIES IN 2 TO 3 KEY SITES FOR EVALUATION, SELECTION
AND ASSIGNMENT TO APPROPRIATE POOL (s)
MT
GENETIC DIVERSITY NARROWS
UNIFORMITY INCREASES
NEW CRITERIA FOR SELECTION DEVELOPED AND IMPLEMENTED
QUALITY ATTRIBUTES AND INSECT AND DISEASE RESISTANCE INTRODUCED
GERMPLASM FEED BACK
GENETIC DIVERSITY MAINTAINED
MT: Multilocation Testing

A. Back-up Unit

The back-up unit handles the maize germplasm bank, new introductions and 34 gene pools that have specified climatic adaptation, maturity, grain color and texture.

The maize germplasm bank has close to 13,000 accessions representing 46 countries. It is a service unit for resident and outside scientists. The bank maintains germplasm collections and renews stocks from time to time depending on the seed viability. The seed stocks in the bank are catalogued. From time to time 400 collections are taken out and systematically evaluated at two or more locations with appropriate pools as checks. The best performers are grouped based on their adaptation, maturity, grain color and texture. In the following season the elite bank collections are incorporated into the corresponding pool only as a female for the first time. The crosses of the pools x collections can be observed separately for their combining ability and if

Table 1. Agroclimatic characteristics considered in classifying maize germplasm.

Maturity class	Altitude m.a.s.l.*	Latitude N-S	Temperature °C **			Days to physiological maturity
Tropical lowland			Min.	Max.	Ave.	
Early	below 1000 m	within 23°	22	32	28	± 80
Medium	below 1000 m	within 23°	22	32	28	± 100
Late	below 1000 m	within 23°	22	32	28	± 120
Tropical highland						
Early	above 1800 m	within 23°	7	22	16	± 150
Medium	above 1800 m	within 23°	7	22	16	± 180
Late	above 1800 m	within 23°	7	22	16	± 220 ***
Subtropical						
Early	below 1800 m	within 34°	17	32	25	± 100
Medium	below 1800 m	within 34°	17	32	25	± 130
Late	below 1800 m	within 34°	17	32	25	± 160
Temperate						
Early	below 500 m	outside 34°	14	24	20	± 110
Medium	below 500 m	outside 34°	14	24	20	± 130
Late	below 500 m	outside 34°	14	24	20	± 160

* Meters above sea level.
** Means of growing season.
*** South American Andean cultivars may take up to 13 months.

needed can be handled to F_2. Based on actual performance of topcrosses and also on judgement, the families from these crosses are later on merged with the main body of the pool.

The seed samples are sent to scientists and research organizations on request and free of cost.

Variety samples from the different national programs are brought personally by visiting CIMMYT staff members or are obtained by request from different sources. Once the samples are received, these are observed in observational nurseries at one or more locations. The good entries are identified and then systematically incorporated into the corresponding gene pool.

Gene Pools

CIMMYT maintains 34 gene pools to meet climatic requirements of tropical lowland, tropical highland and temperate-subtropical zones. (table 1) The pools within each climatic adaptation are further classified on the basis of maturity (early, intermediate, and late), grain color (white and yellow) and grain texture (flint and dent). Of 34 gene pools, twelve are meant for tropical lowland, fourteen for tropical highland and eight for temperate zone (table 2).

Gene pools are mass reservoirs of genes. They have broadbased genetic constitution as these have been formed by genetic mixing of several diverse varieties, variety crosses and hybrids with similar climatic adaptation, maturity, grain color and type.

Some important features in the handling of the pools are the following:

1. All gene pools are handled separately in isolation in a half-sib recombination system very similar to modified ear-to-row crossing block (Lonnquist, 1964). Several modifications to the commonly used half-sib system are, however, used in each pool depending on the priority and objectives that have been set for each pool.

Table 2. Cimmyt's gene pools and corresponding advanced maize populations, 1978

Back-up Stages				Advanced Stages	
Pool No.	Pool designation	Abreviation	Cycles of recombination and selection up to 1978	Corresponding Advanced Populations**	No.
	Highland Pools				
1.	Highland early white flint	HEWF	C-5	–	
2.	Highland early white dent	HEWD	C-5	Blanco Dentado Precoz de Altura	52
3.	Highland early white floury	HEWFL	C-5	Blanco Harinoso Precoz de Altura	53
4.	Highland early yellow flint	HEYF	C-5	Amarillo Cristalino Precoz de Altura	54
5.	Highland early yellow dent	HEYD	C-5	Amarillo Dentado Precoz de Altura	55
6.	Highland intermediate white flint	HIWF	C-2	–	
7.	Highland intermediate white dent	HIWD	C-5	–	
8.	Highland intermediate white floury	HIWFL	C-5	Blanco Harinoso Intermedio de Altura	58
9.	Highland intermediate yellnw flint	HIYF	C-5	–	
10.	Highland intermediate yellow dent	HIYD	C-5	Amarillo Dentado Intermedio de Altura	60
11.	Highland late white flint	HLWF	C-5	–	
12.	Highland late white dent	HLWD	C-5	–	
13.	Highland late yellow flint	HILYF	C-5	–	
14.	Highland late yellow dent	HLYD	C-5	–	
	Tropical-subtropical pools				
15.	Tropical early white flint	TEWF	C-5	–	
16.	Tropical early white dent	TEWD	C-5	–	
17.	Tropical early yellow flint	TEYF	C-5	–	
18.	Tropical early yellow dent	TEYD	C-5	–	
19.	Tropical intermediate white flint	TIWF	C-8	–	
20.	Tropical intermediate white dent	TIWD	C-8	–	
21.	Tropical intermediate yellow flint	TIYF	C-8	Mezcla Amarilla; PD(MS) 6 H.E.o_2 ***	26, 38
22.	Tropical intermediate yellow dent	TIYD	C-8	Antigua x Republica Dominicana	35
23.	Tropical late white flint	TLWF	C-8	Blanco Cristalino 1; ETO Blanco; W.H.E. o_2	23; 32 40
24.	Tropical late white dent	TLWD	C-8	Tuxpeño 1; Mezcla Tropical Blanco; (Mix. 1 x Col. Gpo) ETO, Tuxpeño Caribe; La Posta, Tuxpeño o_2	21; 22; 25; 29; 43; 37
25.	Tropical late yellow flint	TLYF	C-8	Amarillo Cristalino 1; Y.H.E.o_2	27; 39
26.	Tropical late yellow dent	TLYD	C-8	Antigua x Veracruz 181; Amarillo Dentado; Cogollero	24; 28; 36
	Temperate-subtropical pools				
27.	Temperate early white flint	TmEWF	C-8	–	
28.	Temperate early white dent	TmEWD	C-3	–	
29.	Temperate early yellow flint	TmEYF	C-4	Templado Amarillo o_2	41
30.	Temperate early yellow dent	TmEYD	C-4	Compuesto de Hungria	48
31.	Temperate intermediate white flint	TmIWF	C-4	Blanco Subtropical	34
32	Temperate intermediate white dent	TmIWD	C-8	AED X Tuxpeño	44
33.	Temperate intermediate yellow flint	TmIYF	C-8	Amarillo Subtropical	33
34	Temperate intermediate yellow dent	TmIYD	C-8	ETO x Illinois; Amarillo del Bajio	42; 45

* No. H.S. Prog. = No. of Half Sib Progenies

** 250 Full sibs in each Population

*** H.E. o_2 = Hard endosperm opaque ...

2. One cycle of recombination and improvement is completed each year in all highland pools. In tropical lowland and temperate pools, 2 cycles of selection are completed every year.

3. Fairly large population size is handled within each pool. The average number of families within each pool ranges from 400-500. Each family has 16 plants in a 5 m. long row. This gives a total number of female plants within each pool to 64,000-80,000 plants. Another 32,000 – 40,000 plants constitute male plants from the same families. This gives an effective population size of about 96,000 to 120,000 plants within each pool.

4. In all gene pools, the ratio of females to males is kept at 2 to 1 in the recombination block. Both male and female rows are planted at the same time. If needed the male rows can be staggered at different dates to permit thorough mixing within the pool.

5. The male and female rows are usually planted at the same density. However, in some pools, the males are planted at double the density than the females to permit either better expression of the trait (interval between pollen shedding and silking, barrenness) or when pools are subjected to some stress conditions (infestation by cogollero and borers) so that all undesirable plants can be eliminated before pollen shedding without affecting plant stand very much.

6. Once every year the half-sib families from each pool are planted at least at two locations within Mexico to select for broader adaptation.

7. Selection is practiced both in male and female rows. In male rows all tall, diseased and undesirable plants are detasseled before pollen shedding. In this way selection pressure can be exerted in male rows for those characters that can be visually seen before or at the time of flowering. Detasseling undesirable plants in male rows prevents dissemination of pollen from inferior plants to pollinate plants in female rows.

8. Between and within family selection is practiced within each pool at different stages of development.

9. In female rows, the families can be rejected on the basis of family performance. In desirable or selected families, the superior plants within each family can be marked at different stages depending upon special objectives in the pools. Rechecking and marking good plants within each selected family is done in all pools, 2 or 3 weeks prior to harvesting.

10. In all early pools where we are interested in moving the maturity still on the earlier side, tassels from the male rows are removed following 50-60% silking in female rows. This is a good procedure that permits self-elimination of all late families within the pool.

11. Different pools are subjected to different stress pressures depending upon their use in different areas. To name a few of these stress pressures, two pools (19 and 21) are being subjected to borer infestation *(Diatraea saccharalis)*; two pools (24, 26) to infestation by cogollero *(Spodoptera frugiperda)*; two pools (30, 32) to another species of borers *(D. grandiosella)*; pool 3 to corn earworm *(Heliothis zea)*; two pools (23, 25) to stalk rots; and four pools (20, 22, 33, 34) to ear rots.

12. Mild selection intensity is practiced within each pool to prevent depletion of attributes or genes necessary for further advance at some later stage. Lower selection intensity also provides better chance and opportunities for recombination among linked genes which with higher selection intensity will probably be thrown out much earlier. Between family selection of about 50-60% and within family selection in selected families of 6-18% is practiced.

13. At harvest the selected ears from selected families are grouped as male and female ears. The male ears are selected out of very good plants. While in the forthcoming cycle all selected ears, both males as well as females enter as separate families, the male rows are planted with a balanced male composite made up only from selected male ears.

14. In all gene pools, where one or the other stress pressure is being exerted, the ears from the selected plants are grouped and planted to follow some sort of sequence within the main body of the pool. Next time, when these pools are subjected to the same stress conditions, one can make relative comparisons of the families selected from desirable and undesirable plants for this particular trait.

15. Improvements or changes affected in each pool from cycle to cycle can be checked rather easily without much effort by planting two or more rows of each cycle of selection with or without replications at the end of each pool.

16. While gene pools are being improved for superior traits, all possible care is taken to maintain genetic diversity within each pool. This would mean that families or plants not good for stress traits but otherwise good in agronomic traits are saved and used in the next cycle of recombination.

17. New additions from the bank or from the introduction nursery can be added as female rows in the pool. Based on judgment or through further observation or by advancing a generation or two, the families from the cross can be rejected either completely or made part and parcel of the main pool body. New additions permit continuous broadening of the pool.

18. Gene pools corresponding to all advanced unit populations have been developed and are available. The opposite is however, not true. All gene pools do not have corresponding advanced unit populations. Also some gene pools may have one or more corresponding advanced unit populations to support.

19. Advanced unit populations are planted periodically as check entries within each pool to identify superior families for further evaluation and incorporation in the advanced unit population.

20. To obtain quality protein versions of each pool, a bulk of stable hard endosperm opaque-2 families can be planted at the end of each pool as female rows for making backcross once in every 3 or 4 cycles.

21. Bulks from various pools are also sent to different regions where CIMMYT staff members are stationed. Ears saved from each location are brought back to Mexico for inclusion in the pool. This way we introduce potential influence of other environments into the pool.

From the foregoing, it is clear that while pools are being recombined and improved continuously, they are also being broadened regularly with the addition of new introductions from the national programs and with superior matching entries from the maize germplasm bank.

B. Advanced Unit

The advanced unit deals with both normals and quality protein maize populations. Presently the unit is handling 24 populations of which five carry opaque-2 gene. These populations have been chosen because most of these materials have been improved for several cycles for yield, plant height, diseases and other traits. It is, therefore, expected that some of these materials may be of more immediate and direct use to some of the national programs. However, it may be important to mention that whenever any material is advanced or considered for inclusion in the advanced unit several criteria are examined. These are 1) evaluation of the material in some variety test in different countries, 2) based on variety test performance, the progeny tests are also sent to those places where this material may have some potential or role to play, 3) In certain cases the decision is also based on experience depending upon the type of germplasm involved in the genetic constitution of the population. For many populations, it is possible to predict reasonably well the areas or regions of their adaptation.

The advanced unit materials are handled in full-sib family selection scheme. Each population is structured on family basis with 250 full-sibs. In each advanced unit population one cycle of selection is completed in two years. Though it is possible to complete one cycle of selection in one year, non-retrieval of data from all the locations in time prevent us from doing so. Since families from each population are sent to northern as well as southern hemispheres, there is no way of getting data in time from all the locations. One would argue that this results in slow progress. This is true but to compensate for this slow progress we have worked out a system by which the time available between two cycles can be utilized more efficiently and effectively by improving those traits in which these populations are most deficient. In the full-sib family selection improvement the following steps are involved:

a. **Population Improvement**

1. Progeny regeneration: 250 full-sibs are developed from each population through reciprocal plant to plant crosses among families. This is done to obtain enough seed to use in subsequent operations once a family is identified as a good performer. In quality protein populations only those pairs are saved that have both members in a pair well modified with respect to endosperm hardness.

2. Progeny tests: 250 full-sibs plus six checks are sent out to six different countries for evaluation in 16x16 simple lattice with two replications.

3. Family improvement:

i. In the following season all 250 families are planted. Within family selection is practiced for the character in which it is most deficient. If before pollination data becomes available from some locations a preliminary selection can be practiced to save about 50% of the families. In such an instance within family selection will be restricted to selected families.

ii. Either selfs or plant-to-plant sibs are made within each family to keep the identity of the family. For characters such as earliness and plant height which can be seen before or at the time of flowering, within family sibs are usually made. In opaque-2 populations where we are interested in selecting better modifiers, plant to plant sibs within each family are made in a reciprocal fashion. In other characters where the expression can be best judged at harvest time, either selfs or reciprocal plant to plant crosses are made within each family.

iii. At harvest, on the average 3 sibs or 3 selfs are usually saved from each family.

iv. The sibs or selfs saved from each family are again planted in the next season. Full record is kept of all sub-families originating from their parental family. Generally, before making this planting, data arrives from all locations. It is, therefore, possible to finalize families that are best performers on the basis of across location data. In such an instance only the selfs or sibs from selected families will be planted.

Selection is again practiced for the same trait both between and within sub-families of a given parental family. Better family/families and better individuals within the selected sub-families of each parental family or set are marked and bulk-pollinated in a hand-pollinated half-sib fashion.

On the average 2 or 3 half-sibs are selected uniformly from each original parental full sib family that was selected on across location performance.

The selected half-sib ears are again planted on ear-to-row basis. A record is kept of all half-sibs originating from the parental full sib families. Reciprocal plant to plant crosses are made among half-sib families originating from different parental full-sib families. Again at harvest 250 full-sib pairs are saved to continue the next cycle of selection.

It may be important to mention that a selection intensity of 30-35% is used in each population. The gains resulting from each cycle of selection in some populations are given in table 3.

Table 3. Actual gains in some advanced unit populations undergoing full-sib family population improvement (across location data).

Population	Gains Per Cycle		
	Grain Yield (%)	50% Silking	Plant Height (cm)
Tuxpeño-1	3.2	-0.3	-3
Mezcla tropical blanca	2.5	-0.5	-2
Mix. 1-col. GPO. 1 x ETO	5.7	-0.5	-2
Mezcla amarilla	4.4	-1.0	0
Amarillo cristalino	3.0	-0.3	0
Amarillo dentado	2.5	0.0	+2
Tuxpeño caribe	5.4	-0.7	+3
ETO blanco	4.4	-1.3	-6
Cogollero	9.1	-1.0	+2
La Posta	3.8	-0.7	-3

b. Development of Experimental Varieties

In the development of experimental varieties, a very high selection intensity of 2.5% is used. The experimental varieties are developed on the basis of site specific and across site progeny test data. Thus each population has a potential of giving rise to seven experimental varieties (6 site specific and one across site experimental variety). Since the best fraction of each population is taken out to form the experimental variety, one would expect considerably higher genetic gains over the population mean for immediate use and exploitation. In the selection of 10 best families, high yielding families with relatively uniform agronomic attributes are recombined so that the variety may look fairly uniform.

In the formation of experimental varieties diallel matings are made among 10 families. Also at this stage relatively uniform looking plants are used in recombination. From a recombination of 10 families adequate seed is obtained to conduct at least 40 experimental variety trials. A balanced bulk of saved ears goes into a second order seed increase to build up enough seed quantity for each experimental variety. This helps to include the variety into elite experimental variety trial if it turns out to be good in EVT trial.

The experimental varieties are named in such a way that cooperators from different national programs who actually conduct the progeny tests get full recognition. The varieties carry the name of the station where the progeny test was conducted. This is followed by two digits indicating the year. The last two figures show the population number (e.g. Ticuman 7428).

c. Experimental Variety Trials

The site specific and across site experimental varieties are developed on the basis of progeny trial data as mentioned earlier. The experimental varieties so formed from different populations are grouped into different experimental variety trials 11 through 17. Trial 15 is reserved for experimental varieties derived from advanced unit opaque-2 populations. Each experimental variety trial is sent out between 30 to 40 locations. The best performing experimental varieties across locations are promoted to elite experimental variety trials. From the data presented in tables 4 and 5, it can be seen that a number of experimental varieties were quite superior compared to the parental population.

Table 4. Comparison of performance of experimental varieties and their parental population.

Experimental variety	Parental population	Grain Yield (kg/ha.) expt. variety	parental population	Experimental variety yield as percent of parent population
Gemiza 7421	Tuxpeño-1	4456	3965	112.4
Poza Rica 7429	Tuxpeño Caribe-2	4235	4683	110.5
Obregon 7431	Braquiticos	4066	3266	124.4
Across 7443	La Posta	4865	4184	116.2
Sids 7444	A.E.D. x Tuxpeño	4166	3370	123.6

Table 5. Comparison of performance of experimental varieties and their parental opaque-2 populations.

Experimental variety	Parental population	Grain expt. variety	Yield kg/ha. Parental population	Experimental variety Yield as percent of Parent population
Gemiza 7437	Tuxpeño o_2	4539	3343	135.7
Poza Rica 7437	"	4505	3343	134.7
Obregon 7437	"	4429	3343	132.4
Across 7437	"	4563	3343	136.4
DELHI 7439	Yellow H.E.o_2	4272	3410	125.2
Poza Rica 7439	"	4374	3410	128.2
Cuyuta 7441	Composite K H.E.o_2	4363	3685	118.3
Poza Rica 7441	"	4446	3685	120.6
Delhi 7438	(Ver. 181 x Ant. Gpo. 2)x Ven. 1 o_2	4060	3449	117.7
Poza Rica 7438	"	4041	3449	117.1
San Andres 7440	White H.E.o_2	4274	3863	110.6

d. Elite Experimental Variety Trials

The best performing experimental varieties form the elite experimental variety trial. Elite experimental variety trials carry trial numbers from 18 through 20. ELVT's 18, 19, and 20 are reserved for tropical lowland, opaques and temperate-subtropical materials, respectively. The elite experimental variety trials are sent to more than 50 locations around the world. The number of trials sent to different countries during the last four years are presented in table 6.

Table 6. Number of experimental variety trials distributed during different years.

Trial Name	No. of trials sent to dif. country			
	1975	1976	1977	1978
OMPT-11	20*	–	–	44
EVT-12	25	27	31	38
EVT-13	24	27	34	45
EVT-14A	36	33	48	61
EVT-14B	–	34	40	42
EVT-15	27	15	38	36
EVT-16	32	21	35	49
EVT-17	15	16	–	17
ELVT-18	–	73	78	91
ELVT-19	–	60	54	52
ELVT-20	–	40	47	56
	180	367	405	531

e. **Off-Station trials and Farmer's adoption**

Good performing elite experimental varieties in national programs can be tested in off-station trials. Following verification on a big sized plot the variety can be made available to the farmer.

C. **Breeding for earliness**

Early maize varieties are needed in many parts of the world either to fit into the cropping pattern or make full use of the growing season because of a particular rainfall pattern. In general very early materials are very susceptible to foliar diseases and have very low yield potential even under reasonably high plant population density. Over the past four years, CIMMYT has placed major emphasis on developing early genotypes for tropical, temperate and highland areas. The following four approaches are being tried at CIMMYT to develop early materials.

1. Recurrent selection for earliness in a full season maize composite.

2. Crossing early types with mid to full season materials followed by selection for earliness along with other desirable agronomic characteristics.

3. Intercrossing among early types followed by selection for yield and foliar diseases without sacrificing earliness.

4. Intercrossing early tropical maize with corn belt maize with the objective of combining yield, earliness and resistance to foliar diseases.

As regards the first approach, about 400-500 half-sib families are being handled in an early composite using half-sib selection program. Early plants are marked in the families and as soon as 60-70% of the families have silked, tassels are removed from the male rows to eliminate the late fraction of the population. The material is then harvested somewhat earlier to make visual separation of the drier ears. Only good ears from good early plants and relatively more drier are selected for continuation in the next cycle.

The same approach is being used in some pools except that the experimental material has resulted from the crosses of early composites with full to mid season advanced unit maize populations.

From the first two approaches it seems that it is possible to make materials one day earlier each cycle while maintaining more or less the same yield level. The last two approaches are also underway though no evaluation for progress has yet been made.

The results of full-sib family selection for earliness in some advanced unit materials are presented in table 3. It is clear from the table that in many populations maturity has been reduced with the same or increased level of yield.

D. Development of maize populations resistant to downy mildew, stunt and streak.

Breeding for resistance to above diseases is being handled in CIMMYT's collaborative research program. These three diseases already exist and pose potential danger to many maize growing areas of the world. The streak virus is limited to Africa, downy mildew to Asia and stunt to Central America and Mexico. The occurrence of downy mildew has also been reported from Central America, South America and Africa. Materials possessing resistance to each of these problems singly or in combination to each other thus seem very important.

Since resistance to all three diseases cannot be selected effectively in Mexico, we are collaborating with several national programs which are "Hot Spots" for these diseases. We have chosen three broadbased agronomically superior maize populations that have different grain color and type and can be grown satisfactorily in many parts of the world. We are collaborating with El Salvador and Nicaragua to select against stunt. Artificial inoculations can also be done in Mexico to screen for stunt resistance. The work on downy mildew screening is done in Thailand and Philippines while the streak work is restricted to three African countries namely Tanzania, Nigeria and Zaire.

Though the materials have gone through 3-4 cycles of selection, satisfactory levels of resistance have already been built up in all three populations at least to downy mildew and stunt. Combined resistance to stunt and downy mildew has also been built up in three subpopulations of the same three materials though the progress has been somewhat slow.

Downy mildew resistance is also being incorporated into five advanced unit materials through backcrossing program. Segregating generations are screened in Thailand. In due course of time we hope to have resistance in these five populations.

E. Breeding for insect resistance

Breeding insect resistant materials require mass rearing and artificial infestation facilities. To meet this need, an insect rearing laboratory has been established at CIMMYT's premises for the last three years. The laboratory is functioning remarkably well. The rearing of insects can be done for several insect-species such as cogollero *(Spodoptera frugiperda)*, borers *(Diatraea saccharalis* and *D. grandiosella)*, and corn earworm *(Heliothis zea)*.

Enough egg masses can be produced in all these insect species to artificially infest all maize populations that are ear marked for insect resistance work.

The artificial insect infestation technique needs special mention. It is a remarkable improvement over what entomologists have been doing in the past. The new technique uses young hatched larvae instead of egg masses. The egg masses that have just hatched in the laboratory are mixed with ground corn cob grits. This mixture is applied in maize whorl with the help of a "bazooka". In different insects this mixture is applied at different stages of leaf development. This technique works very well for cogollero and borers. The same technique also works well for corn earworm except that the mixture is applied on the silks of the maize ear. This new technique has considerably speeded up insect resistant work at CIMMYT. It has many advantages such as convenience of handling larvae mixture both in the laboratory and in the field, 3-4 times faster, more uniform infestation and less frequency of escape plants.

Various pools and advanced unit populations are being selected for resistance to these insects as mentioned earlier in the text.

From whatever little work has been done at CIMMYT, it seems that there is enough variation in pools and populations to accumulate favorable resistant alleles in maize materials.

F. Breeding for quality protein maize

Quality protein versions of most materials in the advanced and back-up stages of the maize improvement program have been developed through the incorporation of opaque-2 gene. As is well known, the opaque-2 materials suffer from the following problems:

1. Low grain yield
2. Unacceptable soft chalky appearance
3. More vulnerable to ear rots and stored grain pests
4. Slower drying following physiological maturity of the grain

The major emphasis in the quality protein program has been placed on solving the above problems which have acted as the major hurdle in the commercial acceptance of opaque-2 materials. The research strategy used at CIMMYT has concentrated on accumulation of genetic modifiers to solve the problems. Through the use of modifiers it is possible to change the phenotype of opaques from soft to completely normal looking phenotype. In accumulating modifiers one faces several difficulties. In the first place the protein quality tends to decline with the selection of vitreous kernels. Exceptions, however, occur and these should be exploited to accumulate favorable modifiers to develop hard endosperm opaque-2 materials without sacrificing protein quality (table 7). Another problem associated with the selection of modifiers is

Table 7. Protein, lysine and tryptophan in the whole grain of some promising hard endosperm opaque-2 materials

Material	Protein (%)	Lysine in protein (%)	Tryptophan in protein (%)
PD (MS) 6 H.E. o_2	10.8	3.4	0.83
Amarillo dentado H.E.o_2	11.2	3.5	0.88
CIMMYT H.E. o_2	10.9	3.8	0.97
White opaque-2 Back-up Pool	10.4	3.5	0.89
Ant. x Ver. 181 H.E. o_2	11.2	3.6	1.00
Temperate x tropical H.E. o_2	9.2	3.8	1.12

the instability of modifiers under different environmental conditions. Experience gained at CIMMYT seems to show that it is possible to stabilize modifiers by following 6-7 cycles of selection. Once the materials have attained a fairly high frequency of modifiers, it has been observed that the majority of the families over environments appear to be stable (table 8). It is, therefore, suggested that one should not talk about the stability of the modifiers until

Table 8. Frequency of difference in endosperm hardness ratings of opaque-2 families from different populations grown at three locations during the year 1977.

Population No.	Population	Frequency of difference in endosperm hardness ratings of fam.								Total No. of families
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	
38*	PD (MS) 6 H.E.o_2	64	125	45	14	1	1	–	–	250
39	Yellow H.E.o_2	25	119	68	35	2	1	–	–	250
40	White H.E.o_2	20	107	71	44	8	–	–	–	250

* Two locations only.

the material has gone through enough cycles of selection and that variation for hard endosperm opaque-2 character within the population has been reduced to minimum.

At CIMMYT the hard endosperm opaque-2 versions of advanced and back-up materials have been developed. In addition four tropical opaque-2 back-up pools, 3 temperate back-up pools and three high-land back-up pools have been developed. The opaque-2 back-up pools are handled more or less the same way as the normal pools except some additional attributes such as selection of modifiers, maintenance of protein quality, stability of hard endosperm opaque-2 character, and reduced ear rot incidence are given high priority in selection in addition to several agronomic attributes. The performance of some of the opaque-2 materials is given in tables 9 and 10. It can be seen that some opaque-2 materials have yield levels equivalent to that of normals.

Table 9. Results of EVT 15 during 1977 – mean across 14 locations.

Entry No.	Pedigree	Grain yield (kg/ha)	% of best check
1	Ferke 7537	5005	104
2	Cotaxtla 7537	3837	100
3	CIMMYT H.E.o_2	3534	92
4	Ferke 7539	3659	95
5	Suwan 7539	3690	96
6	Poza Rica 7539	3510	91
7	Ant. x Ver. 181 H.E.o_2	3728	97
8	Poza Rica 7540	3232	84
9	Across 7437	3551	92
10	Best Check mean	3833	100

Table 10. Performance of best opaque against normal check, EVT-15 – Year 1977

Location	Grain yield (kg/ha.)	
	Best opaque	Normal Check
San Jeronimo (Guatemala)	5030	3644
Panama	2903	2649
Obregon (Mexico)	2297	1491
Costa Rica	3479	2903
Cotaxtla (Mexico)	4400	3855
Ludhiana (India)	6036	5549
Pirsabak (Pakistan)	4394	2742
Nicaragua	3946	4409
El Salvador	3394	3958
Jamaica	2864	3761
Suwan (Thailand)	5611	6692

REFERENCES

Ariyanayagam, R.P., C.L. Moore, and V.R. Carangal, 1974. Selection for leaf angle in maize and its effect on grain yield and other characters. Crop Sci. 1974: 551-556.

Bauman, L.F., 1977. Improvement of established maize inbreds. Maydica XXII: 213-222.

Compton, W.A. and R.E. Comstock, 1976. More on modified ear-to-row selection in corn. Crop Sci. 16: p. 122.

Comstock, R.E. and H.F. Robinson, 1952. Estimation of average dominance of genes. In Heterosis, Iowa State College press, Ames, Iowa pp. 494-516.

Comstock, R.E., Robinson, H.F. and Harvey, P.H., 1949. A procedure designed to make maximum use of both general and specific combining ability. Agron. Jour. 41:360-367.

Duvick, D.N., 1977. Genetic rates of gain in hybrid maize yields during the past 40 years. Maydica XXII: 187-196.

Eberhart, S.A., 1976. Practical genetics and practical corn breeding. In Proc. of the International Conference on Quantitative Genetics, Iowa State University Press, Ames, Iowa: 491-502.

Gardner, C.O., 1961. An evaluation of effects of mass selection and seed irradiation with thermal neutrons on yield of corn. Crop Sci. 1: 241-245.

Gardner, C.O., 1973. Evaluation of mass selection and of seed irradiation with mass selection for population improvement in maize. Genetics 74: 588-589.

Gardner, C.O., 1976. Quantitative genetic studies and population improvement in maize and sorghum. In Proc. of the International Conference on Quantitative Genetics, Iowa State University Press, Ames, Iowa: 475-489.

Harrison, M.N., 1967. Selection of source material and methods of formation of composites for maize breeding. Paper presented at Eastern African Cereals Research Conference.

Hull, F.H., 1945. Recurrent selection and specific combining in corn. A. Amar. Soc. Agron. 37:134-145.

Jenkins, M.T., 1940. The segregation of genes affecting yield of grain in maize. J. Amar. Soc. Agron. 32:55-63.

Johnson, E.C., 1963. Mass selection for yield in a tropical corn variety. Amer. Soc. Agron. Abst. pp. 82

Lonnquist, J.H., 1964. A modification of the ear-to-row procedure for the improvement of maize populations. Crop Sci. 4:227-228.

Paterniani, E., 1967. Selection among and within half-sib families in a Brazilian population of maize. Crop Sci. 7:212-216.

Paterniani, E., 1978. Phenotypic recurrent selection for prolificacy in maize. Maydica XXIII: 29-34.

Sprague, G.F., 1967. Quantitative genetics in plant improvement. In plant breeding edited by K.J. Frey: 315-354.

Webel, O.D. and J.H. Lonnquist, 1967. An evaluation of the modified ear-to-row selection in a population of corn. Crop Sci. 7:651-655.

BREEDING MAIZE IN SURINAM
Considerations and results

G.A.M. van Marrewijk, Centre of Agricultural Research in Surinam (CELOS)*

SUMMARY

Maize is grown on a very limited scale in Surinam. It is thought, however, that this crop may play an important part, in the governmental schemes for the spreading of agriculture and the diversification of agricultural production. A pre-requisite for the promotion of maize growing is the availability of varieties with high yielding capacity and other desirable agronomic traits.

After considering the different possibilities of variety improvement, viz. selection in local land varieties, importation or local production of hybrids, development of synthetic varieties, an outline is given of breeding work at the Centre of Agricultural Research in Surinam (CELOS). This includes a survey of breeding objectives, selection criteria, the available breeding stock, the breeding methods applied and the results obtained.

To conclude, some reflections are given with respect to the continuation of the breeding work.

MOTIVATION

The production of maize in Surinam is very limited. It is mainly grown as a catch crop on fresh-cleared forest land and as a second crop after rice. Total acreage was about 250 ha in 1974. Generally use is made of local land varieties of unknown origin. These are very heterogeneous and have a low production capacity. Average kernel yields are at a rate of 1200 kg/ha.

Attempts to stimulate maize production by improving the yielding capacity have been undertaken repeatedly by the Suriname Agricultural Experiment Station and other governmental institutions since the early decades of this century. As early as 1930 maize varieties originating from Java were imported to Surinam and grown in observation plots in different parts of the country. Other introductions, amongst them hybrid varieties, followed, but proved far from successful since in a manual on the growing of maize (issued in 1956) it is stated that "no exotic varieties have been found so far which perform better than the local blends". From 1960 onward the experiments with maize were intensified. Particular attention was paid to hybrid varieties and synthetics with good performance in tropical areas, especially the Caribbean region and tropical America.

At the 7th Annual Meeting of the CFCS Huiswoud et al. (1969) reported that in an orientation trial comparing a number of introductions with the local variety, the hybrid variety X332A appeared to be most productive with a converted yield of 3.9 metric tons/ha versus 1.5 t/ha for the local population.

*Present address: Institute of Plant Breeding, Agricultural University, Wageningen, The Netherlands.

In 1964 the Suriname Agricultural Experiment Station started an inbreeding programme with local, Central American and North American materials aiming at the development of synthetic varieties. The last were eliminated soon by *Puccinia sorghi,* but inbred lines were produced of the local (I_8) and of the Central American (I_6) material. This served as part of the starting material of the breeding work at the Centre of Agricultural Research in Surinam (CELOS), which will be discussed in the parts to follow.

CONSIDERATIONS WITH RESPECT TO BREEDING METHODS

In the early sixties the discussion was concentrated on the question in what way maize growing in Surinam could be stimulated most effectively. In theory, the following systems could be adopted:

- selection within local populations;
- introduction of open-pollinated exotic varieties or composites;
- importation of hybrid seed;
- development of local hybrids;
- development of synthetic varieties.

Arguments in favour of selection in local land varieties were the disappointing results with former introductions. Exotic open-pollinated varieties, provided they have superior yielding capacity, are attractive because they allow the farmer to produce his own sowing seed. Main attention in the discussions, however, was focused on the remaining alternatives. It was realized that the explosive gain in maize yield in the US corn belt since 1950 was greatly based on the use of hybrid varieties.

Hybrids unmistakably have many attractive features, the main of which are (i) high produtivity as a result of hybrid vigour, (ii) uniformity, which facilitates mechanical harvesting and cultivation measures, (iii) easy combination of dominant characters such as disease or pest resistances. On the other hand they also have obvious disadvantages: (i) their genetic homogeneity may limit their adaptability to widely divergent conditions of soil and climate, (ii) owing to their genetic uniformity hybrids are vulnerable to epidemics of diseases and pests, (iii) hybrid seed, as a result of its comparatively complicated breeding procedure, is expensive, and (iv) the use of hybrid seed forces farmers to buy new sowing material each season.

Especially the two last-mentioned points are a serious drawback for the introduction of hybrid varieties in developing countries with a majority of family small-holding. Development of locally adapted hybrids by governmental institutions might reduce seed prices as compared with import of foreign seed material, but it requires considerable developmental cost and the availability of a well-organized system of seed propagation and seed distribution. Under the prevailing situation in Surinam a local hybrid industry could not be recommended.

Let us turn now to the last alternative: development of synthetic varieties. Synthetic varieties are compositions of a number of genotypes with a high general combining ability. Through that synthetics combine in them hybrid vigour and genetic plasticity. Their heterogeneity (as compared to hybrids) makes them better suited to areas with changeable growing conditions, while their composition enables the farmer to save his own seed for the next crop. Therefore they may be of value in developing countries, especially those having marginal growing conditions and with an acreage too small to support a hybrid seed industry (Allard, 1960).

Based on the above considerations in 1969 a breeding programme was started at the Centre of Agricultural Research in Surinam (celos) aiming at (i) the improvement of local varieties by recurrent selection, and (ii) the development of synthetic varieties from local and exotic material.

BREEDING WORK AT CELOS.

Recurrent selection for phenotype

Introductional remarks

Recurrent selection is a cyclic process in which the number of acceptable genotypes in the breeding stock is gradually increased. In all systems of recurrent selection selfed progenies of selected plants are allowed to intercross freely in the next generation to provide genetic recombination and to avoid inbreeding depression. The most simple method of recurrent selection, viz recurrent selection for phenotype, is visualized in fig. 1.

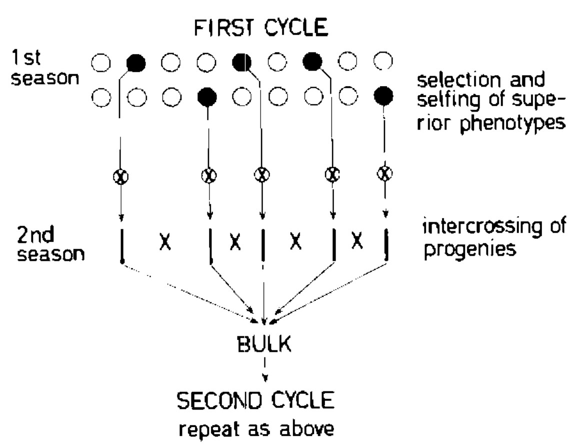


Fig. 1. Diagrammic representation of recurrent selection for phenotype

With two seasons per annum a cycle can be completed within one year. As selection occurs on the basis of the phenotype only, this method is most effective for characters with high heritability, i.e. for characters with simple inheritance and restricted genotype-environment interaction. Under some conditions, e.g. high selection intensity and an environment which maximizes the heritability, selection for quantitative characters such as yield can by this method be successful. In our breeding programme a modified phenotypic recurrent selection procedure was chosen to fulfil the above mentioned requirements.

Selection objectives and criteria.

Main objective of the breeding programme was to raise the yield of the local land race to the assumed economic minimum value of 3000 kg/ha. Since yield is affected by a large number of different components a combination of the following characters served as selection criteria:

1. *Plant characters,* including plant height, flag leaf position, firmness (stem circumference), tassel size, number of days to flowering and synchronization of male and female flowering.

2. *Ear characters,* comprising ear insertion, ear length, mid-ear circumference, ear filling and husk closing.

3. *Kernel characters,* i.a. kernel shape, kernel insertion, kernel type, kernel yield and 1000-kernel weight.

Most of the attention was devoted to the distraction of recurrent selection products from a local blend, registered as accession number 68054. In later years some other breeding stocks entered the programme.

Materials, methods and results.

The selection was initiated in 1968 with two generations of negative mass selection against strikingly off-type plants in a heterogeneous mixture of local origin. From this pre-selected breeding stock 40 superior plants were chosen in 1969. Their off-spring were selected in three successive steps on the basis of (i) synchronization of female and male flowering, (ii) plant habit and ear characteristics, and (iii) kernel characteristics respectively (troika selection). To minimize environmental variance stratified selection was applied. This means that the field was divided in a number of grids and that the best performing plants were chosen within each grid. This procedure enhances the probability of selecting the superior genotypes (Gardner, 1961).

Synchronization between silking and tasseling proved an important selection criterion. With an increase in gap between male and female flowering the percentage of seed set after selfing decreased rapidly (table 1).

Table 1. Relation between the number of days from tasseling to silking and seed set percentage after selfing in a local maize variety.

No. of days	sample	91-100%	76-90%	51-75%	26-50%	< 25%	0-5 seeds
≤ 7	58	41	23	36	–	–	–
8-9	87	25	7	36	3	17	12
10-11	132	8	6	36	9	25	16
12-13	111	2	2	17	11	24	44
≥14	102		-	2	-	13	35

Out of a total of 4000 plants some 111 passed the troika selection. Their selfed progeny was sown in bulk for propagation by random mating giving rise to the first cycle composite. Part of seed was tested for yielding capacity. As the yield equalled 4900 kg/ha (Anon., 1972a) the remainder was released as selection 68054CS1. This first all-suriname selection was tested at several locations by governmental services and private farmers with varying success. It was also adopted as the standard variety of maize in experiments executed at CELOS.

Two further selection cycles were realized in 1972 and 1973 in which closing of the husks and the angle between main stalk and ear were added to the selection criteria of the first cycle. Husk closing is correlated with resistance of the ears against borer attack, whereas outstanding ears facilitate harvesting. The second and third cycle selections were released under the names 68054CS2 and 68054CS3 respectively.

Caribbean blend. Ears of superior open-pollinated plants of a selection field comprising some hundred Caribbean composites obtained from CIMMYT, Mexico, grown in 1971, were put together and named "Caribbean blend". The bulked seed was sown on a 1500 m^2 block on heavy clay soil to test performance and yielding capacity. Despite extremely unfavourable growing conditions in the early stages, caused by water logging and soil capping, which resulted in incomplete and irregular emergence and growth retardation, the ultimate general performance was good and kernel yield amounted to about 3900 kg/ha. It was concluded that the "Caribbean blend" is a valuable source for recurrent selection, reduction of plant height and improving the uniformity of seed characteristics being the primary selection goals. However no further breeding work has been undertaken as yet.

Njoenjacobkondre population. Since all the selection work on the aforementioned material was executed under the conditions of the coastal plain, the resulting selections will be particularly adapted to the locally prevailing soil and weather conditions. This was demonstrated clearly by the comparatively poor performence and yields of the 68054CS-selections on the sandy loams of the Zanderij formation. Therefore an additional selection programme should be started in this region. Some preliminary work was done in 1972 with a grain mixture collected in Surinam's interior near the bush negro settlement Njoenjacobkondre. This was sown on a 1200 m^2 area. Selection was severely impeded by differences in crop stand which reflected the irregularities in soil conditions. To avoid the effects of environmental variability the five best performing plants of each row were selfed and harvested. Their bulked grain together with some 40 kg from open-pollinated plants of good appearance was reserved for further selection. The material, however, was lost as a result of unadequate storing.

Development of synthetic varieties.

Introductional remarks

As stated in section 2 synthetic varieties can be considered as a compromise between the favourable and disadvantageous features of hybrid varieties. On the one hand they have a certain amount of hybrid vigour, resulting in a fair yielding capacity. On the other hand they are less homogeneous which implies loss of uniformity, but increased flexibility. Synthetic varieties can be made in various ways, but I will avoid to engage in speculations about the most effective method. All synthetics have in common that they are selected on the basis of high general combining ability, in other words on the assumption that all components of the variety combine well for yield or other desirable characters. Starting from the relation developed by Sewall Wrigth:

$$\hat{F}_2 = \bar{F}_1 - \frac{\bar{F}_1 - \bar{P}}{n}$$, in which

$\hat{F}_2$ = the estimated value (e.g. yield) of the synthetic variety,
$\bar{F}_1$ = the average yield of all possible single crosses between parents,
$\bar{P}$ = the average yield of the parents, and
n = the number of parents,

it is obvious that the yield level of the synthetic can be enhanced in three different ways, viz.

- high number of parental lines,
- choice of'productive parents, and
- choice of parents giving hybrid vigour in all single cross combinations.

At CELOS determination of the general combining ability was done by polycross and top-cross tests. In a polycross test each component is tested against all the other potential components of the synthetic; a top-cross is effectuated by crossing all the components under investigation with a common tester variety. Components are definitely chosen as parents in a synthetic variety, on the basis of the performance of their polycross or top-cross progenies respectively. The breeding objectives and selection criteria were similar to those formulated in foregoing sections.

Materials

Breeding stock for the synthetic variety programme consisted of the following materials:

- 16 inbreds (I_8) of local origin, and
- 82 inbreds (I_6) extracted from two Central American composites, handed over by the Surinam Agricultural Experiment Station (MA-lines),
- 104 Caribbean composites, obtained from CIMMYT (CC-lines).

Methods and results

Local inbreds

The local inbreds were pre-selected in early 1970 as to reduce the number of potential components for a synthetic variety. Considerable variation between lines was observed for mean plant height (164-214 cm), mean ear number (1.26 – 2.74) and mean kernel yield (47-76 g), the other relevant characters showing a smaller range. Synchronization between silking and tasseling was existent in nearly all lines. Finally ten inbreds were selected for participation in on polycross and two top-cross trials.

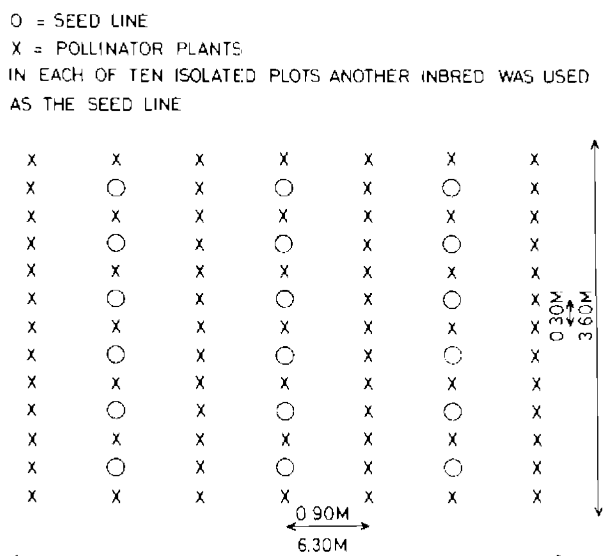


Fig. 2. Composition of a polycross trial plot

The polycross test was performed by planting each of the 10 selected lines on an isolated plot, surrounded by pollinator plants originating from a mixture of equal numbers of kernels of the nine other lines (fig. 2). The top-cross test was laid out on each of two separated locations, and consisted of alternating rows of the 10 selected inbreds and the tester variety (fig. 3). As such served the heterogeneous local land variety, 68054. At the one location the inbreds were emasculated prior to pollen shedding, at the other the line pollen was allowed to compete freely with the pollen of the tester plants. Seed lines of polycross plots and top-cross blocks were harvested separately and seed was put together per line. The bulked seed was used in a comparative yield trial, laid out in randomized blocks at two locations. Two replicates were planted on heavy clay soil at the CELOS grounds and four on a sandy loam soil at the Experimental Citrus Plantation Baboenhol, 80 km south of Paramaribo. Each block comprised 30 plots, viz. 10 progenies of each the polycross, the non-emasculated top-cross and the emasculated top-cross. Plots consisted of 7 rows of 13 plants spaced 90 x 30 cm. The two outer rows and two plants on both ends of the remaining rows served as guards, leaving 45 record plants.

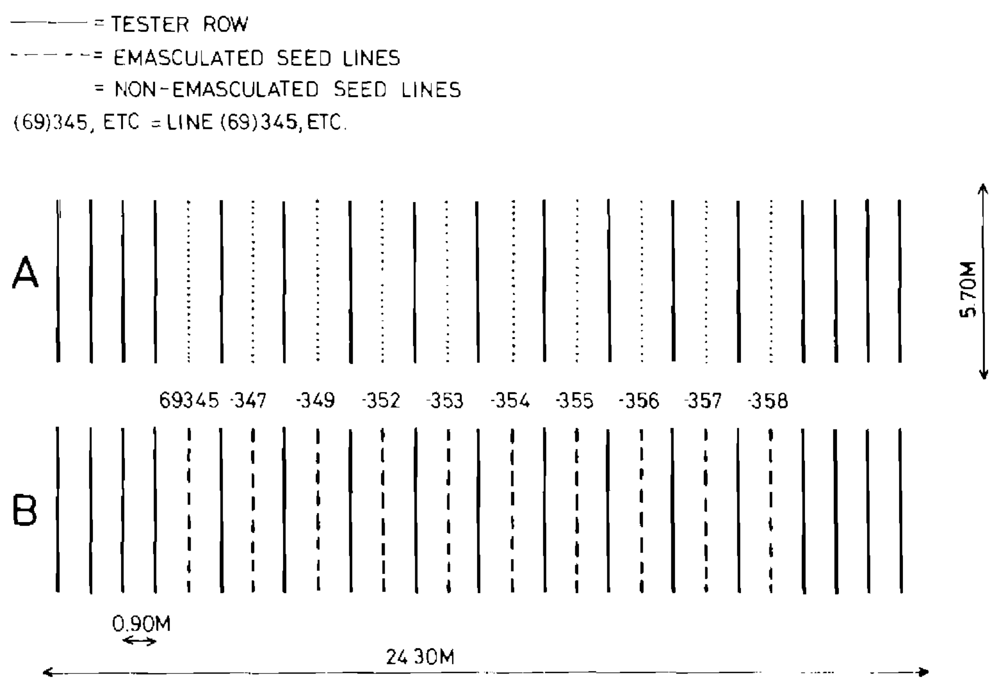


Fig. 3. Lay-out of trop-cross trial blocks. A and B distantly separated.

At the CELOS grounds emergence and growth was excellent and no conspicuous decay of the photosynthetizing organs was found until the ripening stage. Plot yields ranged from 4870 to 8420 g corresponding with 4000 to 6930 kg/ha.

As a result of low and ill-distributed precipitation and heavy borer attack, emergence and growth were poor for the blocks on sandy loam. Percentages unoccupied plant hills per plot two weeks after sowing ranged from 0 to 70. Despite filling up and large fertilizer applications emergence remained irregular and the growth was retarded. Differences in chemical composition and physical structure of the soil were held responsible for the irregularities observed. In some plots hardly any plant reached the stage of kernel-filling. Plot yields varied from 202 to 3065 g, corresponding with 170 – 2520 kg/ha. Even by elimination of the effect of the low number of harvested plants by converting the yields on the basis of 40 plants/plot, i.e. the mean value found in the clay replicates, the results remained far below those on clay soil, viz. 504-3565 g per plot or 410-2930 kg/ha.

The large differences between the results of the two trial locations made it impossible to consider them as replicates of the same experiment. At Bahoenhol both within and between block variation was so big and undirectional that there was no point in analyzing the results. Consequently the choice of lines to be used in a synthetic variety was based only on the results at the CELOS grounds. These are presented in table 2. The final selection of six lines occurred on the basis of average performances in the polycross and top-cross tests. This was done by adding up for each entry the ranking numbers in each of the three tests.

Equal proportions of the six superior lines were mixed and bulk-seeded on a 1200 m^2 block early in 1972. The open-pollinated ears were harvested in bulk and released as synthetic variety SR1.

Table 2. Average dry kernel yields (12% moisture) of polycross (P), emasculated top-cross ($\bar{T}_o$) and non-emasculated top-cross ($\bar{T}_n$) progenies and the sum of their ranking numbers (ΣR) on clay soils at CELOS (December 1971).
x = selected line.

Entry	Descent	P kg/plot	$\bar{T}_o$ kg/plot	$\bar{T}_n$ kg/plot	Average kg/plot	Average kg/ha+	ΣR
1	69345^x	8.0	7.1	7.2	7.4	6080	6.5
2	69347	6.2	6.2	6.8	6.4	5270	24
3	69349^x	7.4	7.2	7.1	7.2	5930	7
4	69352^x	6.7	6.7	6.9	6.7	5550	16
5	69353	6.4	7.0	6.8	6.7	5550	17.5
6	69354	5.9	6.6	6.6	6.4	5240	26
7	69355^x	5.8	6.9	7.4	6.7	5520	16
8	69356	6.2	6.2	6.9	6.4	5280	21.5
9	69357^x	5.3	7.1	7.2	6.5	5350	15.5
10	69358^x	6.2	7.1	6.9	6.7	5520	15

+ based on factual plot yields.

Central American lines.

The 82 I_6 lines derived from two Central American composites were planted for observation and final selection within and between lines in 1970 and 1971. Lines differed largely for plant height and number of ears per plant (table 3), but proved more uniform with respect to most ear and kernel characteristics. Ear length means varied from 9.3 to 16.3 cm, and mid-ear circumference from 9.0 to 13.4 cm (table 7). Common features were (i) orange to yellow kernel colour, (ii) regular seed insertion and ear-filling, (iii) small kernels of the flint type. After selfing and selection 41 lines (I_7) remained, which were sown in a top-cross block in alternate rows with 68054CS1 as the tester parent. Final selection between these led to the choice of 16 of them. Table 4 shows the values for some characters of the selected lines.

Table 3. Average flag leaf height and average ear number/plant for 82 Central American inbreds in two subsequent large dry periods (1970 and 1971).

Flag leaf height (cm)	No. of lines		Ears/plant	No. of lines	
	1970	1971		1970	1971
50 – 99	5	–	0.5 – 0.9	7	–
100 – 149	59	28	1.0 – 1.4	51	10
150 – 199	17	53	1.5 – 1.9	23	33
200 – 249	1	1	2.0 – 2.4	1	21
			2.5 – 2.9	–	13
			3.0 – 3.4	–	5

Table 4. Plant height, ear number, ear length distribution, kernel yield and general performance for 16 selected Central American inbreds (I_7). Average values based on random samples of 20 plants.
S = < 10 cm; M = 10-15 cm; L = > 15 cm
++ = very good; + = good; (+) = fair; ± = average.

Line	Av. plant height (cm) + extreme values	Ears/plant		Ear length			Kernel yield (g)		Esti-mation
		filled	unfilled	L	M	S	total	per ear	
70174-5	242 (200-290)	1.00	1.15	22	11	2	3928	112	++
70161-4	173 (110-215)	0.95	1.10	6	21	3	2179	73	+
70161-11	188 (155-215)	1.00	0.90	5	21	4	1746	58	+
70170-9	199 (170-240)	0.90	0.40	6	21	2	1485	51	+
70181-15	224 (185-245)	1.00	1.05	10	18	2	1883	63	+
70194-3,4	216 (170-255)	1.05	0.80	10	22	1	1977	60	+
70208-6,17	208 (160-270)	0.85	1.05	18	7	5	1928	64	+
70161-12	198 (165-220)	1.00	0.95	10	18	1	1997	69	(+)
70172-11	199 (175-235)	0.95	0.55	7	22	3	1874	59	(+)
70182-3, 15,17	189 (145-260)	1.10	1.10	4	22	5	1751	56	(+)
70195-5, 6,13	199 (140-250)	0.85	0.75	8	13	9	1478	49	(+)
70161-7	173 (155-205)	1.00	0.85	0	23	5	1229	44	±
70177-1, 7,15	182 (125-230)	0.90	1.05	0	13	13	949	37	+
70189-19	185 (150-220)	0.95	0.90	6	17	1	1281	53	±
70193-1, 6,10	219 (130-270)	0.85	1.45	0	27	1	1540	55	±
70210-17, 19	201 (150-250)	0.65	1.05	5	13	8	799	31	±

Eleven MA top-cross progenies were tested at the end of 1976, selection 68054CS2 serving as the control. The progenies were tested both on heavy clay (CELOS grounds) and on sandy loam (Coebiti). Each of the trials was laid out in a randomized block design with four replicates. Nett plots consisted of 6 rows of 17 plants spaced 90 x 30 cm. As the seeds had been stored already for over four years, precautions were taken to obtain a complete plant hill occupation. Depending on the germination percentage as determined on seed in petri dishes, two to five seeds per plant hill were sown and seeds of the less viable entries were pre-soaked in tap water during one day before planting. Unoccupied hills were filled up immediately after emergence.

Table 5. Average numbers of harvested plants and average dry kernel yields (12% moisture) of 11 MA top-cross progenies at different locations (March, 1977).
x = selected line. + = control.

Entry	Descent	CELOS			COEBITI		
		Plants harvested/plot	Kernel yield/plot (kg)	kg/ha	Plants harvested/plot	Kernel yield/plot (kg)	kg/ha
25	70174-5[x]	98	12.0	4300	97	10.7	3880
26	70161-4	99	10.0	3630	90	9.6	3480
27	70161-11	98	9.6	3480	81	8.9	3230
28	70170-9	80	9.4	3410	81	8.2	2980
17	70181-15[x]	96	10.2	3700	97	9.9	3590
18	70194-3,4[x]	94	11.3	4100	86	8.7	3160
19	70208-6,17[x]	97	10.4	3780	91	9.3	3380
20	70161-12	95	10.1	3670	96	9.6	3480
21	70172-11	93	9.9	3590	88	9.4	3410
22	68054CS2+	93	9.0	3560	-	6.3	2290
23	70195-5,6,13[x]	97	10.4	3780	94	10.7	3880
24	70193-1,6,10[x]	97	11.8	4280	87	9.2	3340

Though kernel yield was the main criterion in the top-cross progeny test, some other plant and ear characteristics which bear importance for maize growing on a practical scale were also evaluated, including early vigour, growth rate, plant height, flowering synchronization, ear number, ear size, and ear attachment. These evaluations were made on random samples of 10-20 plants per plot.

At both locations plants grew undisturbed resulting in a regular stand and comparatively high numbers of maturing plants (table 5). On clay soils dry kernel yields ranged from 9.4 to 12.0 kg/plot (3410-4360 kg/ha), of the top-cross progenies yielding more than the control (table 5). The MA-progenies were surprisingly productive at Coebiti with plot yields between 8.2 and 10.7 kg (2980-3880 kg/ha). All top-cross populations outyielded the control by far, but seed set of CS2 may have been negatively affected by mistakenly detasseling of the plants.

Though statistical analyses did not reveal significant differences between the entries, five lines were chosen as components of synthetic variety SR2 on the basis of the average performance on the two soil types. Along with dry kernel yield, plant height and seed production per ear were used as the decisive criteria.

Caribbean composites

As a result of their heterogeneous make-up, the CIMMYT composites were highly variable for all measured characters. Differences between accessions, however, were much bigger than within-composite variation. All 104 accessions were tested in two successive years, 1970 and 1971. Compared to the foregoing year, the 1971-planting performed considerably better. This became manifest mainly in plant height but also in a character as ear number, which is thought less sensitive to environmental conditions (table 6). Most stems were firm with circumference values of 7 cm or more. Though there was also a considerable variation in ear and grain characteristics some general features can be summarized:

Table 6. Average flag leaf height and average number of ears per plant for 103 Caribbean composites planted in subsequent large dry seasons (1970 and 1971).

Flag leaf height height (cm)	No. of composites 1970	1971	Ears/plant	No. of composites 1970	1971
100 – 149	50	10	0.0 – 0.4	3	–
150 – 199	53	20	0.5 – 0.9	33	1
200 – 249	–	62	1.0 – 1.4	59	15
250 – 299	–	11	1.5 – 1.9	8	46
			2.0 – 2.4	–	34
			2.5 – 2.9	–	7

- ears large, thick, and well-filled,
- grain insertion often irregular,
- grains large, alabaster white or ivory, more or less dented, sometimes shrinking and/or sensitive to bolting.

As to ear length and mid-ear circumference variation appeared to be huge. Average ear length varied from 10.9 to 21.8 cm, average mid-ear circumference from 10.6 to 17.2 cm. The distribution of values for these characters is shown in table 7. For a comparison also the values

Table 7. Frequency distribution of average ear length and average mid-ear circumference for 104 Caribbean composites and 82 Central American inbreds grown in 1971.

Ear length (cm)	Caribbean composites size	circumference	Central American inbreds size	circumference
≤ 9.9	–	–	2	7
10.0-11.9	5	11	17	40
12.0-13.9	14	56	40	24
14.0-15.9	26	31	20	–
16.0-17.9	32	6	3	–
18.0-19.9	22	–	–	–
20.0-21.9	5	–	–	–

for the Central American inbreds are given.

Some hundreds of well-performing pre-selected plants were self-pollinated. After hand-harvesting the ears were scrutinized for ear and kernel characteristics. Minimum criteria for final selection were (i) ear size > 20 cm, (ii) mid-ear circumference > 14.5 cm, and (iii) see yield over 160 g. This led to the ultimate choice of 44 plants.

I_1-lines of the selected plants were sown in a top-cross block in alternate rows with tester variety 68054CS1. Very variable lines were discarded beforehand and the remaining ones were evaluated according to the selection criteria. Ultimate selection yielded 16 lines. Table 8 summarizes the values for important characters in the selections.

Table 8. Plant height, ear number, ear length distribution, kernel yield and general performance for 16 I_1 lines selected from the Caribbean composites. Average values based on random samples of 20 plants. S = < 10 cm; M = 10-15 cm; L = > 15 cm.
++ = very good; + = good = (+) = fair; ± = average.

Line	Av. plant height (cm) + extreme values	Ears/plant		Ear size			Kernel yield (g)		Esti-mation
		filled	unfilled	L	M	S	total	per ear	
70049-18	226 (200-250)	1.00	1.00	18	7	0	3016	121	+
70104-2	262 (220-310)	1.00	1.00	21	10	0	3053	98	+
70117-10	281 (245-335)	1.00	0.70	25	4	0	2989	103	+
70015-12	243 (210-285)	0.95	0.70	16	11	2	2951	102	(+)
70032-16	268 (180-310)	1.00	1.00	15	12	0	2186	81	(+)
70082-4	219 (165-250)	0.95	0.60	6	22	1	2573	89	(+)
70084-22	242 (205-285)	1.00	1.15	22	5	0	2761	102	(+)
70054-6	230 (200-290)	1.00	1.00	17	10	0	2741	102	±
70084-21	208 (140-235)	1.00	0.95	18	9	2	2041	70	±
70084-23	214 (155-245)	0.95	0.90	19	10	0	2521	87	±
70065-23	210 (155-250)	0.95	0.95	6	16	3	1594	64	±
70079-23	199 (140-245)	0.75	0.90	14	11	2	2173	80	±
70085-5	299 (195-270)	0.90	1.00	9	16	1	2519	97	±
70085-8	243 (205-285)	1.00	0.85	12	12	2	2526	97	±
70092-21	259 (220-290)	0.95	0.55	11	10	1	1866	85	±
70095-4	236 (215-280)	1.00	1.15	11	16	0	2343	87	±

Twelve CC top-cross progenies were tried out in completely the same way as the MA-entries except that no control variety was included. At Coebiti patches showing poor growth were observed. In these many plants died shortly after emergence or did not reach maturity. Of course, this adversely affected the mean yield per plot of the respective entries. Therefore a corrected yield was computed from which plots with less than 70 occupied hills were excluded. In spite of this correction all yields except one (entry 1) were below 2500 kg/ha (table 9).

Table 9. Average numbers of harvested plants and average dry kernel yields (12% moisture) of 12 CC top-cross progenies at different locations (March, 1977).
At Coebiti plots with less than 70 harvested plants left out of consideration (see text).
+ = corrected; x = selected line.

		CELOS			COEBITI		
Entry	Descent	Plants harvested/plot	Kernel yield/ plot (kg)	kg/ha	Plants harvested/plot	Kernel yield/ plot (kg)	kg/ha
1	70049-18^x	86	12.4	4500	91 +	8.3	3010
2	70104-2	81	10.3	3740	78	5.4	1960
3	70117-10^x	88	10.9	3960	92	6.7	2430
4	70015-12	88	9.7	3520	93	5.4	1960
5	70032-16	75	9.5	3450	82 +	5.4	1960
6	70082-4	86	10.7	3880	95 +	6.2	2250
7	70084-22^x	87	11.9	4320	80 +	5.2	1890
8	70054-6	68	7.7	2800	80 +	4.7	1710
9	70084-21^x	89	11.7	4250	91 +	5.5	2000
10	70084-23^x	88	11.3	4100	92 +	5.5	2000
14	70085-8	87	10.4	3780	91	5.8	2110
16	70095-4^x	88	11.4	4140	92 +	5.8	2110

On clay-soil plants grew well and plot yields amounted from 7.7 to 12.4 kg corresponding with 2800-4500 kg/ha. At composing a synthetic variety of CC-lines (SR3) only the results on clay soils were taken into consideration. Comparing the results of the MA and CC progeny trials it is obvious that the respective performances on clay soil are not very divergent. At Coebiti, however, CC-progenies are outclassed by far by the MA-progenies. Though this partially might be explained by differences in soil condition — the MA and CC progenies were tested at different sites of the experimental garden — it looks as if the CC-material is only suited for heavy soils, whereas a synthetic variety which is based on MA-lines can be cultivated both on clay and sandy loam soils. The different habit of MA- and CC-progenies is visualized in table 10.

Trials with the CELOS-selections.

Since their release the CELOS selections have been tried at several locations and by various potential users, including private farmers, extension officers and the Agricultural Experiment Station. Reported results, however, are scarce. The author compared performance and yield of 68054CS2 with eight tropical Pioneer hybrids in two similar experiments, one on heavy clay soil (CELOS-grounds), the other on sandy loam at Coebiti (Anon., 1973).

On clay soils the local selection flowered 10-15 days later than the hybrids and about the same delay was found with respect to ripening time.

Though CS2 had the highest number of ears, it was less productive than the hybrids because of its smaller ears and low kernel weight (table 11). However, according to Duncan's multiple range test, only the yields of X304B, X105A and X101A were significantly better than that of CS2.

Table 10. Comparison of dry kernel yields of CC and MA top-cross progenies at two locations

Entry	CC-progenies Kernel yield (t/ha) CELOS (A)	Coebiti (B)	B/A	Entry	MA-progenies Kernel yield (t/ha) CELOS (A)	Coebiti (B)	B/A
1	4.5	3.0	0.67	25	4.4	3.9	0.88
2	3.7	2.0	0.54	26	3.6	3.5	0.97
3	4.0	2.4	0.60	27	3.5	3.2	0.91
4	3.5	2.0	0.57	28	3.4	3.0	0.88
5	3.5	2.0	0.57	17	3.7	3.6	0.97
6	3.9	2.3	0.59	18	4.1	3.2	0.78
7	4.3	1.9	0.44	19	3.8	3.4	0.89
8	2.8	1.7	0.61	20	3.7	3.5	0.95
9	4.3	2.0	0.47	21	3.6	3.4	0.94
10	4.1	2.0	0.48	22	3.6	2.3	0.64
14	3.8	2.1	0.55	23	3.8	3.9	1.02
16	4.1	2.1	0.51	24	4.3	3.3	0.77
Mean	3.9	2.1	0.55		3.8	3.4	0.91

Table 11. Average values of ear number, kernel weight and kernel yield for eight hybrids and local selection 68054CS2 grown on two soil types.

Entry	Clay soil ears/plant	1000-grain weight (g)	yield (kg/ha)	Sandy loam ears/plant	1000-grain weight (g)	yield (kg/ha)	Yield ratio clay/sandy loam
X101A	1.00	277	4800	1.05	248	3175	1.52
X105A	0.97	282	4900	0.99	267	3450	1.42
X304A	0.92	299	4475	0.94	280	3300	1.35
X304B	0.99	295	5050	0.99	267	3300	1.53
X306A	0.93	290	4375	0.97	279	3175	1.38
X306B	0.91	325	4200	0.97	287	2650	1.59
X352	0.96	308	4200	1.07	303	3525	1.20
X354	0.93	285	4425	0.89	246	3275	1.35
68054CS2	1.07	274	4000	1.05	248	3050	1.31
Average	0.96	293	4500	0.99	269	3200	1.41

More detailed measurements were done at Coebiti. Again CS2 lagged behind the hybrids for flowering and maturation. In average plant height and place of ear attachment it exceeded by far the hybrid varieties (table 12). With respect to the average number of ears per plant no large differences were found. Kernel yield and grain weight were lower on sandy loam than on clay (table 11), X306B being the lowest producer followed by CS2. Yield differences, however, were less obvious than on clay; none of the hybrids appeared to be significantly superior to the local selection. This might be explained by a larger adaptive value of the synthetic. The relative flexibility of the synthetic can further be illustrated by the relative yields on clay and sandy loam (table 11). Only one hybrid (X352) was more stable than CS2 in this respect. Crude protein percentage ranged from 9.9 to 11.8, CS2 having the highest content.

Table 12. Plant height, flag leaf position and ear insertion for eight hybrids and local selection 68054CS2 grown on sandy loam.

Entry	Plant height (cm)		Ear insertion	t-f	t/e
	total (t)	flag leaf (f)	(e) (cm)		
68054CS2	233	192	118	41	2.0
X101A	202	160	71	42	2.8
X105A	212	167	72	45	2.9
X304A	199	163	74	36	2.7
X304B	204	159	73	45	2.8
X306A	203	161	72	42	2.8
X306B	199	153	66	46	3.0
X352	204	161	75	43	2.7
X354	205	157	68	48	3.0

In an experiment comparing different tillage systems at Coebiti, CS1 yielded between 2410 and 2980 kg/ha dry kernel weight (12% moisture) depending on the tillage procedure (Van der Sar, 1976).

Much lower yields were obtained for CS3 on sandy and sandy loam areas of the same experimental garden (Consen-Kaboord et al., 1975). Here dry kernel yields (15% moisture) ranged from 1420 kg/ha on sand to 2320 kg/ha on sandy loam.

Synthetic variety SR1 was tested in 1972 both at CELOS and Coebiti (Anon., 1972b). Dry kernel production amounted to 4070 kg/ha at CELOS, but on the sandy loams, despite high doses of fertilizer, only 1940 kg/ha was realized.

Local selections CS1 and CS2, the Caribbean blend (CB) and the synthetic variety SR1, propagated both at Coebiti (SR-Co) and at CELOS (SR-Ce) were tried at the experimental garden Tijgerkreek West in 1975 (Anon., 1976). The relevant data are presented in table 13.

Table 13. Yield data of some maize selections and composites at Tijgerkreek West (adapted from Anon., 1976).

Selection	Ears/ plant	Ear weight (g)	Kernel yield (kg/ha)	1000-kernel weight (g)	Crude protein (%)
CS1	1.3	103	4630	299	10.7
CS2	1.2	113	4630	303	11.2
SR-Co	1.3	86	4010	275	11.5
SR-Ce	1.3	87	4100	285	11.5
CB	1.0	173	5690	383	10.1
LSD (Scheffe, 10%)			1030		0.8

The Caribbean blend yielded significantly higher than all of the Surinam selections, its protein content being lowest of all except CS1.

REFLECTIONS

Agricultural production in Surinam is rather unbalanced with paddy rice in a dominating position. For many food- and fodder crops and their derived products Surinam depends on import. Therefore diversification and increase of agricultural production are put forward as major goals of Surinam agricultural policy (Werkgroep Raamwerk Ontwikkelingsplan, 1975). In this scheme maize seems to play an important role. Maize is imported in increasing quantities to meet the local demand for poultry-feed and concentrated fodder for cattle. The value of imported maize displayed a rapid growth between 1971 and 1974 as can be seen from table 14. Large quantities of meat, mainly beaf, are imported in Surinam to a value surpassing Sf 10,- million per year. Expansion of the local beef cattle industry would require further imports of maize.

Table 14. Local production and imports of maize in 1971 and 1974 in Surinam (from: Sjauw Koen Fa, 1976a).

Year	Production		Imports		
	ha	tons	tons	price (Sf/ton)	value (Mill.Sf)
1971	126	150	10,200	147	1.5
1974	250	300	15,000	267	4.0

Sjauw Koen Fa (1976b) estimates the present amount of maize to replace today's import and to increase the local beef production at almost 20.000 tons per year.

Promotion of the cultivation of maize can only be successful if it becomes a profit-earning undertaking and an attractive alternative for other cultures, such as rice. Sjauw Koen Fa (1976b) computed that at the present level of prices and costs and a minimum living of Sf 4500,- per year, the farmer should achieve a yield of 3000 kg/ha on coastal clay soils. Though there are no exact computations on hand for the Zanderij soils, a similar minimum yield seems required for a profitable culture, partly on the basis of high demands of manure with such poor soil types.

When the maize breeding programme of CELOS was set up, an increase of the yielding capacity to an economically acceptable level was deliberately chosen for a main criterion. The selections obtained so far and the synthetic variety SR1 meet the basic requirement of a production of 3000 kg/ha, at least on maritime clay soils.

A further increase of the yield seems attainable once the synthetic varieties SR2 and SR3 have been introduced and via selection in the Caribbean blend population. Especially SR3 may offer adequate possibilities for cultivation on sandy soils. Thus the first breeding goal has been materialized.

In the second phase of the investigations one is to pay attention to the reduction of plant height (to reduce lodging) and to site and mode of ear insertion (to enable mechanical harvesting). Tolerance to abiotic factors as water logging (especially on heavy clays) or drought (mainly on sandy soils) is another major objective, just like resistance to animal parasites as *Spodoptera frugiperda* and the corn-earworm, *Heliothis zea.* Fungal diseases do not seem to play such an important part as yet, but this may come to change when the maize area is strongly increased. It is possible that under the influence of natural selection pressure the local populations have obtained a certain degree of resistance. Thus, in an experiment to compare yields on Coebiti in 1972, all hybrids were rather heavily attacked by southern corn leaf blight *(Helminthosporium maydis),* whereas the local selection 68054CS2 remained practically free from infestation.

A last breeding objective is protein content and improved protein composition. As far as the former is concerned, selection CS2 appeared to be superior when compared with a number of hybrids. Imported opaque and flury-2 varieties generally performed badly at CELOS (Consen-Kaboord, 1973). The CIMMYT composite KC2 (o_2,fl_2) and the Venezuelan variety Simeto (o_2) were the only ones to attain a yield of 3 tons/ha. They could be valuable progenitors in crossing programmes.

ACKNOWLEDGEMENTS.

The author is much indebted to Ir. G.W. Hofstede and Ir. S.B. Hofstede-Van der Meer for continuing and supervising the experiments after his leave from Surinam. He gratefully acknowledges the assistance by CELOS-workers and by students of Wageningen Agricultural University, during their practical training, who enabled him to execute the extensive programme. Thanks are due to Ir. I. Bos for his valuable comments and to Mr. J.S. de Block for correcting the manuscript.

REFERENCES

Allard, R.W., 1960. Principles of plant breeding. John Wiley & Sons, Inc., New York etc. 485 pp.

Anon., 1972a. Recurrent selection in maize, *Zea mays* L. CELOS bulletins 18:40-41.

Anon., 1972b. Breeding synthetic varieties in maize, *Zea mays* L. CELOS bulletins 18:41-42.

Anon., 1973. Performance and yield of tropical maize hybrids. CELOS bulletins 28:29-30.

Anon., 1976. Graangewassen. In: Jaarverslag 1975, Landbouwproefstation Suriname (Bulletin 101): 44-48.

Consen-Kaboord, M.J., 1973. Opbrengst, eiwitgehalte en eiwitsamenstelling van tien maïscultivars. CELOS rapporten 88:22 pp. (internal report).

Consen-Kaboord, M.J., H.J. Veltkamp en K. Manniesing, 1975. Graangewassen. In: Jaarverslag 1974, Landbouwproefstation Suriname (Bulletin 97): 48-53.

Gardner, C.O., 1961. An evaluation of effects of mass selection and seed irradiation with thermal neutrons on yield of corn. Crop Science 1:241-245.

Huiswoud, R.R., F.A. del Prado, E.W. van Brussel and F.W. van Amson, Corn growing in Surinam. Proc. 7th Annual Meeting Caribbean Food Crops Society, 1969: 354-356.

Sar, T. Van der, 1976. Tillage for dry crops in the humid tropics. Surin. Landb. 24:98-98.

Sjauw Koen Fa, A.R. 1976a. Mogelijkheden voor de teelt van mais in Suriname. Deel I. (Doctoraalthesis Agric. University, Wageningen): 34 pp.

Sjauw Koen FA, A.R., 1976b. Mogelijkheden voor de teelt van mais in Suriname. Deel II. (Doctoraalthesis, Agric. University, Wageningen): 46 pp.

Werkgroep Raamwerk Agrarisch Ontwikkelingsplan, 1975. Het landbouwbeleid: een visie omtrent doelstellingen en middelen. Surin. Landb. 23:57-75

A PRELIMINARY EVALUATION OF CROPS UNDER TWO FARMING SYSTEMS AT COEBITI

R.P.S. Ahlawat and R. Samlal

Agricultural Experiment Station, Paramaribo

SUMMARY

The grain yields of legumes and cereal compared as sole and intercropping were up to 85% and 53% more, respectively at pasture location than zero pasture. Maize with 6.4t/ha as sole crop at pasture location out-yielded other crop or crop combinations. Intercropping at pasture location was inferior to sole but superior especially maize + cowpea; and maize + sweet potato at zero pasture. Among the intercropping treatments, maize + cowpea with 4.49t/ha at pasture and 3.73t/ha at zero pasture stood first.

INTRODUCTION

Tropical soil have not only badly suffered from vagaries of weather i.c. high temperature floods and draughts but also from ill handling by man especially through cut and burn agriculture. Although climate can not be altered, changes in plant environment by manipulating the farming systems and cultivation practices leave an option for a viable agriculture. The important recourse is to revive the ecological sembalance of the natural resources forming plant-environment by keeping these soils under some vegetational cover, be it a grain legume or their mixtures or cereals in quick succession preferably with a legume as cover or inter crop, all the year round in order to provide protection to the soil against sun and rains as proposed by Strange (1952) and Bennett et. al. (1976).

Martin (1944) and Griffith (1949) from Uganda; Turpin and Rowland (1951) from South Africa; and Bennett et. al. (1976) empharised on short term grass ley inclusion in the cropping programme for restoring soil fertility. Schofield (1945) from Queensland; Stobbs (1969) from Uganda; Moore (1962) from Nigeria and Vicente-Chandler et. al. (1953) from Puerto Rico reported better results with grass-legume leys than grass alone.

In countries where farmers holdings are small, the solution of the problem lies partly in adoption of relay cropping with inclusion of a legume as main or intercrop or cover crop and partly in efficient soil and water management practices as is evident from the results reported by Munro (1960), Bodade (1964), Andrews (1972), Enyi (1973) and Ofori (1973), who obtained up to 80% more returns per acre in intercropping and 59% more in relay cropping compared to sole.

A substantially large area at and around Coebiti falls under non bleached and bleached cover soils, which are basically coarse sands, acidic and of poor fertility status (App. I), besides having been subjected to an escalating cut and burn agriculture by men. This paper presents the results of a preliminary trial conducted to evaluate possible crops at pasture and zero pasture locations in an effort to collect first hand information as to which farming system and crop combination would fit best to these agro-climatic conditions.

MATERIALS AND METHODS

14 treatments were selected from 6 crops as below:

1. Sole-Cassava (Indis), Peanut (Matjan), Cowpea (77096), Cowpea (77097), Maize (CYMMIT Elite), Sweet Potato (Blauw kop) and Pigeon Pea (a dwarf strain from W.I.).

2. Intercropping- Maize + Peanut; Maize + Sweet Potato; Maize + Cowpea; Maize + Pigeon Pea; Cassava + Peanut; Cassava + Cowpea; and Cassava + Pigeon Pea.

Two sites were chosen (I) a six year old pasture which had been used for grazing cows and (II) a zero pasture land, which was reclaimed in 1976. The land was ploughed in strips leaving 2.5 m land in between followed by rotovating and minor shaping. Strip width varied from 3-4 m depending upon the row distances, which were decided keeping in view mechanizing intercropping; the length was kept 20 m in all treatments. Thenceforth, soil was limed @ 2t/ha and followed with rototilling.

Soil samples were drawn before and after liming from the plough layer (0-25 cm depth) from each plot at the pasture location and one representative sample from zero pasture site. The results of the soil analyses are presented in App. I.

The fertilizer was applied in split doses but a certain amount was placed 8-10 cm away and 5-8 cm deep from the seed row in a furrow prepared before planting. Subsequent applications were as well drilled in the soil except third instalment of urea in maize. The doses of fertilizer and schedule of application are given in Appendix II. Micronutrients in the form of Nutra spray @ 30 kg/ha + Borax @ 15 kg/ha were sprayed immediately following planting. All crops were planted simultaneously on June 2, 1978 at both locations except cassava in intercropping treatments which was planted 2 weeks later. The row distances and planting pattern are given in App. III.

Diptherex was sprayed at weekly intervals till 70 days stage against insects/pests. Against leaf cutting ants, which are a common problem, Mirex granules were used. In Peanuts, 3 sprays of Benlate @ 2 gm/litre were done as a safeguard measure against *Cercospora.*

RESULTS

Plant Height

The crops at pasture location grew rapidly and were taller irrespective of the intercropping treatment than zero pasture except Peanut in Cassava + Peanut treatment which was taller at zero pasture

Intercropping maize with legumes or Sweet Potato at pasture location tended to decrease its height. The reduction being greatest with Peanut and lowest with Cowpea; where as at zero pasture, intercrops increased its height the gain was maximum in Maize + Cowpea and minimum with Peanut. Maize retarded Peanut and Cowpea but the magnitude was larger in Cowpea: Pigeon pea on the contrary gained height. Intercropping of legumes with Cassava lead to reduction in their height.

Dry-matter yield

Dry-matter production was slow immediately following seedling emergence till 35 days; rapid thenceforth till 65 days in Maize, Peanut and Cowpea and till 80 days in Pigeon pea. Subsequently, it slowed or dropped down. Dry matter accumulated rapidly and was higher at pasture location regardless of intercropping except in Peanut intercropped with Cassava, but the differences became apparent after 50 days of sowing.

The dry matter yield of Maize with Pigeon pea and Cowpea weighed more at 35,50 and 65 days stages at pasture location and 35, 50, 65 and 80 days stages at zero pasture location. The minimum dry matter yields were obtained with Peanuts. Sweet Potato as intercrop increased dry weight at zero pasture only.

Dry matter yields in legumes except Cowpea at zero pasture were low when grown with Maize. Intercropping with Cassava increased their dry weight except Peanut at Pasture location.

Crop Growth Rate

The crop growth rates of crops were comparatively rapid at pasture location than zero pasture.

The crop growth rate of Maize was enhanced by Pigeon pea, Cowpea and Sweet Potato — the highest being with Pigeon Pea; a maximum value was reached between 50-65 days stage, after which the rate declined steeply. Sole crop had comparatively a slow but substained crop growth rate which is conspicuous by the steady drop after 65 days. The slowest growth rate was observed when intercropped with Peanut. Maize on the contrary, depressed the legumes growth. Legumes when intercropped with Cassava had a higher growth rate.

Grain Yield and Yield attributes

The grain yield of crops regardless of intercropping treatments were 7-85.7% higher at pasture location except Peanut with Cassava, which yielded more at zero pasture location. The maximum yields at pasture location were obtained from Sole Crop of Maize (6.407t/ha) followed by Maize + Cowpea (4.499t/ha); Maize + Peanut (4.408t/ha) and Maize + Sweet Potato (4.163t/ha from Maize alone); where as at zero pasture location Maize + Sweet Potato with 3.643t/ha from Maize alone and Maize + Cowpea with 3.735t/ha produced convincingly more. Among the legumes, the highest yields were obtained from Peanut followed by Cowpea at both locations (table 1).

Grain yield of Maize except with Sweet Potato at zero pasture were reduced in intercrop - ing, the reduction being greatest with Peanut and Pigeon Pea and least with Cowpea. The number of ear bearing plants, grain yield per plant and 1000 grain weight which are the important yield attributes were reduced by intercropping, Peanut and Pigeon Pea had the greatest adverse effect (table 2).

Legumes in intercropping treatments particularly with Maize produced very low grain yields except Pigeon Pea at zero pasture. Percentage yield reduction was higher at pasture location owing to higher yields from sole crops.

DISCUSSION

Studies on growth (height, fresh weight and dry weight), yield and yield attributes clearly indicate that higher yields at pasture location were chiefly due to improved physical properties of the surface soil and partly because of improved soil fertility status, which helped plants to attain normal growth rate and full height. It was observed that soils at zero pasture became hard

Table 1: Grain Yield and Percentage Grain Loss of intercrop over sole crop.
(Maize yield at 15% moisture; Legume yields at 12% moisture).

Comparisons for	Treatment	Observed Grain Yield t/ha		Percentage Grain/Loss of Intercrop over Sole crop		Increase/decrease in Yield over zero pasture	
		Pasture	Zero Pasture	Pasture	Zero Pasture	t/ha	%
Maize	Maize Sole	6.407	3.518	–	–	+ 2.889	+ 82.1
	Maize + Peanut	2.524	1.647	–60.6	– 53.1	+ 0.877	+ 53.2
	Maize + Sweet Potato	4.163	3.643	–35.0	+ 3.6	+ 0.520	+ 14.2
	Maize + Cowpea	3.692	3.062	–42.3	– 12.9	+ 0.630	+ 20.5
	Maize + Pigeon Pea	2.635	2.462	–58.8	– 30.0	+ 0.173	+ 7.0
Peanut	Peanut Sole	3.333	2.500	–	–	+ 0.833	+ 33.3
	Maize + Peanut	1.884	1.692	–43.4	– 32.3	+ 0.192	+ 11.3
	Cassava + Peanut	1.809	2.006	–45.7	– 19.7	– 0.197	– 9.8
Cowpea	Cowpea Sole	2.166	1.166	–	–	+ 1.000	+ 85.7
	Maize + Cowpea	0.877	0.673	–62.7	– 42.3	+ 0.204	+ 19.9
	Cassava + Cowpea	1.684	1.151	–21.0	– 1.2	+ 0.533	+ 46.3
Pigeon Pea	Pigeon Pea Sole	1.291	0.416	–	–	+ 0.875	+ 210.3
	Maize + Pigeon Pea	0.692	0.500	–46.3	+ 20.1	+ 0.192	+ 38.4
	Cassava + Pigeon Pea	1.085	0.986	–15.9	+137.0	+ 0.099	+ 10.0

Table 2. Effect of Intercropping on the yield attributes of Maize

Treatment	Ear bearing plants/row		Grain yield per plant (gms)		1000 grain wt (gm)		Shelling %	
	Pasture	Zero Pasture	Pasture	Zero Pasture	Pasture	Zero Pasture	Pasture	Zero Pasture
Maize Sole	92	84	125	75	350.0	281.0	79.6	76.6
Maize + Peanut	64	76	103	56	316.5	254.5	77.6	76.6
Maize + Sweet Potato	80	84	104	87	325.0	273.0	79.1	80.0
Maize + Cowpea	84	91	114	84	322.0	280.0	77.3	76.8
Maize + Pigeon Pea	76	78	90	82	294.5	269.50	76.9	80.0

Table 2. Effect of Intercropping on the yield attributes of Maize

Treatment	Ear bearing plants/row		Grain yield per plant (gms)		1000 grain wt (gm)		Shelling %	
	Pasture	Zero Pasture	Pasture	Zero Pasture	Pasture	Zero Pasture	Pasture	Zero Pasture
Maize Sole	92	84	125	75	350.0	281.0	79.6	76.6
Maize + Peanut	64	76	103	56	316.5	254.5	77.6	76.6
Maize + Sweet Potato	80	84	104	87	325.0	273.0	79.1	80.0
Maize + Cowpea	84	91	114	84	322.0	280.0	77.3	76.8
Maize + Pigeon Pea	76	78	90	82	294.5	269.50	76.9	80.0

and impervious after 2-3 rains immediately following planting leading to the formation of an impervious thick layer of crust which delayed seedling emergence too long. As a result many seedlings were mutilated; occasional heavy rains lead to run off and erosion as well. Beneficial effects of grass ley on the yields of subsequent crops were reported by Wilkinson (1975) and Bennett et. al. (1976); the reasons attributed for higher yields were increased water retention, better soil structure and improved fertility status.

Among the intercrops grown with Maize, Peanut had the greatest depressing effect on the growth and yield of Maize. It might be attributed to prolonged flowering and fruiting habit of the crops resulting inconsistent competition for nutrient absorption. Pigeon Pea, although initially, enhanced the crop growth rate, had a equally depressing effect on the grain yield as Peanut. It could be ascribed to erect and slow growing habit till flowering stage (60 days); and prolonged flowering and fruiting subsequently.

Likewise, Cowpea too increased the crop growth rate but depressed the yield although not as much as Peanut + Pigeon Pea. Late flowering and fruiting, which coincided with Maize reproductive phase might be attributed to depressed yields. Enyi (1973) from Tanzania reported adverse effects of Cowpea beans and Pigeon Pea on the grain yield of Maize and ascribed it to higher nutrient requirement of the legumes and partly to the competition for nutrients especially during reproductive phases. In Sweet Potato + Maize plots, 4 rows of Maize were planted compared to 3 in other intercropping treatments. Secondly it being a longer duration crop (5-6 months) grows slowly compared to legumes included in the experiment. Thirdly, its requirement for nutrients is not very high. Tallyrand and Lugo Lopez (1976) reported N40, P45 and K28 to have given good yields (14.5 t/ha) on an ultisol in Puerto Rico. The growth of Sweet Potato at zero pasture had been poor as reflected by a higher crop growth rate and higher yields in Maize; where as at pasture location the trend was opposite.

The legumes in intercropping with Maize yielded generally low both in terms of dry matter yield and grain yield except Pigeon Pea at zero pasture, mainly because of restricted nutrient availability and partly due to shading effect. The comparison of Pigeon Pea yields at zero pasture location stand invalid since the sole Pigeon Pea crop was badly damaged by leaf cutting ants during flowering.

Legumes with Cassava yielded more than when intercropped with Maize, as Cassava was planted 2 weeks later and it is a slow growing crop due to which competition for nutrients was never as high as with Maize.

REFERENCES

Andrews, D.J. 1972., Expl. Agric.; 8: 139-15u.
Bennett, O.L.; E.L. Mathias and C.B. Sperow 1976. Agron, J. 68: 250-254
Bodade, V.N. 1964. Ind. Oil Seeds J., 8 (4): 297
Enyi, B.A.C. 1973. Expl. Agric. 9: 83-90
Griffith, G. 1949. E. Afr. Agric. J., 14: 187-188
Martin, W. 1944. E. Afr. Agric. J., 9: 189-195
Moore, A.W. 1962. Emp. J. Exp. Agric., 30: 239-248
Munro, J.M. 1960. Progr. Reps. Exp. Sta. Emp. Cott. Gir. Corp. Nyasaland
Ofori, C.S. 1973. Expl. Agric., 9: 15-22
Schofield, J.L. 1945. Od. J. Agric. Sci., 2: 170-174

Stobbs, T.H. 1969. J. Brit. Grasslds-So, 24: 81-86

Strange, L.R.N. 1972. Cited from Legumes in Agriculture. F.A.O. Agricultural Studies No. 21:128-129

Tallyrand, H. and Lugo Lopez, M.A. 1976. J. Agri. Univ. P.R., 60: 9-14

Turpin, H.W. and Rowland, J.W. (1951). Vicente-Chandler, J., Silva, S. and Figarella, J. (1953). Fmg. S. Afr., 26: 145-147; Agron. J., 45: 397-400

Wilkinson, G.E. 1975. Trop. Agric., 52 (2) : 97 : 103

APPENDIX I

RESULTS OF SOIL ANALYSIS
(B.L.– Before Liming; A.L. – After Liming)

	Cassava		Peanut		Cow Pea		Cow Pea		Maize		Sweet Potato	
	B.L.	A.L.	B.L.	A.L.	B.L.	A.L.	B.L.	A.L.	B.L.	A.L.	B.L.	A.L.
pH (H_2O)	5.8	6.1	5.3	5.9	5.8	6.3	6.0	6.5	5.8	6.6	5.5	6.6
pH (KCl)	4.3	4.6	4.2	4.6	4.5	5.0	4.7	5.2	4.4	5.2	4.4	5.2
CEC Me %	3.60	4.67	4.62	4.32	4.25	4.57	4.20	5.67	4.60	4.07	3.90	4.45
Base Saturation %	77	100	54	100	64	100	62	100	53	100	45	100
Exch. Al. Me %	0.14	0.12	0.20	0.10	0.10	0.07	0.10	0.03	0.18	0.00	0.15	0.02
Total N%	0.11	0.10	0.12	0.10	0.11	0.09	0.09	0.09	0.08	0.09	0.09	0.09
P Truog P205	11	4	8	8	7	7	6	9	7	10	7	12
Avail. K20	120	105	120	70	110	85	105	140	50	95	75	105
Avail. CaO	440	500	325	1400	505	730	445	1650	425	730	310	1125
Avail. MgO	115	110	110	85	150	125	155	245	100	150	105	135

Pasture

	Pigeon	Pea	Maize+Cow	Pea	Maize+Sweet	Potato	Maize+Cow	Pea	Maize+Pigeon	Pea
	B.L.	A.L.	B.L.	A.L.	B.L.	A.L.	B.L.	A.L.	B.L.	A.L.
pH (H_2O)	5.4	6.6	5.4	6.0	5.2	6.0	5.2	5.8	5.2	5.8
pH (KCl)	4.3	5.0	4.1	4.6	4.1	4.6	4.1	4.4	4.1	4.5
CEC Me %	3.25	4.67	3.70	3.92	4.02	4.10	4.45	4.22	4.53	4.67
Base Saturation %	47	100	31	100	39	100	34	100	34	100
Exch. Al. Me%	0.19	0.03	0.57	0.03	0.49	0.20	0.56	0.16	0.49	0.28
Total N %	0.08	0.08	0.09	0.08	0.11	0.08	0.09	0.08	0.10	0.08
P Truog P205	3	4	5	5	5	5	5	4	4	6
Avail. K20	45	120	55	50	95	115	55	50	80	90
Avail. CaO	215	565	165	490	200	340	380	620	215	375
Avail. MgO	80	115	80	75	90	70	80	75	80	105

Zero Pasture

	Cassava+Peanut		Cassava+Cow Pea		Cassava+Pigeon Pea		Representative sample	
	B.L.	A.L.	B.L.	A.L.	B.L.	A.L.	B.L.	A.L.
pH (H_2O)	5.5	6.2	5.8	6.4	5.7	6.1	4.9	5.4
pH (KCl)	4.3	4.9	4.6	5.2	4.6	4.8	3.8	4.3
CEC Me %	4.80	4.97	5.60	5.10	6.80	6.20	3.72	3.80
Base Saturation %	47	100	65	100	59	100	4	100
Exch. Al. Me %	0.26	0.10	0.07	0.03	0.11	0.03	0.86	0.05
Total N%	0.08	0.10	0.12	0.10	0.12	0.10	0.08	0.07
P Truog P205	5	5	8	5	6	7	8	3
Avail. K20	110	115	125	125	85	130	10	15
Avail. CaO	380	635	610	800	840	740	–	285
Avail. MgO	110	140	165	160	185	170	–	35

APPENDIX II

SCHEOULE OF FERTILLIZER APPLICATION

	Crop	Rate			Time of application
1.	Cassava	N100	P100	K250	All P and ½K as basal; ½N 2 weeks after planting; remaining N and K after 10 weeks.
2.	Maize	N150	P100	K100	1/3N, all P and ½K as basal; 1/3N and ½K at knee high stage; 1/3N at silking stage.
3.	Sweet Potato	N45	P90	K140	½N, all P and ½K as basal; ½N and ½K after 6 weeks.
4.	Peanut, Cowpea and Pigeon Pea	N25	P60	K60	All as basal.

SOURCES OF NUTRIENTS

N – Urea
P - Tripple Super Phosphate
K – Patent Kali
Micro-nutrients – Nutra spray + Borax

APPENDIX III PLANTING PATTERNS

Treatment	Row distances (cm)	Lines	Plot width (m)
Cassava	100	3	3.0
Peanut	45	8	3.6
Cow Pea	45	8	3.6
Cow Pea	45	8	3.6
Maize	90	4	3.6
Sweet Potato	75	4	3.0
Pigeon Pea	60	6	3.6
Maize + Peanut	15 M 45 PN 45 PN 45 PN 45 M 45 PN 45 PN 45 PN 45 M 15	M PN 3 + 6	3.9
Maize + Sweet Potato	15 M 60 M 62.5 SP 62.5 SP 62.5 SP 62.5 M 60 M 15	M SP 4 + 3	4.0
Maize + Cow Pea	Same as Maize + Peanut	M SP 3 + 6	3.9
Maize + Pigion Pea	Same as Maize + Peanut	M PP 3 + 6	3.9
Cassava + Peanut	50 C 50 PN 40 PN 50 C 50 PN 40 PN 50 C 35 PN 10	C PN 3 + 5	3.8
Cassava + Cow Pea	Same as Maize + Peanut	C CP 3 + 5	3.8
Cassava + Pigeon Pea	Same as Maize + Peanut	C PP 3 + 5	3.8

NAME OF PAPER: A Preliminary Evaluation of Crops under two Farming Systems at Coebiti. (R.P.S. Ahlawat & R. Samlal)

Questions by John Hammerton
Country: Belize

QUESTIONS:

1. Have you attempted to calculate the Energy yield and the Crude Protein yield of the intercropped or mixed systems? If so, what are the results?

2. In the analysis of your data, how do you reconcile differences in crop duration (i.e. the time from sowing to harvest)?

ANSWERS:

1. Our emphasis had been only on grain yield and growth. However, this is a good suggestion and we shall incorporate this point in our programmes. 2nd phase beginning from next year.

2. One longer duration crop shall be compared with 2 harvests of shorter duration crop — one in long season and another in short season.

Questions by A.M. Pinchinat
Country: Rep. Dominicana

QUESTIONS:

1. In measuring biomass production how do you compensate for the differences in cropping cycles, such as short cycles: Maize + Peanut, Maize + Sweet Potato. . . .and long, full-year cycles such as Cassava + Peanut. . . . .

2. What is the economics of the systems?

ANSWERS:

1. We shall compare the returns of Cassava sole and with intercrops with two harvests of short season crops (Cereals, legume or Sweet Potato or their combinations) — one planted in large rainy season and harvested in September and another planted in short rainy season.

2. Economics have not been worked out as we have just initiated the programme. Next year i.e. in 2nd phase when we conduct statistical experiments the cost factor shall be taken into account.

PERFORMANCE OF FOURTEEN ELITES AT TWO LOCATIONS IN SURINAME

G.S. LATA
Agricultural Experiment Station, Paramaribo

SUMMARY

Sixteen varieties, fourteen elites from CIMMYT (maize and wheat improvement center) and two local floury flints were tested at two different locations on two types of soil.

1. Tijgerkreek West, with a fine sandy loam soil of medium fertility on coastal area; derived from Demerara formation.
2. Coebiti, with a coarse sandy loam soil of poor fertility and low pH; derived from Zanderij formation.

Compared to local cultivars, CIMMYT elites produced outstanding grain yields of an approximately 7,000 kg per hectare at Tijgerkreek West whereas the local checks produced a maximum grain yield of 5,000 kg per hectare. On the Zanderij formation, at Coebiti the grain yields were depressed by almost fifty percent of those at Tijgerkreek West. A significant correlation was found between number of leaves (per plant) and plant height. Plant height and grain yield were negatively correlated.

INTRODUCTION

Hybrids are recognized by their vigorous growths, high yields and uniformity which result from crossing two dissimilar parents, but these features are lost in the second generation. This means that with hybrid maize the farmer has to buy new seed each year, indicating in many cases a serious drawback for the small peasant farmers in developing countries who usually prefer to keep his own seed. For that reason the maize breeding program in developing countries is at present more concpntrated on improvement by means of open-pollinated varieties. Bolton (1977) summarized the advantages of a maize breeding program aimed at the production of improved open-pollinated varieties as follows:

1. Seed can be saved from each seasons crop for planting the following season; unlike hybrid seed;
2. The yield can be maintained with simple selection methods.
3. Open- pollinated varieties can be made available in the very early stages of the breeding program whereas hybrid varieties only emerge after completion of the entire breeding process.

Under bad husbandry conditions hybrids and new varieties with a high yield potential will yield no more than local varieties. It means that the introduction of high yielding cultivars should follow, not precede good cultural practices as they are bred to perform well under favourable growing conditions.

In recent varietal trials at the experiment station local synthetics and composites produced grain yields of 5,000 kilograms per hectare on the average at a plant population of about 40,000 plants per hectare, but low yields of 2 to 2.5 tons per hectare were common in the previous years due to the low plant populations used. There is a growing need for superior cultivars with high and consistent grain yields in Suriname to boost corn production which had tremendously decreased in recent years (Lata, 1978).

The elites used in the present varietal trials were developed at CIMMYT International experimental varieties which were tested at 25 to 30 locations: which in turn were developed from International progeny testing trials. Elites, which are superior in grain yield and other features are tested at 100 to 125 locations. The best performing elites in each country are moved into national demonstration trials and considered for national release. In the present Elite trials 14 elites (1977) along with two local checks were tested at two locations on different types of soil to compare the growth and yield of all varieties (at two locations) and the elites with local ones. At Tijgerkreek West two elite trials were carried out; one in 1977, long rainy season, (code no TK 129) and the other in 1977 short rainy season (TK 150). At Coebiti the trial (no Co 116) was conducted in the short rainy season (Dec.-January) with a week's difference in the sowing date from TK 150. As there were no significant differences in plant height measurement etc. between TK 129 and TK 150 only the grain yields and rainfall data are presented from the trial TK 129, but comparisions are made for the two locations Tijgerkreek West and Coebiti from the results of two simultaneous trials, TK 150 and Co. 116.

MATERIALS AND METHODS

Location and climate of Suriname

Suriname is situated between 2^{o} and 6^{o} North latitude and 54^{o} and 58^{o} West longitude, on the northeast coast of South America. Annual mean temperature is $27.1^{o}C$ with insignificant differences between months. At daytime the average maximum is $30.9^{o}C$. The daylength varies from 11h46 – 12h28. The relative humidity is rather high throughout the year with the lowest (76%) in November and the (average) highest (86%) in June. Rainfall is abundant for maize, though erratic in distribution. The average annual rainfall is 2300 mm with about ± 1,200 mm in the major rainy season (May-September) and about ± 900 mm in the minor rainy season (November to January). The wind velocity ranges between 1.1 and 1.7 m per sec.

The soil at location 1, Tijgerkreek West is sandy loam with medium fertility derived from Demerara formation) and at location II. Coebiti is well drained coarse sandy loam with very low organic matter and pH derived from Zanderij formation (see table 1.)

Table 1. Soil Analysis (depth 0-30 cm)

	Tijgerkreek-West	Coebiti
pH – H_2O	7.0	5.0
pH – KCl	6.4	3.9
EC 2½	0.24 mmho/cm	0.05 mmho/cm
C (W.B.) %	1.11	0.71
Org. matter	2.49	1.60
P (Truog)	32 ppm	6 ppm
Available K_2O (3% acetic acid)	110 ppm	15 ppm
Available MgO (3% acetic acid)	780 ppm	15 ppm
Available SO4 (3% acetic acid)	10 ppm	35 ppm
Percentage of sand (53 mu)	70.0	81
Percentage of silt (2-53 mu)	15.5	4
Percentage of lutum (2 mu)	14.6	15
Texture	Fine Sandy loam	Coarse Sandy loam
Water holding capacity: Available moisture (50 cm top soil)	140 mm	60 mm

The origin and name of each cultivar used is given in table 2. The layout was a randomized block design with four replications. The row distance was 75 centimeters and the plant distance was 50 centimeters with two plants per hole, giving a plant population of 53,333 plants per hectare. (suggested by CIMMYT). In each plot 4 rows were planted which were 5 meter long and two middle rows including the end plants were harvested for grain yield. Grain yields were adjusted to 14% moisture. Measurements of plant height (up to the flag node), ear height (up to the topmost ear), number of leaves per plant were taken after fifty percent silking. Days were counted from planting to fifty percent silking as a measure of maturity. At TKW the total amount of fertilizers used was 250kg urea, 300 kg sulphate of potash and 100 kg double super phosphate split into three applications at planting, four weeks after planting and seven weeks after planting. All phosphate was applied at planting. At Coebiti 217.5 kg urea 209.3 kg double super phosphate and 300kg sulphate of potash per hectare were applied (split) in three applications as for TKW. Chlordane 1 gm/m^2) and Furadan (15 gm/10 meter row) were used at planting and 4 weeks after planting, respectively, against mole crickets and *Spodoptera frugiperda* which are the major problems in corn growing in Suriname.

Total rainfall during the three growth periods were 636.9 and 471.1 mm at Tijgerkreek West and 468.9 mm at Coebiti. Weekly rainfall in growth period is plotted in figure 1 for both locations and also for the prevous elite trial (TK 129).

Table 2. International Elite Variety Trial, 1977, ELVT 18 (Ensayo International de Variedad Elite, 1977. ELVT 18)

Location: 1. Tijgerkreek-West 2. Coebiti

Entry No.			Parent AU Population	Origin	Replication 1	2	3	4
1.	Across 7422 (White)	Across Location	Mezcla trop. Blanco	PR 76B Lote 1B	2	18	37	56
2.	Poza Rica 7523 (White)	Mexico	Blanco Cristilano 1	PR 76B Lote 10	8	32	47	59
3.	Gemiza 7523/2 (White)	Egypt	"	TL 76B Lote 149	11	31	42	53
4.	Across 7524 (Yellow)	Across Locations	Ant. x Ver. 181	TL 76B Lote 149	5	23	38	51
5.	Pantnagar	India	"	PR 76B Lote 76B	16	17	33	55
6.	Across 7425 (White)	Across Locations	(Mix. 1x Col.gpo.1)	PR 76B Lote 77	1	29	48	62
7.	Poza Rica 7526 (Yellow)	Mexico	Mezcla Amerilla	PR 76B Lote 23	7	20	41	64
8.	San Andres 7528/1 (Yellow)	El Salvador	Amerillo Dentado	PR 76B Lote 37	3	28	36	54
9.	Cotaxtla 7429 (White)	Mexico	Tuxpeno Caribe 2	TL 75B Lote 127	6	30	43	49
10.	Pichilingue 7429 (White)	Ecuador	"	PR 76B Lote 78	15	24	39	50
11.	Across 7429 (White)	Across Locations	"	PR 76B Lote 67	10	29	45	63
12.	Check 1: La Maquina 7422 (White)			PR 76B Lote 24	14	27	35	57
13.	Check 2: Tocumen 7428 (Yellow)			PR 76B Lote 20	12	22	46	61
14.	Check 3: Across 7443 (White)			TL 75B Lote 138	4	26	40	58
15.	Check 4: Suriname Caribbean mixed population (White)				13	21	34	52
16.	Check 5: Suriname Synthetic (Celos) (Yellow)				9	25	44	60

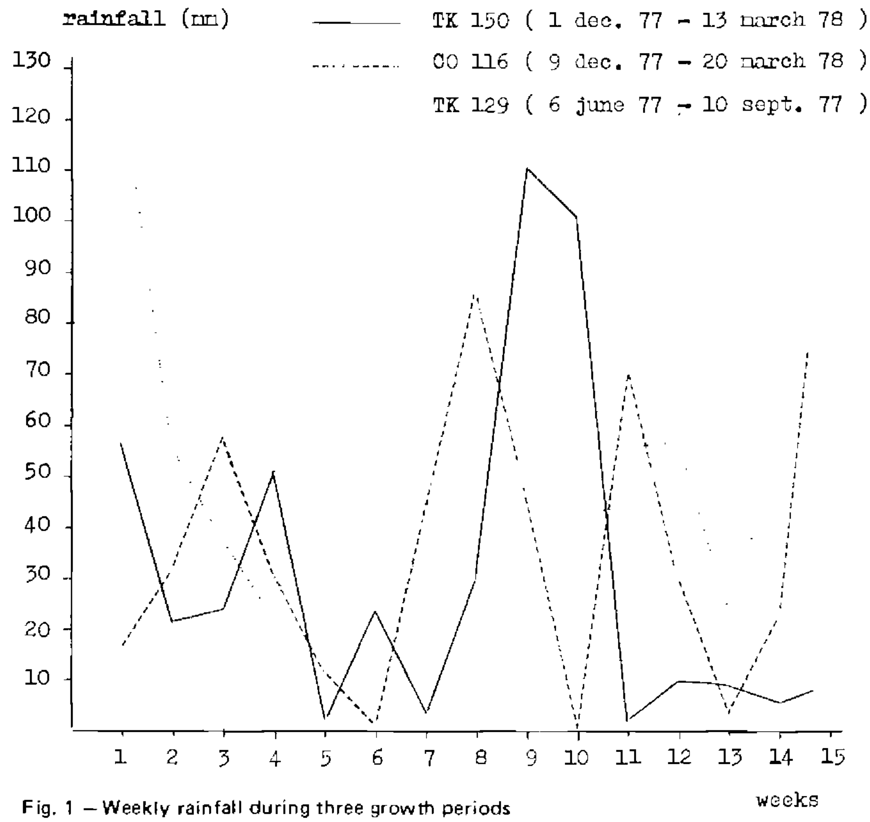


Fig. 1 — Weekly rainfall during three growth periods

RESULTS AND DISCUSSION

In this paper, the results of two simultaneous trials conducted at Tijgerkreek West and Coebiti (TK 150 and Co 116) are discussed. Similar previous elite trial at Tijgerkreek West is also discussed in terms of grain yield while the yields in long and short rainy seasons are compared.

Plant height: plant height is one of the decisive factors determining the plants resistance to lodging. In recent years, by continuous selection of short statured plants and by crossing tall plants with short types, dwarf varieties have been developed with low ear placement and upright leaves. The plants new features make it possible to increase population density and so the grain yield. Elites used in the present trials were not of the dwarf type but short-statured with low ear placement and plant height compared to local varieties. At tijgerkreek West, elites had an average plant height of 215 cm whereas the local caribbean mixed population and synthetic had an average of 255 cm and 236 cm respectively. At Coebiti plant height was reduced to an average of 188 cm in elites and to 242 cm and 210 cm in local ones, Entries 15 and 16 respectively. At Coebiti, ear height was also reduced to 92 cm from 115 cm in elites and to 134 cm in local cultivars from an averaged 159 cm. The data on plant, ear height, number of leaves per plant and leaf length are presented in table 3.

Table 3. Growth of corn at two locations

Entry	Plant Height (cm)	Ear Height (cm)	No of leaves per plant	Leaf length (cm)	PLant height (cm)	Ear height (cm)	No of leaves per plant	Leaf length (cm)
1	214	117	13.0	94.4	191	90	13.6	87.2
2	209	101	12.3	94.3	173	77	11.6	89.4
3	212	105	12.5	96.2	188	85	12.2	87.7
4	205	112	12.7	94.7	176	89	13.4	87.3
5	214	118	12.9	98.4	181	89	13.2	86.8
6	203	101	12.2	98.2	177	81	12.7	89.0
7	202	104	12.3	94.3	178	82	12.9	90.0
8	216	111	12.8	96.6	207	110	13.7	94.0
9	210	110	12.7	99.8	182	86	12.7	90.3
10	213	117	13.2	99.3	173	88	13.5	91.1
11	211	109	12.3	99.8	179	87	12.9	89.5
12	227	121	13.4	97.7	199	99	13.9	89.8
13	235	136	13.0	99.2	209	113	14.0	95.3
14	251	148	13.5	99.7	219	117	14.8	92.5
15	255	167	13.9	105.8	242	142	14.7	96.7
16	236	151	13.8	98.2	210	125	14.9	90.5
Mean	219	120	12.9	97.9	193	98	13.4	90.4

From the above information it is obvious that considerable differences in plant and ear heights did exist not only between CIMMYT and local cultivars but also between the two experimental sites, the latter probably due to the nature of the soil and weather conditions during the growing season.

Maturity: Maturity as measured by counting days up to flowering (from planting) did not differ significantly between locations but differed with varieties. Elites matured a week earlier than local varieties. Elites took an average of 55 to 60 days to half-silk while the local ones took an average of 60 to 67 days. A significant negative correlation was found between plant height and maturity in both trials.
Correlation coefficient(r) values are presented in table 4.

Table 4. Correlation coefficients (r)

	TK 150	Co 116
Plant height and Leaf number	0.8762**	0.7734**
Plant height and grain yield	– 0.4716 NS	– 0.5575*
Leaf number and grain yield	– 0.5402*	– 0.6034**
Leaf number and days to half silk	0.8418**	0.6572**
Plant height and days to half silk	0.8114**	0.6722**

* ** significant at .05 and .01 percent level of significance, respectively.

Leaf number: Number of leaves per plant varied with the varieties and locations. At Coebiti, the elites produced an average of 14 leaves per plant and local ones, 15 leaves but at Tijgerkreek West the leaf number was lower, 13 in elites and 14 in local cultivars. In the previous season at Tijgerkreek West the number of leaves per plant in elites were from 12 to 14 and 16 in local varieties. It is known that leaf number is generally affected by environmental variables and even cultural practices. A significant correlation was found between leaf number, plant height and maturity.

Tall plants tend to have more leaves than short plants. Elites which were early maturing had fewer leaves than tall, late maturing local ones. The results agree with those of various investigators who concluded that a good relationship existed between number of leaves per plant height;

(Cross and Zuber, 1973); number of leaves per plant and maturity (Arnold, 1969; Chase and Nanda, 1965; Kuleshov, 1932). Leaf number was negatively correlated with grain yield. Short plants had better yields than tall varieties.

Leaf length was longer in all cultivars at Tijgerkreek West than at Coebiti and slightly longer in local varieties than in CIMMYT elites.

Ear characteristics: Number of ears per 100 plants and seed yield per ear were calculated. More number of ears per 100 plants (1.2 per plant) were noticed in local ones than in elites. Elites produced mostly one cob per plant. If there was a second one on the plant it was invariably very small. Cobs were comparatively smaller at Coebiti than those at Tijgerkreek West.

Most important of all, the cobs were poorly filled with grains and second in grain quality to that of Tijgerkreek West. Average cob length was found to be 18 cm at Tijgerkreek West and 15 cm at Coebiti. No significant varietal differences were found among the elites and only in local, Synthetic variety the cobs were slightly smaller (16 to 18 cm) than others.

Table 5. Ear and grain yields of corn at two locations

Entry	Tijgerkreek-West (TK 150)			Coebiti (Co 116)			TK 129 Previous trial
	No of cobs per 100 plants	Seed yield per ear (gms)	Grain yield per hectare (kg)	No of cobs per 100 plants	Seed yield per ear (gms)	Grain yield per hectare (kg)	Grain yield per hectare (kg)
1	101	148	6,182	100	93	3,721	6215
2	101	147	6,333	100	87	3,636	7254
3	100	153	6,576	98	86	3,472	7503
4	100	152	6,455	102	87	3,700	7163
5	103	154	6,909	99	90	3,585	6442
6	100	143	6,242	101	88	3,861	6366
7	101	147	6,394	100	89	3,733	4772
8	100	146	6,272	100	90	3,794	7136
9	102	168	7,424	102	88	3,664	6806
10	101	161	6,909	99	81	3,186	7821
11	101	159	6,969	100	87	3,669	7342
12	103	150	6,697	99	84	3,158	6081
13	100	154	6,727	101	84	3,412	7366
14	101	147	6,333	101	88	3,533	6103
15	106	151	5,182	99	76	2,930	6388
16	109	103	4,152	101	60	2,400	3985
Mean	102	149	6,360	100	85	3,466	6546

The seed yield per ear varied from 146 to 168 grammes in elites at Tijgerkreek West, compared to and 81 to 93 gms at Coebiti; and 151, 103 gms in local varieties 15 and 16 at TKW and 76 and 60 in local entries 15 and 16 respectively at Coebiti.

Grain yield: Data on grain and ear yields are presented in table 5 and fig 2. Grain yields were calculated at 14 percent mesture content. Data were statistically analysed and the analysis of variance showed significant differences between the varieties at both location at 0.01 percent level of significance. Grain yields varied with the season at TKW. Elites produced a calculated top yield of 7190 kilograms per hectare in the long rainy season (previous trial; TK 129) whereas the average grain yield of same elites was about 6360 in the short rainy season (present trial, TK 150).

Fig. 2. Grain yields from three elite trials (1977-78)

Yield differences of 200 to 1200 kg/ha were observed in varieties between the two seasons. In the long rainy season (636.9 mm rainfall) there was a better distribution of rainfall (fig 1) than in the short rainy season (471.1 mm) when there were three dry periods of a week during the 5th, 7th and 11th week after planting. At Coebiti there were two dry spells in the 6th and 10th week after planting and the plants showed symptoms of water stress by "wilting" due to the nature of the soil. So this variation in yields can presumably be due to the rainfall pattern and distribution. Grain yields of all the 16 varieties were drastically reduced at Coebiti by about ± 54% those at Tijgerkreek West-Average elite grain yield was 3600 kilograms per hectare. Besides the poor chemical nature of the soil, and low water holding capacity, dry periods and low rainfall were important factors which contributed to such low yields. At both sites,elites outyielded local varieties by about ± 1,000 kg per hectare. Local, Synthetic variety (Entry 16) produced lowest yields of 4,150, 4,152 and 2,400 at Tijgerkreek West and Coebiti, respectively.

Highest yielders differed at the two trial sites. Entry 9, Cotaxtla 7429 produced a top grain yield of 7,424 kilograms per hectare at TKW while entry 6, Across 7425 yielded 3,861 kilograms per hectare at Coebiti. In the previous season at Tijgerkreek West Entry 10, Pichilingue 7429 produced highest yield of 7,821 kilograms per hectare.

CONCLUSIONS

From the above results, it can be concluded that the elites produced superior yields compared to local varieties at both the experimental sites, but unfavourable soil and climatical conditions resulted in lower grain yields at Coebiti. Previously research workers already concluded that the short rainy season is not favourable for maize growing at Coebiti and grain yields were lower to those of Tijgerkreek West due to the erratic distribution of rainfall, dryness during critical stages (fig 1), poor chemical status and low water holding capacity of the soil. (Consen an Veltkamp, 1976).

Though elites proved to be better yielding compared to local varieties maize cultivation is less profitable at Coebiti than at Tijgerkreek West considering the application of high fertilizer levels transport costs etc.

At Tijgerkreek West, elites gave an outstanding performance and the best yielders should be planted on a large scale to confirm their stability for production and to observe their susceptibility to pests and diseases before releasing them to farmers.

REFERENCES

Arnold, C.Y, 1969. Inherited characteristics of sweet corn as they relate to the time required for development, J. Amer Soc. Hort. Sci 94: 112 – 115.

Bolton, A, 1967. Quoted from Fertilizer Guide 1970. Centre d' Etude de l'Azote.

Chase, S.S. and Nanda, D.K., 1965. Relation between leaf number and maturity in maize (zea mays) Amer. J. Bot 52; 628.

Consen, K and Veltkamp, H.J., 1976. Report no. 26, Agricultural Experiment Station, Parmaribo.

Cross, H.Z. and Zuber, M.S., 1973. Interrelationships among plant height, number of leaves and flowering dates in maize. Agr. J 65 no 1: 71 – 73.

Kuleshov, N.J., 1932. Behaviour of American corn strains and hybrids in USSR. J. Amer. Soc. Agron 24: 416 – 417.

Lata, G.S., 1978. "Maize cultivation in Suriname", Proc. CFCS Vol. XV : 119 - 126.

NAME OF PAPER: Performance of fourteen elites
(G.S. Lata)

Question by Abdul Wahab
Country: Jamaica

QUESTION: As grain yields seem not to differ dramatically between (some of the) CIMMYT elite varieties what other criteria will be started to make a final selection?
Some suggestion should be: *Pucinia*-resistance *(Heliothis, Spodoptera, Diatraea* etc.) protein contnt and composition. Uniformity (especially ripening time).
Did you do directed observations for any of these characters?

ANSWER: Besides grain yields, color of the grains, maturity, resistance to major pests and diseases such as *Spodoptera frugiperda, Heliothis zea* and *Helminthosporium maydis*, respectively, are considered.
We did have observation on rate of infection of *Helminthosporium maydis* but could not find great differences between the varieties.

Question by: R. Segeren – v.d. Oever
Country: Suriname

QUESTION: Did you observe or do you expect birds are more becoming a problem in these elite varieties because of their longer cobs and because of cobs are filled to the end. Are the cobs completely covered by the husks?

ANSWER: The cobs are not completely covered with husks.
The protruded ends attract birds.
I don't see an immediate solution for this problem, however.

MAIZE CULTIVATION IN SURINAME

G.S. Lata
Agricultural Experiment Station, Paramaribo

SUMMARY

This paper provides background information on maize cultivation, area and production in Suriname. Data on area and production of maize since 1945 and export and import figures are presented.

History

It is not known when maize was introduced in Suriname. It is believed that it was grown before the Africans and Indians immigrated to Suriname. Amerindians were believed to cultivate corn even before the eighteenth century and it was presumably originated in Central America. In Suriname, it is the second important grain crop after rice.

Location

Suriname is situated between 2^{o} and 6^{o} North latitude and 54^{o} and 58^{o} West longitude on the Northeastern coast of South America. It borders on the Atlantic Ocean to the North, on Guyana to the West, on French Guiana to the east and on Brazil to the South. Its size is 160,000 square kilometers with a total of about 400,000 inhabitants.

Ecological conditions of maize growing areas.

Climate

Rainfall in the coastal area (elevation, 10 to 30 meters) is erratic in distribution. The annual precipitation ranges from 2,000 mm to 2,500 mm. There are two rainy seasons, one long season from May to September (± 1,200 mm) and the short rainy season from November to February (± 900 mm). Annual mean temperature is around 27^{o} C and the mean day temperature is 30,9^{o}c with insignificant differences between the months. The relative humidity is high throughout the year (70 to 80%) with maximum humidity (86%) in June. Daylength varies from 11 h 46 – 12 h 28.

The average percentage of sunshine hours at Paramaribo are:

J	F	M	A	M	J	J	A	S	O	N	D
42	49	45	42	31	45	57	68	72	71	61	43

Soils

The soils on the coastal regions vary from medium to high fertile soils, from sandy loams and loamy sands to clay and clay loams. In the Demerara formation two main landscapes can be distinguished.

Symposium on maize and peanut, Paramaribo,
Nov. 13 - 18, 1978

a. the young sea clay landscape, covering 14,600 sq. km
b. the ridge landscape, covering 1,300 sq. km. The young sea clay landscape has a flat topography and consists of very heavy textured soils (clay 60-70%) with strong swelling and shrinkage capacities. The material originates from the Amazon estuary and was transported by the sea current. Under natural conditions the clay landscape is characterized by the occurrence of swamps. The dominating soil colors become more pronounced. The pH (H_2O) of clay soils varies from 4.5 to 5.5 and the organic matter average percentage is 3.0. The ridge landscape consists of long, by the rivers sedimented sand bodies separated by more or less parallel swamps filled with heavier material. Generally it can be stated that the chemical level of the sandy ridges is low. The pH (H_2O) of sandy loam varies from 5.3 to 6.0 and the organic matter percentage from 1.0 to 2.5. A detailed description of soils of Suriname is given by van Amson (1966).
   In Zandery formation, the soils (sand, sandy loam and loamy sand) are drought succeptible, acid and low in organic matter and other nutrients.

Farm size

Maize is usually grown on small areas as a backyard crop mostly on less than a hectare (400 to 2,000 m^2). On large farms which are very few in number (2 to 5 hectares), the farmers grow maize under good management with standard cultural practices, though not mechanized.

Cultural Practices

In humid tropics there has been a traditional cultural pattern related to corn production. Virgin areas of bush are cut and burnt towards the end of the dry season preceding the rainy season in which corn is planted. The burning destroys tons of green organic material which would be impossible to integrate with the soil. The ash residue from the burnt material contributes to calcium, potassium, phosphate and other mineral content of the soil. This system which is traditionally used in South and Central America and Africa is still being used in Suriname by 20% of the farmers who grow maize. Maize is commonly planted after a fallow, in shifting cultivation, in relay and intercropping patterns.

Other previous crops besides maize include legumes, mostly peanut, soya, and cowpea, Amsoi, cassava or even fruit crops. Maize is planted after the first rains in May or June and November or December.

A survey recently conducted in two major maize growing areas, districts Saramacca and Commewijne, revealed that the maize growing is still primitive and the average findings of the cultural practices are briefly described below.

Plantmaterial

Almost all the farmers buy the seeds either from the local market or from the neighbour without having any knowledge of the variety, maturity or yield of that particular cultivar. Floury flints are commonly grown. There are no authorized seed companies or such organizations where the farmers can easily buy the seeds in large quantities.

Ploughing

No ploughing is usually practiced except weeding and slightly moving the soil with simple implements. 50% of the growers prepared seed beds (3 to 10 metres wide) especially on clay soils with poor drainage. No beds are needed on the well-drained soils of the interior.

Planting

Farmers use planting distances according to their conveniences. The plant populations vary from 10,000 to 25,000 plants per hectare. Mostly one seed per hole is planted and no replanting is done except in cases of poor germination and such other problems. Planting is done by machete (or drill stick).

Weed control

Weeding is usually done by hand using simple implements such as a cutlass. Two to five percent of the farmers use preemergence or postemergence herbicides. Handweeding is done once or twice during the growth period and the first weeding is done within four weeks after planting and the second one in seventh or eighth week.

Fertilizers

None of the farmers who were part of our survey used any fertilizer. Probably because of the fallow land used to obtain a first crop. Only on large farms, chemical fertilizers such as urea, double super phosphate and sulphate of potash are in use, for corn growing.

Insect pests

None of the small holders take notice of the minor infestation rate of *Laphygma frugiperda* which is the major pest in corn growing in Suriname. Dipterex or Sevin is used against this insect on large farms (1 to 5 hectares).

Harvesting

Very small percentage pick green ears and mostly the ears are left to dry on the plant. The green maize are sold for human consumption and the dried corn mainly as chicken feed or as grown maize for human consumption. Harvesting is done entirely by hand when the leaves turn brown and the cobs are dry.

Threshing is also done by hand and sun drying of the cobs is a common practice. Forty percent of the farmers treat the seeds before storing and the same seeds are used for next season sowing again. The crops which are planted after maize include legumes, maize and vegetable crops such as amsoi and cucumber.

Yield

Grain yields are very low ranging from 750 kg to 2,000 kg per hectare on individual farms. The average falls around 1,500 kg. This is due to the primitive method of cultivation and lack of attention given to the crop.

Few farmers who grow maize on 2 to 5 hectare reported 4 to 5 tons of grain yield per hectare under good management.

These farmers are interested in mechanization which would be ideal in Suriname as there is always a labour shortage. However, on the young coastal plain-soils the introduction of machines can be hampered by the bed-system. Maize remained as a second important crop to rice for a long time because the farmers were never encouraged or educated on maize growing. Without machines, the maize cultivation, area and production would remain the same as the farmers have to consider labor shortages and high labor costs which would lessen their profit margins.

Evidence suggests that maize has been growing in Suriname since many decades. Though small quantities of grain were produced, it was exported to the neighbouring countries, mostly to Guyanas between since 1930's and 1961. Maize was first imported in 1950 to Suriname and the imports gradually increased from 12 tons in 1950 to 14,000 tons in 1975 at a price of about Sf 280 per ton. Maize was exported at a price ranging from Sf 160 to Sf.200. In 1976, over 3 million guilders were spent on corn imports mainly utilized in the animal feed mills.

In 1945, 996 hectares were used for corn growing, mostly in the district of Saramacca, Commewijne, Nickerie and Suriname. The area of production was gradually decreased until 1958 when it was 1,024 hectares with the maximum production of 1,851 tons. The area and production had gone down to 96 hectares and 132 tons in 1976. Area and production values are plotted in figure 1, while import and export data are presented in table 1. (Corn was grown mostly as a catch crop after clearing. In the past clearing was traditionaly done by hand and corn was planted before putting the land into permanent use. Today most of the land is cleared by machines and little attention is given to grow a catch crop which is presumably one of the reasons for a drop in area and production of maize in recent year.)

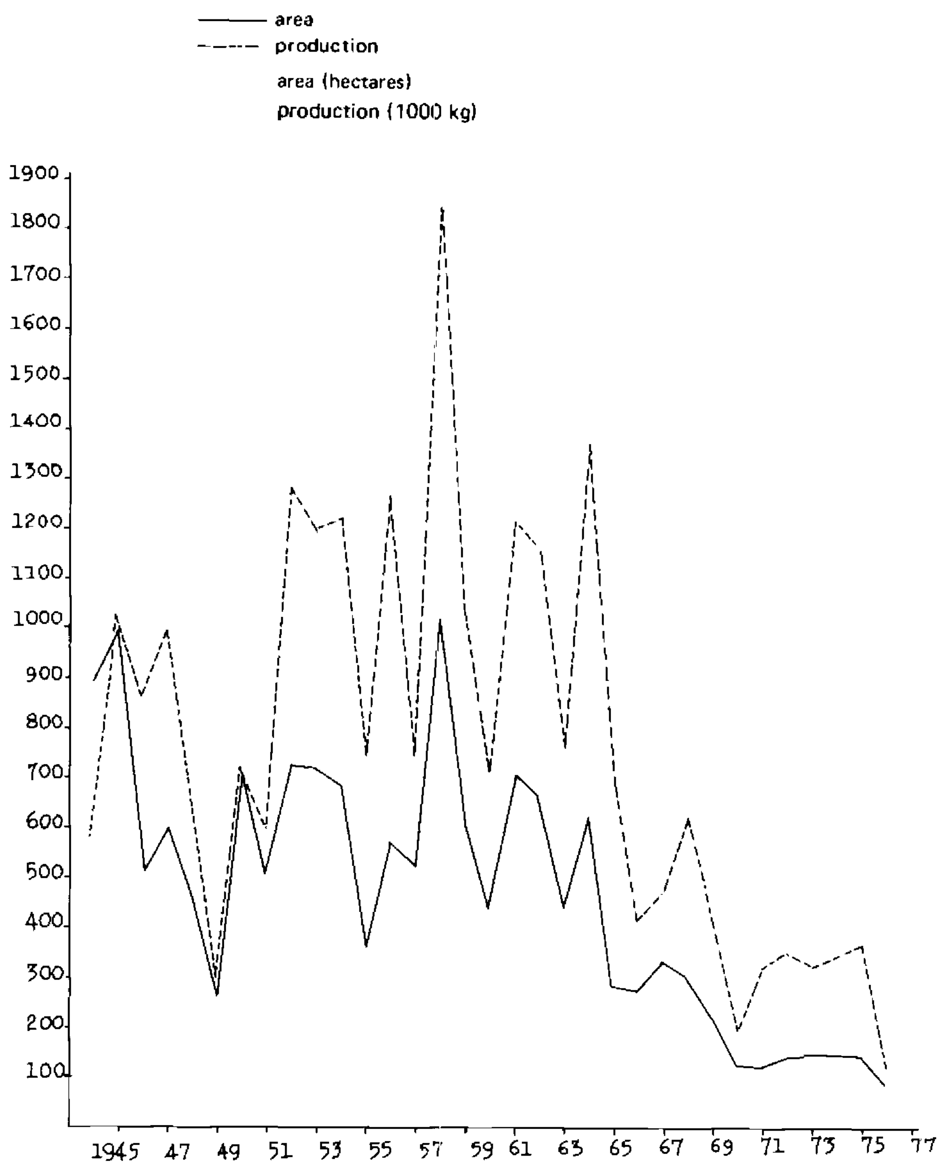


Fig. 1 — Area and Production of Maize in Suriname

Table 1 Exports and Imports of maize

Year	Export (1000 kg)	Value (1000 sf)	Import (1000 kg)	Value (100 Sf)
1945	37	8	–	–
1946	228	36	–	–
1947	222	40	–	–
1948	176	35	–	–
1949	–	–	–	–
1950	–	–	25.426	4.987
1951	3	–	82	10
1952	16	4	92	23
1953	–	–	68	12
1954	–	–	10	2
1955	–	–	–	–
1956	2	1	–	–
1957	1	0	138	48
1958	–	–	101	33
1959	–	–	135	45
1960	16	4	154	57
1961	84	26	70	37
1962	–	–	90	50
1963	–	–	76	32
1964	–	–	139	49
1965	4	1	125	44
1966	–	–	3.847	611
1967	–	–	4.848	824
1968	–	–	1.915	1.369

Source: Suriname Trade book

Table 1 (continued): Imports and Exports of maize

Year	Imports (MT)	Value (100 $ U.S.)
1970	10.093	650
1971	10.196	690
1972	7.200	490
1973	12.300	1.460
1974	10.015	1.287
1975	17.349	1.919
1976	22.099	2.459
1977		

source: FAO Trade book 1975 and 1976

Uses

Corn has its origin in Central America and has been a basic food in the nutrition of Aztec, Incas and other civilizations of the Americas. In Suriname maize is used by Amerindians, creoles, bush-negroes and others in preparing an oat meal substitute milk for babies, or as roasted green corn, or boiled medium ripe corn. The creoles make excellent corn puddings and cakes which are of a nourishing quality when eaten with young pods of okra, or althaea plant (J.G. Stedman 1796.) Most of the dry kernels of maize is used for non-ruminant animals. Other products such as corn oil, corn starch and corn flakes are widely in use, but are imported from the U.S.A.

Research on Maize

The Agricultural Experiment Station is the only center for maize agronomic research, while the Center of Agricultural research creates some facilities for research work in the tropics.

At the experiment station trials were started as early as 1917 with Suriname cultivars some of which were originated from Java and Near East. Varietal trials with American hybrids started in 1964. Weed control experiments were initiated in the seventies. *Laphygma (Spodoptera) frugiperda* and *Heliothis zea,* the important insect pests are under study. The first cost analysis experiment was conducted at Tijgerkreek-West in 1977 and the price per kilogram of corn grains was calculated to be around 28 cents after considering the cost of chemical fertilizers, herbicides, insecticides and labor input. First international Elite Variety trial (ELVT) was carried out in co-operation with CIMMYT (maize and wheat improvement center-Mexico). This ELVT – 18 included 14 short statured, open pollinated white and yellow cultivars and two local varieties. Elites were found to be promising with high yields (up to 6 tons per hectare) compared to local varieties which produce a maximum yield of 5 tons per hectare under favourable conditions. Elite trial was also carried out in the interior (Zanderij formation) at Coebiti where the soils are poor and drought susceptible and the yields were depressed by almost 50% compared to those at Tijgerkreek-West. Few promising elites will be planted on large areas to confirm their stability for production before releasing to the farmers.

CONCLUSION

Maize cultivation in Suriname is still primitive, though it is grown since many decades. Extensive production was never ensured or encouraged perhaps due to the non-surinamese interests of the erstwhile rulers of the country. The result is that the country is not self sufficient in corn and have been importing corn since many years spending approximately 3 millions of guilders on maize imports annually. The imported grain is mostly used for animal feed. Maize grows well under Suriname conditions with abundant rainfall and sunshine hours. There is a good possibility that this country could become self-sufficient in corn providing that interest is stimulated among the farmers by for example a price guarantee.

It was calculated that 500 hectares should be adequate to meet local production demand of corn.

It will be a long term project as the farmers are not too enthusiastic to grow this grain crop on large scale due to the labor shortage in Suriname. Also inexpensive machine types should be imported to stimulate maize growing in Suriname. It is certainly an economically important crop as indicated by the import value. It requires sincere efforts of research extension service workers and others to educate the farmers in this so important crop for Suriname.

REFERENCES

Ostendorf, F.W. 1962. "Nuttige planten en sierplanten in Suriname". Bull. Agr. Expt. Sta. Paramaribo.

Van Amson, F.W. 1966. "Some aspects of clay soils in the Demerara formation of Suriname". Bull. 84 Agr. Expt. Sta. Paramaribo.

Stedman, J.G. 1976. In Narrative; "of a five years expedition against the Revolted Negroes of Suriname in Guyana on the wild coast of South America from the year 1772-1777" Vol. 1 p. 324.

ACKNOWLEDGEMENTS

I wish to thank the extension service officers at Saramacca and Commewijne and Mr. Jubithana for conducting the survey on maize growing. I am also indebted to many of my colleagues for their valuable comments on the paper.

ATTEMPTS AT THE BIOLOGICAL CONTROL OF MAJOR INSECT PESTS OF MAIZE IN BARBADOS, W.I.

M.M. ALAM
Caribbean Agricultural Research and
Development Institute, (CARDI) Barbados, W.I.

SUMMARY

In Barbados, over seventeen species of insects have been found attacking maize.

Amongst the *Lepidoptera, Spodoptera frugiperda* is the leading pest, causing considerable damage to the young crop. Thirteen species of indigenous natural enemies, attacking eggs, larvae and pupae have been recorded. Because of the ineffectiveness of these natural enemies to control the pest, a number of exotic parasites were introduced from the Indian and Pakistani Stations of the Commonwealth Institute of Biological Control.

Of these imported species, an egg-parasite *Telenomus remus* and a pupal parasite, *Trichospilus pupivora* became established; the former now destroys over 80% egg-masses of *Spodoptera spp.,* contributing to the reduction of the pest populations in Barbados. At this stage, it is quite possible that the addition of some other larval/pupal parasite(s) in the existing complex should solve the pest problem permanently.

The establishment of *T. remus* in Barbados, is a step forward towards the final goal, and this parasite can now be supplied to other Caribbean territories, where *Spodoptera's* are the main problem.

INTRODUCTION

Due to the ever increasing demand of food throughout the world, maize, because of its high yield per hectare, and its ability to grow in varied climatic conditions, has become one of the leading food crops, and the area under it is increasing every year.

Like most other crops, maize also suffers a number of agronomic, pathological and entomological problems, which hinder the farmers from achieving maximum returns.

In Barbados, maize is attacked by a complex of insect pests, some of which are very serious and cause considerable damage. Such insects need special attention to reduce their ravages, while the others are of less economic importance, and need little or no control measures.

The insect pests and their natural enemies recorded in Barbados are listed in Appendix 1 and are discussed in the following pages.

There are a number of insects attacking stored grains, some of which are secondary pests, viz. saprophytic species, etc.

THE MAIN PESTS AND THEIR NATURAL ENEMIES.

THE FALL ARMY-WORM: *(S. frugiperda).*

It is one of the most serious pests, attacking maize in the New World. In Barbados, the leaves to a greater or lesser degree are skeletonized by the larvae, which usually appear in large numbers. Young corn, which has still not reached 34 to 40 cm height is often completely destroyed. On infested older plants, the mid-ribs are often left unharmed. Hybrid corn is more seriously attacked than the local varieties.

A female lays about 1,000 eggs in clusters of 30 to 250 eggs per cluster, on the underside of the leaves, and these are covered with felt-like scales from the female's body. The highest concentration of egg-masses is on the lower-most leaves of the plant. The young caterpillars feed in groups on the young leaves in the whorls of the plants. Full-grown larvae show great colour variation, but can be identified from the white, Y-shaped marking (epicranial suture) on the front of the head.

After destroying a crop in one area, the larvae migrate in large numbers to other areas in search of food. The larvae pupate in soil.

During wet weather infested plants are subsequently attacked by fungi and bacteria, which render the cobs unfit for human consumption.

Alternate host plants: The pest has also been recorded from sugarcane *(Saccharum officiarum)*, guinea corn *(Sorghum saccharatum)*, sweet potato *(Ipomoea batatas)*, cabbage *(Brassica oleracea)*, caulifolower *(Brassica oleracea var. botritis)*, cucumber *(Cucumis sativus)*, cucurbits *(Cucurbita spp.)*, beet *(Beta vulgaris)*, beans *(Phaseolus valgaris* and other *Phaseolus spp.)*, prickly and white caterpillars *(Amaranthus spinosus* and *Amaranthus viridis)*, and a number of other grasses and wild and cultivated plants.

These alternate host plants provide excellent breeding areas for the pest, and in the absence of its main host *(Zea mays)* in the field, support the pest throughout the year.

The biology of the pest in Barbados was studied in the laboratory. Generally the larvae pass through six, but in some cases seven instars. The period occupied by various developmental stages is given in table 1.

Table 1 — Life cycle of *S. frugiperda*

Incubation period:	3 days
Larval period:	
1st Instar	2 — 3 days, av. 2.8 days
2nd Instar	1 — 3 days, av. 1.6 days
3rd Instar	1 — 5 days, av. 2.4 days
4th Instar	1 — 5 days, av. 2.2 days
5th Instar	1 — 3 days, av. 2.5 days
6th Instar	1 — 3 days, av. 2.6 days
7th Instar	3 — 8 days, av. 5.5 days
Total larval period	16 — 20 days, av. 17.9 days
Pupal period	7 — 10 days, av. 8.8 days
Total development period	26 — 33 days, av. 29.7 days

From the development period studied in the laboratory, it appears that under ideal conditions, the pest can complete 9 to 10 generations a year.

a. Indigenous natural enemies: The eggs, larvae and pupae of *S. frugiperda* are attacked by a group of natural enemies in Barbados. These are –

Parasites:
Trichongrammatidae: Trichogramma fasciatum Perk. (An egg-parasite)

Braconidae: Apanteles sp. (Glomeratus group) (larval-parasite), *Chelonus antillarum* (Marshall) (egg-larval parasite)

Eulophidae: Euplectrus plathypenae How. (an ecto-larval parasite)

Tachinidae: Archytas analis Fab., *Archytas marmoratus* (Townsend), *Archytas piliventris Wulp and* Eucelatoria sp. australis *Towns. (larvalpupal parasites).*

Predators:

Coccinellidae: Cycloneda sanguinea (L.) and *Nephus sp.*
Chrysopidae: Chrysopa lanata Bks. and *Chrysopa limitata* Nav.
Carabidae: Calosoma alternans (F.)
Carcinophoridae: Euborellia sp.

Chelonus antillarum: An egg-larval parasite of *Spodoptera spp.* in Barbados. The female deposits its eggs into the eggs of its host, and the development is completed in the 3rd to 5th larval instar. The parasite appears during a certain time of the year, when it destroys up to 30! larvae.

Apanteles sp. (glomeratus group) – A solitary, larval parasite, attacks up to 12! of the young to half-grown larvae.

Euplectrus plathypenae – An ecto-larval parasite. The population of this parsite is the highest during wet season, when it attacks some 18.5! larvae. The female deposits 13-32 eggs on the host's body. On hatching, the grubs feed gregariously on the body fluids of the host larva. The parasitised larvae do not moult, though they continue normal feeding, throughout the development of the parasites. The full-grown parasite grubs move alongside the dead body of the caterpillar and spin brownish-yellow cocoons, in which these pupate. The total development period, i.e. egg to adult emergence occupies 12 to 13 days.

Archytas analis, Archytas marmoratus, Archytas piliventris and Eucelatoria sp. australis, collectively attacked only 6! of the larvae.

From the above information, it appears, that the combined effect of all these parasites on the larval population would be enough to bring the pest under reasonable control. But unfortunately, these parasite species do not appear all at one time in the field, and therefore fail to produce the desired effect on the pest. *Euplectrus* is more abundant between August and December; *Apanteles* and *Chelonus*, between January and March; while the populations of the *Tachinids* fluctuate throughout the year. It is therefore, this seasonal appearance of these parasites, which provides a better chance for the pest to survive and continue inflicting heavy damage to the crop.

Despite such a wide range of parasites and predators present in Barbados, it was realised that these were ineffective in controlling the pest. It was therefore, decided to introduce some exotic natural enemies, and between 1969 — 76, the following were obtained and released in the field.

b. Exotic natural enemies:

Trichogrammatidae: *Trichogramma achaeae* Nagaraja and Nagarkatti and *Trichogramma chilotraeae* Nagarkatti; and

Scelionidae: *Telenomus remus* Nixon, (egg-parasites), from India.

Braconidae: Chelonus formosanus *Senan,* Chelonus heliopae *Gupta and* Chelonus texanus Cress (of U.S. origin) (egg-larval parasites), from India; *Apanteles sp.* and *Macrocentrus collaris Spen.* (larval parasites), from Pakistan.

Ichneumonidae: Campolitis chloridae (Ecphoropsis perdistinctus Vierech) (a larval parasite), from India.

Eulophidae: Trichospilus pupivora Ferriere (a pupal parasite), from India.

Of these, *T. remus* and *T. pupivora* became established. *T. remus* now has a significant effect on the pest population in the island. This parasite not only attacks the egg-masses of *S. frugiperda,* but all other species of this genera, on a wide range of crops, vegetables and wild plants, and keeps these insects under reasonable control.

On maize, an average percentage destruction of egg-masses by various parasites and predators, recorded at different times in given in table 2.

Table 2: Average percentage destruction of egg-masses of *S. frugiperda,* at different times in Barbados.

Time	*Telenomus*	*Trichogramma*	Predators
August	17.6	2.8	10.6
September	26.4	4.9	9.7
October	60.7	4.5	6.5
November	63.6	0.1	3.4
December	81.4	0.0	0.0
January	25.8	33.4	0.7
February	59.3	15.3	3.4
March	68.4	0.0	5.3

(Between April and July, there is no maize crop in the field)

The overall destruction of egg masses by these parasites and predators, during the years 1972 – 76 was:

1972 – 67.3 – 83.3%: average 63.2%
1973 – 75.5 – 100 %: average 79.3%
1974 – 43.6 – 100 %: average 47.4%
1975 – average 84.5%
1976 – 83.3 – 100 %: average 87.4%

From the above table it is quite evident that prior to the introduction and establishment of *T. remus,* the level of egg-destruction by the indigenous natural enemies was significantly low. The addition of this micro-wasp into the existing bio-complex enhanced the mortality factor many times, resulting in a great reduction in the post population.

As the addition of *T. remus* in a group of egg destroying natural enemies has increased the egg mortality considerably, so too the addition of some larval/larvalpupal parasite (s) in the existing complex of natural enemies should change the status of *S. frugiperda,* in Barbados. Efforts to achieve this goal are being continued.

S. latifascia and S. ornithogalli – These insects have occasionally been recorded in small numbers on maize.

Natural enemies: Same as under *S. frugiperda.*

THE CORN EAR-WORM: *(H. zea).*

It is a minor pest of maize in Barbados. The eggs are laid singly on the silks. The hatching larvae bore through the tip of the cob, and destroy the grains. The full-grown larvae migrate to the soil and pupate in U-shaped earthen cells,

Alternate host plants: The pest has been recorded from cotton *(Gossypium barbadense)* and tomato *(Lycopersicum esculentum).*

a. Indigenous natural enemies:

Tachinidae: A. piliventris, attacked some 30.8% larvae in the field.

Exotic natural enemies: A number of natural enemies were introduced against *(Heliothis spp.,* particularly for *H. virescens,* (F.) a serious pest of pigeon pea *(Cajanus cajan).* These were:

Trichogramma spp., as under *S. frugiperda.* (egg-parasites).
Braconidae: Apanteles sp. and
C. chloridae (larval parasites) from Indian Station of C.I.B.C. None of these was recovered in the field.

THE SUGARCANE MOTH BORER: *(D. saccharalis).*

Besides sugarcane, which is the main host of this pest, maize serves as an important alternte host. Until recent years it was the most serious pest of sugarcane in Barbados, reponsible for the destruction of an average of 13,911 tons of sugar annually (Alam, et al., 1971).

The small succulent maize plants provide an easy entrance for the young larvae, and serve as excellent breeding ground for the pest. The number of larvae reaching maturity in this plant is far greater than/sugarcane, and therefore the maize when planted near sugarcane fields, considerably increases the pest population in the latter host. It is therefore generally advised to avoid planting maize near sugar estates.

Alternate host plants: Sugarcane *S. officinarum),* guinea corn *(S. saccharatum),* "Khus Khus" grass *(Vetiveria zizanioides)* and elephant grass *(Pennisetum purpureum).*

a. Indigenous natural enemies: *T. fasciatum.;*
Scelionidae: Prophanurus alecto (Crawf.) (egg-parasite).

b. Exotic natural enemies: As there were no indigenous larval and pupal parasites of this pest, a large number of these were obtained from the Americas, the Caribbean Islands, India and East Africa. Most of these were locally multiplied in large numbers and released in the fields, while the others were directly liberated in the heavily infested areas. Of these two species, i.e. a Tachinid – *Lixophaga diatraeae* (Tns.) (the Cuban fly) and a Braconid – *Apanteles flavipes* (Cam.) (Indian wasp) became established.

Since 1968, the moth-borer population in sugarcane has remained below economic level. As these parasites also attack their host (pest) in other host plants, the pest does not pose any serious problems to maize growers in Barbados.

THE SUGARCANE ROOT-BORER *(D. abbreviatus.)*

It is mainly a pest of sugarcane, but the young maize plants attract large numbers of adults and serve as the egg-laying and feeding grounds for them. The eggs are laid between the split leaf-tips. On hatching, the grubs fall on the ground and enter the soil. Initially these feed on fibrous roots, and in their advanced stage, bore into the main roots (Alam, 1976).

Alternate host plants: Sugarcane *(S. officianarum),* citrus *(Citrus spp.)* and grasses, etc.

Natural enemies: (a) Indigenous: *Eulophidae: Tetrastichus sp.* (egg-parasite).

b. Exotic natural enemies: *Elateridae: Pyrophorus luminosus* Illiger. The larvae of this beetle attack the grubs in the soil. The giant toad, *Bufo marinus* (L). feeds on grubs and adults. (For other details, see Alam, 1976).

The pest can also be controlled by other means, viz., by ploughing the infested fields or by the use of chemicals, like Chlordane, Heptachlor and Aldrin, etc.

THE CORN LEAF-APHID *(A. (R.) maidis.)*

The insect attacks the young leaves and whorls. Dark green to bluish aphids in their various development stages feed and cause yellowing and yellowish-brown spots on the leaves. The infested plants are impregnated with honeydew, on which sooty mould develops, and inhibits photosynthesis. The young infested leaves curl, become stunted and die.

Alternate host plants: Sugarcane *(S. officinarum)*, imphee *(Sorghum sp.)*, guinea corp *(S. saccharatum)* and para grass *(Panicum muticum)*.

Natural enemies:

Parasite:
Braconidae: Aphidius sp.

Predators:
Coccinellidae: C. sanguinea and *Nephus sp.*
Chrysopidae: C. lanata and *C. limitata.*
Syrphidae: Allograpta exotica Wied., *Baccha clavata* F. and *Baccha dimidiata* F.

Generally these natural enemies keep the pest under control.

THE CORN LEAF-HOPPER – *(P. maidis).*

Normally a minor pest. The nymphs and adults feed in the whorl of young plants. It is a known vector of a virus causing "Stripe disease", which can be identified by the longitudinal yellow streaks in the leaves, and the stunted and distorted plant growth.

Though, generally the pest does not build-up high populations in Barbados, being a vector of the virus, it needs close attention, to avoid any serious damage to the crop.

Natural enemies:
Predators:
The same as under *A. maidis.*

OTHER PESTS.

The Cicadellids, Coreids, Lygaeid, Pentatomid, Cixiid and Agromyzid pests, occur is mall numbers, and do not cause much damage to the crop.

A major pest of stored maize – Sitophilus zeamais can infest the dry cobs in the field and the eggs and larvae contribute to rapid population build-up in storage.

Several other Nitiduliids infest injured cobs but are considered secondary or minor pests.

Rats and birds and in some parts of Barbados, monkeys are serious pests of this crop.

ACKNOWLEDGEMENTS

These studies were supported in part by funds from the Barbados Sugar Producers' Association, and Barclays Bank International. Some of the work was pursued while the author was employed as Entomologist, Ministry of Agriculture, Food and Consumer Affairs, Barbados.

REFERENCES

Alam, M.M. 1976 — Recent outbreak of sugarcane root-borer and white grubs in Barbados. Proc. W. Ind. Sug. Tech. Conf. Jamaica, November 1976.

Alam, M.M., Bennett, F.D. and Carl, K. 1971 — Biological control of *Diatraea saccharalis* (F) in Barbados by *Apanteles flavipes* (Cam.) and *Lixophaga diatraeae* (Ths.). Entomophaga 16 (2), 151-158.

APPENDIX

LEPIDOPTERA:

Noctuidae:

Spodoptera frugiperda (S. & A.) — The Corn Ear-Worm/The Fall Army-Worm.

Spodoptera latifascia (Walker)
Spodoptera ornithogalli (Gn.)
Heliothis zea Boddie

Pyraustidae:

Diatraea saccharalis (F.) — The Surgarcane Moth-Borer

COLEOPTERA:

Curculionidae:

Diaprepes abbreviatus (L.) — The Sugarcane Root-Borer

HEMIPTERA:

Delphacidae:

Peregrinus maidis (Ashmead) — The Corn Leaf-Hopper

Aphididae:

Aphis (Rhopalosiphon) maidis (Fitch) — The Corn Leaf-Aphid

Lygaeidae:

Pachybrachius sp. ? bilobatus scutellatus Dall.

Coreidae:

Liorhyssus hyalinus F.
Stenocoris (Oryzocoris) filimoronis (Fabr.)

Pentatomidae:

Nezara viridula L. — The Green Stink-Bug

Cicadellidao:

Balclutha sp.
Balclutha rosea (Scott.)
Baldulus maidis DeLong and Wolcott

Hortensia similis (Walk.)
Cixiidae:
Oliarius maidis (Fennah)

DIPTERA:
Agromyzidae:
Agromyza sorosis Williston – *The Corn Leaf-Miner*

ACARINA:
Tyroglyphidae:
Tyroglyphus sp.
An unidentified mite.

NAME OF PAPER: Attempts at the biological control of major insect pests of maize in Barbados W.I. (N.N. Alam)

Question by: Remillet
Country: French Guyana

QUESTION: A propos de *Spodoptera spp* et *d'Heliothis spp* a Barbados, monsieur Alam a t'il repertorie d'autres ennemis tels que champignons pathogenes, maladies ou nematodes parasites.

Are there found any pathogenic fungi or nematodes at Barbados.

ANSWER: Metarhizium has been found recently on *Diatraea sacdioralis, Anomis argellicaea & Anticarcia gemmatatis* in Barbados & Guyana.

INTRODUCTION OF EXOTIC PARASITES FOR CONTROL OF *SPODOPTERA* AND *HELIOTHIS* IN TRINIDAD

M. Yaseen
Commonwealth Institute of Biological Control
Curepe, Trinidad, W.I.

INTRODUCTION

In several West Indian territories, corn, *Zea mays*, is cultivated as a subsistence crop. Recently, in order to meet the increasing demands for human consumption as well as for animal feeds, corn production is expanding. Production is adversely affected by the noctuid pests *Spodoptera* spp. and *Heliothis* spp. As control by chemical pesticides is not feasible under local conditions biological control would be desirable. Commencing in 1976 the Commonwealth Institute of Biological Control (CIBC) was commissioned by the Ministry of Agriculture, Republic of Trinidad and Tobago to attempt biocontrol of these pests by the introduction of readily available natural enemies from the CIBC Stations in India, Pakistan and Europe.

Spodoptera spp.

Several species of *Spodoptera (eridania, frugiperda, latifascia* and *sunia)* are known to attack corn in the Caribbean. In Trinidad, *S. frugiperda* is the major pest of young corn. It occurs throughout the West Indies, on the mainland from northeastern Canada to northern Argentina and Chile. This species has a wide host range including tomatoes, pepper, egg plant and grasses.

Attack usually commences while the plants are very young and may continue until the corn is mature. Eggs laid in clusters of up to 200 are covered with hairs or scales shed from the body of the female. Eggs hatch in two days and the larvae feed mainly on the leaves but also attack the developing ears. The larval period lasts for 12 – 16 days. Pupation occurs in soil and adults emerge after 7 – 8 days.

Parasites recorded in Trinidad include:-

Species	Stage attacked
Apanteles sp. (Braconidae)	young larvae
Palinzele sp. (Braconidae)	young larvae
Chelonus insularis (Braconidae)	egg – larval
Euplectrus plathypenae (Eulophidae)	larval
Archytas marmoratus (Tachinidae)	larval – pupal
Winthemia sp. (Tachinidae)	larval

Incidence of parasitism is very low amongst larvae collected on maize.

Symposium on maize and peanut, Paramaribo, Nov. 13 - 18, 1978

INTRODUCED PARASITES

Stocks of several parasites of *Spodoptera* spp. were obtained from the Indian and Pakistan Stations of the CIBC. These included *Apanteles ruficrus, Chelonus heliopae, C. formosanus, Macrocentrus collaris* (Braconidae), *Paribaea orbate* (Tachinidae) and *Telenomus remus* (Scelionidae). To initiate laboratory stocks of parasites a colony of the host was set up on a synthetic diet, slightly modified from the formulation given by Yaseen (1975). The formula for the diet is the following:-

Corn meal	40.0 g	Sorbic acid	0.4 g
Wheat germ	20.0 g	Vitamin mixture	20 ml
Ascorbic acid	1.3 g	Agar	5 g
Brewers yeast	12.5 g	Antibiotic (Tetracycline)	250 mg
Methyl paraben	1.0 g	Water	

This amount of diet was sufficient to rear 50 two – three days old larvae.

The numbers of adults of *C. heliopae, M. collaris* and *P. orbata* obtained from the incoming shipments were insufficient to establish laboratory colonies while cultures of the others were set up and releases made.

Telenomus remus occurs naturally in Sarawak (Rothschild, 1970); it is an egg parasite. Stocks were obtained from the Indian Station for Barbados and elsewhere. Egg to adult development at laboratory conditions of 82 – 84°F is completed in ten days. Following its successful establishment in Barbados (Alam 1974), stocks were obtained in 1976.

Apanteles ruficrus is widely distributed in Europe, Asia, Australia, New Zealand and Africa. It is a gregarious larval endoparasite with a wide host range but mainly attacks noctuids. A strain of this parasite introduced from Pakistan into New Zealand against *Mythimna separata* has provided excellent control (Mohyuddin and Shah 1977). In Trinidad it has been bred.

C. formosanus is an egg-larval parasite. Eggs are deposited within the host eggs and hatch in the host larvae. In about 12 days the larva leaves the host, constructs a protective cocoon and pupates. The pupal period lasts for five to six days. Stocks from the Indian Station, CIBC, were obtained in March, 1978, and it is being cultured in the laboratory in Trinidad.

Details of releases are given in table 1.

Table 1. Releases of *Spodoptera* parasites in Trinidad 1976 – 1978

Species	Origin	Numbers released			
		1976	1977	1978	Total
Apanteles ruficrus	Pakistan	2910	2090	–	5000
Chelonus formosanus	India	–	–	1105	1105
Telenomus remus	India	5850	7300	30750	43900

Releases have been mainly in the market garden areas of Macoya and Aranguez. Shortly after the release of *C. formosanus* a few specimens of a *Chelonus,* probably the released species, were reared from host larvae collected at Macoya. *T. remus* has been occasionally reared from eggs of *Spodoptera frugiperda* at Macoya.

In addition, stocks of *T. remus* have been supplied to Antigua, Colombia, Nicaragua and Guatemala. While no recovery surveys have been made in Antigua it is firmly established in the Cauca Valley of Colombia and is considered to have effectively controlled *Spodoptera sunia.* (J. Gaviria, Per. Comm.). It was released in St. Kitts and Montserrat in 1973 and shortly thereafter it was recovered from Montserrat (F.D. Bennett, Per. Comm.). Detailed recovery surveys have not been made since and it is not certain whether it is established permanently.

Corn ear worms Heliothis spp.: Heliothis zea and H. virescens) have a wide host spectrum including maize (corn ear worm), cotton (boll worm), pigeon pea (pod borer) and fruits of tomatoes, etc. An account of the life histories of the pests, their native natural enemies and attempts to establish exotic natural enemies in the Lesser Antilles have been given by Bennett and Yaseen (1972) and Yaseen (1975). Recent investigations in Trinidad and Tobago have shown that with the exception of a complex of native Trichogrammatid egg parasites, *Trichogramma brasiliensis, T. exiguum (=fasciatum)* and *T. semifumatum,* there is a general paucity of natural enemies. The Trichogrammatids seasonally exert some level of control; in September — October 1978, about 5% to 37% eggs in corn silks at Macoya were parasitised. There was some predation by Anthocorids, Chysopids and Hemerobids but these are general predators.

Several parasites of *Heliothis armigera* are known form India and Southern Europe (Achan et al, 1968 Carl 1977). Stocks of several of these as well as parasites of *Heliothis* spp. from Texas have been obtained. (table 2)

Table 2. Exotic parasites of *Heliothis* spp. obtained for trial in Trinidad.

Parasite	Host	Stage Attacked	Origin
Braconidae			
Microplitis croecipes	*H. virescens*	Larvae	Texas, USA
Ichneumonidae			
Campoletis chloridae	*H. armigera*	Larvae	India
Cardiochiles nigriceps	*Heliothis* spp.	Larvae	Texas, USA
Eriborus argentiopilosa	*H. armigera*	Larvae	India
Hyposotor didymator	*H. armigera*	Larvae	Yugoslavia
Tachinidae			
Goniophthalmus halli	*H. armigera*	Larvae	India
Palexorista laxa	*H. armigera*	Larvae	India
Trichogrammatidae			
Trichogramma achaeae	*Achaea janata*	Egg	India
Trichogramma chilotraeae	*Chilo* spp.	Egg	India
Trichogrammatoidea armigera	*H. armigera*	Egg	India

Due to the high rate of mortality as a result of delays, insufficient adults of *M. croecipes, C. nigriceps* and *G. halli* were obtained to start laboratory colonies. We have confired our attention to the propagation of parasites attacking eggs and early larval instars as these are the stages of the pest most exposed to parasites. The later larval stages are concealed in the corn ear which bestows some degree of immunity from attack. Cultures of several of the parasites were set up and released are in progress. Details are given in table 3.

Table 3. Releases of *Heliothis* parasites in Trinidad, 1976 – 1978.

Species	Numbers released			Total
	1976	1977	1978	
Bracon hebetor	7,376	20,761	1,150	29,287
Campoletis chloridae	–	185	748	933
Trichogramma achaeae	–	18,100	18,600	36,700
Trichogramma chilotraeae	2,300	1,500	700	4,500
Trichogrammatoidea armigera	1,450	3,400	18,500	23,350

*A tachinid *Eucelatoria* sp. (origin Arizona, USA) was released against *Heliothis* spp. on pigeon peas in several territories in the Caribbean including Grenada, St. Vincent, Antigua, Barbados, St. Kitts, St. Lucia, Dominica and Trinidad in 1972 but recoveries have not been reported.

Releases of these species are being continued and those of other parasites attacking young larvae *E. argentiopilosa* and *H. didymator* are planned next season. When adequate release of *C. chloridae* has been made recovery surveys will be conducted.

Stocks of *T. armigera* have been provided to Colombia and Nicaragua.

DISCUSSION

While both *Telenomus remus* and *Chelonus formosanus* have been recovered from a few samples it is too early to say if establishment is permanent and whether effective biocontrol of *Spodoptera frugiperda* will be achieved. Although the introduced parasites of *Heliothis* spp. have not yet been recovered additional releases are warranted to enhance the possibilities of establishment.

There are several other species of parasites which can be introduced against *Spodoptera* and *Heliothis* spp. Also, trials with pathogens including *B. thuringiensis* and the nuclear polyhedrosis virus *Baculovirus heliothis* should be undertaken against the earworms. Bearing in mind the threat posed by these two pests to any future plans for large-scale maize cultivation in Trinidad and the rest of the Caribbean continued attempts are warranted to obtain biological control.

* Trichogrammatidae

REFERENCES

Achan, P.D., Mathur, K.C., Dharamadhikari, P.R. and Manjunath, T.M. 1968. Parasites of *Heliothis* spp. in India. Tech. Bull. Commonw. Inst. biol. Control 10: 129-149.

Alam, M.M. 1974. Biological control of insect pests of horticultural crops in Barbados. In Crop Protection in the Caribbean (C.W.D. Brathwaite, R.H. Phelps and F.D. Bennett, eds.) Univ. West Indies, Trinidad. pp. 253-261.

Bennett, F.D. and Yaseen, M. 1972. Parasite introductions for biological control of three insect pests in the Lesser Antilles and British Honduras. PANS 18(4): 468-474.

Carl, K.P. 1976. Survey, propagation and importation of natural enemies of *Heliothis armigera* Hb. CIBC report (unpublished).

Mohyuddin, A.I. and Shah, S. 1977. Biological control of *Mythimna separata* (Lep.: Noctuidae) in New Zealand and its bearing on biological control strategy. Entomophaga 22 (4): 331-333.

Rothschild, G.H.L. 1970. Parasites of rice stem borers in Sarawak (Malaysian Borneo). Entomophaga 15: 21-51.

Yaseen, M. 1975. A further note on the introduction of *Heliothis* parasites into the Lesser Antilles. PANS 21(2): 155-157.

NAME OF PAPER: Introduction of exotic Parasites for control of *Spodoptera* and *Heliothis* in Trinidad (M. Yaseen)

Question by: Remillet
Country: French Guyana

QUESTION: Have you found any bacterial or fungal disease, virus or – nematode on *Spodoptera* or *Heliothis*. What is the potential of these diseases in *Spodoptera* control.

ANSWER: A virus on *Heliothis* i.e., *Baculovirus heliothis* is known and can be tried against *Heliothis Armigera*.
We have not encountered with any disease on *Spodoptera* in Trinidad.

Question by: Muller
Country: Guyana

QUESTION: What is the potential for commercial application of biological control of maize pests in the Carribean?

ANSWER: Here have been several successful examples of biocontrol of pests in the caribbean like the citrus black fly and cottony cushion scale in several islands. As for biocontrol of pests of maize *Telenomus remus* is already established in Barbados. It is hoped to exert a controlling effect on Spodopters of given trial established in other territories. Similarly there are several parasites to be tried against *Heliothis*. While we still believe in classical biological control attention should be paid to develop a pest management programme where all available methods of control should be used in such a way that natural enemies play the major role and exert an appreciable level of control.

Questions by: P. Segeren
Country: Suriname

QUESTIONS:

1. Why control by chemical insecticides is not feasible under local conditions in Trinidad?

2. What numbers of the different parasites have to be released for any effective control or is this only related to the time after releasing?

3. What is the infestation-level of *Spodoptera* at not-treated plots in Trinidad?

4. Is super-parasitism by local super-parasites noticed with one of the imported and released parasites?

ANSWERS:

1. To small substitute farms where chemical application becomes uneconomic. More *Spodoptera* occurs in wild growth around the small corn plots.

2. It is difficult to determine the exact number of parasites to be released but due consideration should be given to its biotic potential, searching ability and availability of the host in the field at the time of the release. It is advisable to release fairly large numbers over a considerable period to give an adequate chance for establishment.

3. Usually up to 100% in 2-4 weeks old plants.

4. Not yet.

INSECT CONTROL ON MAIZE IN SURINAME

P.A. Segeren and S.R. Sharma
Agricultural Experiment Station, Paramaribo, Suriname

SUMMARY

Major insect problems on maize are caused by *Scapteriscus spp* (mole cricket), *Spodoptera (Laphygma) frugiperda, Heliothis zea, Diatraea sacharalis* and harvesting ants *(Atta spp.)*.

Because the majority of the farmers grow maize only as a first crop just after clearing and burning their fields, insect infestation is rather low and regeneration is good. However, when maize is growing as a regular crop infestation of *Spodoptera* and *Heliothis* becomes high. Results of control experiments mainly on *Spodoptera frugiperda*, during the last two years, are presented.

INTRODUCTION

Insects which may be found regularly damaging maize plants in Suriname are mole-crickets *(Gryllotalpidae)*, stemborers *(Diatraea spp)* ants *(Atta. spp)*, *Heliothis zea* and *Spodoptera (Laphygma) frugiperda*. *Atta sexdens* L and *A. cephalotes* L. incidentally cause severe damage especially in the interior of the country.

No studies on economic losses have been done of these insects in Suriname. The ants are controlled by use of Mirex, Chlordane or aldrin, which in the interior is given free by the government to the farmers.

Scapteriscus spp and *Gryllotalpa spp* are found mostly on sandy soils in the coastal area, damaging seedlings during four weeks after emerging; in first two weeks plants may be cut off completely just under soil surface. Control has been done with chlordane (40% a.i.; 1 gr/m^2), but this is no longer adequate; diazinon and chlorfenvinphos have been introduced recently. Research on the biology ot these mole-crickets has been started this year.

The effect of *Heliothis zea* on the yield of maize is regarded as of minor importance; 1, 1, 1.5 and 0.5 percent yield reduction have been recorded in four experiments during the last two years.

However, when maize is growing for selling it as a vegetable, economic losses are higher, as in these experiments about 25 percent of the cobs were infested with larvae and this makes them more difficult to sell as a vegetable.

Diatraea spp were found in 8, 9 and 30 percent of the stems in three experiments for the control of *Spodoptera*. Till now no study of the economic importance of this pest on maize in Suriname has been made.

Spodoptera frugiperda is the major pest in maize growing in Suriname. However, differences in infestation-level occur. When maize is grown as a first crop after cleaning bush, the population of *Spodoptera* doesn't reach a high infestation level, and plants recover well.

In Tijgerkreek-West Experiment Station, where maize is grown season after season, in the first season of 1977 fifty percent of the plants got infested dispite a spraying scheme with trichlorphon, carbaryl and malathion in weekly intervals. In two seasons following this experiment up to 60 and 70% infestation of non treated plots was observed. However, in the second season of 1978 (July – October) only 22% of plants in control-plots were infested (fig. 1.).

Bertels (1970) also mentioned the influence of humidity as a regulating factor of *Spodoptera frugiperda* in Rio Grande do Sul in Brasil. More population data are required to confirm this statement under conditions of Suriname.

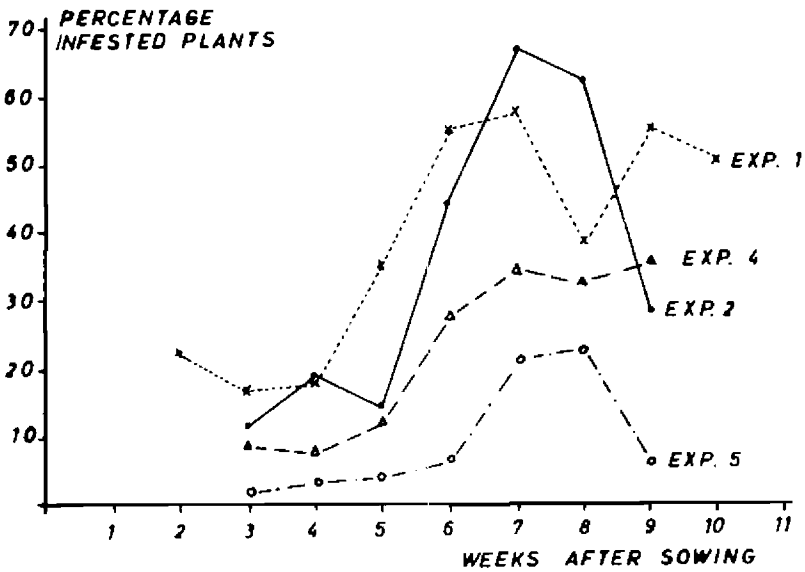


Fig.1. Population growth of *Spodoptera frugiperda* in nontreated plots of four control experiments on maize

NATURAL CONTROL

Van Dinther (1955) mentioned the following natural enpmies of *S. frugiperda* in Suriname: *Polybia liliacea* F., *P. striata* F., *P. sericea* 01., *P. chrysothorax* Web., *P. rejecta* F., *Gymnopolybia vulgaris* Ducke, *Polistes canadensis var. paramensis* Holm, *P. versicolor* 01., *Apanteles marginiventris* Cress, *Meteorus laphygmae* Vier and *Archytas piliventris* (Wulp). Birds were also noticed as predators viz. *Leistes militaris* ("roodborstje") and *Crotophaga ani* L. ("kawfoetoe-boi"). No details about the impact of these natural enemies on the population of *Spodoptera* are mentioned, however.

During 1977-1978 we did collect about 500 *Spodoptera* larvae of different ages and reared them in the laboratory. Only two percent appeared to be parasitized.

Two dipterous and two hymenopterous parasites, which still have to be identified, were found. *Polistes spp.* are frequently observed in the fields and the impact of these predators on the population of *Spodoptera* would be worthwile to study.

In July 1978 the egg-parasite *Telenomus remus* Nixon, which originates from Serawak and which is introduced in the Americas by CIBC (Trinidad), was introduced in Suriname. This parasite is now being reared in the laboratory and will be released in the field as soon as a sufficient number of parasites is available.

CHEMICAL CONTROL

In a first experiment 6 insecticides were screened for control of *Spodoptera*. Insecticides were sprayed with a knapsack sprayer, only carbofuran was applied as a granule to the whorl of the plants. Carbofuran and phosphamidon, both systemic insecticides, were applied twice with an interval of 4 weeks. The other insecticides were four times applied with intervals of two weeks.

Every week the rate of infestation was measured by observing 100 plants at regular distances in the plots; plot size was 16 x 15 m. From these figures the mean infestation percentage over the whole growing period up to blooming of the crop was calculated.

In table 1 results are given, without data of diazinon (Basudine)(25% a.i.; 24 l/ha) which proved to give some phytotoxic effect on maize.

Table 1. Effect of 5 insecticides on the infestation by *S. frugiperda* and yield of maize.

Treatment	a	b	Average infestation %	Yield/ha (kg)	LSD (5%) (kg)
trichlorphon (95% a.i.; 0.6 kg/ha)	4	3	10.2	1781	315
tetrachlorvinphos (24% a.i.; 2.4 l/ha)	4	2	23.2	1711	384
decamethrine (2,5% a.i.; 0,5 l/ha)	4	2	8.3	1670	384
phosphamidon (100% a.i.; 0.3 l/ha)	2	2	27.4	1517	384
carbofuran (5% a.i.; 22 kg/ha)	2	2	15.2	1577	384
control	–	3	38.7	1485	–

a = number of applications during the season
b = number of replications
LSD = Lowest Significant Difference test; at 5% level no differences in yield are significant.

Decamethrine, trichlorphon and carbofuran did control *Spodoptera* satisfactorily, although effectiveness of carbofuran was not longer than 3 weeks. Diazinon, tetrachlorvinphos and phosphamidon in these concentrations did not give adequate control.

Although a significant correlation between mean percentage infested plants per plot and yield per plot was found (r = 0.59; a = 1806 kg/ha b = 8,8 kg/% infestation) no significant differences in yield between the treatments have been found; maybe due to waterlogging in part of the plots.

In a second experiment another way of application of insecticides was tested. Sawdust was mixed with water (2:1) and the insecticide and applied to the whorl of the plant. About 0.6 gr. of sawdust per plant was given. This method is common in Central America and is suggested to be more effective with less use of insecticide. Six insecticides were tested and plots were treated three times with intervals of two weeks. Results are given in table 2.

Table 2. Effect on control of *S. frugiperda* by mixing insecticides with sawdust.

Treatment	a	b	Average infestation %	Yield/ha (kg)	LSD (5%) (kg)
trichlorphon (95% a.i.; 0.6 kg/ha)	3	2	7.5	4385	422
carbaryl (85% a.i.; 0.6 kg/ha)	3	2	7.7	4551	422
fenithrothion (50% a.i.; 1 l/ha)	3	2	4.2	4523	422
decamethrine (2.5% a.i.; 0.5 l/ha)	3	2	4.8	4852	422
control	–	2	27.3	4107	–

a = number of applications
b = number of replications
plotsize = 10 x 10 m
LSD = Lowest Significant Difference test

By this way of application diazinon did cause also some phytotoxicity, and results are not mentioned further.

All other insecticides did control the fall armyworm very well in this method of application. (fig 2.) Three ways of control with trichlorphon were tested in an experiment at Coebiti.

Application of the insecticide was done

a. with knapsack sprayer
b. mixed with sawdust
c. as a granular

In method a. 0.6 kg (95% a.i.) was used per hectare per treatment and in the other methods half of this quantity.

Three applications are given during the growing season, with intervals of two weeks. Control of *S. frugiperda* was as effective in each of these methods of application (table 3).

The method with the sawdust, although very effective and safe, is expensive regarding costs of labour in comparison with spraying the insecticide. Sparing costs of insecticides this method will be advisable when surplus of labour is available or a knapsack sprayer is not at hand.

As carbofuran is said to control soil-insects as well as plant-infesting insects an experiment was set up to check if granular carbofuran is controlling *Spodoptera* as well when applied to the soil as to the whorl.

Three different treatments are given:

a. in seed furrow (1x) + around plants (2x)
b. around plants (2x)
c. in whorl of plants (2x)

Table 3. Control of *S. frugiperda* by three ways of application of trichlorphon.

Treatment	Av. infestation %	Costs of application (Sf)/ha		
		Labour	Insecticide	Total
spraying (95% a.i.; 0.6 kg/ha)	7.2	43.50	18.90**	61.40
sawdust (95% a.i.; 0.3 kg/ha)	6.1	150	9.45	159.45
granules (2.5% a.i.; 10 kg/ha)	4.8	150	75	225.00
control	27.6	–	–	–

number of applications = 3
* spraying insecticides = 7 hours/ha
applying sawdust or granules in whorls: 25 hours/ha
** including costs of knapsack sprayer

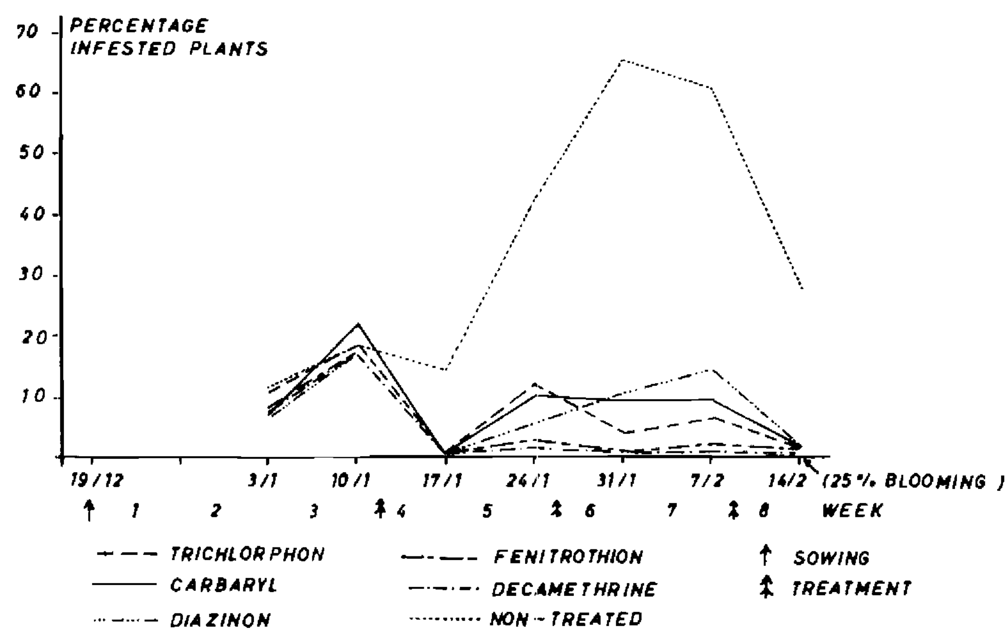


Fig. 2. Population growth of *Spodoptera frugiperda* during the growing season of maize with different insecticides mixed with sawdust.

Plots were made of one row of 15 m. Every week infestation level was measured on 25 plants per plot. Mole crickets did almost not occur; only 0.5 percent of plants were cut.

No differences in rate of infestation were found between the three methods of application, control of *Spodoptera* was even good; about 6 percent (average of whole season) got infested versus 23 percent in the control plots. Yields, however, were rather different between the three methods of application as is shown in table 4.

Table 4. Control of *S. frugiperda* with carbofuran, granular

Application	Average infestation %	Yield/ha (kg)	DMRT (5%)
1. seedfurrow (1x) + around plants (2x)	6.8	4096	a
2. around plants (2x)	5.2	3541	ab
3. leaf-whorl (2x)	6.9	3219	b
4. control	22.6	2542	c

dose: carbofuran 5% a.i. granules; ± 0.4 gr/plant
DMRT: Duncan's Multiple Range Test, yields with different letter are significant different (5%).

From these figures it is obvious that carbofuran is not only controlling the attack of *S. frugiperda,* but must have some other influence on the yield.

In a fifth experiment only one application was given to the plants in the seed furrow (0.25 gr/planthole) to analyse the effect of carbofuran in more detail. Plots were made 5 x 8 m, and the population was counted weekly. Population of *S. frugiperda* was very low during the whole season, as well in treated (4.3% av.) as non treated (6.7 av) plots, but differences in infestation-level are statistically significant.

The yield of treated plots is 10% higher as in control plots (see table 5). At harvest stem-borers *(Diatraea spp)* were found as much in treated (29.4%) as non treated (27.6%) plots.

Table 5. Effect of one dose of carbofuran in the seedfurrow on the infection-level of *S. frugiperda* and the yield of maize.

Treatment	Average infestation %	Yield/ha
carbofuran (5% a.i.; 0.25 gr/plant)	4.3	6174
control	6.7	5563

Differences in yield and infestation are statistically different (F-test, = 5%)

As no plants were found damaged by mole crickets or other soil inhabiting insects we must conclude carbofuran gives some extra growth to the plants besides the control of insects.

This was already shown at 6 weeks after sowing, when plant height was measured. The average length of the plants in the treated plots was 102.5 cm (n = 337) versus 83.2 cm in non treated plots (n = 1017). Regression-analysis of the data of four experiments is to support this hypothesis: regression coefficients are much higher when carbofuran is being used. (table 6)

Table 6. Regression analysis of yields and average percentage of infected plants (X) of four experiments on the control of *S. frugiperda.*

Exp. no and variety	a	insecticides	r	Regression equations: Yield/ha (kg)	Regression equations: Yield in %
1. CS 3	15	several	0.59*	1806–, 8.8 X	100-0.49 X
2. Gemiza	12	several	0.63*	4712–21.8 X	100-0.46 X
3. CS 3	28	carbofuran	0.43*	3826–46.7 X	100-1.22 X
4. Gemiza	16	carbofuran	0.71*	7243–253.0 X	100-3.5 X

r = correlation coëfficient
* = statistically significant at 5% level
a = number of observations

Where the impact of the leaf consumption by the larvae of *S. frugiperda* on the yield by the same level of infestation will be about the same with the use of different insecticides, the effect of carbofuran must be found in stimulating the growth, as shown in experiment 5.

DISCUSSION

The experiments on the control of *S. frugiperda* revealed decamethrine as a very promising insecticide.

The local price of this product, however, inhibits the use by the farmers in insect control of maize. Lowering the dose to 0.25 l/ha must be a following step in research — to see if this new insecticide may be of practical use in crop protection of maize.

On rice in Wageningen (W. Suriname) this concentration has proved to be adequate. Spraying trichlorphon is the cheapest way of control, when applied in correct way to the whorls of the plants. As fenitrothion may be effective for longer periods and proved to be very effective when mixed with sawdust, this insecticide will further be tested.

The method of mixing insecticides with sawdust is very safe and easy to do, but is costly with the local prices of labour.

The use of carbofuran may be acceptable as higher output can be expected. From the regression equation of % infection and yield shown above, extra yields due to insect control can be derived and compared with costs of application. (table 7).

Table 7. Comparison of costs and yields of four insect control experiments in maize.

Treatment	Application	No. exp.	Costs of insect control (Sf)*				Yield/ ha (kg)	$\Delta Y = \frac{Yt - Ynt}{Ynt} \times 100\%$	$\Delta Y = b\,(Xt - Xnt)$
			Insecticide	Labour	Total	% of yield[xx]			
trichlorphon (95% a.i.; 0.6 kg/ha)	spray 4x	1	25.20	58	83.20	18.7	1781	19.9	14.0
	sawdust 3x	2	18.90	150	168.90	15.4	4385	6.8	9.1
fenitrothion (50% a.i.; 1 l/ha)	spray 3x	–	31.50	43.50	75	–	–	–	–
	sawdust 3x	2	31.50	150	181.50	16.1	4523	10.1	10.6
decamethrine (2.5% a.i.; 0.5 l/ha)	spray 4x	1	130	58	188	45	1670	12.5	14.9
	spray 3x (1/2con)	–	48.75	43.50	92.25	–	–	–	–
	sawdust 3x	2	97.50	150	247.50	20.4	4852	17.9	10.4
carbofuran (50% a.i.; 22 kg/ha)	whorl 2x	1	90	100	190	48.2	1577	6.2	11.5
	whorl 2x	4	90	100	190	23.6	3219	26.6	19.2
	soil 1x	5	45	50	95	6.2	6174	11	8.4
	soil 2x	4	90	100	190	21.5	3541	39.3	21.2
	soil 3x	4	135	150	285	27.8	4096	61.1	19.3
			maximum costs:		125	10	5000	10	
					187.50	15	5000	15	
					250	20	5000	20	

* Costs of insect control: (Labour Sf 2.00/h), spraying = Sf 14.50/ha, sawdust-granular application = Sf 50.–/ha
xx = *Price of maize* (14% M.S.) = Sf. 0.25/kg

Y = Yield, Yt = yield of treated plots, Ynt = yield of non-treated plots, ΔY = extra yield
b = regression coefficient
X = average percentage of infection during growing season. Xt = % infection in treeted plots. Xnt = % infection in non-treated plots.

In a final experiment with fenitrothion and carbofuran the economic threshold (1, 2 or 3 applications during a growing season) for the use of these insecticides will be evaluated.

REFERENCES

Bertels, A., 1970. Studies on the influence of humidity on the population dynamics of Lepidoptera that attack maize. Pesquisa Agropecuaria Brasileira 5; 67-79

Dinther, J.B. van 1955. *Laphygma frugiperda* S & A and *Mocis repanda* F. in Suriname. Ent. Berichten 15; 407-411, 427-431.

NAME OF PAPER: Insect Control on Maize in Suriname
P. Segeren & Sharma

Questions by: Van Marrewijk
Country: The Netherlands

QUESTIONS:

1. It is very striking that in many reports on maize experiments in Suriname but also in other Central American or Caribbean countries the fall armyworm is mentioned as the causal agent of disappointing results. This should be a good reason to intensify activities in the field of biological control of *Spodoptera*, including search for resistant genotypes. What is the reason that so far this pest escaped attention of entomologists and breeders in a high measure (compared e.q. with borers)?
   Were it not advisable to include tests for *Spodoptera* resistance in the maize variety trials of the Suriname Agricultural Experiment Station?

2. What is the chemical structure of carbofuran?
   Is it related to any known growth-regulating compound which could explain growgt-enhancement by this pesticide?
   Did you find other reports mentioning growth-enhancement by carbofuran?

ANSWERS:

1. CIMMYT (Mexico) is screening all maize varieties now for tolerance/ resistance of *Spodoptera frugiperda*. I am not sure the varieties we did obtain from CIMMYT have also been tested.

2. Chemical structure of carbofuran:
   N-methyl carbamate.

Question by: The audience

QUESTIONS:

1. Don't you think that the other effect of furadan on maize can be due to the control of soil living organisms as cricket or for example nematodes that could live in the soil and were not initially considered?

2. What about applying granulate insecticides by plane and a large corn producing scale? Would that decrease the cost of applying insecticides?

ANSWERS:

1. Mole cricket damage was checked three or four times in two weeks after emergence. No differences between treated and not treated plots did occur.

Total number of plants was very low however, the occurrence of nematodes has not been checked.

2. The use of granular insecticides by plane is possible as known from the rice cultivation. If it will be as effective in maize has not yet been revealed
   It will surely decrease the costs of application strongly.

Question by: C.A.L. Phillips
Country: Trinidad

QUESTIONS:

1. What are the carriers and spray volumes employed in the trials?

2. If high volumes were employed have low volume and ultra low volumes application techniques using mineral spray oils as the chemical carrier been tried in or considered for future trials with the object of reducing application costs?

ANSWERS:

1.

carbofuran	:	granule	)	
trichlorphon	:	s.p.	)	
fenitrothion	:	e.c.	)	+ 320-400 liters of water/ha
decamethrine	:	e.c.	)	
carbaryl	:	w.p.	)	
phosphamidon	:	e.c.		

2. Low and ultra low-volumes applications are supposed not to be effective as the insecticide may not reach the *Spodoptera* in the whorl of the plant.

Questions by: K.E. Neering
Country: Suriname

QUESTIONS:

1. 500 *Spodoptera* larvae where collected in order to obtain information about parasitism. In what kind of areas were they collected and are there any influences of pesticides in those particular areas?

2. About *Telenomus remus:* is there enough known about the pest and the parasite to justify release? Maybe the parasite is already existing in areas were little insecticides are used?

3. There is quite a difference in yields between the different experiments mentioned. Is there anything known about the cause?

ANSWERS:

1. Most larvae are collected in Tijgerkreek-West Experimental Garden from non-treated plots. Another part is collected from Coebiti

Experimental Garden.

2. Advises are given by Dr. Bennett from Commonwealth Institute of Biological Control (Trinidad).

3. Reasons for differences in yield:
   - climatic conditions
   - soil preparation
   - different varieties.

Questions by: Horace Payne
Country: Jamaica

QUESTIONS: Please supply more informations on the conditions of experiment.

1. What was the condition of Field Sanitation
2. Weedness
3. Soil Type
4. Variety + Population

ANSWERS:

1. Experiments are laid down on beds, as shown at Tijgerkreek-West (with exception of exp.3 (Coebiti)). Fields areploughed and rotavated yust before sowing. In experiment drainage was poor.

2. A pre-emergence herbicide (Probe 2 kg/ha) was used one day after sowing in all experiments. After six weeks grasses did give some concurrence and have been eliminated by hand-weeding.

3. Soil: exp. 1, 2 and 4: loamy sand or sandy loam: Tijgerkreek-West exp. 5 sandy loam with shell grit: Tijgerkreek-West; exp. 3 loamy sand on sandy loam on sandy clay loam: Coebiti

4. Population Density: 40.000-44.000 plants/hectare
   Variety: Exp.: 1, 3, 4: CS3: local, synthetic variety
   2, 5: Gemiza: CIMMYT synthetic variety

Questions by: K. Ittyeipe
Country: Jamaica

QUESTIONS:

1. Is there a nematode problem in maize? If there is, was the increase in yield due to soil application of carbofuran due to the control of nematodes?

2. Was any leaf analyses done to detect possible increase in uptake of nutrients — possibly potassium — in carbofuran-treated plots?

ANSWERS:

1. Nematode problems in maize are not yet identified in Suriname. Some specimen of *Pratylenchus Sp.* have been found in a first survey.

2. No leaf analysis has been done in this experiment.

Question by S.K. Vasal
Country: Mexico

QUESTION: I wonder if you have tried seed treatment with furadan. I am mentioning this because at Cimmyt we have found it very effective to control *Spodoptora* in the first three weeks after planting.

ANSWER: We have not tried yet.

Questions by: K.U. Buckmire
Country: St. Kitts

QUESTIONS:

1. What are the effects of weedicides, weed population, fertilizer amount and regime, the water availability on the insect population on Maize?

2. Have any work been done on the effects of insecticides especially the systemics on the natural predators and parasites of *Spodoptera frugiperda?*

3. Are the varieties (maize) generally used been tested for tolerance or resistence to both field and storage pests?

ANSWERS:

1. Weedicides were applied 1 day after sowing and are non-systemic, so no effect on *Spodoptera* is expected. Weed population, especially grasses may have quite a high infestation of *Spodoptera.* Van Huis (UNDP – Nicaragua) did some research on this subject. We have not done any study on the subject. Also effects of fertilizing, and water availability on the insect population have not yet been studied.

2. No research has been done.

3. The Cimmyt varieties are tested for *Spodoptera* resistance tolerance at CIMMYT – Mexico. The local variety has not been tested as far as I know.

Question by: Miss E. Metcalf
Country: Antigua

QUESTION: Was the population of nematodes in the soil mentioned in the experiment? Possible reason for improved performance of carbofuran when applied in the soil.

ANSWER: No observations have been done in this experiment.

MAIZE VIRUS AND VIRUS-LIKE DISEASES IN FRENCH WEST INDIES

Migliori A. and Marchoux G.
Station de Pathologie Végétale
Centre de Recherches Agronomiques des Antilles et de la Guyane
97170 PETIT-BOURG GUADELOUPE F.W.I.

In French West Indies maize is not cultivated in large surfaces. Nevertheless in 1969 *Messiaen* et al, observed the virus diseases. Since this time, these diseases have not been studied. Since 1975 severe attacks of virus diseases on maize have been observed, However.

SYMPTOMATOLOGY.

Distinction between different viruses on the base of disease symptomatology is very difficult. Yet, However our observations permit to distinguish four types of symptoms which approximate those described by Castillo-Loyza, Exconde, Fajemisin, Gamez, Martinez-Lopez, Lastra. (1976).

These symptoms are:	Stripes regular and continuous,	(fig 1)
	Stripes irregular and discontinuous,	(fig 2)
	Clear bands,	(fig 3)
	Stunting and deformation,	(fig 4)

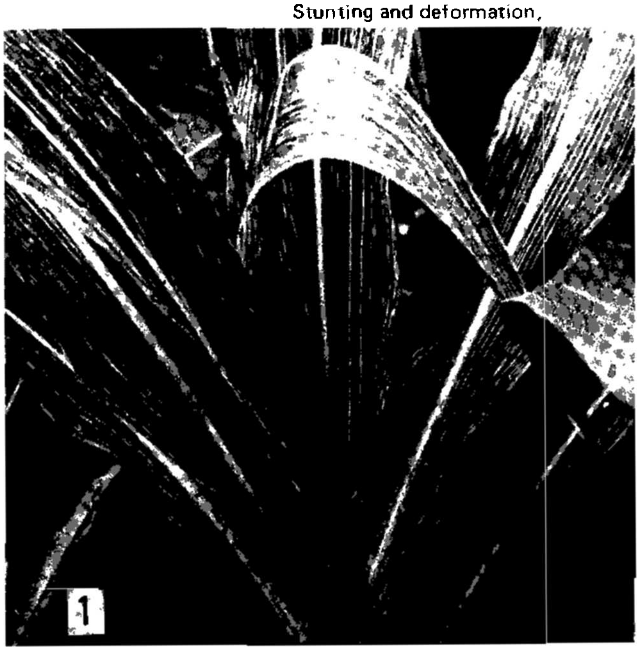


Fig 1 Maize plant infected, stripes regular and continuous.

Symposium on maize and peanut, Paramaribo,
Nov. 13 - 18, 1978

Fig 2 Maize plant infected, stripes irregular and discontinuous.

Fig 3 Maize plant infected, clear bands.

Fig 4 Stunting and deformation.

VECTORS.

Peregrinus maidis is present in French West Indies Bonfils et Delplanque 1970) and *Dalbulus maidis* (Delong et Wolcott) has been observed in Guadeloupe only once this year (Bonfils, personal communication). The first species of leafhopper is numerous in healthy or diseased maize crops.

TRANSMISSION OF VIRUS DISEASES.

Forty infected samples of many varieties of maize and sorghum were tested by mechanical transmission but did not succeed. Young infected samples of maize colonized by the leafhoppers *Peregrinus maidis* were put in a cage with about 15 seedlings of maize. After 18 days plants showed to be infected.

PLANTS HOSTS.

In Guadeloupe *Rottboellia exaltata* L (Graminaceous) is often infected. In Venezuela Lastra (1976) describes this plant as a host of Maize Mosaic Virus (MMV) and Maize White Leaf Virus (Hoja Blanca del Maiz). But this plant is a host of Maize Dwarf Mosaic Virus, (MDMV) (Martinez-Lopez 1976) Maize Streak Virus (MSV) (Guthrie 1976) and Corn Stripe Virus (CSV) too (Exconde 1976). *Pennisetum purpureum* is another graminaceous plant which is rarely been found infected in Guadeloupe. The *Pennisetum* genus perhaps infected with Maize Chlorotic Dwarf Virus (MCDV) (Nault and al 1976) and Sugarcane Mosaic Virus (SCMV) (Sutabutra and al 1976)

RESISTANCE.

The local varieties of the Carribeans seem less susceptible than European varieties to the different viruses. The varieties Revolution and Mayorbella were observed to be tolerant or resistant to the maize viruses like in Guadeloupe (by Messiaen, Jacqua in 1974, personal communcation).

At present studies are carried out to determine which viruses are responsable for the diseases of maize.

REFERENCES

Bonfils J. et Delplanque A. 1971. Distribution des principales cicadelles des prairies aux Antilles Francaises (Homoptera).
Ann. Zool. Ecol. anim. 3 (2), 135-150.

Castillo-Loayza J. 1976. Maize Virus and Virus-Like Diseases in Perou.

Exconde O.R. 1976. Viral Diseases of Maize and National Programs of Maize Production in the Philippines. Proceedings International Maize Virus Diseases Colloquium and Workshop, O.A.R.D.C. Wooster. (USA)

Fejamisin J.M. and Shoynka S.A. 1976. Maize Streak and Other Maize Virus Diseases in West Africa. Proceedings International Maize Virus Diseases Colloquium and Workshop, O.A.R.D.C. Wooster. (USA)

Gamez R. 1976. Leafhopper transmitted Maize Rayado Fino Virus in Central America. Proceedings International Maize Virus Diseases Colloquium and Workshop, O.A.R.D.C. Wooster. (USA)

Guthrie E.J. 1976. Virus of Maize in East Africa.
Proceedings International Maize Virus Diseases Colloquium and Workshop, O.A.R.D.C. Wooster. (USA)

Lastra R. and Trujillo G. 1976. Enfermedades del maiz en Venezuela causdas por virus y microplasmas.
Agronomia Tropical 26 (5), 441-445

Lastra R. 1976. Maize Mosaic and Other Maize Virus and Virus-like Diseases in Venezuela. Proceedings International Maize Virus Diseases Colloquium and Workshop, O.A.R.D.C. Wooster. (USA)

Martinez-Lopez G. 1976. New Maize Virus Diseases in Colombia. Proceedings International Maize Virus Diseases Colloquium and Workshop O.A.R.D.C. Wooster. (USA)

Messiaen C.M., Quiot J.B. and Jailloux F. 1969. Nécessité d'adaptation au climat et de tolérance aux maladies pour les variétés de maïs destinées aux Antilles. CR. 7e Congrès CFCS. Martinique Guadeloupe 339-341

Nault L.R. Gordon D.T. Robertson D.C. and Bradfute O.E. 1976. Host range of maize chlorotic dwarf virus. Plant Dis. Reporter 60 (5), 374-377

Sutabutra T. Kornkanhaeng P. Sirithorn P. and Kositaratana W. 1976. A Mosaic Virus Disease of Maize in Thailand. Proceedings International Maize Virus Diseases Colloquium and Workshop, O.A.R.D.C. Wooster (USA)

A MECHANICALLY TRANSMISSIBLE VIRUS ISOLATED FROM MAIZE IN HAITI.

G. Marchoux and A. Migliori.
Station de Pathologie Végétale
Institut National de la Recherche Agronomique
Centre des Antilles-Guyane
97170 PETIT-BOURG GUADELOUPE (French West Indies)

In december 1977 (Toribio and Marchoux, 1977) numerous plants on one field collection of maize (Touvin, 1978) in southern of Hait exhibited typical mosaic with dark and light green striped areas. Affected plants are more or less stunded, probably depending on the age at which they are infected. Incidenceof the virus-like diseases seems to reach a high incidence.

METHODS AND RESULTS

Mechanical inoculation.

Young leaves of one diseased plant were triturated in 0.01 M phosphate buffer pH 7.0 (1:5 W/V). Inoculations were made with 75 mg/ml of carborundum as an abrasive and XL50 Activit carbon as an anti inhibitor.

Maize.

small chlorotic spats and later yellow mosaic running parallel to the veins.

Three Haïtian ecotypes (426 C, 480 C, 393) are sensitive.

Sorghum.

Mottle or mosaic, sometimes later with necrotic reaction on old leaves KS 18, SC 170.6.8.8, SCHALLU MP 10, SDR 040 and SDB 006 from INRA-Duclos collection-are more or less sensitive.

Aphid transmission.

Isolate maintained onto SC 170.6.8.8., corn is transmitted to new young SC 170.6.8.8. or 480 C sorghum seedlings by *Myzus persicae* aphid in the nonpersistent manner.

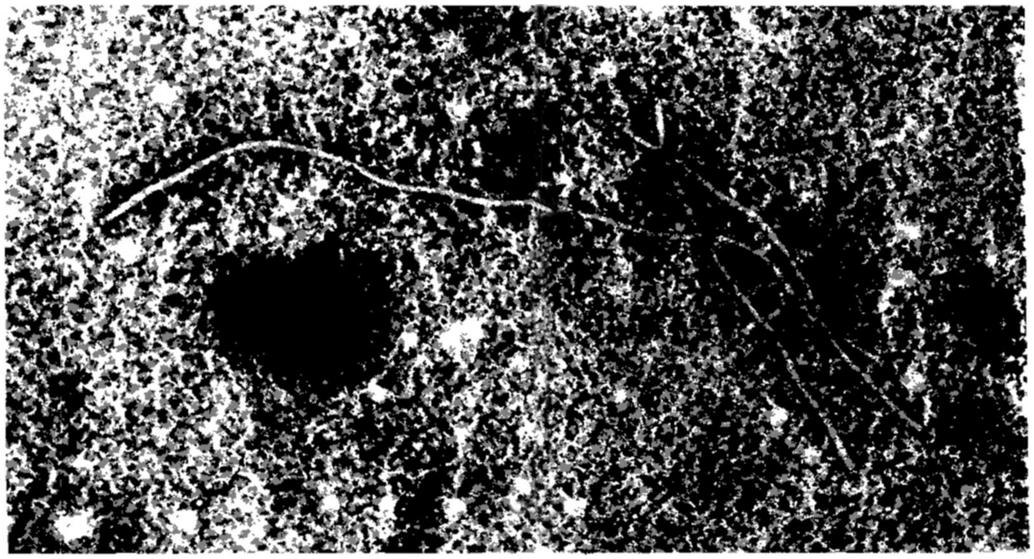


Fig 1: Filamentous particles observed in leaf-dip prêparation from maize sample from Haiti.

Electron microscopy.

Preparations obtained by the leaf-dip method showed viral particle is flexuous filament of approximately 750 nm in length. (fig 1)

DISCUSSION

A sap and aphid-transmissible virus was isolated from mosaic-affected maize plants grown in south of Haiti.

The potyvirus is suspected to be Maize Dwarf Mosaic Virus (MDMV) already identified on maize and sorghum in USA (Williams and Alexander, 1965; Williams et al., 1977). MDMV is a strain of sugarcane mosaic virus suspected in many parts of the caribbean area where susceptible varieties of cane are grown. (Pirone, 1972; Snazelle et al., 1971).

REFERENCES

Lastra R. 1976. Maize Mosaic and Other Maize Virus and Virus-like Diseases in Venezuela. Proceedings of the International Maize Virus Disease Colloq. and Workshop. Wooster. (USA) O.A.R.D.C.

Ordosgoitty A. and Malaguti 1969. El mosaico de la cana de azucar en siembras comerciales de maiz y sorgo. Agronomica Tropicale 19: 189-195.

Pirone T.P. 1972. Sugarcane mosaic virus CMI/AAB Descriptions of Plant Viruses. N° 88

Snazelle T.E., Bancroft J.B., and Ullstrup A.J. 1971. Purification and serology of Maize Dwarf Mosaic and Sugarcane Mosaic Viruses. Phytopathology 61: 1059-1063

Toribio A., et Marchoux G. 1977. Compte rendu de la mission en République d'Haïti. 7-14 Décembre 1977. Dactylog. 12 p.

Touvin H. 1978. Compte rendu de mission en Haïti. CRA-AG Dactylog. 10 p.

Williams L.E., and Alexander L.J. 1965. Maize dwarf mosaic, a new corn disease. Phytopathology 55, 802-804

Williams L.E., Gordon D.T. and Nault L.R. 1977. Proceedings of the International Maize Virus Disease Colloquium and Workshop, Wooster, (USA) O.A.R.D.C. 145 p.

POST-PLANTING WEED CONTROL TREATMENTS FOR MAIZE IN SURINAME

R.E. Dumas and S. Ausan

Agricultural Experiment Station, Paramaribo

SUMMARY

Information is given on the crop and the weed control treatments tested. Control effectiveness of the selected treatments, i.e. alachlor, atrazine, cyanazine, methazole, paraquat, hand-hoeing, inter-row rotavating and spiral plowing are discussed. Except for cyanazine and paraquat, the experimental results are summarized with regard to seedling emergence, flowering, number of ears per plant, grain yield and N-content of the grains. Alachlor pre-em. had a depressive effect on seedling emergence, whereas a lower N-content of the grains was recorded after pre-em. use of atrazine. The remaining effects of the weed control treatments on the crop were not statistically significant at the 5% level. The damage symptoms encountered are described. Eventually the labour requirements are given for hand-hoeing, inter-row rotavating, spiral plowing and spraying.

INTRODUCTION

As a result of low yields and unattractive prices farmers preferred to grow more profitable crops than maize in the course of time. The ever increasing imports (Lata, 1978) and the availability of locally developed high-yielding maize varieties in the early seventies stimulated the Agricultural Experiment Station to reconsider the feasibility of maize growing in Suriname. A more comprehensive research programme was drawn up with the objective to minimize limiting production factors. Up to then research on maize had been mainly focussed on breeding and selection work. Research on weed control in maize which started in 1975 is being carried out as part of the earlier mentioned programme. No systematic research on this subject had been conducted before. This paper reports the results obtained so far with the screening of post-planting weed control treatments.

Part of the information on land preparation, soil cultivation and weeds given in the paper on peanuts (Dumas & Ausan, 1978) also applies to maize.

CROP INFORMATION

The weed control experiments were carried out with CS 3, a locally developed maize variety. The seeds were sown at a depth of about 4 cm at a plant spacing of 90 x 30 cm. Each planting hole, made by dibbing stick, contained 2 or 3 seeds.

Chlordane at the rate of 10 kg/ha was applied immediately after sowing, either by knapsack sprayer as a blanket treatment or by hand in strips over the plant rows in order to protect the germinating seeds and the young seedlings against mole-crickets *(Scapteriscus spp.)*. Seedling emergence normally started at 4-5 days after sowing. Filling in was carried out at about 8 days after sowing. At the same time the crop was top-dressed at the rate of 200 kg NPK (15-15-15) per ha. The fertilizer was applied by hand along the plant rows. The mean height of the maize

Symposium on maize and peanut, Paramaribo,
Nov. 13 - 18, 1978

plants up to canopy closing, 6 weeks after sowing, as measured from ground level up to the last ligule visible (the base of the whorl), is given in table 1.

Tabel 1. Mean height of the maize plants at weekly intervals up to canopy closing.

	weeks after sowing				
	2	3	4	5	6
height (cm)	9	17	30	62	112

Thinning was done by hand at 3 weeks after sowing, leaving one plant per hill. The first prop roots started to appear at the lowest visible node about 4 weeks after sowing, prior to the second topdressing at the rate of 200 kg NPK (15-15-15) per ha. At 6 weeks the second crown of prop roots started to develop at the second node from ground level. The last topdressing was applied a week later at the rate of 100 kg NPK (15-15-15) and 100 kg urea per ha. The third crown of prop roots became visible at about 8 weeks after sowing. At that time the male inflorescence had emerged from some maize plants. Data on flowering have been given in table 4. The grains ripened at 110-115 days after sowing. By that time the plants had reached a height of more than 2 m. Trichlorfon was used in the early growth stages of the crop to control *Spodoptera (Laphygma) frugiperda.*

WEED CONTROL TREATMENTS

Testing started with a primary screening trial including the following treatments:

- paraquat 0.30 ≠ [+] at 6 days prior to sowing + paraquat 0.30 ≠ at 3 days after sowing
- pre-emergence: alachlor 3.00 ≠, prometryne 1.25 ≠, methazole 1.87 ≠, atrazine 1.60 – 4.80 ≠, ametryne 1.00 – 3.00 ≠, 2,4 – D amine 0.72 – 2.16 ≠, amitrole 1.50 – 4.50 ≠
- early post-emergence (overtop spray): 2.4 – D amine 0.72 ≠ at 17 days after sowing, atrazine 3.20 ≠ at 17 days after sowing
- post-emergence (directed spray): paraquat (0.4% solution) at 4,5 and 6 weeks after sowing, dalapon (1.5% solution) at 4 and 6 weeks after sowing
- hand-hoeing at 4 weeks
- no weeding at all.

[+]≠: kg active ingredient per ha.

Of these treatments atrazine, alachlor and methazole were selected for advanced testing in two randomized block experiments. Inter-row rotavating and spiral plowing by means of a two-wheeled tractor were included in these trials because of the popularity of this machine in Suriname. Spiral plowing was substituted for hand-hoeing in the second trial. Although effective and most probably not harmful to the crop ametryne (WP) was excluded because of the poor solubility of the powder causing frequent clogging of the nozzle. Eventually observational plantings were laid out where the performance of the selected treatments, excluding hand-hoeing, was observed on an area of at least 150 m^2 per treatment. This opportunity was also used to start testing cyanazine, to collect more information on post-emergence application of paraquat and to test atrazine, alachlor, methazole and cyanazine application at seedling emergence. However, a reliable picture of the effects of these early post-emergence treatments was not obtained as rain interfered with the sprayings.

All testing was done at the Tijgerkreek-West Experimental Farm on a fine sandy loam soil (pH-H_2O: 6.0; org. matter content: 2.40%).

CONTROL EFFECTIVENESS

This was assessed by visual score at different times after sowing. Scoring was done independently by 2-4 persons. At the same time the predominant weeds per treatment were listed. An overall picture of the mean scores for the selected treatments is given in table 2.

The treatment effects on the main weeds were as follows:

Alachlor. Alternanthera spp., *Digitaria* spp. and *Portulaca oleracea* were usually present at 4 weeks after sowing, *Digitaria* being mostly predominant at 8 weeks after sowing. *Eleusine indica* and *Aneilema* sp. were controlled properly.

Atrazine. The killing effect of the chemical started at about one week after application. Almost all weeds were perfectly controlled. *Digitaria* spp. and to a minor extent *Aneilema* sp. were the only weeds present from 2-4 weeks onwards up to harvest. The rate of 2.40 ≠ proved adequate to allow sparse weed growth only during the crops' lifespan.

Cyanazine. At the rate of about 1.40 ≠ *Digitaria* spp. and *Eleusine indica* were the predominant weeds at 4 weeks after sowing. *Aneilema* sp. and *Portulaca oleracea* were controlled partially. Better control of *Aneilema* sp. was observed where the chemical was applied early post-weed-emergence. *Phyllanthus amarus* was controlled properly.

Methazole. Best results were obtained at about 2.00 ≠ but even then *Aneilema* sp. *Digitaria* spp. and *Eleusine indica* were present within 4 weeks from sowing. However, the degree of infestation remained reasonably poor up to harvest. Control of *Aneilema* sp. was negligible at about 1.50 ≠, whereas *Phyllanthus amarus* and *Portulaca oleracea* also escaped from control at this rate. Better control was noticed where weeds were sprayed early post-emergence.

Paraquat. With a view to damage to the maize plants spraying at about 5 weeks after sowing seemed most appropriate. Difficulties were encountered where the weeds had grown up as high as the crop plants. In such cases spraying was done after trampling down the weeds, resulting in reduced effectiveness. A 0.25% spray solution was not as effective as a 0.40% solution, but was adequate to obtain satisfactory control in the case of a moderate weed infestation.

Table 2 – Mean visual scores at different times after sowing for a number of post-planting weed control treatments in maize.

Weed control treatments	Exp. no.	Rate*	Weeks after sowing 4	6	8	14
pre-emergence						
	TK 81	3.00	7.7**	5.6	–	–
	TK 116	2.32	8.4	5.9	4.5	–
alachlor	TK 142	2.52	7.6	6.6	5.6	4.7
	Observ.	1.52	8.0	5.8	5.7	–
	TK 81	1.60	7.1	–	5.8	3.4
	TK 81	3.20	8.4	–	7.6	6.7
atrazine	TK 116	2.40	8.4	6.8	5.3	–
	TK 142	2.39	8.9	7.8	6.8	5.8
	Observ.	2.43	8.9	7.9	7.2	–
cyanazine	Observ.	1.42	7.5	5.6	5.3	–
	TK 81	1.87	6.6	4.8	–	–
	TK 116	1.99	9.1	7.7	6.3	–
methazole	TK 142	1.56	6.7	6.1	4.3	2.5
	Observ.	1.50	6.7	4.6	2.9	–
early post-emergence						
alachlor	Observ.	1.60	8.3	6.6	6.2	–
atrazine	Observ.	2.18	8.8	8.2	7.5	–
cyanazine	Observ.	1.48	7.1	5.4	4.5	–
methazole	Observ.	1.40	7.3	5.1	3.7	–
post-emergence						
paraquat at 4 weeks	TK 81	0.40 % sol.	4.3	6.0	–	–
" " 5 "	TK 81	id.	4.7	–	8.6	7.5
" " 5 "	TK 81	id.	4.1	–	7.3	5.8
" " 5 "	Observ.	id.	5.3	7.6	7.5	–
" " 5 "	Observ.	0.25 % sol.	5.3	6.9	6.4	–
mechanical						
hand-hoeing at 4 weeks	TK 81		2.5	–	7.9	6.7
id.	TK 116		2.6	7.2	6.8	–
inter-row rotavating at 3 w.	TK 116		5.4	3.4	2.2	–
id.	TK 142		5.1	4.7	3.6	3.6
inter-row rotavating at 5 w.	Observ.		5.9	6.9	6.6	–
spiral plowing at 3 w.	TK 142		6.4	5.8	5.0	3.9
spiral plowing at 5 w.	Observ.		5.3	7.9	7.5	–

* kg active ingredient per ha, paraquat solutions in terms of commercial product

** Visual scoring: 1 = plot completely occupied by weeds
10 = plot completely weed – free

Hand-hoeing. One treatment at 4 weeks after sowing proved effective up to harvest. *Digitaria* spp., *Aneilema* sp., *Portulaca oleracea* and *Eleusine indica* which predominated prior to hoeing regenerated poorly afterwards.

Inter-row rotavating. This treatment was least effective of all treatments, particularly where a portable cultivator was used. A better but still unsatisfactory effect was obtained where a heavier machine was employed enabling a deeper cultivation and a more thorough mixing effect. Weeds within the plant rows, where *Digitaria* spp. and *Aneilema* sp. predominated at the time of cultivation remained uncontrolled. In fact their growth, in particular that of grasses, was stimulated by the fertilizer applications along the rows at 1, 4 and 7 weeks after sowing. Other important weeds present were *Eleusine indica, Portulaca oleracea, Phyllanthus amarus* and *Alternanthera* spp.

Spiral plowing. With this cultivation soil is moved from the interrow-space towards the plant rows giving rise to ridges. Weeds within the plant rows which had grown up too much were not buried completely. The weeds present were the same as those with the inter-row rotavating, *Digitaria* spp. and *Aneilema* sp. being also predominant at the time of execution.

Digitaria spp. remained predominant up to harvest, but the total amount of weeds was generally less than with inter-row rotavating.

EFFECTS ON THE CROP

– Seedling emergence

Atrazine and methazole had no adverse effect on seedling emergence. A depressive effect was observed where alachlor had been applied (see Visual damage). The results of two randomized block experiments are presented in table 3.
Figures are treatment means of 4 replications.

Table 3. Percentage emergence at 8 days after sowing.

Exp. no.	no herbicide	alachlor		atrazine		methazole	
		2.32	2.52	2.40	2.39	1.99	1.56
TK 116	53.5	47.2		59.5		55.8	
TK 142	83.3		77.5		86.9		82.9

The treatment effect of Exp. TK 116 is highly significant (1% level), whereas that of Exp. TK 142 is not significant at all.
Scheffe's-test (10% level) applied on the treatment means of the former experiment denotes a significant difference between the seedling emergence with alachlor and that of both atrazine and methazole. Other differences are absent.

– Visual damage

Alachlor. At the rate of 2.52 ≠ a delay in seedling emergence was evident at 6 days after sowing. Two days later about 21% of the maize seedlings which had emerged had stiff, malformed leaves with a ribbed appearance.

Unfolding of the leaves seemed to be hampered. The injury symptoms occurred more or less at all rates used. The damage was temporary.

Atrazine. At the three rates used in the primary screening trial, namely 1.60 ≠, 3.20 ≠ and 4.80 ≠, a decrease in plant height was observed with increasing rate. Flowering was delayed at the highest rate. No damage symptoms were noticed where atrazine was used at the recommended rate of 2.40 ≠, both pre-emergence and at seedling emergence.

Cyanazine. Preliminary observations indicated that no damage should be expected following pre-emergence use.

Methazole. No damage was observed after pre-emergence use at 1.50 – 1.99 ≠. Crop injury occurred where the herbicide was applied at seedling emergence. Part of the plants died or had wilted leaves.

Paraquat. Injured plants had scorched patches and/or turned yellow. More damage was observed as maize plants were smaller. Spraying at 6 weeks after sowing caused damage to the prop roots but did not result in lodging.

Spiral plowing. Small plants were buried together with the weeds within the plant rows. A certain minimum height of the plants proved necessary to prevent losses. Spiral plowing at 3 weeks after sowing appeared too early.

– Flowering

The influence of the treatments on seedling emergence (table 3) to a certain extent was reflected in the figures regarding flowering (table 4). The delay in seedling emergence as observed with alachlor was still present at flowering.

Table 4. Percentage flowering plants at 9 weeks after sowing.

Exp.	Inflorescence	hand-	inter-row	spiral	alachlor		atrazine		methazole	
no.	visible	hoeing	rotavating	plowing	2.32	2.52	2.40	2.39	1.99	1.56
TK 116	♂	60.7	51.7	–	46.7		65.3		56.0	
TK 142	♂	–	85.5	77.1		75.8		81.3		78.8
TK 142	♀ +	–	80.4	72.1		71.7		74.3		76.6

\+ assessed 4 days later

The treatment effect of Exp. TK 116 is significant at the 10% level, that of Exp. TK 142 is not significant.

— Ears per plant

No convincing differences in the mean number of ears per plant have been found for the different weeding treatments.
The results presented in table 5 are again means of 4 replications.

Table 5. Mean number of ears per plant.

Exp.	hand-	inter-row	spiral	alachlor		atrazine		methazole	
no.	hoeing	rotavating	plowing	2.32	2.52	2.40	2.39	1.99	1.56
TK 116	1.37	1.27	–	1.40		1.43		1.41	
	(88.2)+	(89.3)		(81.8)		(89.3)		(83.6)	
TK 142	–	1.20	1.25		1.21		1.25		1.28
		(96.9)	(92.9)		(96.9)		(97.9)		(95.2)

\+ in brackets: the percentage of hills occupied at harvest.

The treatment effect of Exp. TK 116 is significant at the 10% level, that of Exp. TK 142 is not significant. The mean number of ears per plant was lowest for inter-row rotavating in both experiments.

— Grain yield

In spite of clear differences in control effectiveness and in Exp. TK 116 also in crop vigour there were no statistically significant differences in grain yield. The figures in table 6 are means of 4 replications.

Table 6. Grain yields in kg/ha at 15% moisture content.

Exp.	hand	inter-row	spiral	alachlor		atrazine		methazole	
no.	hoeing	rotavating	plowing	2.32	2.52	2.40	2.39	1.99	1.56
TK 116	5695	5110	–	5365		5893		5675	
TK 142	–	4293	4047		4106		4392		4330

– N-content of the grains

The N-content was determined according to the Kjeldahl method. The results presented in table 7 are means of 4 replications.

Table 7 – N-content of the grains.

Exp.	inter-row	spiral	alachlor	atrazine	methazole
no.	rotavating	plowing	2.52	2.39	1.56
TK 142	1.99	1.96	1.99	1.89	1.92

The treatment effect is significant at the 5% level, but Scheffe's-test at the 10% level denotes no differences between the treatment means.

LABOUR REQUIREMENTS

– Hand-hoeing

The time needed for hand-hoeing 4 plots of 49 m^2 each was recorded. The work was done by 2 labourers who worked separately. Hoeing was done at 4 weeks after sowing. The debris was left between the plant rows. The nett labour requirement varied from 186 to 284 man hours/ha, the mean being 226 man hours/ha.

– Inter-row rotavating

A nett labour requirement of 25.5 man hours/ha was calculated when a portable cultivator with a working width of about 50 cm was used. Each inter-row was passed 2 times to cover the inter-row space. The time was recorded on 4 plots of 49 m^2.

A heavier machine with the same working width used on 4 plots of 47 m^2 required 15.8 man hours/ha, excluding turning times. The same two-wheeled tractor employed on beds of 150 and 310 m^2 required 14.4 and 16.7 man hours/ha respectively, turning times excluded as well. Nett labour requirements of 16.1 and 18.3 man hours/ha respectively were calculated if turning times were included. The machine drove in the second gear (high) and passed each inter-row 2 times.

– Spiral plowing

The time required for spiral plowing 4 plots of 47 m^2 amounted to 8.5 man hours/ha, excluding turning times. Time recordings on 2 beds of 310 m^2 each resulted in labour requirements of 11.0 and 11.8 man hours/ha; 12.4 and 12.6 man hours/ha respectively were needed if turning times were included. The same two-wheeled tractor as for inter-row rotavating was employed. Each inter-row was passed once, using the second gear (low).

– Spraying

The time required for mere spraying ranged from 10.6 to 11.1 man hours/ha. A mean time of 14.3 man hours/ha was needed if the time for walking up and down to the tap, filling and cleaning of the sprayer was included for calculation. Water was available at a distance of about 100 m from the field.

The times were derived from recordings on 3 beds of 310 m^2 each where paraquat was sprayed between plant rows at a distance of 90 cm. A knapsack sprayer was used with a tank volume of 20 l. A blue poly-jet nozzle was fitted to the spray lance. The amount of water required per ha was 657 litres.

DISCUSSION

Of the mechanical treatments hand-hoeing at 4 weeks was most effective, but also most time-consuming. Inter-row rotavating and spiral plowing were tested as alternative treatments for owners of two-wheeled tractors. Neither method was satisfactory, though they may be used under certain circumstances e.g. under dry conditions to reduce competition for water by weeds. In the case of inter-row rotavating luxurant grass growth within the plant rows may lead to continuous infestations of *Spodoptera (Laphygma) frugiperda,* a major insect pest of maize in Suriname. Moreover moist conditions around the plant base may stimulate infection by *Erwinia* spp., a bacterial disease. In this respect spiral plowing should be suspected more than rotavating. Another disadvantage of spiral plowing proved to be the presence of stagnant water in the furrows after heavy rains.

The use of pre-emergence herbicides is particularly advantageous if wet conditions prevail around sowing time. Under such circumstances seedling emergence of the crop is usually delayed enabling the weeds to grow ahead of the crop. Of the herbicides tested atrazine performed best. More experiments are necessary to find out if it really affects the N-content of the grains and if it is harmful to the next crop in the rotation. Methazole can be safely used in maize. The rate of 1.56 ≠ proved adequate although better control of the weeds was observed at 1.99 ≠. The compatibility of methazole and chlordane deserves attention as damage was suspected in a planting where shortly after the pre-emergence use of methazole chlordane had been sprayed over the maize seedlings. The same applies to alachlor: cowpea seedlings *(Vigna unguiculata)* were seriously injured where pre-emergence use of the herbicide was followed by an overtop treatment of chlordane. It may be that the early phytotoxicity observed after pre-emergence use of alachlor in maize can be attributed to the incompatibility of the two chemicals.

In the weed control experiments chlordane had been applied one day prior to herbicide spraying. Other possible causes of the injury are the rates used, whether or not in relation to sowing depth and varietal differences in susceptibility. Cyanazine needs further testing to allow proper judgement and ametryne can be included in further experiments now that a flowable formulation is available. Post-emergence spraying of paraquat should preferably take place at 4-5 weeks from sowing if weed height permits. Earlier spraying increases the risk of damage to the whole plant, whereas damage to the prop roots can be expected if spraying is carried out from six weeks on. Anyhow, careful spraying should be pursued in all cases.

As to the yields it can be said that the absence of significant yield reductions for the mechanical treatments is in accordance with experiences in the USA Kasasian,(1971), quoting Danielson, states: "Maize appears to be unusually tolerant of cultivations, as even during a sever drought repeated cultivations, close enough to cause root pruning, did not reduce yield as long as weed control was effective". Kasasian (1971) further mentions that rotary hoeing in and between the.rows is recommended in the USA and that it is most satisactory on dryish, lightly crusted soils, but that timing is critical.

REFERENCES

Dumas, R.E. 1978. S. Ausan — Research results and practical experiences regarding weed control in peanuts in Suriname. Symposium on Maize and Peanuts, Paramaribo, Suriname. Proc. CFCS Vol. XV : 272 – 287.

Kasasian, L. 1971. — Weed control in the tropics. Leonard Hill, London.

Lata, G.S. 1978. — Maize cultivation in Suriname. Symposium on Maize and Peanuts, Paramaribo, Suriname. Proc. CFCS Vol. XV : 119 – 126.

NAME OF PAPER: Post-Planting Weed Control Treatments for Maize (R.Dumas and S. Ausan)

Question by: Errol B. Whyte
Country: Barbados

QUESTION: Page four of your Paper — What does (—) mean? If it means no reading was taken — then why?

ANSWER: (—) means: no score available.
There were several reasons why no scoring was done:

* interference of the control effectiveness picture
* too short a period elapsed after treatment application
* lack of time because more important observations had to be done
* in general the scorings at 14 weeks were not supposed to be of great importance. So the scorings were done only if time was available.

Questions by: K.U. Buckmire
Country: St. Kitts

QUESTIONS:

1. Why is chlordane still being used as a pre-emergence insecticide? Is it now still available in Suriname?

2. Are there any regulations on pesticide use in Suriname?

ANSWERS:

1. As the law on use of pesticides is approved but not yet in action, endrin is still available. Is it a very cheap insecticide it is rather popular for control of mole crickets. As mentioned in the paper of Segeren and Sharma about pests of maize in Suriname, diazinon and chlorfenvinphos have been introduced recently as a substitute.

2. We introduced some baits for mole cricket- control from abroad but costs of use at the recommended rates were so high (about Sf. 200.- per hectare) that the use of these baits for insect control never will become popular, unless prices go down by local production of the baits.

EFFECT OF POST–EMERGENCE APPLIED ATRAZINE/DALAPON/OIL MIXTURE ON WEED GROWTH AND CORN PRODUCTIVITY

C.A.L. Phillips
Textrin Research Laboratory, Texaco Trinidad, Inc.,
Pointe-a-Pierre, Trinidad.

and

David Martin
Chaguaramas Agricultural Development Project,
Macqueripe, Chaguaramas, Trinidad.

SUMMARY

Atrazine and dalapon are used as post-emergence herbicides in corn. Dalapon is also recommended as a pre-plant soil treatment for soybean. However, the high rates of atrazine used with pre-emergence applications in corn result in the build-up of residues which adversely affect the ensuing crops of the rotation. The application of low rates of atrazine in such grain/legume rotation is desirable. The use of spray oils as an adjuvant in atrazine/dalapon mixtures would therefore be advantageous since the oil increases the post-emergence activities of atrazine. The current trial was conducted to determine the optimum levels of atrazine and dalapon, in an oil/water emulsion, consistent with proper weed control and good corn production under Chaguaramas conditions.

A simple randomised block design trial was conducted on weeds in corn (var. X-304B) grown at Tucker Valley, Chaguaramas. There were 14 treatments, replicated three times in three blocks and included four rates of a atrazine (0 to 2.24 kg. a.i. per hectare); in factorial combination with three rates of dalapon (0 to 1.12 kg. a.i. per hectare); giving 12 treatments, and two controls; an unweeded and a weed-free achieved by paraquat applications. The atrazine and/or dalapon were carried in oil/water emulsions, and applied post-emergence to the weeds and corn seedlings.

Increments of atrazine and dalapon up to 1.12 kg. a.i. per hectare suppressed weed growth; the spray oil/herbicide mixture with atrazine and dalapon at 1.12 kg. a.i. per hectare respectively was the most effective suppressor of weed growth. The blanket spray application of the herbicide/oil emulsion did not affect adversely plant stand and seedling growth. In fact, grain yield increased with increments of atrazine at the middle and high levels of dalapon. The mixture of atrazine and dalapon at 1.12 kg. a.i. and 0.56 kg. a.i. per hectare respectively in the oil/water emulsion seems to be the most suitable formulation.

INTRODUCTION

Weeds are of great economic importance in agricultural cropping programmes. In the absence of weed control measures, yield reduction as high as 70 percent has been reported for corn and soybean. Indeed total crop losses may be experienced when mechanical harvesting is made impossible due to choking of the combine harvester by ranked weed growth. Such occurrences have been reported in corn crops grown in Trinidad and Guyana, respectively. Atrazine and/or atrazine/dalapon in oil/water emulsions have proven quite successful as early post-emergence herbicide treatments in corn (Escaff, 1971; Hammerton, 1973; Kesasian, 1971). The oil/water emulsion carrier permits using lower chemical rates than for aqueous carrier, thus reducing the potential for atrazine residue which could adversely affect subsequent crops (soya, black-eye, oats, etc.) of the rotation. In an unreplicated trial at Tucker Valley, Chaguaramas in Trinidad, Gesaprim (atrazine at 2 kg./hectare) carried in Spraytex-CT/water emulsion gave the most effective weed control in field corn. The corn yields, however, were not ascertained. A further trial was therefore conducted at Chaguaramas to determine a suitable post-emergence herbicide formulation, using mixtures of atrazine and dalapon carried in Spraytex-CT/water emulsions, consistent with proper weed control and high corn yields. This paper describes the trial, and presents the results on weed-growth, crop-growth and grain yield.

MATERIALS AND METHODS

The trial was conducted on field corn (Variety X-304B) planted on River Estate sandy loam at Tucker Valley, Chaguaramas. A simple randomised block design was used with 14 treatments replicated three times in three separate blocks. The treatments included four rates of atrazine (0, 0.56, 1.12 and 2.24 kg. a.i. per hectare) in factorial combination with three rates of dalapon (0, 0.56 and 1.12 kg. a.i. per hectare) thus giving rise to 12 treatments in addition to a weed-free and an unweeded control. The weed-free condition was achieved by applying paraquat at the rate of 1.43 litres per hectare at weekly intervals in accordance with prevailing weed conditions. The atrazine and/or dalapon were carried in Spraytex-CT/water emulsions applied at the rate of 370.6 litres per hectare. The oil was 11 percent (40.8 litres per hectare) of the spray volume and the emulsifier (Sponto AC 60) 1 percent (0.8 litres per hectare) of the spray oil. The herbicide mixtures were applied broadcast, using a manually operated knapsack sprayer. The corn seedlings were about 18 cm tall and the weed about 3-5 cm tall at the time of spraying. The weeds infesting the corn field were *Cyperus rotundus, Rottboellia exaltata* and species of *Digitaria, Eleusine,* and *Amaranthus.*

RESULTS

Weed growth and corn growth were assessed four weeks after applying the herbicide treatments. The treatment effect on weed growth was highly significant (table 1), but that on corn seedling survival, phytotoxicity and growth respectively was not significant, basis the variance (F) ratio (tables 2, m and 4). Increased rates of atrazine and dalapon up to 1.12 kg. a.i. per hectare significantly suppressed weed growth. The mixture of atrazine and dalapon, each at 1.12 kg. a.i. per hectare give the best weed control, but was not significantly better than those of atrazine at 1.12 kg. and 2.24 kg. a.i. plus dalapon at 0.56 kg. a.i. per hectare, respectively. Atrazine at 1.12 kg. a.i. plus dalapon at 0.56 kg. a.i. per hectare carried in the Spraytex-CT/ water emulsion would therefore be the preferred formulation.

Table 1. Chaguaramas herbicide triel in field corn: mean treatment effect on weed growth

Atrazine (kg/ha.)	Dalapon (kg/ha.)		
	0	0.56	1.12
		(Weed Score*)	
0	8.4 e	1.6 ab	3.9 bcd
0.56	6.1 cde	6.2 cde	2.1 abc
12	3.0 abc	0.9 ab	0.1 a
2.24	3.0 abc	0.5 ab	2.8 abc
No Weeding = 7.9 ed		Weed Free = 0.1 a	

Figures followed by the same letters are not significantly different (5% level)

* — Weed Score:

0 = No weed	
1 = 1 to 10% weed	6 = 51 to 60% weed
2 = 11 to 20% weed	7 = 61 to 70% weed
3 = 21 to 30% weed	8 = 71 to 80% weed
4 = 31 to 40% weed	9 = 81 to 90% weed
5 = 41 to 50% weed	10 = 91 to 100% weed

Table 2. Chaguaramas herbicide trial in field corn: mean treatement effect on plant survival

Atrazine (kg/ha.)	Dalapon (kg/ha.)		
	0	0.56	1.12
		[No. of Plants/ha. ('000)]	
0	27.0 abc	24.8 abc	24.1 abc
0.56	27.5 abc	31.3 ab	21.8 bc
1.12	27.2 abc	25.4 abc	25.3 abc
2.24	32.5 a	18.9 c	32.6 a
No weeding = 18.5 c		Weed free = 27.9 abc	

Figures followed by the same letters are not significantly different (5% level)

Table 3. Chaguaramas herbicide trial in field corn: mean treatment effect on crop phytotoxicity

Atrazine (kg/ha.)	Dalapon (kg/ha.)		
	0	0.56	1.12
		(Phytotoxicity score)*	
0	0.7	0.3	0
0.56	0	0	1.0
1.12	0	1.0	1.3
2.24	0	1.0	0

No weeding = 0.3 Weed free = 0.7

* – Phytotoxicity score: 0 = No damage
1 = Slight
2 = Moderate
3 = Severe

Table 4. Chaguaramas herbicide trial in field corn: mean treatment effect on crop growth

Atrazine (kg./ha.)	Dalapon (kg/ha.)		
	0	0.56	1.12
		(Crop growth score)*	
0	2.3 ab	3.0 a	2.7 ab
0.56	2.7 ab	2.7 ab	2.7 ab
1.12	2.0 b	2.0 b	2.3 ab
2.24	3.0 a	2.3 ab	3.0 a

No weeding = 2.0 b Weed free = 2.3 ab

* – Crop growth Assessment: 1 = Poor growth
2 = Moderate growth
3 = Good growth

Figures followed by the same letters are not significantly different (5% level)

The corn cobs were harvested mid-October. The cob weight and grain weight respectively were determined, and the grain moisture content was 20 percent. Of the production parameters measured, only the grain yield was significantly affected by the herbicide treatments, basis the variance (F) ratio. At 0.56 kg. and 1.12 kg. a.i. dalapon per hectare, grain yields increased with increments of atrazine in the herbicide mixtures up to the third and fourth levels respectively

Table 5. Chaguaramas herbicide trial in field corn: mean treatment effect on corn yield

Atrazine (kg./ha.)	Dalapon (kg/ha.) 0	0.56	1.12
		(Grain yield tons/ha.)	
0	2.06 bcd	2.58 abc	1.76 cd
0.56	1.99 cd	2.78 abc	2.51 abc
1.12	1.62 cd	3.48 a	2.79 abc
2.24	2.70 abc	1.73 cd	3.31 ab
No weeding = 0.93 d		Weed free = 1.68 cd	

Figures followed by the same letters are not significantly different (5% level)

Table 6. Chaguaramas herbicide trial in field corn: mean treatment effect on cob production

Atrazine (kg./ha.)	Dalapon (kg/ha.) 0	0.56	1.12
		[No. of Cobs/ha. ('000)]	
0	20.2 bc	20.8 bc	16.8 bc
0.56	21.3 abc	23.3 ab	20.1 bc
1.12	16.9 bc	24.5 ab	20.1 bc
2.24	24.1 ab	13.4 c	30.5 a
No weeding = 13.5 c		Weed free = 17.4 bc	

Figures followed by the same letters are not significantly different (5% level)

(table 5). Also, the number of cobs harvested at 0.56 kg. a.i. dalapon per hectare and the cob weight at 1.12 kg. a.i. dalapon per hectare increased with increments of atrazine in the mixture up to the third level (tables 6 and 7 respectively). Conversely, the grain yields at all, except the highest levels of atrazine and cob weight at the second and third atrazine levels increased with dalapon addition to the mixture up to 0.56 kg. a.i. per hectare.

Table 7. Chaguaramas herbicide trial in field corn: mean treatment effect on cob weight

Atrazine (kg./ha.)	Dalapon (kg/ha.) 0	0.56	1.12
		[Cob Weight (gm)]	
0	106 abcd	138 ab	104 abcd
0.56	92 cd	119 abc	123 abc
1.12	100 abcd	144 a	140 a
2.24	116 abcd	121 abc	108 abcd
	No weeding = 79 d	Weed free = 94 bcd	

Figures followed by the same letters are not significantly different (5% level)

DISCUSSION

The trial results are similar to those of trials conducted by other workers with atrazine and/or atrazine/dalapon formulations on weeds in corn (Almodovar-Vega & Ilnicki 1970; Escaff, 1971; Hammerton, 1973). *Rotboellia exaltata* is the most serious weed at Onaguaramas, but its growth was adequately controlled by some of the herbicide formulations tested. In fact, increased rates of both atrazine and dalapon in the oil/water emulsion formulation increased the suppression of weed growth. The post-emergence activity of atrazine in particular is known to be increased by emulsifying the suspension with non-phytotoxic vegetable or mineral spray oils. Mixtures of the mineral and vegetable oils in herbicide formulations have given good control of grass weeds (Almodovar-Vega & Ilnicki , 1970). However, paraffinic oils of medium to high viscosity, and which are similar to the Spraytex-CT employed in the trial, are preferred (Kasasian, 1971) The oil content of the formulations used in the trial was 11 percent of the spray volume, but quantities as low as five percent have given satisfactory results. The oil's function in the formulation is to solubilize the waxy cuticle of the weed leaf thus facilitating the entry of the chemical into the plant's tissue (Peacock, 1970). The presence of the non-phytotoxic oils, therefore, results in a synergistic action causing lower rates of the chemical to produce similar effectiveness as higher ones in aqueous formulations. The chance of residue build-up and damage to subsequent sensitive crops of the rotation is therefore minimized when low rates of atrazine are carried in oil/water emulsions. The corn seedlings and plant stand were not adversely affected by the blanket spray applications. Directional spraying of the atrazine/dalapon in oil/water emulsion formulation is therefore unnecessary. Aircraft application of such herbicide formulations with appropriate reduction in the carrier volume is therefore a distinct possibility for large-scale operations.

The seed for follow-up trials of this nature at Chaguaramas and elsewhere is quite evident. However, on the basis of the current results, atrazine at 1.12 kg a.i. plus dalapon at 0.56 kg a.i. per hectare carried in an oil/water emulsion are recommended for use until enlightened by future experience.

ACKNOWLEDGEMENT

The authors are indebted to (1) the Authorities of the Chaguaramas Agricultural Development Project for providing the facilities for conducting the trial and for permitting the publication of the results, and (2) to Texaco Trinidad, Inc., for providing the spray oil.

REFERENCES

Almodovar-Vega, L. and Illnicki, R.D., 1970. Enchancing atrazine activity with the additions of mineral and vegetable oils. Northeastern weed control Conf. Proc. 24, 31 and 32.

Escaff, G.M. 1971. Trop. Abstr. 26, u853.

Fink, R.J. 1970. Crops Soils 22(4); 18-19 in PANS 17:74.

Hammerton, J.L. 1973. Weed control work in progress at the University of the West Indies, Part 3, PANS 18:383.

Kasasian, L. 1971. Weed control in the tropics, Leonard Hill, London.

Peacock, J.F. 1970. Enhancement of foliar penetration and herbicide activity by oils. Ph.D. Thesis, South Dakota State University, Brookings.

NAME OF PAPER: Effect of Post-Emergence applied Atrazine/Dalapon/Oil Mixture on Weed Growth and Corn Productivity. (C.A.L. Phillips)

Question by: Bruce Lauckner
Country: Barbados

QUESTION: What is the reason for the poor performance (high weed growth, poor plant survival, poor yield etc.) for the corn treated with 2.24 kg/ha Atrazine and 0.56 (kg/ha) Dalapon?

ANSWER: Distribution of weed species in the trial area was very variable. The relatively high incidence of weed in plots receiving high levels of Atrazine and Dalapon was due to that of *Cyperus rotundus* which the chemicals did not control on those plots.
Poor plant survival and poor yields may have been due to inherent soil plot variation and not a treatment effect.

WEED CONTROL IN CORN *(ZEA MAYS L.)* AND PEANUTS *(ARACHIS HYPOGAEA L.)* IN THE CARIBBEAN

John L. Hammerton*
CARDI – BELIZE

SUMMARY

The importance of weeds in reducing corn and peanut yields, and the need for control of weeds early in the crops' lifespan are stressed. Some of the advantages and disadvantages of herbicides vis-a-vis manual methods for the smaller farmers are discussed. A tentative list of the major weeds of arable land in the Caribbean Region comprises nine grass species (or genera where several species of a genus are important), four broad-leaved species or genera, and *Cyperus rotundus* (nutgrass). Nine herbicides are recommended for corn, and nine for peanuts, of which two are provisional recommendations. Interactions of weed control, particularly by herbicides, with rainfall and soil moisture conditions and with several agronomic factors are discussed, and finally the importance of developing production packages to include weed control as an integral part is emphasized.

INTRODUCTION

Weeds compete with crop plants for mineral nutrients, water and light, thereby reducing yields. Expenditure on weed control increases the cost of production. Weeds interfere with reaping and may reduce the quality of the harvested product, perhaps necessitating additional cleaning and drying. Control of weeds is therefore basic to attempts to increase yields and improve farm incomes.

There is wide variation in the level of weed control technology practised in the Caribbean Region. Corn and peanuts are both grown by traditional methods, with zero or very small inputs of purchased materials, using manual labour for land preparation, seeding, weed control and reaping. At the other extreme corn is grown with full mechanisation of all operations, using herbicides and mechanical interrow cultivations for weed control. I am not aware of any large-scale mechanised production of peanuts in the Region. Between these extremes are various combinations of herbicide usage plus hand-hoeing or hand pulling for weed control, or of mechanised inter-row cultivation plus manual work.

EFFECTS OF WEED ON CORN AND PEANUTS

Unweeded plots of peanuts gave yields that were 31, 52, 50 and 14% of those of clean-weeded plots in a series of four experiments carried out in Jamaica (Hammerton, 1976a). The difference in the magnitude of the loss due to weeds was due to difference in the density and competitiveness of the weed floras, and probably also to differences in rainfall and irrigation frequency. In two of these experiments seed number per pod was significantly less in the

* Address: CARDI, Ministry of Agriculture and Lands, Belmopan, BELIZE C.A.

unweeded plots and mean dry weight per seed was also significantly reduced by weeds in one experiment.

Unweeded plots of corn gave only 26% of the yield of clean-weeded plots, averaging over three years in experiments carried out in Mexico (Nieto, 1959). In Ghana, values of 70% and 27% were reported for two trials (Ruinard, 1966) but the former was based on fresh weight of cobs including husks. In the second trial in Ghana grain weight per cob was almost halved when weeds were not controlled.

These examples serve to illustrate that the loss due to weeds can vary widely, so that the benefits from weed control will also vary. The economic implications are clear: more money (or physical effort) can justifiably be spent to control a weed infestation likely to cause large losses than to control an infestation that will give only a small loss of yield. Judgement, and a knowledge of the weediness of the land, are necessary in order to decide what expenditure for weed control can be justified.

But weed control is seldom totally neglected. Traditional manual control of weeds is often done too late however to prevent some loss of yield. For annual or short-term crops there is a "critical period" during which competition from weeds will reduce yields, even though subsequent control of weeds is good. This "critical period" is approximately the first one third of the crops' lifespan (Kasasian & Seeyave, 1969).

In peanuts, for example, maintaining weed-free conditions for 40 or 60 days from pre-emergence gave yields similar to those obtained from plots kept weed-free throughout (table 1). Weed growth from 40 days onward was relatively sparse because the crop had an almost completely closed canopy and competed with the weeds. Those weeds that did appear did not interfere with reaping. Conversely, delaying weed control until 40 days reduced yields by 30% compared with clean-weeded plots. In this experiment weed dry weights were 605 kg/ha at 20 days and 3150 kg/ha at 60 days.

Table 1. Effects of time-of-weeding and duration of weed control on the yield of peanuts *(Arachis hypogaea* L.). (Figures in parenthesis are percentages with the yield of the weed-free throughout treatment = 100)

Weed-free conditions maintained for the first	Yield (in shell) kg/ha[1]	Weed-free conditions maintained from	Yield (in shell) kg/ha[1]
20 days[2]	1735b[3] (83)	20 days[2]	1965ab (94)
40 days	1965ab (94)	40 days	1460c (70)
60 days	1930ab (92)	60 days	1180d (56)
Weed free (clean-weeded) throughout	2090a (100)	Weedy (unweeded) throughout	625e (30)

[1] at 88%dry-matter [2] days from crop emergence

[3] means with a letter in common do not differ significantly (P=0.05) by multiple range test.

Source Hammerton *1976a)

In corn, delaying weeding until 25 days after sowing reduced yields by 15%, and yield reductions increased with further delays in commencing weed control (table 2). In these experiments it was necessary to maintain weed-free conditions for 35 days in order to obtain a obtain a yield comparable to that of the clean-weeded plots. Ruinard (1966), in Ghana compared no weeding with bad weeding and good weeding yields of dry corn in one trial were respectively 0.68, 1.78 and 2.48 tons per ha.

Table 2. Effect of time-of-weeding and duration of weed control on the yield of corn. Values are means over three years. (Figures in parenthesis are percentages, with the yield of the weed-free throughout treatment = 100)

Weed-free conditions maintained for the first	Yield of grain kg/ha	Weed-free conditions maintained from	Yield of grain kg/ha
15 days[1]	3325 (78)	15 days[1]	4013 (94)
25 days	3636 (85)	25 days	3607 (84)
35 days	3965 (93)	35 days	2047 (48)
45 days	4182 (89)	45 days	1314 (31)
weed-free (clean-weeded) throughout	4278 (100)	Weedy (unweeded) throughout	1109 (26)

[1] Days from sowing
Source: Nieto (1959)

The above results suggest that any herbicide treatment or weed control regime, should give good control of weeds for between 35 and 40 days at least — or for the first one-third of the crops lifespan. These findings also indicate why preplant incorporated (ppi) and pre-emergence (pre-em) herbicide treatments are so useful because they control weeds from crop emergence. Post-emergence (post-em) treatments, and manual or mechanised cultivations for weed control, must await emergence and growth of the weeds and crop, and competition may have already reduced yields by the time weeds are controlled. This is not to disparage such methods, but to emphasize that they should be employed as early as is practical.

Apart from direct effects on yields, weeds can interfere with both hand and mechanical reaping. Weeds may also interfere with field curing of peanuts in windrows, perhaps increasing the danger of aflatoxin development. Weed fragments in harvested product reduce quality, may result in heating and spoilage, and may necessitate artificial drying and additional cleaning. Weeds may also harbour pests and diseases of both corn and peanuts.

TRADITIONAL MANUAL METHODS VERSUS HERBICIDES

It is tempting to equate modern weed control technology with herbicides. While herbicides can be of value to the small peasant farmer (Hammerton, 1974a) manual methods should not be neglected. We should also bear in mind that a majority of Caribbean farmers are "small" farmers with limited funds and limited access to credit.

Some advantages of manual methods (e.g. hoeing, pulling, macheting) are:-

a. They can be totally effective and totally selective. That is to say they can give 100% control of all weed species, with a minimum of crop damage.
b. They involve no cash outlay for special equipment (e.g. sprayers) or materials. The only outlay may be to replace tools, and if labour is hired. In many cases the farmer and his family will provide the manual labour needed.
c. They avoid the need to carry water (for spraying) which may be available only at some distance. Water is both heavy and awkward to carry. Granular herbicides would avoid the need for water, but do not seem to be available in most of the Caribbean, perhaps because of shipping bulk.

Advantages of herbicides, over manual methods, include the following:-

a. They can give control of weeds during the "critical period" often more effectively than manual methods, and also earlier, when hoeing may be difficult because crop seedlings are small and obscured by weed growth.
b. They are often more effective when wet soils or frequent rain render manual methods impractical or ineffective.
c. They require less labour for application than is required by manual methods. The farmer may therefore be able to cultivate a larger area, grow another crop or seek off-farm employment. Even if herbicidal control is only partially effective, the supplemental hoeing required will be less than if no herbicide had been used.

I have deliberately digressed from the topic of corn and peanuts to emphasize that herbicides are not necessarily appropriate for all small farmers. It is up to extension workers to devise systems of weed control, perhaps including herbicides, to suit the needs of small farmers. My own view is that granular herbicides would be much more useful to the small farmer than herbicides which must be applied by sprayer.

MAJOR WEED SPECIES

There are inadequate data to identify these species that are particularly serious weeds of corn and peanuts in the Caribbean Region. The factors that demarcate a serious weed include:-

a. rapid growth and agressiveness as a competitor
b. fecundity of seed production or an effective method of vegetive propagation
c. tolerance to, or ability to rapidly recover from, control measures.

Based on these criteria, using my own experience, and with reference to Adams, Kasasian and Seeyave (1970), Cardenas, Reyes & Doll (1972), Garcia et al. (1975) and Holm et al. (1977), table 3 was prepared. The listing is in alphabetical order and in some instances genera rather than individual species are listed. It is worth noting the preponderance of grasses, along with the "world's worst weed", *Cyperus rotundus* (Holm et al. (1977). Most of the weeds listed are, of course, common to many crops, but Holm et al. (1977) lists *C. rotundus, E. indica, E. colonum and Digitaria sanguinalis* as the four most important weed of corn, and *E. indica, C. rotundus, D. sanguinalis* and *P. oleracea* as the most important weed of peanuts.

The territories of the Caribbean no doubt differ in their major weed of corn and peanuts, so that table 3 can be only a summary of the major weeds.

Table 3. A list of major weed species of the Caribbean Region, with an indication of habit and main method of reproduction.*

Scientific name for authorities Holm et al. (1977)	Broad-leaved	Grass	Sedge	Annual	Perennial	seeds	Vegeta-tive
Amaranthus spp.	x			x		x	
Bidens pilosa	x			x		x	
Brachiaria mutica		x			x		x
Cenchrus echinatus		x		x		x	
Cynodon dactylon		x			x	*?	x
Cyperus rotundus			x		x	?	x
Digitaria spp.		x		x	x	x	?
Echinochloa colonum		x		x		x	?
Eleusine indica		x		x		x	
Euphorbia spp.	x			x		x	
Panicum spp.		x			x	x	x
Paspalum spp.		x		x	x	x	x
Portulaca oleracea	x			x		x	?
Rottboelia exaltata		x		x		x	

*? indicates a secondary, relatively unimportant, or doubtful method of reproduction. Note that some weeds *(eg. Panicum spp.)* reproduce both by seed and vegetatively. Some *Digitaria* and *Paspalum spp.* are perennials, and some "annuals" can root at the nodes and behave es perennials.

HERBICIDE RECOMMENDATIONS

Of the many herbicides that can be used in corn and peanuts, those listed in tables 4 and 5 represent, to some extent, a personal selection, based on experience and on reports and summaries (Feakin, 1973; Hammerton, 1974b; Kasasian, 1971; Kasasian, & Seeyave, 1968).

Table 4. A list of recommended herbicides for use in corn *(Zea mays* L.) in the Caribbean Region

Common name[1]	Proprietary name[2]	Application method[3]	Application rate kg/ha a.i.[4]
alachlor	Lasso	pre-em	3.0 - 3.5
atrazine	Gesaprim	pre-em	2.5 - 3.0
ametryne	Gesapax	pre-em	1.5 - 2.5
butylate	Sutan	ppi	3.5 - 4.5
cyanazine	Bladex	pre-em	2.5 - 3.0
2,4-D		post-em	0.5
dalapon	Dowpon	directed	5.0
dicamba	Banvel	post-em	0.5
EPTC + safener	Eradicane	ppi	3.0 - 4.0 (total)

[1] Follows Martin & Worthing (1977)

[2] Only the original or commonest name is given. For many herbicides there are several proprietary names, and for 2,4-D there are numerous names.

[3] ppi = preplant incorporated, pre-em = pre-emergence, post-em = post-emergence, directed = post-em but kept off the crop.

[4] a.i. = active ingredient.

2,4-D and dicamba are post-em herbicides for control of broad-leaved weeds only in corn (table 4). They require a few hours of dry weather after spraying in order to be effective. Corn should suffer no damage from overall sprays of these materials at early stages of growth, but 2.4-D may cause some damage if applied overall after cobs have begun to develop. Directed sprays should then be used. These herbicides are most effective when weeds are small — not more than 3 or 4 inches high. 2,4-D can give temporary chlorosis and control of nutgrass. Formulations of dicamba with 2,4-D or MCPA are also marketed and can be used in corn.

Atrazine and cyanazine are essentially similar, controlling a wide range of broad-leaved weeds, annual grasses and seedlings of some perennial grasses, but giving little or no control of perennial grasses or nutgrass from vegetative propagules. Atrazine can be used as a directed post-em spray in oil (Stoddard Solvent or Kerosene) or as an oil-in-water emulsion at 0.6 — 0.8 kg/ha active ingredient (a.i.) for control of grasses and broad-leaved weeds. Ametryne can also be used in this way, but in water plus 0.5% surfactant to give foliar absorption. Dalapon can be used as a directed post-em spray for grasses only, but not when soil conditions are wet.

Table 5. A list of recommended herbicides for use in peanuts *(Arachis hypogaea* L.) in the Caribbean Region

Common name[1]	Proprietary name[2]	Application method[3]	Application rate kg/ha a.i.[4]
alachlor	Lasso	pre-em	3.0 - 3.5
benfluralin	Balan	ppi	1.25 - 1.5
diphenamid	Dymid	pre-em	2.5 - 3.0
metobromuron	Patoran	pre-em	2.0 - 2.5
napropamide[5]	Devrinol	ppi	2.0 - 4.0
naptalam + DNBP	Dyanap	Cracking	4.0 - 5.0 (total)
penoxalin [5,6]	Prowl	ppi	1.0 - 2.0
prometryne	Gesagard	pre-em	1.0 - 1.5
vernolate	Vernam	ppi	2.5 - 3.0

[1]Following Martin & Worthing (1977)

[2]Only the original or commonest name is given

[3]See footnotes to table 4, cracking = application as peanut seedlings are emerging or cracking the soil surface

[4]a.i. = active ingredient

[5]A provisional recommendation: requires further testing

[6]The WSSA common name. The chemical name is N- (1 - ethylpropyl)- 2,6-dinitro - 3,4-xylidine.

Butylate and EPTC + safener both give temporary control of nutgrass. Because of their volatility they require immediate incorporation by rotavation or discing. Haste is particularly necessary if the soil surface is moist at the time of spraying. Both butylate and EPTC + safener control a wide range of broad-leaved weeds and grasses originating from seed, as well as checking perennial grasses and nutgrass. EPTC alone (proprietary name Eptam) is toxic to corn unless an interval of at least a week elapses between incorporation and sowing. Addition of the safener (NN – diallyldichloroacetamide) protects the corn against EPTC damage.

Alachlor gives excellent control of many annual grasses and of some broad-leaved weeds, but is poor on perennial grasses (unless from seed) and on nutgrass. Mixtures of alachlor and atrazine, at the half-rate for each, have an enhanced weed "spectrum" (i.e. the range of weed species controlled). In very weedy situation it may be necessary to use sequences, such as ppi butylate or pre-em alachlor/atrazine, followed by post-em ametryne or 2,4-D or dicamba or mechanical inter-row cultivation or, hand-hoeing.

At the rates given in table 4 residues of ppi or pre-em herbicides should not damage subsequent susceptible crops. Both 2,4-D and dicamba pose a drift hazard to nearby susceptible crops such as legumes, bananas and vegetables. Amine formulation are less volatile and so give less vapour drift, but every care must be taken to avoid spray drift by choosing a windless time of day for application.

For peanuts benfluralin and vernolate both require immediate incorporation to be effective.

They give good control of many grasses and some broad-leaved weeds: vernolate is better for control of the latter, and gives some control of nutgrass. A mixture of the two herbicides, each at a half-rate has an enhanced spectrum.

Naptalam + DNBP is most effective if applied as the peanuts are just emerging or "cracking" the soil. The DNBP component will control most seedling weeds present at "cracking". Application at the correct time requires daily inspection to detect the start of "cracking". The mixture controls a wide range of both grass and broadleaved weeds. DNBP is extremely toxic to mammals, so the mixture must be handled with great care. Diphenamid gives poor control of broad-leaved weeds, and is probably best used in combination with prometryne (at 2.0 – 2.5 kg/ha diphenamid plus 0.6 – 0.75 kg/ha prometryne). The latter should not be used at more than 1.25 kg/ha a.i. although at this maximum rate control of grasses may not be very good. Napropamide is effective against many annual grasses and some broad-leaved weeds. It can be applied as pre-em but should then be followed by irrigation unless rain falls within a few days. Metobromuron has a weed spectrum similar to that of alachlor and napropamide. Penoxalin (the WSSA approved common name) merits further investigation in peanuts: its performance is better when incorporated than when applied pre-em. It may also have uses in corn.

Three additional herbicides that may be useful in peanuts, but for which experience is lacking in the Caribbean, are butachlor (Machete), chlorbromuron (Maloran) and oxadiazon (Ronstar). Bentazon (Basagran) may also be useful as a post-em treatment in both corn and peanuts, but testing is needed.

Some small effects of herbicide treatments on mean seed dry weight have been reported (Hammerton, 1976a), but there is no evidence that herbicide treatments significantly affect the market quality of peanuts (Hauser, Santelmann & Buchanan, 1970).

The higher of the rates given in tables 4 and 5 are for heavy soils and the lower for lighter soils. Unless a lower rate is used on light soils, crop damage may result. The rates given are for over all treatment: if "banding" is used (i.e. application to a band of soil straddling the row of seeds) the rate must be reduced pro rata. For instance, if a 30cm band is to be treated (i.e. 15cm either side of the crop row) and row spacing is 90cm, one-third of the rates shown will be needed, since only one-third of the soil surface is to be sprayed. Banding saves money on herbicides but is only practical with mechanical seeding, when seeding, band-sprayed, and perhaps fertilizing, are done with a single rig in one pass. Weed growth between the band-sprayed strips must be controlled by inter-row cultivations, using either drop-tines, rolling cultivators or rotary hoes. Inter-row cultivation will often be necessary, even with overall herbicide application, to control resistant weeds or to control weeds that emerge when herbicide residues are no longer toxic to weeds. As an alternative to inter-row cultivation in corn post-em herbicide application of ametryne, 2,4-D, dalapon or dicamba can be made. Weeds that emerge within, or close to, the crop row can only be controlled by hand-heing or by directed, spot or overall application of 2,4-D or dicamba. These two herbicides however will only control broad-leaved weeds. A vigorous crop of corn will often compete with, and suppress, weeds within the row. In peanuts care is necessary not to damage branches or to disturb gynophores by inter-row cultivations. These must cease once the crop has begun to spread.

Most, but not all, of the herbicides mentioned, are available in more than one formulation – as wettable powders, flowables, emulsifiable concentrates and/or granules. There is no difference in efficacy between formulations at the same rate of active ingredient (a.i.). Careful attention must be given to the directions on the label, and care must be exercised in calculating the amount of formulated product required to give the desired rate of active ingredient. All herbicides should be stored in a cool, dry, well-ventilated place and kept under lock-and-key. Every care should, of course, be exercised in handling herbicides to avoid ingestion, inhalation and splashes onto skin or into eyes.

It will be clear from the above that perennial grasses and nutgrass are the most difficult to control with herbicides, and are often hard to control with inter-row cultivation. Where these are serious it may be desirable to use a dry-fallow (i.e. regular cultivation during the dry season to desiccate vegetative propagules) or to spray a vigorous growth of the weeds with glyphosate (Round-up), at 1.5 - 2.0 kg/ha a.i., before attempting to grow a crop of corn or peanuts.

Where the seedbed has been prepared, but rain has delayed seeding, and many seedling weeds have emerged, paraquat (Gramoxone) at 0.25 to 0.5 kg/ha a.i., can be added to pre-em sprays to give a rapid "knockdown" of these seedling weeds. Paraquat can also be used as a very carefully shielded spray, if wet weather prevents inter-row cultivation, and the intervals between rain are insufficient to enable post-em ametryne, 2,4-D or dicamba to be effective, since paraquat is effective with a much shorter period of dry weather.

If soil conditions are relatively dry, or if only light rainfall is anticipated following herbicide application, pre-plant incorporation can improve the efficacy of herbicides such as alachlor, atrazine and cyanazine. Further work on the safety of these materials when incorporated is necessary.

WEED CONTROL INTERACTIONS

The major factors likely to influence herbicide performance in corn and peanuts are discussed briefly below.

a. Rainfall and soil moisture. Most soil acting herbicides (i.e. those applied ppi or pre-em) are relatively insoluble in water, but nevertheless require soil moisture if they are to be taken-up by germinating weed seedlings. The solubilities of atrazine and benfluralin, in water for example are, respectively 33 ppmw (at 27^{o}c) and $<$ 1 ppmw (at 25^{o}c) (WSSA, 1974). Equally, soil moisture is necessary for weed seed germination: dormant ungerminated seeds cannot be killed by herbicides. If the soil surface is dry at the time of spraying pre-em herbicides, the herbicide will remain there and not go into solution. Crop and weed seeds may then germinate in the moister subsurface soil, and the seedlings emerge unharmed. Rain would activate the herbicide, and, provided the weed seedlings were not too large, should give control of susceptible species. It is preferable to spray pre-em herbicides onto moist soil, or to seed and spray when rain is anticipated, or to irrigate following seeding and spraying, or to shallowly incorporated (as a preplant treatment) to ensure that the herbicide is located in moist soil.

Rain closely following post-em spraying will generally reduce the effectiveness of such sprays, the reduction being greater the shorter the interval between spraying and the rain. Normally 4 or 5 hours dry weather are desirable for full effectiveness. An exception is paraquat, which because of its adsorption onto plant surfaces and its rapid absorption into the plant, is fully effective with no more than half an hour of dry weather.

Wet soils prevent inter-row cultivation, and rain following such cultivations will usually reduce their effectiveness by enabling many weeds – particularly grasses – to re-establish. Post-em herbicides, applied by knapsack sprayer if necessary, can be useful in such situations, provided a sufficient spell of dry weather to ensure effectiveness, can be found.

b. Varietal differences in susceptibility to herbicides. As far as I am aware significant differences among commercially available corn and peanut varieties in their tolerance to recommended rates of herbicides, have not been reported. Occasionally, symptoms of herbicide damage, usually evident as a partial chlorosis or stunting, may be observed following unusual weather conditions. these symptoms are usually temporary and are not a varietal effect.

c. Sowing depth. Deep sowing of corn or peanuts, by increasing the time during which the shoot is growing through herbicide — containing soil may increase herbicide uptake, resulting in some temporary symptoms of toxicity. Deep sowing in itself is likely to reduce crop emergence, a result which is sometime unjustly attributed to herbicide damage.

d. Crop plant spacing. Competition from the crop can influence the level of weed control achieved by herbicides (Hammerton, 1967, 1970). A higher crop plant population, and increased squareness of spacing, can materially improve weed control by intensifying competition from the crop canopy. Thus in a spacing experiment with peanuts (Hammerton, unpublished data), using the fan design of Nelder (1962), no hand weeding was necessary at the closer spacings, following pre-em alachlor, because the crop canopy was closed within 3 or 4 weeks of sowing. At reaping, the land was free of weeds beneath these close spacings. On the other hand, several weedings were necessary at the wider spacings where the crop canopy did not close for 10 or more weeks.

Close row spacings and higher plant populations prevent inter-row cultivations for weed control. Unless the land is known to be relatively weed-free it is advisable to retain the option of cultivation for weed control, by using wider rows, in case the herbicide treatment is only partially effective. Furthermore, the rainfall may not be adequate to sustain a greatly increased plant population, and the increased population may not be economic, when the additional costs of establishment are weighed against the increases in yield and additional harvesting costs.

e. **Cultivations.** Inter-row cultivations for weed control should be kept as shallow as possible. Deep cultivations may bring up dormant weed seeds and propagules to where they can germinate. Furthermore deep cultivation will dilute the herbicide residues in the surface layer, thereby reducing the residual weed control activity and may damage crop roots.

Moulding-up of corn may bury, and therefore kill, small weeds growing in, or close to, the crop row. In peanuts the practice is no longer favoured in the U.S.A. (Hauser, Santelmann & Buchanan, 1970) as it can increase the incidence of *Sclerotium rolfsii* and reduce yields. Moulding reduced the yield of peanuts in an experiment in Jamaica, at least in the absence of the growth regulator B-9 (Hammerton, 1976b). Moulding can also damage branches and disturb gynophores.

SYNTHESIS AND CONCLUSIONS

Weed control has tended to be regarded as an "optional extra" and not as an integral part of a total production package. Perhaps this is because damage from weeds is less obvious than damage from diseases or insects, and because it was always possible to send in labour to weed, if the weeds became really bad, albeit that this was often done late, when loss of yield had already occurred. Farmers, both large and small, must be persuaded to recognize weeds as a serious problem, and to plan ahead for their control. A difficulty in encouraging farmers to use ppi and pre-em herbicides is that the investment in materials and their application must be made before the weeds have appeared. Many farmers perhaps hope that the weed problem will not be too bad, and prefer to "wait and see". A proper approach to weed control in corn and peanuts on normally weedy land, should be to use ppi or pre-em herbicides, having available for early post-em use post-em herbicides and/or equipment for inter-row cultivation. A good post-em herbicide for peanuts is urgently needed.

I would suggest that the ultimate in peanut production would be close row spacings (ca. 25 cm) with seeds sown not more than 15 cm apart. Wheel ways adapted to the tractor's wheel track and width of spray boom would be needed, or pathways spaced so as to allow complete crop coverage by knapsack sprayers or mistblowers, so that a pre-em herbicide and post-em fungicide and insecticide treatments could be applied. The row spacing would preclude inter-row cultivation for weed control, so a proven ppi or pre-em herbicide would be essential (backed up by a post-em herbicide if and when available). Lifting and windrowing equipment would need to be developed to handle these close rows, and it might be necessary to use raised beds containing several rows to facilitate lifting.

In conclusion, I hope this paper will stimulate interest in better weed control not solely by herbicides, but by developing integrated packages.

REFERENCES

Adams, C.D., Kasasian, L. & Seeyave, J, 1970. Common Weeds of the West Indies. Univ. West Indies, St. Augustine, Trinidad.

Cardenas, J., Reyes, C.E. & Doll, J.D, 1972. Tropical Weeds (Malezas Tropicales) Vol. 1. Internat. Plant Protection Center, Oregon State University, Corvallis, Oregon, U.S.A.

Feakin, S.D. (Ed.), 1973. Pest Control in Groundnuts. PANS Manual No. 2 (3rd Ed). Centre for Oversease Pest Res., Foreign & Commonwealth Office. Overseas Devel. Admin., London.

Garcia, J.G.L., Mac Bryde, B., Molina, A.R. & Herrera – MacBryde. O., 1975 Malezas. Prevalentes de America Central (Prevalent Weeds of Central America). Internat. Plant Protection Centre, Oregon State Univ., Corvallis, Oregen, U.S.A.

Hammerton, J.L., 1967 Environmental factors and susceptibility to herbicides. Weeds, 15: 330-336.

Hammerton, J.L., 1970. Crop seed-rate and MCPA effectiveness. Weed Res., 10: 178-180.

Hammerton J.L. 1974a. Problems of herbicide use in peasant farming. Internat. Plant Protection Center, Oregon State Univ., Corvallis, Oregon, U.S.A.

Hammerton, J.L., 1974b. Herbicides: a Guide to Terminology, Properties and Uses. Ext. Bull. No. 9, Univ. West Indies, St. Augustine, Trinidad.

Hammerton, J.L., 1976a. Problems of herbicide assessment in peanuts in Jamaica. Weed Res., 16:27-35.

Hammerton, J.L. 1976b. Effects of B-9 (N - dimethyl-aminosuccinamic acid) on growth and yield of peanuts *(Arachis hypogaea L.)* J. agric. Sci., Camb., 86:211-218.

Hauser, E.W., Santelmann, P.W. & Buchanan, G.A., 1970. Weed control methods, losses and costs due to weeds and benefits of weed control in peanuts. In 1st FAO Internat. Conf. on Weed Control. Davis, Calif., U.S.A. pp. 16.

Holm, L.G., Plucknett, D.L., Pancho, J.V. & Herberger, J.P., 1977. The Worlds Worst Weeds. Distribution and Biology. Univ. Press Hawaii, Honolulu.

Kasasian, L. 1971. Weed Control in Tropics. Leonard Hill, London.

Kasasian, L. & Seeyave, J. 1968. Weedkillers for Caribbean Agriculture. Univ. West Indies, St. Augustine, Trinidad.

Kasasian, L. & Seeyave, J., 1969. Critical periods for weed competition. PANS, 15:208-212.

Martin, H. & Worthing, C.R. (Eds.), 1977. Pesticide Manual (5th Ed.). Brit. Crop Protection Council.

Nelder, J.A., 1962. New kinds of systematic designs for spacing experiments. Biometrics, 18: 283-307).

Nieto, J., 1959. Elimine las hierbes a tiempo. Agricultura Tecnica, 9:16-19.

Ruinard, J. 1966. Notes on the importance of proper husbandry in some tropical crops. Neth. J. agric. Sci., 14:263-279.

WSSA 1974. Herbicide Handbook of the Weed Science Society of America (3rd Ed.) Weed Sci. Soc. Amer., Champaign, Illinois, U.S.A.

MICRO-ECONOMIC ASPECTS OF MAIZE IN SURINAM IN RELATION TO IMPORT SUBSTITUTION

A.W. Graanoogst

INTRODUCTION

In Surinam maize is grown mostly as a catchcrop after clearing virgin or secondary forest. Most of the area planted with maize consists of small plots (0.1 – 0.5 ha) with a few plots larger than 2 ha. Total acreage amounted to ± 100 ha in 1977, with a total production of 210 tons dry crops; local production is used as poultry feed; small amounts are prepared as cooked corn (green corn) and maize meal. Total import amounts to 23,000 tons of grains (1977).

PRODUCTION TECHNIQUES AND COST OF PRODUCTION

Local production technique is still on a primitive level. After clearing and burning the forest, maize is planted as the first crop. Thereafter the area is used for other crops (ground provisions; vegetables, pulse).

There is a minimum of tillage (cutlass or hoe): sowing, weeding and harvesting are done by hand; no fertilizer and pesticides are applied. Yields of the plots with this traditional cropping system are very low (750-1200 kg/ha).

Apart from the system mentioned above there are a few farms where maize is regularly planted once a year or once in two years. Mechanization of seedbed-preparation is becoming an often used practice on these farms, due to the increasing labor costs. Also more attention is paid to the crop on these relatively larger farms, resulting in higher yields (up to 1800 kg of grains/ha).

- Production costs for the traditional system ranges from Sf 935 – Sf 1035/ha.
  With the low yields which are obtained on these plots the cost per kg varies from Sf 1.00 – Sf 1.10/kg (grain).

- Mechanization of seedbed preparation and the application of fertilizers as is done by the few farmers holding larger plots results in production costs of ± Sf 0.29 per kg (grains).

- A couple of field experiments were carried out by the Ministry of Agriculture, where more emphasis was laid on the mechanization aspects and the aspects concerning plant nutrition and plant-protection. These experiments resulted in a cost-price for grain corn of ± Sf 0,29 per kg (grains).
  Those experiments included the following activities:
  a. seedbed preparation with 2 and 4-wheel tractors
  b. sowing by 1-row handsower
  c. thinning and plant replacement with machete
  d. fertilizing by hand
  e. weed and insect control with knap-sack sprayer
  f. harvesting by hand
  g. treshing by mobile field-tresher (Borgia).

A total of 38 man-days were needed for the 1 ha-crop (except seedbed preparation and field control).

COST OF PRODUCTION IN RELATION TO IMPORT SUBSTITUTION

With reference to the national development target of import-substitution of agro-imports and bearing in mind the existing import price of maize (grains), the results of the above-mentioned experiments should be subject for further study.

Compared with the traditional cropping system and the system whereby only seedbed preparation is done with machines, the latter appears promising.

MAIZE PRODUCTION THROUGH PROJECT-DEVELOPMENT

As a consequence of the still existing constraints (e.g. plant protection, crop rotation), no commercial large-scale operations of maize-growing can be expected in the nearest future. This does not mean that the acreage of the individual small-holders cannot gradually increase.

Bringing at the farmers disposal the necessary imputs such as machinery and implements, intensive extension services, marketing and credit facilities, will in short term certainly result in a gradual increase of local maize production of up to 1000 hectares (2500 tons = 10% of imports). An important role should be played by pilot farms (eq. Tijgerkreek, L.O. Commewijne) providing inputs and marketing services to surrounding farmers in an outgrower setting. Besides, such a setting offers opportunities to conduct further practical studies on aspects of further mechanization, co-operation, farm size and income crop rotation.

This and the exploitation of one or two pilot-farms in the interior can provide further useful data for projects of middle and large scale maize operations.

List of tables

Table 1. Regional division maize acreage and production (1973 – 1977)

District		1973	1974	1975	1976	1977
Commewijne	(ha)	21.6	20.1	10.5	7.1	16.9
	(ton)	36.6	37.3	21.4	6.6	33.2
Coronie	(ha)	29.4	37.0	34.0	37.0	15.0
	(ton)	43.9	66.2	60.0	66.2	22.6
Marowijne	(ha)	16.6	–	21.8	17.0	46.4
	(ton)	49.6	–	64.0	19.0	108.9
Suriname	(ha)	11.7	7.0	10.4	3.8	8.0
	(ton)	23.8	10.7	9.5	3.6	18.1
Saramacca	(ha)	59.7	54.0	65.2	30.0	–
	(ton)	94.0	73.3	115.7	36.4	–
Para	(ha)		2.3			
	(ton)		5.9			
Totaal	(ha)	139	120.4	141.9	94.9	86.3*
	(ton)	247.9	193.4	270.6	131.8	182.8

* dried cobs

Source: Ministry of Agriculture
Agro-Economic Division

Table 2. Imports of maize

1975	17.000 tons*	value Sf 3.40 million
1976	22.000 tons	value Sf 4.35 million
1977	23.000 tons	value Sf 5.18 million

*yellow corn unmilled

Source: USDFA Service
American Embassy in Surinam

Table 3. Estimate of inputs and production costs (traditional system)

	mandays per		costs per
	ha	acre	ha
seedbed preparation and sowing	25	10	Sf 375,–
weeding	20-30	6-12	Sf 300, – Sf 400,
picking and hurking	12	5	Sf 180, –
drainage	3	1	Sf 45, –
seed	–	–	Sf 25, –
tools and bags	–	–	Sf 10, –
Total labour input 60-70	22-28		
Total production costs			Sf 935 – Sf 1.035
Average production 1000 kg per ha (400 kg per acre)			
Total per ha		43 mandays	Sf 1.360,–

US$ 1.00 = Sf 1.77

Source: Ministry of Agriculture
Agro Economic Division

Table 4. Inputs and production costs (transitional system)

	mandays per ha	costs per ha
seedbed preparation by contracters machines	–	375
sowing and thinning	10	150
fertilizing	3	45
weeding	10	150
drainage	5	75
picking and hurking	15	225
seed (25 kg)	–	25
Urea and NPK (600 kg)	–	300
tools and bags	–	15
Total per ha	43 mandays	Sf 1.360,–

Average yields 1800 kg/ha; 70-80 bags of 35 kg (dry cobs)
US$ 1.00 = Sf 1.77

Source: Ministry of Agriculture
Agro Economic Division

Table 5. Production costs of field experiments Min. of Agriculture
Tijgerkreek West – 1 ha (2,5 acres)

wages[1]	costs of machinery	materials	total costs
seedbed preparation	Sf 175.00		Sf 175.00
sowing – thinning and plant replacement	Sf 62.50		62.50
weed control	37.50		37.50
fertilizing	50.00		50.00
pest control	75.00		75.00
picking and transport	162.50		162.50
seed (20 kg)		Sf 20.00	20.50
herbicides		22.50	22.50
pesticides		64.00	64.00
fertilizer		380.00	380.00
Total field production costs			Sf 1,049.00
Field production costs per kg (yield 4650 kg/ha		Sf 0.23/kg	
husking and treshing		0.04/kg	
drying[2]		0.02/kg	
Total production costs		Sf 0.29/kg	
US$ 1.00 = Sf 1.77			

[1] Wages were calculated on the basis of Sf. 12.50/manday.
Adjustment of these costs to Sf 15.00/manday would add another
Sf 0,02 to the realized production costs, this bringing the cost-price to Sf 0.31/kg.

[2] Estimation by the Agro Technical Division- Min. of Agric.

Source: Ministry of Agriculture

CONCLUSIONS

1. Development of maize production in Suriname is only possible by through integrated approach whereby all the various aspects concerning the crop are taken into account.

2. Substitution of 10% of imported maize can be aphieved on short term providing the necessary inputs to farmers: an important role in this development should be played by pilot farms.

3. For obtaining further data on the various aspects of middle and large scale maize production pilot-farms should be established in the interior.

NAME OF PAPER: Micro-economic aspects of maize in Surinam in relation to import substitution.
(A.Graanoogst)

Question by: van Marrewijk
Country: The Netherlands

QUESTON: Leaving out of discussion whether the computations of cost-price of maize in Surinam (based on one single experiment) has much validity, I should like to raise the question whether local production should necessarily be cheaper than world market prices, especially in the early phase of introducing new crops. Since diversification of agricultural production and import substitution are political goals, one should create the right atmosphere for the pursued change. This might include protection of local farmers by restricting imports, imposing import taxes and by a system of guaranteed prices.

ANSWER: It is agreed with Mr. v. Marrewijk that for realization of the objectives concerning diversification of agro-production and substition of agro-imports the right atmosphere should be created. Apart from the suggested economic measures like import-restriction, import-taxes and guaranteed prices for farmers, the right atmosphere also includes non-economic measures such as methods of research focused on the local needs. However, before putting into operation the suggested economic measures the following should be taken into account: unmilled corn is mainly imported for the processing of poultry-feed. Putting up e.g. import-taxes, 26% at present source, Marketing Section Ministry of Agriculture, will result in higher poultry prices provided no further steps are taken like raising productivity in poultry-farming and price-control. Since consumption of poultry meat is almost the only way to relatively cheap protein for the lower-income classes, a raise in poultry prices should be avoided (social economic reasons) unless alternative inexpensive sources of protein-supply such as pulse and fish are available.
In this context the need for an integrated program on maize-research including crop rotation calls for special attention.

PRODUCTION COSTS OF MAIZE IN THE COASTAL AREA OF SURINAME

K. Manniesing
Agricultural Experiment Station, Paramaribo

SUMMARY

During the short raining season of 1976 – 1977 a 1.05 ha plot was planted to maize at the experimental farm of Tijgerkreek-West in the coastal plain of Suriname. The crop was grown using standard cultivation practices. The inputs in terms of labour, machine-hours and materials were carefully recorded from day tot day.

The yield was 4650 kg/ha at a costprice of Sf. 0.30 per kg (1-US $ = Sf. 1.80).

INTRODUCTION

Suriname annually imports large amounts of cereals both processed and unprocessed. The imported maize, about 12,000 tons, is solely used for cattle feed. In 1971 it presented a value of about 4 million guilders. The expected demand for 1985 is estimated at 16,000 tons.

The maize area in Suriname is small. In 1969 about 226 ha of maize were grown with a total production of approx. 280 tons of grain. So far research on this crop has been mainly focussed on varietal selection and aspects of crop husbandry. Since little was known about the production costs of maize, a 1.05 ha plot was planted to this crop and an analysis made of the amount of labour and other inputs required. Standard cultivation practices were used. On the basis of the data thus collected a cost price was calculated.

EXPERIMENTAL SITE

The study was carried out at the experimental farm Tijgerkreek-West located in the coastal plain. Part of the soil of the plot was loamy sand (approx. 40%) and part sandy loam (approx. 60%). The plot was divided into 45 m long cambered beds varying in width from 5.5 to 10 m.

The soil was disc-ploughed and subsequently rotavated, both of which were done with a four-wheeled tractor two weeks before sowing. Immediately before planting the soil was lightly rotavated using a two-wheeled tractor.

VARIETY, SOWING AND PLANT ARRANGEMENT

A locally developed synthetic maize variety was used. Sowing was done with a hand – operated precision seeder (Esmay, model 1001-B). Row distance was 90 cm, plant distance in the row 29 cm as established by plant counts at the time of harvesting.

Where seeds failed to germinate and plant distances were more than 30 cm, infilling took place. It was done by hand one week after sowing. One week later plants were thinned if distances were less than 20 cm.

The total amount of seed used was 20 kg or 19 kg/ha.

Symposium on maize and peanut, Paramaribo, Nov. 13 - 18, 1978

CROP PROTECTION

Two days after sowing half of the plot was sprayed with the pre-emergence herbicide alachlor at the rate of 6 litres commercial product (Lasso) per hectare; one day later the other half was treated with methazole at the rate of 2,5 litres commercial product (Probe) per hectare. Six weeks from sowing some paraquat was used for a spot application. The herbicides were applied with a hand-operated knapsack sprayer.

To protect the germinating seeds and the young seedlings against mole — crickets chlordane was applied in strips over the plant rows immediately after sowing. This insecticide was applied with the same precision seeder, at the rate of 5 kg/ha.

Insecticides to control *Spodoptera frugiperda* were applied about every 6 days for 6 weeks starting 10 days from sowing. The chemicals used were trichlorfon, carbaryl and malathion. The amount of caterpillar damage to the ears, determined at harvesting, was estimated at 6%.

FERTILIZING

Fertilizer rates were based on soil chemical analyses. The following amounts were applied per hectare. At sowing 100 kg sulphate of ammonia, 100 kg triple superphosphate and 40 kg potassium chloride were band placed over the plant rows. Four and seven weeks from sowing 200 kg sulphate of ammonia and 40 kg potassium chloride were band placed along the plant rows. All fertilizer was applied by hand.

HARVESTING

The maize was harvested between 105 and 110 days from sowing. The ears were hand picked, piled, bagged and carried to the edge of the field.

COST ANALYSIS

Table 1 summarizes the number of man hours, the cost of labour, materials and machinery use required for the growing of one hectare of maize. Most activities were timed in a number of sub plots so that lowest and highest figures are given. The cost of one 8-hour man-day is Sf. 12.50 or Sf. 1.56 per hour. The yield was 4650 kg grain/ha.

Not included are the interest on the money invested in the clearing, the management costs and other indirect costs such as rent. The cost of threshing and artificial drying were not determined in this trial. The data presented are bound on figures supplied by the department of Agricultural Engineering.

Table 1. Direct costs per item for the growing of one hectare of maize.

item	man — hours		labour — costs		other costs (materials, etc.)
	lowest	highest	lowest	highest	
ploughing	7.0				
rotavating			Sf 20.00	Sf 20.00	Sf. 105.00
4-wh. tractor	6.0				
2-wh. tractor	4.5	5.5	7.00	9.00	40.00
seed					8.00
sowing	6.0	11.5	9.00	18.00	
infilling	14.5	30.0	23.00	47.00	
thinning	17.0	18.5	27.00	29.00	
chlordane application	4.0	5.0	6.00	8.00	23.00
herbicides application	12.0	19.0	19.00	30.00	87.00
fertilizing	26.0	34.5	41.00	54.00	380.00
insecticides *(Spodoptera)* application	45.5		71.00	71.00	64.00
picking and piling	25.5	42.0	40.00	66.00	
bagging and transport	67.0	77.0	105.00	120.00	
threshing	20.0	32.0	31.00	50.00	154.00
drying					93.00
			Sf 399.00	Sf 522.00	Sf 954.00

From the data it appears that the total direct costs to grow one hectare of maize varied between Sf. 1353,— and Sf. 1476,— which corresponds with a price per kg of 29.1 and 31.7 cents respectively.

DISCUSSION

The price of one kilogramme of maize as determined in this trial was hardly lower than the one of imported maize which varied between 30 and 35 cents. The question arises whether cost price reduction is possible and where such reductions could be achieved.

The intensity of soil preparation very much depends on soil type and on the amount of weeds present. With a clean field and a light soil texture the time lapse between the first rotavating and the sowing can be reduced so that the second rotavating with a 2-wheeled tractor is not required. This would mean a price reduction of 1 cent per kilogramme.

Infilling and thinning together meant between 31.5 and 48.5 hours of labour which added between Sf. 50.00 and Sf. 76.00 to the total costs. A better adjusted seeder or another sowing machine plus high quality and more uniform seed treated with a seed-dressing could cut out these practices and reduce the costs by 1.5 cent.

The larvae of *Spodoptera frugiperda* cause much damage and regular sprayings were required to control this insect. Unfortunately the chemicals currently advised do not seem very effective nor persistent. A cheap effective and persistent insecticide like chlordane that can be applied to the soil at sowing and that is effective against soil insects at first and later to *Spodoptera*, could reduce the production costs with at least Sf. 77.00 in labour and Sf. 64.00 in insecticides. Per kilogramme of maize this would mean 3 cents.

Further reduction in labour costs are possible with the picking, piling, bagging and carrying the ears to the edge of the field. In view of the large number of man hours necessary for these operations this point needs further study.

It is the author's opinion that given current practices the cost price of maize could be reduced to 25 cents per kilogramme.

NAME OF PAPER: Production Costs of Maize in the Coastal Area of Suriname (K. Manniesing)

Question by: R.P.S.Ahlawat
Country: Suriname

QUESTION: What about land rent, depreciation cost and capital interest which I feel are also important investments and should be considered while calculating the net profits.

ANSWER: First – Land rent is not included
Second and Third – no depreciation costs and capital interest because working with wage-earners is being supposed.

Question by: E.B. Whyte
Country: Barbados

QUESTIONS:

1. On page 5 of your Paper, (the section dealing with *Spodoptera* Control) you seem to be advocating a return to chlorinated hydro-carbons – are you really serious?
   In this period of environmental concern, price should not be the only factor for selecting a pesticide.

2. At what rates were the insecticides trichlorfon, carbaryl and malathion used?
   Please also indicate the current prices per kg.

ANSWERS:

1. I agree with you, but up to now we did not find an effective substitute.

2. trichlorfon – 2-4 gr/l water – Price Sf 12.50/kg
   carbaryl – 2-4 gr/l water – Price Sf 10.–/kg
   malathion – 2-6 cc/l water – Price Sf 7.50/l

Questions by: P. Segeren
Country: Suriname

QUESTIONS:

1. How do you think to reduce production costs with at least Sf 77 in labour and Sf 64.00 in insecticides as total labour costs for applying insecticides mentioned in table 1 are only Sf 79.00 and for insecticides Sf 87.–.

2. Is it not better to sow some extra seeds instead of controlling mole crickets by insecticides?

ANSWERS:

1. Sf. 77.– is composed of lowest labour costs of chlordane application (Sf. 6.–) and insecticides application (Sf. 71.–).

2. mole crickets attack usually all seedlings in their vicinity.

PEANUT

SOIL SUITABILITY FOR GROUNDNUT CULTURE IN SURINAME

P.D. Rellum
Soil Survey Department Suriname

SUMMARY

Between 1966 and 1977 the local production of groundnuts dropped from 827 tons in 1966 (local area 712 ha) to 338 tons in 1977 (local area 282 ha).

After 1966 the import of groundnuts increased rapidly and at this moment the import of groundnuts (in 1977: 446 tons) is more than the local production (in 1977: 338 tons).

It is of great importance to increase the local production as much as possible and decrease the import.

The required area to substitute the import of groundnuts is about 400 ha. Research was done by the author in order to find out "which type of soil was the most suitable and the total acreage of these soils. The requirements with respect to soil properties for groundnut culture are:

a. texture: loamy sand or sandy loam or sand with some organic matter
b. drainage class: moderately well drained or well drained
c. no impermeable or slowly permeable layer within a depth of 100 cm
d. at least 0,6 meq Ca/100 gram of soil

More than 80% of the local area lies on soils suitable for groundnut culture. In the young coastal plain the suitable soils occur on the shell – and sand ridges of the Comowine – and Molesonphase and on sand ridges of the Wanicaphase.

In the old coastal plain the suitable soils occur on sand ridges of the Lelydorp landscape. In the Zandery belt and the terraces the suitable soils occur mostly on plateaus and sometimes on slopes.

The most important possibilities for enlargement of groundnut culture are on the Zandery belt and the young coastal plain. On the Zandery belt fertilization with Ca is necessary.

The total area of the suitable soils is several times more than the required area to substitute the import.

Symposium on maize and peanut, Paramaribo
Nov. 13 - 18, 1978

General information

Table 1. Local production and import of groundnuts in Suriname

Year	Local production (in tons)	Local area (in hectares)	Import (in tons)	Required area to substitute the import (in hectares)
1965	628	648	no figures	no figures
1966	827	712	"	"
1967	640	601	"	"
1968	492	429	"	"
1969	247	240	"	"
1970	281	284	"	"
1971	215	220	"	"
1972	183	212	"	"
1973	344	287	203	169
1974	382	318	487	406
1975	391	326	331	276
1976	290	242	427	356
1977	338	282	446	372

Source Mahabir 1978

Conclusions:

- After 1966 the local production and the local area decreased
- In 1977 the total required area for the whole production was smaller than the local area in 1966. In other words the import of groundnuts would not have been necessary if the local area in 1977 had been as large as that of 1966.

Information about the present groundnut areas

Suriname can be divided from North to South in:

- Coastal plain, subdivided in the young and old coastal plain.
  The coastal plain is about 40 km wide in the East and about 120 km in the West. It is almost flat and consists mainly of marine sediments with heavily textured clay soils, locally with swamps and sand – and shell ridges. Its elevation varies from about 0 (in the North) to about 10 m (in the South).

- The Zandery belt

  The Zandery belt forms a zone which is widest in the western part and narrowest in the eastern part.
  It consists of flat to undulating forest land and savannes, bordered in the North by the coastal plain and in the South by the interior uplands.
  Most of the cover landscape consists of well drained to excessively drained soils, with swamps bordering creeks and rivers. Its elevation varies from about 10 m (in the North) to

about 50 m (in the South).

The interior Uplands

They occupy more than 80% of the total area of Suriname, varying from undulating to steep and rugged land with an elevation of 50 to about 1280 m and underlain by the Pre-cambrian Crystalline Basement rocks, belonging to the Guiana Shield.
The parent material mainly consists of deeply weathered gneiss, schist, granite, diorite and dolerite.

The present groundnut areas lie mostly on ridge soils of the young and old coastal plain, especially on ridges with shells or fine sand. These ridges are mostly well-drained at the top and moderately well drained or imperfectly drained on the slopes.
Since 1972 different research workers have made different experiments with groundnuts on the Cover landscape.
Still the area planted with groundnuts in this landscape is small. On terraces a small area is planted with groundnuts.
South of the Cover landscape, on the interior Uplands the groundnut areas are negligible. In most cases groundnuts are planted by small holders on small areas from about 0.25 ha to about 5 ha. Soil preparation, weeding and earthing up are often mechanized.

Soil suitability for groundnut culture

Suitability of soil for groundnut culture depends on its suitability for:

a. the growth and development of the groundnuts
b. workability of the land
c. the ease of harvesting without loss of pods

Growth and development and ultimately the production, of groundnuts depends on:

a. moisture availability
b. nutrient availability
c. oxygen availability in the root zone
d. rate of soil toxicity
e. the rooting possibility

From experiments made on soil suitability we may draw the following conclusions:

Texture

Groundnuts grow better on light (textured) soil. The reasons are:
a. In most cases rooting of groundnut is much better on light (textured) soils than on heavy (textured) soils (Go Ban Hong and Van Schuylenborgh, 1953). Good rooting on heavy (textured) soils only takes place on soils with a crumbly structure.
b. The gynophore penetrates much easier into the ground on light (textured) soils.

c. During the growth of the pods they increase in volume. The pods cannot easily increase in volume and cannot penetrate further into the soil if the soil is too heavy. In light soil, which is sand or a mixture of sand and clay, the pods grow easily.
d. During the ripening of the pods different processes occur which need oxygen and produce carbon dioxide.
   This breathing of the pods only takes place if the soil is well areated. Normally light soils are well aerated if the groundwater table is not to high. Heavy soils mostly have a bad aeration because of a slow permeability.
e. Lifting of the groundnut to plant and pods at harvesting will be much easier on light soils than on heavy ones; very few pods will be left in the ground if the soil is light (Van Slobbe, 1973). In Suriname the most suitable soils for groundnut culture are the loamy sands and sandy loam (Ter Horst, 1969; Hoving, 1973), and sandy soils with some calcium.
   Sandy soils, low in organic matter have the following disadvantages:
   1) a very low soil fertility
   2) a very low cation exchange capacity
   3) a low moisture availability

   Hoving (1973) found on Coebiti that on sandy soils the yield to the hectare was lower than on loamy sands (because of reasons mentioned above).

The occurrence of sufficient calcium in the soil

In groundnuts calcium plays a very important role in determining the yield and the quality of the groundnut.
Ca is important for the nitrogen fixation, the fruit setting and the development of the pods. Gynophores and pods pick up the calcium from the soil.
Reasearch in- and outside Suriname shows that for a good yield and a good quality of the pods the soil must contain at least 0,6 meq calcium / 100 gram of soil. (Van Muylwijk, 1974).

Drainage class

During different stages in the development of the groundnut the moisture availability determines he resulting yield and quality of the groundnut. At periods of germination, strong vegetative growth and flower formation the plant needs sufficient water for the different physiological processes. During the growth and development and harvest of the pods there must not be much water in the soil. This for the following reasons:

a) if there is too much water in the soil the pods may rot.
b) for breathing of the pods during the ripening the soil must be well aerated. If there is too much water aeration can hardly take place.
c) if the soil is too moist the seeds may germinate.
d) harvesting in a dry soil is much better because when the soil is too moist different pods may stick on the clods (Wienk, 1972).

The yield of the groundnuts was high on the top of ridge soils of the young coastal plain

with a groundwater table at a depth of 40 cm during the rainy season and a depth of 120 cm during the dry season, (Ter Horst, 1961). On the lower laying side of the ridges the yield was much lower.
soil, suitable for groundnut culture, needs one of the following drainage classes:
well drained or moderately well drained.

The occurrence of impermeable or slowly permeable layers within the profile

An impermeable or a slowly permeable layer is important for the groundnut culture when it influences the rooting and the moisture content in the rooting zone.
Such a layer is very often unfavourable during the rainy season and sometimes favourable during the dry season. Furthermore root growth is stunted.
Combining all these conclusions we see that suitable soils for groundnut culture have the following special features:

a. texture: loamy sand or sandy loam (or loam) or sand with some organic matter
b. Ca: at least 0.6 meq Ca/100 gram soil
c. drainage class: well drained or moderately well drained
d. impermeable or slowly permeable layer: not within a depth of 100 cm.

When we examine the local area on the features, mentioned before, than it appears that more than 80% of the local area lie on soils suitable for groundnut culture.

The occurrence of suitable soils in Suriname

Research was done on:

a. the Young coastal plain
b. the Old coastal plain
c. the Zandery belt
d. the Terraces

The reasons for doing this only on these landscapes are:

- the present groundnut area lies mostly in the young and old coastal plain;
- most of the soil research work done in Suriname, was made on these landscapes.

By selecting the suitable soils on the different soil maps (scale 1:100.000) we will find the following possibilities:

1. Young coastal plain
1.1. Ridge soils of the Comowine- and Molesonphase
1.1.1. Well (to poorly) drained shells, shell grit, shellsand, medium and fine sand
Total area ± 3200 ha
Present usage a) horticultural (and agricultural) purposes (vegetables)
b) dwelling
c) material for road construction etc.

Part of these soils is inaccessible at this moment because of the surrounding swamps. From these soils the most suitable sites must be selected; sites with shell-grit, shellsand and some organic matter and as drainage class well drained or moderately well drained.

1.1.2 Well drained medium and fine sand to sandy loam

Total area ± 4600 ha
Present usage — a) horticultural purposes (vegetables)
b) dwelling
c) material for heightening farmyards etc.

A reasonable part of these soils is till now inaccesable because of the surrounding swamps. The most suitable sites are the heavier ones (loamy sand or sandy loam) or sand with some organic matter.

1.2. Ridge soils of the Wanica phase

1.2.1. (Moderately) well drained medium and fine sand
Total area ± 52000 ha
Present usage: — a) horticultural purposes (vegetables)
b) agricultural purposes (plantations)
c) dwelling

Part of these soils is not exploited. Some of them occur within the old plantations. The most suitable sites are the fine sand ones with some organic matter.

2. Old coastal plain
2.1. Ridge soils of the Lelydorp landscape
2.1.1. Well drained, locally bleached, fine and very fine sand

Total area 13.300 ha
Present usage: — a) horticultural purposes
b) agricultural purposes
c) dwelling (in the neighbourhood of Pad van Wanica)

The most suitable sites are the non-bleached ones with some organic matter.
2.1.2. Moderately well drained weakly to moderately bleached fine and very fine sand over loam

Total area 9.600 ha
Present usage: — a) pastures
b) horticultural purposes
c) dwelling

The most suitable sites are the weakly bleached ones with some organic matter. The depth at which the loam occurs is also important.

3. Zandery belt
3.1. Plateau Soils
3.1.1. Well drained medium and coarse sand to sandy clay loam

Total area 55.000 ha
Present usage: forestry (extraction forestry and artificial forestry)

The most suitable sites are soils with loamy sand and sandy loam (or sand with some organic matter). Fertilizing with Ca is necessary because of a deficiency of Ca in these soils.

3.2. Slope and Plateau Soils
3.2.1. Moderately well and imperfectly drained sandy loam (to sandy clay loam)

Total area 8.400 ha
Present usage: forestry (extraction forestry)

The most suitable sites are the sandy loam ones, that are moderately well drained. Fertilizing with Ca is necessary because of a deficiency of Ca in these soils.

4. Terraces
4.1. Plateau and Slope Soils
4.1.1. Well drained and moderately well drained medium and coarse sand and (sandy) loam to sandy clay loam and (sandy) clay

Present usage: a) pastures
b) agricultural purposes (oranges, oilpalm)

The most suitable sites are the medium coarse sand (with some organic matter), the sandy loam and the loam soils. Of the suitable soils, mentioned before, the most important possibilities for enlargement of the groundnut culture are on the Zandery belt and the Young coastal plain (especially the shell ridges).

REFERENCES

Boer, M.W.H. de, 1977. "Landgeschiktheidsklassifikatie voor de kokoscultuur in Suriname". D.B.K.-rapport nr. 59 (Dept. on Soil Survey-Suriname).

Evelyn, S.H., and I. Thornton, 1964. "Soil Fertility and the Response of Groundnuts to Fertilizers in the Gambia". Emp. J. exp. Agric. 32: 153 – 160

F.A.O. 1970. "Groundnuts" better farming series nr. 19

Go Ban Hong and J. van Schuylenborgh, 1953. "Bodemkunde en bemesting van de katjang tanak *(Arachis hypogea.* L.)" Landbouwk. Tijdschr., 65: 339 – 352

Horst, K. ter, 1959. "Het optimale plantverband voor pinda van het ras Matjan". Sur. Landb. 7: 121 – 128 (Agricultural Experiment Station Suriname)

Horst, K. ter, 1961. "Onderzoek naar de bemesting van pinda in Suriname" Meded. Landbouwproefstation Suriname 27 (Agricultural Exoeriment Station Suriname)

Hoving, E., 1973:4). "Eerste aanplantingen van peulgewassen in de proeftuin Coebiti" Celos rapport nr. 83 (Centre for Agricultural Research Suriname)

Mahabir, R., 1978. "Agrarisch- Statistische gegevens over de periode 1970 – 1977" Dienst Landbouw Economische Zaken, Ministerie van L.V.V.

Muylwijk, T. van, 1974:1). "Een plantverbandproef met aardnoot"
2) "Een bakalkingsproef met aardnoot"
3) "Onderzoek aan aardnoot te Coebiti in de periode december '73 – april' 75" – Celos rapport nr. 95 (Centre for Agricultural Research Suriname).

Purseglove, J.W., 1968. "Tropical crops- Dicotyledons 1" Longmans London.

Smartt, J., 1964. "Factor influencing Yield and Quality of Groundnuts in Northern Rhodesia" Emp. J. exp. Agric. 32:343 – 351

Slobbe, W.G. van 1973. 1) "Een vergelijkende opbrengstproef met aardnoten". Celos rapport nr. 86 (Centre for Agricultural Research Suriname)

Working Group on landevaluation, 1975. "Enige landgebruikstypen in Suriname. Kriteria voor Landgeschiktheidsklassifikatie.
D.B.K.- rapport nr. 53 (Dept. 53 (Dept. of Soil Survey Suriname)

Working group on landevaluation: Melitz, P.J. (ed.), 1976:
"Globale actuele landgeschiktheid van het Tibitie- Boven Coesewijne areaal voor diverse soorten gebruik".
D.B.K.-rapport nr. 53 (Dept. of Soil Survey Suriname)

Working Group for Soil-classification, 1978. "Surinaamse bodemklassifikatie – Bodemseries." D.B.K. (Dept. of Soil Survey Suriname)

Wienk, J.F., 1972. "Een vergelijkende opbrengstproef met aardnoten" Celos rapport nr. 64. (Centre for Agricultural Research in Suriname)

Wit, Th. de, 1974: "Economic Aspects of Partly Mechanized Groundnut Production in Suriname". De Surinaamse Landbouw 22:45 – 51.

GROUNDNUT EXPERIMENTS AT COEBITI IN THE PERIOD 1972-1975: A SUMMARY OF RESULTS

J.F. Wienk
Centre for Agricultural Research, Suriname

SUMMARY

In Suriname groundnuts are grown on sandy ridges in the coastal area. Farmers' plots are small. Labour is scarce and the possibilities for mechanization are limited. As a result the total groundnut acreage is gradually decreasing. Large areas of sandy soil occur immediately south of the coastal clay belt. They vary in texture from sands to sandy loam and seem suitable for mechanized crop production. The potential of these soils, particularly the sandy loams, for annual crops is being studied in an experimental farm named Coebiti. One of the crops is groundnuts of which various agronomic aspects have been studied so far. The present paper summarizes the main results of experiments on the subjects of liming, plant density and spacing, and *Cercospora* leaf spot control, that were carried out in the period 1972-1975.

INTRODUCTION

In Suriname groundnuts are predominantly a crop of the coastal plain where they are grown on the sandy ridges present in the coastal clay belt. As a rule these ridges are narrow and the farmers' plots small; large production units are absent. Mechanization is restricted to soil preparation and labour is scarce, rendering it difficult to farm economically. As a result the total groundnut acreage is gradually decreasing.

Outside the coastal area groundnuts are found on the garden plots of the bushnegroes living in the interior on the banks of the country's main rivers. Here the crop is grown for home consumption and does not enter local trade. Until fairly recently groundnut research therefore was confined to coastal conditions.

During the sixties the sandy soils of the Zanderij formation immediately south of the coastal clay belt gradually became accessible. Their relatively flat topography, their good soil physical properties and their presence in large areas, which all are a prerequisite for mechanization, aroused agricultural interest. In 1969 an experimental farm, named Coebiti, was laid out at about 30 km south-west of the international airport Zanderij (fig. 1). Its soils represent the various types encountered in the Zanderij formation.

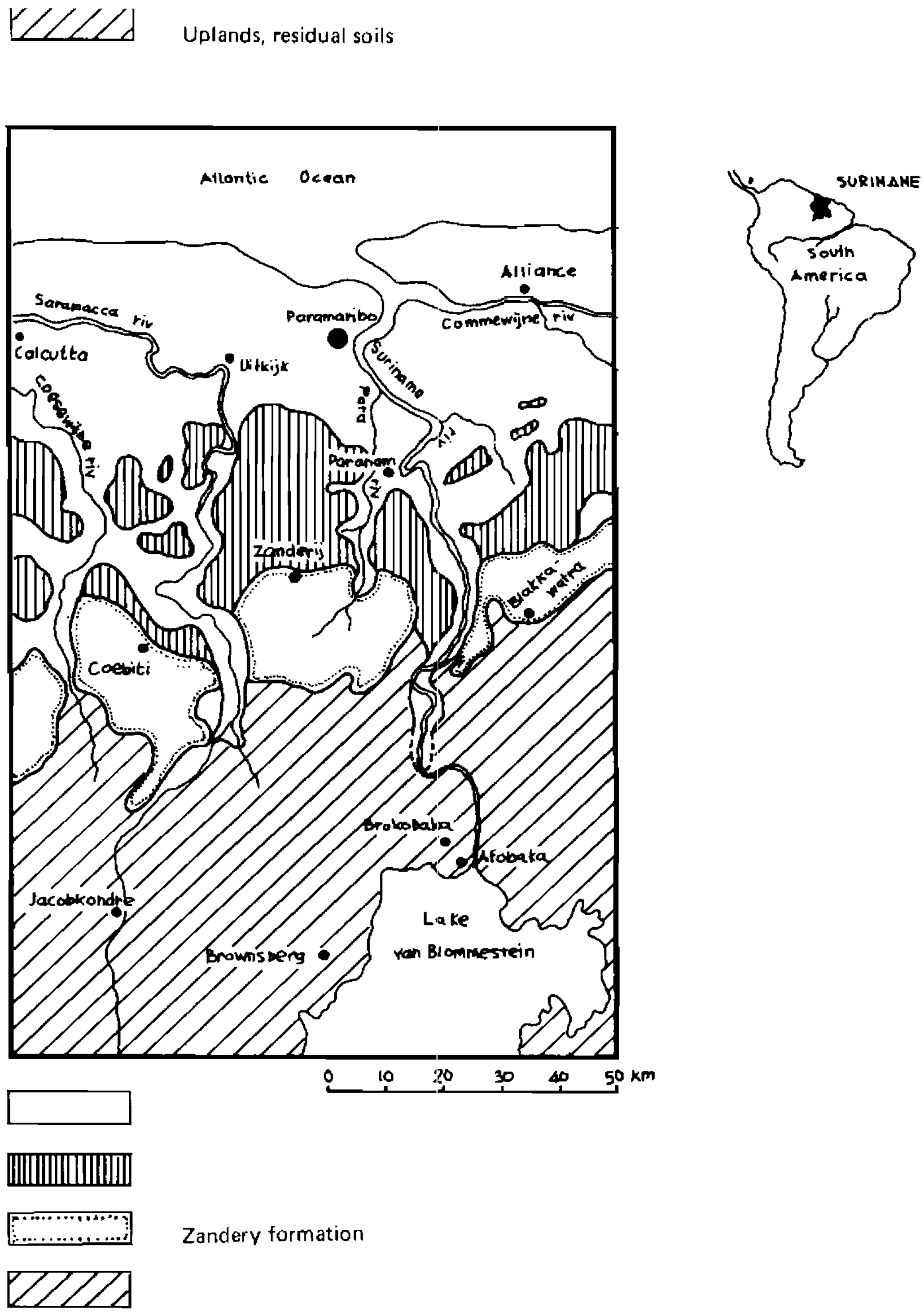


Fig.1. Schematic geomorphological map of part of Suriname (after Brinkman & Pons, 1968)

At Coebiti research on annual crops started in 1972 when a number of food crops were taken into observation. One of them was groundnut. The encouraging results obtained with this crop led to a more or less continuous series of field experiments during the following years. Various aspects were studied. This paper presents an account of the most important work that was carried out in the period 1972-1975.

GENERAL

Climate

Suriname has a tropical rainforest climate. In the period 1931-1960 the average monthly temperature at Paramaribo varied between 26.4 and 28.5°C, the relative humidity between 75 and 85% and the wind velocity between 1.1 and 1.7 m/sec. The annual rainfall distribution fluctuates strongly.

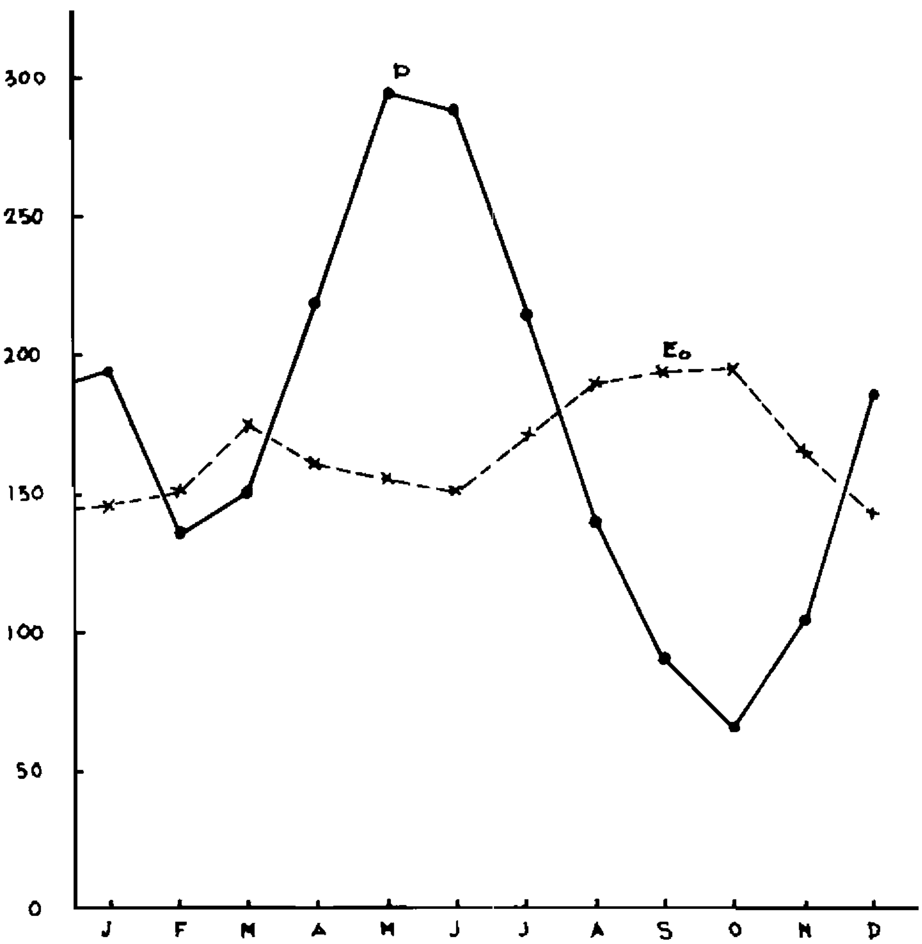


Fig.2. Average monthly precipitation (C) and free water evaporation (E_0) at Republiek, for the years 1906-1972 except 1912 and 1957.

Figure 2 depicts rainfall and free water evaporation data collected at Republiek, the nearest place to Coebiti (approx. 35 km) where rainfall has been measured over a long period. Four seasons are distinguished: the long rainy season, April-July; the long dry season, August-November; the short rainy season, December-January and the short dry season, February-March. The transitions from one season to another are not sharp and particularly the short rainy and short dry season set in very irregularly.

Soil

The experimental farm of Coebiti is located between the Saramacca and Coesewijne rivers (fig. 1). The texture of its topsoils, which belong to the oxisols, range from sand to sandy loam, the latter increasing with depth to sandy clay loam. With a few exceptions all experiments were carried out on sandy loam (see below). Table 1 presents some soil chemical data; the soil had not been cropped so far.

Table 1. Soil chemical data based on seven samples (0-20 cm) taken in May 1974

	average	range
Organic C, % (Walkley-Black)	1.17	0.80- 1.46
Total N, %	0.08	0.05- 0.10
C/N	15	14 -18
pH-KCl	4.1	3.9 - 4.3
pH-H_2O	4.7	4. 3- 5.0
CEC (pH=7), me/100 g soil	3.86	2.66- 4.69
exch. Ca, "	0.52	0.34- 0.84
exch. K "	0.06	0.04- 0.10
exch. Na, "	0.01	0.00- 0.04
P-Bray I, ppm P	1.8	0.7 - 4.4

The cation exchange capacity depends largely on soil organic matter, the kaolinitic clay being of minor importance. The amount of potentially available soil moisture (between pF 2.0 and pF 4.2) is low; the mean value for one metre depth is 145 mm (Janssen and Van der Weert, 1977).

Experimental

All experiments were carried out with the Spanish type cultivar Matjan. It was introduced from Java in 1950 and is the recommended cultivar in Suriname. Compared with other Spanish type cultivars it has large leaves and large seeds. Its growth duration is about 100 days. The gynophores do not easily rot through, which is an attractive characteristic in view of Suriname's climatic conditions. The cultivar is susceptible to *Cercospora* leaf spot and to leaf rust *(Puccinia arachidis)*.

Unless otherwise stated, plant spacing was 60 x 15 cm. Fertilizer rates were 40 kg P_2O_5, as triple superphosphate, and 40 kg K_2O, as potassium sulphate, per hectare; in later experiments some nitrogen (urea) was applied at the rate of 10 kg/ha. The fertilizers were placed along the plant rows soon after emergence. The potassium was split, 15 kg being applied at emergence, the remainder three weeks later when plants started flowering. Weeding was done by hand. Apart from *Cercospora* leaf spot and leaf rust, diseases were absent. As to insects only *Stegasta basquella* sometimes caused damage to the foliage; the insect was controlled with a single application of trichlorphon. Occasional slugs were controlled with methicarb. All weights are expressed on the basis of 12% moisture content.

PRELIMINARY EXPERIMENTS

Towards the end of the long rainy season in 1972 small (480 m^2) observation plots were planted with various annual food crops one of which was groundnuts (Hoving, 1973). Plots were laid down on sand and on sandy loam. Half of each plot was limed; fertilizer was applied and *Rhizobium*-inoculated seed was used. The soil had never been cropped before: in 1969, immediately after clearing, kudzu *(Pueraria phaseoloides)* had been planted as a cover crop.

Of the annual crops planted groundnuts appeared most promising. The yield on sandy loam was double that obtained on sand. Liming had improved the yield both quantitatively and qualitatively: the percentage (w/w) of non-filled pods (pops) on the non-limed plots was nearly three times that on the limed ones.

Following these results a second series of trial plots was planted on both soil types during the short rainy season of that same year (Van Slobbe & Wienk, 1973). Again non-cropped soil was used. Three liming rates were included, i.e. 0, 2000 and 4000 kg $CaCO_3$/ha on sandy loam, and 0, 1500 and 3000 kg $CaCO_3$/ha on sand. The rates were compared in replicated randomized block experiments. Agricultural lime (Emkal) was used. Fertilizer rates were 40 kg N, 60 kg P_2O_5 and 80 kg (sand) or 60 kg (sandy loam) K_2O per ha.

Liming did not affect plant growth on either soil type, but on sandy loam plants grew better and a closed crop surface was obtained earlier than on sand, where the crop remained green much longer. Plants on the non-limed plots were still flowering when the trials were harvested, i.e. 111-118 days after planting (DAP).

Table 2. Effects of lime (Emkal) on yield and yield quality of groundnuts on sand and sandy loam

Soil type	liming rate (kg $CaCO_3$/ha)	pod yield (kg/ha)	shelling %	number of pods per kg	
				total	pops
sand	0	499	53	1196	542
	1500	680	56	1134	304
	3000	723	60	1043	264
sandy loam	0	1556	71	876	149
	2000	2287	75	749	80
	4000	2316	75	726	83

Lime again showed a marked effect, the differences being largest between limed and non-limed plots (table 2). They yields on sand were very low, non-limed plots on sandy loam yielding more than twice as much as limed plots on sand. Apart from less pods per unit area, many of the pods produced were empty. Though lime considerably reduced the number of pops, on sand this number remained very high even at the highest liming rate. In view of these results it was decided not to continue with groundnuts on the sand.

LIMING

The preliminary experiments had clearly demonstrated that for groundnut production on the sandy loam soils of Coebiti liming is essential but that little was gained from increasing the amount of lime from 2 to 4 tons per hectare. However, the lime had been applied shortly before planting. A different effect might have been obtained if the groundnuts had been grown as the second crop following the liming. To obtain further information on liming effects, liming materials and liming rates some additional experiments were conducted.

The replicated trial mentioned in the previous chapter was replanted in 1973 at the end of the long rainy season to study the residual effects to the lime (Wienk & Van Muijlwijk, 1973). During the preceding months a leguminous cover crop *(Mucuna sp.)* had been planted to protect the soil from the heavy rain.

The incidence of *Cercospora* leaf spot now was higher and the disease appeared earlier than in the previous cycle of this trial; the crop was harvested 97 DAP. In spite of this the yields and the yield composition (table 3) were better than in the foregoing cycle. The results for the "non-limed" plots indicate that these plots could no longer be considered as such; apparently some calcium had been translocated from neighbouring, limed plots.

Table 3. Residual effects of liming (Emkal) on yield and yield composition of groundnuts on sandy loam

liming rate (kg $CaCO_3$/ha)	pod yield (kg/ha)	shelling %	number of pods per kg	
			total	pops
0	2757	72	679	54
2000	2781	74	604	5
4000	3006	76	599	7

These findings show that the effect of lime on both the quantity and the quality of the groundnut crop was greater in the second cycle than when the crop was planted immediately upon liming.

The lime used in the previous experiments was Emkal, an agricultural lime imported from Europe. In further trial Aragonite (90% $CaCO_3$) a cheaper liming material of marine origin was used (Van Muijlwijk, 1974b). In a replicated experiment the rates 0, 450, 900 and 1350 kg $CaCO_3$/ha were compared. The soil had never been cropped before. The trial was planted in July 1973 at the end of the long rainy season.

Cercospora leaf spot occurred later in this experiment than in the second cycle of the liming trial reported above. No obvious differences in plant growth were observed. Flowering was noted to continue on the non-limed plots and to some extent also on the plots limed at the rate of 450 kg $CaCO_3$/ha. The experiment was harvested 103 DAP.

As to the yields and yield composition (table 4), , the results suggest that the optimum liming rate is somewhere between 450 and 900 kg $CaCO_3$/ha. Yields at the highest two rates differed little from those obtained on sandy loam in the preliminary experiment (table 2). The effect of calcium on yield composition was again clearly demonstrated.

Table 4. Effects of lime (Aragonite; 90% $CaCO_3$) on yield and yield composition

Liming rate (kg $CaCO_3$/ha)	pod yield (kg/ha)	shelling %	number of pods per kg		
			total	partly filled	pops
0	1115	49	1411	344	737
450	1939	67	871	213	187
900	2323	72	732	164	64
1350	2422	71	721	111	27

To study the residual effects of the Aragonite the experiment was replanted in December 1973 at the onset of the short rainy season (Van Muijlwijk, 1974b).

Growth was good during the first month after planting. *Cercospora* leaf spot appeared early in the growing season and affected the plants badly: two months after planting still no closed crop surface was obtained, which was in contrast to simultaneously planted trials where the previous season no groundnuts had been grown. As a result the trial suffered much from weed growth particularly in the plant rows. The experiment was harvested 104 DAP.

The results obtained (table 5) clearly demonstrate an effect of liming. Again the differences between the effects of 900 and 1350 kg $CaCO_3$ were small. The expected effect, i.e. higher yields in the second cycle following liming, was not realised, most likely because of the early attack from *Cercospora* leaf spot. Nevertheless, there appeared some after effect: the quality of the harvested crop was somewhat better now than in the previous cycle. Also here lime had been translocated to the "non-limed" plots: less pops were present per kilogramme pods now than in the first cycle of this trial.

Table 5. Effects of lime (Aragonite) on a second crop of groundnuts following the application of the lime

Liming rate (kg $CaCO_3$/ha)	pod yield (kg/ha)	shelling %	number of pods per kg		
			total	partly filled	pops
0	972	66	946	119	226
450	1050	73	750	138	86
900	1381	76	678	54	37
1350	1490	76	662	56	30

At harvesting composite soil samples were taken and analysed for Ca. The Ca-contents were 0.18, 0.30, 0.95 and 0.90 me/100 g soil for the 0, 450, 900 and 1350 kg $CaCO_3$ treatments, respectively.

In groundnut cultivation lime primarily serves to correct a calcium deficiency, fruit setting requiring the presence of calcium in the immediate vicinity of the pegs and the young pods. Application of the lime in 30 cm wide strips at a row spacing of 60 cm would mean a reduction of 50% lime as compared with the amount required in the case of broadcasting. Both methods of application were compared in a replicated field experiment using a rate of 1000 kg $CaCO_3$/ha effectively treated (Van Muijlwijk, 1974c). The soil had not been cropped before and the lime was applied shortly before planting. The trial was planted at the onset of short rainy season. *Cercospora* leaf spot did not appear until late in the growing season and caused very little damage.

As expected the results (table 6) did not reveal any differences between the two methods of application. Strip application was as effective as broadcasting the lime, the amount per unit area effectively limed being the same in both cases.

Given the non-cropped soil and the recent lime application the yield levels were reasonable.

Table 6. Effect of broadcasting (1000 kg $CaCO_3$/ha) versus strip application (500 kg $CaCO_3$/ha) of lime on yield and yield composition

Method of application	pod yield (kg/ha)	shelling %	number of pods per kg: total	partly filled	pops
broadcast	2305	78	650	17	20
strip application	2331	78	618	24	4

Discussion and conclusions

Liming had a marked influence on the yield. As the vegetative growth was not affected the large differences in yield cannot be described to growth differences. The number of pods formed increased only slightly so that the higher yields were the result mainly of more seeds, i.e. better filled pods. If the calcium supply is inadequate many young pegs become necrotic and do not further develop; of the developed pods most are empty or only half filled thus reducing the quality of the harvested crop. These results demonstrate the well known phenomenon in groundnuts that calcium affects pod development rather than plant growth and thus is required most in the soil surrounding the developing pods (Brady, 1947).

An optimum liming rate was found between 450 and 900 kg $CaCO_3$ per hectare. With 900 kg $CaCO_3$ the amount of exchangeable calcium was raised from 0.18 to over 0.90 me per 100 g soil. This is well above the critical level reported by Colwell and Brady (1945) who found that below 0.60 me Ca per 100 g soil no good pod quality was obtained. No critical value was established, however, for the sandy loam soil at Coebiti. To be on the safe side a rate of 1000 kg/ha is therefore advised.

When applied to the preceding crop the effect of the lime was greater than when given at planting, the developing pods apparently reacting better to exchangeable calcium than to calcium carbonate. The solubility of the latter is low so it requires some time for the calcium ions to enter the exchange complex.

No experiments were conducted on the frequency of liming. In rotations this will depend on the calcium requirements of the other crops, on the rate of leaching and on the time lapse between two groundnut crops. With groundnuts every two years an annual application of 1000 kg $CaCO_3$/ha would seem adequate to maintain the calcium status of the soil.

Once the soil has been limed and lime applications are required only to maintain the calcium-status of the soil, strip application may be considered. As expected liming in strips so that half the amount of $CaCO_3$ is used, gave the same result as liming the entire area. In rotations of groundnuts with crops that demand less calcium, the lime can be more effectively applied in strips, concentrating it around the plant rows. With the tillage operations for the following crop the lime will be gradually distributed over the entire field.

Suriname has no limestone sources and agricultural lime needs to be imported. From an economic point of view nearby sources and cheap liming materials are required. Aragonite, which is used in Guyana's sugarcane industry, meets these criteria. Though it is much coarser than agricultural lime, it gave good results, suggesting that the coarseness does not play an important role. A direct comparison with agricultural lime was made but the experiment had to be abandoned, however.

The liming trials all suffered in various degrees from *Cercospora* leaf spot. On soil that had not been cropped before the symptoms were virtually absent until late in the season when the crop started ripening. When groundnuts followed groundnuts the leaf spots were observed as early as three weeks from planting. They rapidly spread and led to serious defoliation and yield reduction. In one instance a loss of 40% was estimated. From this it became obvious that *Cercospora* leaf spot was an important bottle-neck in the production of groundnuts at Coebiti.

PLANT DENSITY AND SPACING

The optimum plant density for Matjan under coastal conditions has been established at about 110,000 plants per hectare; a plant spacing of 30 x 30 cm was advised (Ter Horst, 1959) The small farmer usually plants at 30 x 15 cm (Veltkamp and Samlal, 1976). Most of them do not use Matjan, however.

For the time-being, awaiting experimental results, a density of 110,000 plants per hectare was chosen for the soils at Coebiti. The spacing was altered to 60 x 15 cm to allow agricultural equipment entering the field.

Spacing

In a replicated field experiment planted in 1973 towards the end of the long rainy season four plant spacings were compared, viz. 60 x 15, 75 x 12, 90 x 10 and the double row 70 x (20 x 20) cm (Van Muijlwijk, 1974a). With a view to the possible mechanization of cultural practices like weeding and ridging row distances smaller than 60 cm were not considered. The experiment was planted on a site where in the previous season maize and groundnuts had been grown; the soil had been limed. *Cercospora* leaf spot appeared early in the growing season. The disease was probably aggravated following heavy showers which caused lodging.

The yield (table 7) was highest for the 60 x 15 cm spacing; no statistical differences were found between the other three plant arrangements. The quality of the harvested pods was good, indicating that there was sufficient calcium in the soil. Weight per pod decreased as the plant distance in the row decreased but the differences were not statistically significant.

Table 7. Effect of plant spacing on yield and yield composition

Spacing (cm)	pod yield (kg/ha)	shelling %	number of pods per kg		
			total	partly filled	pops
70 x (20 x 20)	2271	78	602	26	2
60 x 15	2750	78	605	17	4
75 x 12	2086	78	622	22	1
90 x 10	2263	78	631	33	1

Density

The effect of plant density on yield was investigated in a replicated experiment of the fan design (Bleasdale, 1967). Ten densities based on a square plant arrangement and ranging from 45,200 to 250,000 plants/ha were compared. Apart from the standard amounts of phosphatic and potassic fertilizer fritted trace elements (FTE-181) were applied at the rate of 140 kg/ha. The soil had been cropped before; lime had been applied in the previous season. The experiment was planted in 1973 at the beginning of the short rainy season (Van Muijlwijk, 1974c).

About three weeks after planting the first symptoms of *Cercospora* leaf spot were observed. The disease rapidly spread and after another three weeks had caused a considerable loss of leaves. No correlation between the amount of leaves lost and the plant density was established. Ten weeks from planting the entire experiment benomyl was sprayed.

Table 8. Effect of plant density on yield and shelling %
Experiment 1; *Cercospora* leaf spot not controlled

density (plants/ha)	pod yield		shelling
	g/plant	kg/ha	%
45,200	39.4	1511	75
54,600	31.4	1713	77
65,800	29.7	1956	77
80,000	26.6	2128	78
96,200	23.0	2212	77
117,600	20.1	2360	78
140,800	17.1	2412	78
169,500	14.6	2480	78
208,300	11.8	2458	78
250,000	10.4	2592	78

From the results (table 8) it appears that the yield per unit area rapidly increased with density until 117,600 plants/ha. Above this number the yields further increased but at a much lower rate. A marked optimum was not found. Assuming that *Cercospora* leaf spot did not affect the results, a plant population of 110,000 per hectare seems acceptable.

Since an influence of *Cercospora* in the above experiment on the performance of the crop at high densities could not be excluded, the density trial was repeated in the following short rainy season (Van de Wall, 1975). The same densities were compared. *Cercospora* leaf spot was controlled with two-weekly applications of benomyl over a period of 10 weeks starting three weeks from planting.

Cercospora leaf spot did not become a problem and the crop retained its leaves until the ripening stage. In this experiment markedly higher yields were obtained than in the first one. Nevertheless, the same effects of plant density on yield were observed (fig. 3): pod yields rapidly increased with density until 117,600 plants/ha; above 140,800 plants/ha the yield increased very little if at all.

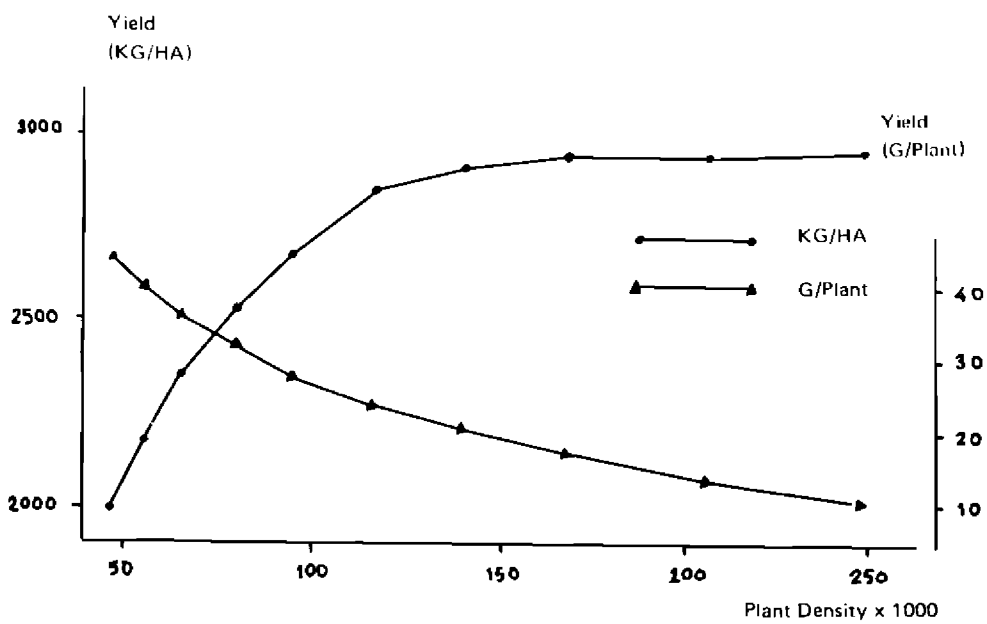


Fig.3. Pod yield per hectare and per plant for the cultivar Matjan, as affected by plant density.

Discussion and conclusions

The results of the density trials closely agree with those obtained by Ter Horst (1959) under coastal conditions. At densities higher than 110,000 plants per hectare yields per unit area still increased but the rate of increase was much less than at lower densities. Ter Horst (l.c.) considered the differences too small to offset the higher costs of the extra seed, the planting, the harvesting and the stripping at higher densities. It should be added that the small farmer does everything manually. On the other hand, even when completely mechanized the relatively small yield increases seem of little practical interest. A density of 110,000 plants per hectare as under coastal conditions can also be used for the sandy loam soils at Coebiti.

When *Cercospora* leaf spot was controlled the yield level was about 20% higher than when no measures had been taken. Plant density appeared not to have affected this relative difference. Whether the level of infection was influenced or not cannot be concluded; no disease scores were taken.

The absence of an effect on yield and perhaps also on disease incidence could well be explained by the experimental design used. The different densities being represented by individual arcs in one plot, the disease may have easily spread from one arc to another. A randomized block design may have presented a completely different picture and revealed such a relation much better than the fan design.

Generally plant populations of 160,000 to 180,000 per hectare are advised for groundnut cultivars of the Spanish type (Gillier and Silvestre, 1969). The comparatively low optimum for the cultivar Matjan probably must be ascribed to its relatively large leaves and its open growth habit which is characterized by long upright branches.

The spacing trial clearly showed that an arrangement of 60 x 15 cm was superior to wider row spacings. As observed by Fung Kon Sang (1966) this might be explained by the closer plant distances in the row which favourably influenced the development of *Cercospora* leaf spot through a better micro-climate. The performance of the double-row arrangement too can be explained by this, the micro-climate in the two closely planted rows being different from widely spaced single rows with the same plant distance. Unfortunately, as no disease scores were taken, a definite conclusion cannot be drawn. The experiment needs to be repeated and include disease control measures to avoid any interaction.

CERCOSPORA LEAF SPOT CONTROL

The cultivar Matjan proved very susceptible to *Cercospora* leaf spot. Yield losses were not actually assessed but preliminary estimates indicated that the yield could be reduced by some 40% if the crop was preceded by groundnuts (Van Muijlwijk, 1974b).

In a replicated field experiment planted towards the end of the long rainy season of 1974, the effects of (a) *Cercospora* leaf spot control, (b) removing the weeds from the plant rows, and (c) fertilizing on yield were studied (Bink, 1975). A 2^3 factorial design was used. The experiment was planted on a site where in the previous season groundnuts had been grown.

Cercospora leaf spot was controlled with benomyl applied four times at 2-weekly intervals starting three weeks from planting. The experiment was weeded between the plant rows 10 and 34 DAP. The second time also the plant rows were weeded where appropriate. The fertilized plots received 10 kg N (urea), 40 kg P_2O_5 (triple superphosphate), 40 kg K_2O (potassium sulphate) and 140 kg fritted trace elements (FTE-181) per hectare.

Five weeks from planting a few leaf spots were recorded in the non-sprayed plots. The disease gradually spread and two weeks later clear differences were observed between the sprayed and the non-sprayed treatments. Nine weeks from planting the plants in the non-sprayed plots had lost many leaves; in the sprayed plots the older leaves were still green. Very small differences, if any, in leaf spot incidence were noticed between the weeded and the non-weeded plots or between the fertilized and the non-fertilized ones.

Weed growth was not excessive. Fertilizing did not affect the amount of weeds as determined by their dry weight at harvesting. Leaf spot control affected the amount of weeds markedly.

About 75% of the total amount of weeds was present on the non-sprayed plots, the reduced soil cover being completely responsible for this effect. The removal of weeds from the plant rows 34 DAP had reduced the amount of weeds present at harvesting by 50%. Fertilizing, weeding and spraying together reduced the weed growth to one sixth of that on the combined non-fertilized, non-weeded and non-sprayed plots.

Cercospora leaf spot control affected the yield more than weeding or fertilizing (table 9); the effect as opposed to not spraying was 36%. Weeding had not improved the yields whereas the effect of fertilizing was only 9%. No significant interactions were found.

Table 9. The effects of *Cercospora* leaf spot control, weeding and fertilizing on yield (kg/ha)

Cercospora leaf spot	fertilized		not fertilized		
	weeded	not weeded	weeded	not weeded	mean
controlled	3596	3220	3036	3319	3293
not controlled	2187	2305	1980	1916	2097
mean	2827		2563		
	weeded 2700				
	not weeded 2690				

The differences in yield between the sprayed, fertilized and weeded crop and the crop where none of these measures had been taken, is spectacular. The reduction by not taking the measures was 47% of which four fifth was accounted for by leaving out the spraying and one fifth by not fertilizing. As to the quality of the crop the spraying with benomyl had resulted in halving the number of germinated seeds. Also, at harvesting less pods remained in the soil than on the non-sprayed plots.

Since the losses from *Cercospora* leaf spot can be high, some measure of control seems essential. At Coebiti the systemic fungicide benomyl had proved very successful in controlling *Cercospora*. However, the protracted use of benomyl increases the danger of inducing resistance in the pathogen (Clark et al., 1974). Moreover, at Coebiti the impression had been obtained that the use of benomyl increased the incidence of leaf rust *(Puccinia arachidis)*. In view of this an experiment was conducted in which the effects of benomyl (Benlate) were compared with those of three non-systemic fungicides, viz. propineb (Antracol), copper oxychloride (Cupravit) and fentin acetate (Brestan) (Van de Weg, 1975). The experiment was planted in the short rainy season, January 1975 on a site where the previous season also groundnuts had been grown but where no disease control measures had been taken. Each fungicide was applied at two frequencies. Benomyl was applied 2- and 3-weekly, the other fungicides weekly and 3-weekly. The concentrations used were Benlate 1 g/litre, Antracol 3 g/litre, Cupravit 5 g/litre and Brestan 2 g/litre.

Cercospora leaf spot was already present at three weeks from planting when a start was made with the fungicide treatments. Spraying was continued until about two weeks before harvesting, 100 DAP. The incidence of *Cercospora* leaf spot and leaf rust was recorded weekly (index 0-5; 0 = no symptoms). The sum of the weekly scores is presented in table 10.

Table 10. Effect of fungicides and frequency of application on yield, fresh weight of stems and leaves at harvesting, and on the incidence of *Cercospora* leaf spot and leaf rust

Fungicide	frequency of application	pod yield (kg/ha)	fresh weight stems and leaves (kg/plot)	incidence *Cercospora*	incidence leaf rust
benomyl	2-weekly	2826	14.8	3.8	2.3
	3-weekly	2569	11.8	10.4	9.3
propineb	weekly	2728	12.8	42.0	0.0
	3-weekly	2111	10.5	59.7	2.0
copper oxy-chloride	weekly	2830	15.2	20.3	0.0
	3-weekly	2546	13.5	42.3	1.0
fentin acetate	weekly	2917	15.6	20.7	0.7
	3-weekly	2870	13.8	36.3	0.7

Benomyl appeared to control *Cercospora* best. Leaf rust incidence was highest in the plots sprayed 3-weekly: at harvesting no green leaves were left. This effect is clearly demonstrated by the fresh weights of the above-ground parts at harvesting (table 10).

Propineb provided least control of *Cercospora.* The disease rapidly spread and resulted in leaf loss, particularly at the lowest frequency of application. A few leaves with rust symptoms were observed but at the lowest frequency only.

Fentin acetate appeared to be phytotoxic during the first seven to eight weeks, particularly at weekly application. Later these symptoms disappeared completely. At first the level of *Cercospora* infection was fairly high (up to 40 spots per plant) and little difference was observed between the two frequencies of application. Later, weekly spraying provided a reasonable control. At 3-weekly applications the disease was not controlled adequately and resulted in extra leaf loss. Very little rust was observed.

Copper oxychloride controlled *Cercospora* in much the same way as fentin acetate; weekly application being better than 3-weekly sprayings particularly at a later growth stage of the crop. Also with this fungicide very little rust was observed.

The yield differences were not very large (table 10). No statistical differences were found between the fungicide treatments. Within fungicides, generally the lowest frequency of application resulted in the lowest yield but the difference was only significant in the case of propineb.

Discussion and conclusions

The results of the fertilizing x disease control x weeding experiment confirmed that the yield of the cultivar Matjan can be considerably reduced if no disease control measures are taken. When occurring early in the growing season *Cercospora* leaf spot causes serious defoliation which in turn leads to increased weed growth. Since weeding had no effect on the yield the reduced yield caused by *Cercospora* must be entirely ascribed to the loss of photosynthetic leaf area. On the other hand, the presence of weeds can lead to pod loss at harvesting, pods becoming entangled in the weeds' roots, especially if the weeds occur in the plant rows. In the present experiment the soil was carefully searched for detached pods which were included in the harvest.

Excessive weed growth, particularly of broad-leaved species, could also influence the crop's micro-climate and so favour the development of *Cercospora* leaf spot. Such an effect was not observed, probably because weeds consisted mainly of grasses and were not a real problem.

Cercospora leaf spot can also have a qualitative effect on the yield. The groundnut crop ripens earlier and more uneven than when the disease is absent. If the ripening of such a crop coincides with a wet spell many seeds may germinate, as was the case in this experiment. The fungicide treatment reduced the number of germinated seeds by half. Germinated seeds are vulnerable to infection with *Aspergillus flavus* thus favouring the development of aflatoxins.

Benomyl effectively controlled *Cercospora*. But when applied 3-weekly this fungicide led to a severe attack of leaf rust. Also from the literature (Harrison, 1973) it is known that benomyl does not control *Puccinia arachidis*. Probably it kills the pathogens that compete with this fungus so that the rust can develop more easily and more agressively.

The yields obtained with fentin acetate and copper oxychloride differed little from the one when benomyl was used. Only propineb, when applied at 3-weekly intervals, gave significantly lower yields. As expected the higher frequency of application gave for each fungicide the best results. The incidence of *Puccinia arachidis* was negligeable for all three non-systemic fungicides.

Fentin acetate has also been recommended by Ter Horst (1961). He used the same concentration but at weekly intervals. In view of the phytotoxicity symptoms observed at this frequency ot application a 2-weekly application seems more appropriate. The chemical is cheaper than benomyl. A disadvantage is that at small quantities fentin acetate is much more toxic than other fungicides.

Benomyl and related chemicals are known to be able to cause resistance in *Cercospora*. This phenomenon has also been reported for *Cercospora arachidicola* and *C. personata* (Clark et al., 1974), the two causative organisms of *Cercospora* leaf spot in groundnuts. Genetic changes that may lead to resistance require sexual propagation of the fungus. The perfect stages of *Cercospora* are not likely to occur in the tropics so that the chances that in Suriname resistance to benomyl develops probably are much smaller than where the perfect stages are known to exist. The possibility cannot be completely ruled out, however. Some precaution may be necessary. Resistant strains are known to spread rapidly when benomyl is used repeatedly and exclusively. Alternating use of fungicides with different action spectra seems therefore advisable.

From the results obtained it appears that apart from benomyl chemicals like fentin acetate and copper oxychloride can be used to effectively control *Cercospora* leaf spot.

REFERENCES

Bink, J.P.M., 1975. Een cultuurmaatregelenproef bij aardnoot, *Arachis hypogaea* L. cv. Matjan; De effecten van bemesten, bespuiten tegen bladvlekkenziekte en wieden op de opbrengst. CELOS Rapporten, 110.

Bleasdale, J.K.A., 1967. Systematic designs for spacing experiments. Expl Agric., 3: 73-85.

Brady, N.C., 1947. The effect of period of calcium supply and mobility of calcium in the plant on peanut fruit filling. Proc. Soil Sci. Soc. Amer., 12: 336-341.

Brinkman, R. & L.J. Pons, 1968. A pedo-geomorphological classification and map of the Holocene sediments in the Coastal Plain of the three Guianas. Soil Survey Papers, 4. Soil Survey Institute, Wageningen, the Netherlands.

Clark, E.M. et al., 1974. *Cercospora* and *Cercosporidium* tolerance to benomyl and related fungicides in Alabama peanut fields. Phytopathology, 64: 1476.

Colwell, W.E. & N.C. Brady, 1945. J. Amer. Soc. Agron., 37: 413 (In: Goldsworthy, P.R. & R. Heathcote, 1963). Fertilizer trials with groundnuts in Northern Nigeria. Emp. J. exp. Agric., 31: 351-366).

Fung Kon Sang, E., 1966. Het optimale plantverband bij gemechaniseerde pindacultuur. Internal Report. Agricultural Experiment Station, Suriname.

Gillier, P. & S. Silvestre, 1969. L'arachide. Maisonneuve & Larose, Paris.

Harrison, A.L., 1973. Control of peanut leafrust alone or in combination with *Cercospora* leafspot. Phytopathology, 63: 668-673.

Horst, K. Ter, 1959. Het optimale plantverband voor pinda van het ras Matjan. Surin. Landb., 7: 121-128.

Horst, K. Ter, 1961. Enige proeven ter bestrijding van de *Cercospora* bladvlekkenziekte van de aardnoot. Surin. Landb., 9: 103-111.

Hoving, E., 1973. Eerste aanplantingen van peulgewassen in de proeftuin Coebiti. CELOS Rapporten, 83.

Janssen, B.H. & R. Van der Weert, 1977. The influence of fertilizers, soil organic matter and soil compaction on maize yields on the Surinam 'Zanderij' soils. Plant and Soil, 46: 445-458.

Muijlwijk, T. Van, 1974a. Een plantverbandproef met aardnoot. CELOS Rapporten, 95.

Muijlwijk, T. Van, 1974b. Een bekalkingsproef met aardnoot. Celos Rapporten, 95.

Muijlwijk, T. Van, 1974c. Onderzoek aan aardnoot te Coebiti in de periode december 1973 – april 1974. CELOS Rapporten, 95.

Slobbe, W.G. Van & J.F. Wienk, 1973. Peulvruchtenonderzoek in de STIPRIS-proeftuin Coebiti. Verslag over de periode december 1972 – mei 1973. Internal Raport. Centre for Agricultural Research, Suriname.

Veltkamp, H.J. & R. Samlal, 1976. De teelt van pinda en het voorkomen van met aflatoxinen besmette pinda bij klein-landbouwers in het district Saramacca. Rapport no. 23. Afd. Gewassenonderzoek. Agricultural Experiment Station, Paramaribo.

Wall, F.W. van de, 1975. Vaststelling van de optimale plantdichtheid van de aardnootcultivar Matjan bij de bestrijding van de bladvlekkenziekte. CELOS Rapporten, 110.

Weg, W. Van de, 1975. Vergelijking van fungiciden en hun toepassings-frequenties ter bestrijding van *Cercospora spp.* bij aardnoot. CELOS Rapporten, 110.

Wienk, J.F. & T. Van Muijlwijk, 1973. Onderzoek aan peulvruchten in de STIPRIS-proeftuin Coebiti. Internal Report. Centre for Agricultural Research, Suriname.

NAME OF PAPER: Groundnut Experiments at Coebiti in the period 1972–1975: a summary of results.
(J.F. Wienk)

Question by: A . Wahab
Country: Jamaica

QUESTION: It appears that higher densities produce higher yields. In Jamaica on newly terraced hillside soils (25^{o} slope) we (Wahab and Campbell) compared peanut yields (Spanish Var.) at 10, 50, 100 kg/ha Nitrogen as urea against a standard application of P_2O_5 (300 kg/ha) K_2O (150 kg/ha). Plant density was 500.000 plants/ha 40 cm rows with 1 plant per 5 cm row. First trial indicated no significant difference between N levels.
Averaging 4.3. tons/ha of shelled peanuts. May be you ought to try higher densities vs. var. trials?

ANSWER: The results from the density trials show that yields level off at fairly low densities. This could indeed be a varietal characteristic, as I think it is. It could also suggest that mineral nutrition was a limiting factor. As I explained we used standard fertilizer rates throughout the various trials. These were rather low so that greater amounts of fertilizer could alter the relation density-yield. This will need further systematic research. On the other hand we did some experiments in which we applied higher rates of fertilizer. No response was obtained. We also took leaf samples for chemical analysis. The mineral contents when compared with critical values as reported in the literature, did not suggest that mineral nutrition was sub-optimal. I am convinced that there must be other cultivars with a higher yield potential than the cultivar Matjan. In fact we do have some experimental lines which were selected from an unselected family we received from Nigeria some years ago. They are less susceptible to *Cercospora* and at a density of 110.000 plants/ha produced more than Matjan but did not provide a closed canopy so that the optimum density is likely to be much higher with a correspondingly higher yield.

Question by: B. Lauckner
Country: Barbados

QUESTION: The tables in the paper give many statistics, but little indication of whether there are any significant differences between these statistics. Only ocassionally does the text indicate whether differences are significant or due to experimental error. Why were (at least) standard errors not quoted?

ANSWER: I would say that this is criticism rather than a question. But let me make myself clear: I consider it valid criticism. However, in my paper I did not pay much attention to the statistical aspects because, as indicated in the title, it is a summary of results so I left it out. Of course if the meeting feels that it is a serious ommission I am quite prepared to add what Mr. Lauckner calls at least the standard errors. Whether differences are statistically significant very much depends on the probability level used. Mostly 5% is taken. Some are satisfied with 10%, others want 1%. Furthermore, what test is used to define significance. Student, Gabriel-Scheffé, Duncan? This is personal. Therefore I prefer to give the basic information of standard error, general mean of replications so that everybody for himself can try and work out the significance the way he wants and the probability level he prefers.

POTENTIALS AND PROBLEMS OF PEANUT PRODUCTION IN ST. KITTS

K.U. Buckmire
Caribbean Agricultural Research and Development Institute

The peanut industry in St. Kitts is reviewed. An account of the production systems practised by small farmers and the large National Agricultural Corporation (NACO) is given.

Yields for the island are given together with the main plant protection problems encountered and the control measures are listed.

Experimental results from St. Kitts are summarised from trials designed to demonstrate (1) the effects of spacing on yield on the local Valencia variety (2) yields of three introduced varieties.

Current Caribbean production and consumption are reviewed as well as the strategies and technologies for increasing the crop profitability.

INTRODUCTION

The groundnut or peanut, *Arachis hypogaea* L., has been grown in St. Kitts for over fifty years. The crop was generally cultivated by small farmers (mostly estate workers) on the marginal lands not being utilised for sugar cane cultivation. Plots were very small, mostly less than 25 acres.

In spite of the smallness of the plots peanut has been an important snack food to the majority of the St. Kitts population. It was a Saturday evening tradition for the children to obtain their small packets of roasted nuts from the roadside vendors who thus had a lucrative business.

The estate workers, who were the only producers of the crop often used immature peanuts as a vegetable after the full pods were selected. The immature pods were boiled and served as a cooked vegetable.

With the uncertainty of the sugar market, together with Governments policy diversifying the economy, increased peanut production was undertaken by the National Agricultural Corporation (NACO). Since 1975 NACO has, as a matter of policy, cultivated peanuts as an intercrop with sugarcane or as a pure stand on sugar cane fields that are being left fallow.

LOCATION, SIZE and CLIMATE

The island of St. Kitts (St. Christopher) is an associated state of the United Kingdom located between 17^{o} 13′ and 17^{o} 25′ and longitude 62^{o} and 63^{o} W. The total area of the island is 65 square miles.

Because of its size and location the climate is tropical and maritime. Diurnal temperature variations are small. The average yearly maximum and minimum temperatures for the island are 31°C and 24°C respectively. At the highest elevations (900ft and above) lower temperatures with minimum of 15°C being experienced between January and February. The relative humidity ranges between 65% and 89%. The prevailing wind is the Easterly Trades with an average velocity of 10 to 12 miles per hour. These winds exert a desiccating effect on the soils thus effectively increasing the number of dry months.

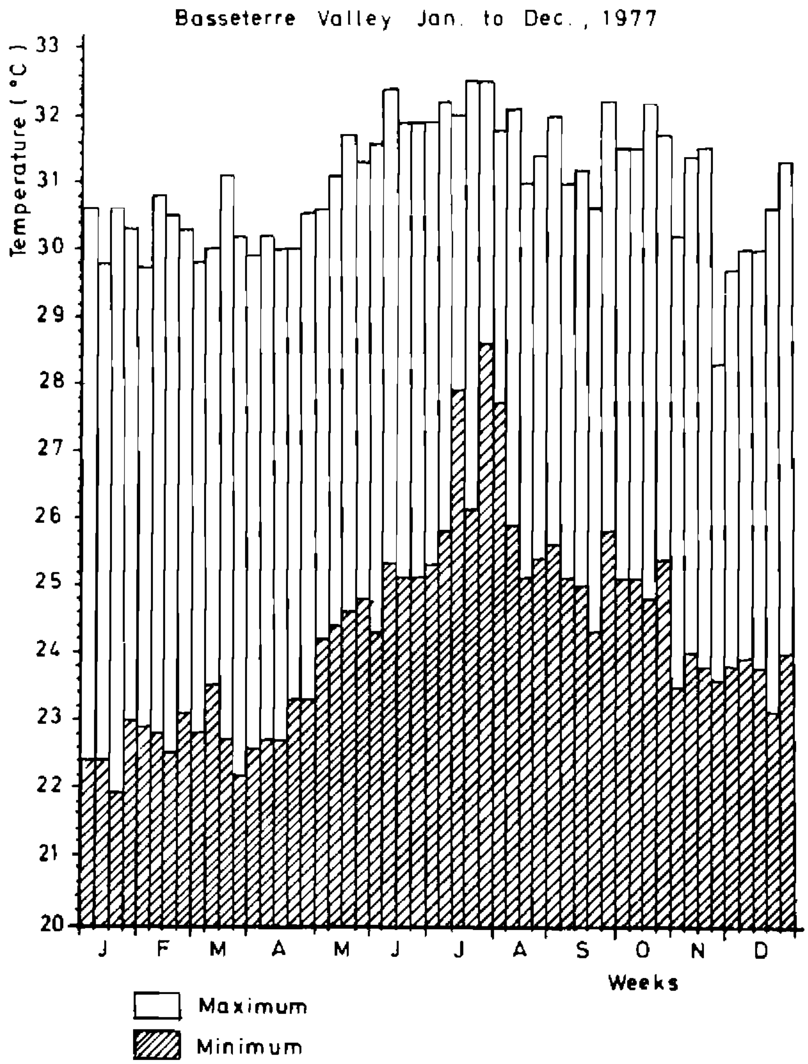


Fig.1. Mean maximum and minimum temperature at Basseterre Valley.

Figure 1 shows the mean maximum and minimum temperature recorded at the Basseterre Valley for 1977, the region where the experiments were conducted.

Rainfall and open pan evaporation data collected at Basseterre Sugar Agronomy about one mile from the experimental site are depicted in figure 2. The data show that rainfall is a major constraint to agricultural production. The records for 1977 indicate only three weeks when rainfall exceeded evaporation. There were few occasions when weekly rainfall exceeded 4.6 cm. Though July to early December could be considered the wet months, irrigation was necessary for good crop yields.

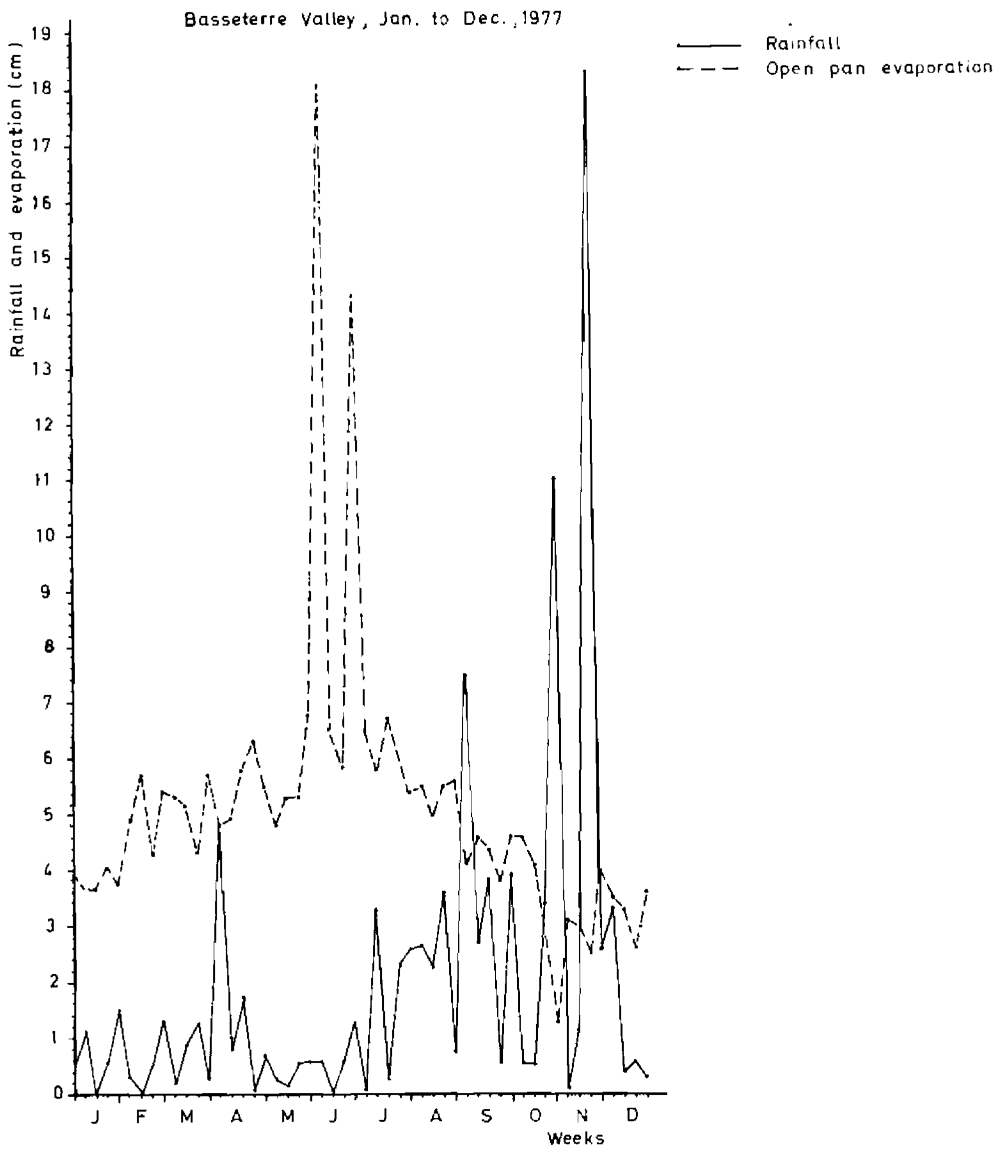


Fig.2. Rainfall and open pan evaporation at Basseterre Valley.

SOIL

The soils of St. Kitts have been described (Lang and Carrol,1966). A brief description of the more important agricultural types are:

(i) Protosols	Raw soils having a dominantly sandy texture being sandy loam to loamy sand. Derived from beach sand and volcanic ash they are considered moderately fertile and freely drained.
(ii) Young soils	Shallow, immature soils with a relatively high content of unweathered primary minerals.
(iii) Latosolics	Moderately mature soils developed on fragmented volcanic materials under relatively wet and humid conditions. There is a fair amount of clay.
(iv) Smectoid clays	Moderately mature soil formed over andesitic agglomerates. The unweathered primary minerals differ according to the degree of slope.

The experimental area is located in the protosols of the Basseterre Valley. It is of a fine gritty texture over loose volcanic ash. The series show signs of incipient cementation and is liable to wind deflation and gullies during heavy rains. table 1 presents some physical and chemical properties of the experimental site.

Table 1. Some physical and chemical data of the soil at the experimental site in the Basseterre Valley, 1977.

Coarse sand (% oven dry soil)	45
Fine sand "	28
Silt "	13
Clay "	13
C "	3.2
N "	0.25
C/N	12.8
% Base Sat^{n}	100
Truog P (ppm)	121
pH	5.8
C.E.C (m.e. per 100g oven dry soil)	9.3
Ca "	7.4
Mg "	3.0
K "	0.52
Na "	0.25
Elec cond. (mhos x 10^{-6})	177

PRODUCTION SYSTEMS

The production systems practiced in St. Kitts are as follows:

1. Small farmers produce peanuts by tilling the land with hoes making ridges six to nine inches high. The seeds are then planted by hand six to twelve inches apart. By the time young plants are four to eight weeks they are mound once or twice both to keep the weeds down and to increase the coverage of the plant base with soil.
   No pest control is practiced nor is any fertilizer used. Harvesting is by hand, sometimes using a hoe to help break back the ridge. The pods are removed from the plant by hand then dried in the sun on mats or any firm surface.

2. NACO and large farmers practice partial mechanization. Tractor is used to plough and harrow the soil to a fine till. Fertilizer is usually incorporated in the final land preparation. On pure stands the field is left flat but where intercropping is practiced, ridges are made 4.5 to 5 feet apart with the peanut seeded on the ridges while sugar cane is planted in the furrows.
   Seeds are sown 1, 4, 6 or 8 rows spaced 16 to 18 inches apart depending on the seeder used. The soil is then treated with a pre-emergence weedicide (usually alachlor).
   Should any weed control become necessary this is done manually.
   Insecticides and fungicides are applied with either knapsacks, mistblowers or tractor boom sprayers.
   At harvesting the plants are wind rowed either mechanically or by hand and left in the field 24 to 48 hours. The pods are then removed by hand and transported to sheds where they are placed in wire mesh containers to dry.

ST. KITTS PEANUT INDUSTRY

St. Kitts is both an importer and exporter of peanuts. Since 1975 NACO has been the major producer. Most of the planting takes place between September and February. This allows for seeding during the rains while harvesting takes place during the early dry season. Table 2 shows NACO production for 1976-1978.

Table 2. Groundnut production (NACO)

	1976 – 1977		1977 – 1978	
	Acres	Yield (lbs)	Acres	Yield (lbs)
Pure stand	7.5	7932	126.75	104993
Intercropping	175	80652	51.75	31602
+Mixed	144.5	51515	–	–
Totals	327	140099	178.50	136595

+ Mixed: areas of intercropping as well as pure stands.

Table 3. Groundnut and Groundnut products imported into St. Kitts 1968 – 1977 – Kitts 1968 – 1977

Country	1968		1969		1970		1971		1972		1973		1974		1975		1976		1977	
of Origin	lbs	$EC	lbs	$EC	lbs	$EC	lbs	$EC	lbs	$EC	lbs	$EC	lbs	$EC	lbs	$EC	lbs	$EC	lbs	$EC
Barbados	–	–	–	–	–	–	475	100	–	–	–	–	–	–		–	–	–	–	–
Jamaica	–	–	–	–	–	–	–	–	130	222	–	–	10000	5222		–	–	–	–	–
St. Lucia	–	–	5360	486	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–
Trinidad & Tobago	40	53	114	128	–	–	–	–	426	188	130	136	125	178	4070	5206	1228	3286	2124	6881
U.S. Virgin Islands	–	–	–	–	–	–	–	–	–	–	–	–	30	157	30	30	–	–	–	–
Netherland Antilles	–	–	–	–	–	–	–	–	–	–	–	–	–	–	80	80	–	–	–	–
Puerto Rico	–	–	60	117	–	–	140	73	–	–	–	–	–	–	–	–	–	–	–	–
USA	63	128	1220	1663	763	1380	879	1419	1429	2338	1014	1506	1149	1731	1586	4622	15045	36186	–	–
Canada	1653	1487	292	501	791	971	489	746	472	796	145	138	529	830	270	736	–	–	–	–
U.K	1414	3385	6370	7501	6769	7534	7690	8996	5352	7536	2542	4253	4126	7090	3051	8275	–	–	–	–
Netherlands	11184	4447	10160	1015	4275	2262	210	440	–	–	–	–	–	–	–	–	–	–	–	–
Br. African Cou/y	1100	430	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Egypt	–	–	–	–	3234	1750	660	360	–	–	–	–	–	–	1650	1881	–	–	–	–
Israel	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9900	29557	–	–
Syria	968	395	–	–	–	–	–	–	–	–	1650	1205	–	–	–	–	–	–	–	–
Madagacar	–	–	–	–	1100	564	–	–	–	–	2750	1777	–	–	–	–	–	–	–	–
China	–	–	550	279	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Brazil	–	–	–	–	–	–	–	–	100	532	–	–	–	–	–	–	–	–	–	–
Totals	9122	10325	24126	116900	6932	14461	10543	12134	7909	11612	8231	9015	15959	15158	10737	20830	26173	69029	2124	6881

Source Statistics Office, St. Kitts

Table 3 lists the imports of peanuts and peanut products into St. Kitts from 1968 to 1977. Over this 10 year period the country spent $173,035 EC. with the USA being the most consistent supplier. Though Trinidad and Tobago exported the commodity to St. Kitts it is to be noted that the product is only re-export as Trinidad has no commercial peanut production.

The figures on export (table 4) indicate fluctuations. In 1977 the reduction was due to the lower acreage under cultivation as a result of shortage in planting materials and drought conditions. Production of peanut is totally rain fed.

Table 4. Groundnut export from St. Kitts 1975 — 1977

Country	1975		1976		1977	
	lbs	$ EC	lbs	$EC	lbs	$ EC
Antigua	5000	6000	7846	9823	3000	4200
Barbados	—	—	82400	98880	—	—
Dominica	—	—	40	40	70	50
Grenada	—	—	210	210	50	50
Guyana	—	—	50000	60000	—	—
Montserrat	1680	2008	3050	3100	1250	1525
Netherland Antilles	80	80	1620	2200	115	130
Surinam	—	—	35000	42000	—	—
Trinidad & Tobago	—	—	22050	26450	66240	86112
U.S. Virgin Island	30	30	2149	1774	380	360
Totals	6790	8118	204365	244507	71025	82447

St. Kitts with fertile sandy loam soils is ideally suited for peanut production. The added advantage of having lands with a gradient of 0-10^{o} makes for mechanization. Major constraints are availability of water at the production site. The other problems encountered by the industry can be listed as:

1. unavailability of dryers during the rainy season
2. inefficient harvesting, resulting in about 2-5 percent of the pods being left in the field.
3. manual grading of the pods thus adding significantly to the cost of production.
4. inadequate storage facilities.
5. plant protection. This can be itemised as weed, pest and disease.

WEED CONTROL

A newly prepared field just out of sugar-cane be kept free of weeds for 4-8 weeks by one application of prometryne (2 kg a.i/ha), nitrofen (2 kg a.i/ha) diphenamid (6 kg a.i./ha) or alachlor (3 to 3.25 kg a.i./ha) as a pre-emergence. On land that was recently cultivated with vegetables no weedicide gives adequate control and therefore paraquat (0.75 kg a.i./ha) and hand-hoeing has to be employed.

PEST CONTROL

The ecological niche of the peanut crop is rich in animal species. In St. Kitts a few pests are of economic significance. *Spodoptera sunia* is the major caterpillar between September and December. *Spodoptera frugiperda, Spodoptera exigua* and *Heliothis zea* can sometimes be a problem. Recently mealy bugs (not yet identified) became a problem during the dry season. Recommendations for chemical control are show in table 5.

Table 5. Recommendations for insect chemical control

Insects	Chemicals % a.i.		
	Dimethoate	Trichlorphon	Methamidophos
Spodoptera sunia	0.1	0.24-0.32	0.05
Spodoptera frugiperda	0.08	0.24	–
Spodoptera exigua	0.08	0.24	–
Heliothis zea	0.08	0.24	–
Mealy bug	0.1	–	0.05

DISEASE CONTROL

There are two major disease problems namely *Cercospora* leaf spot and rust. Maneb 30 kg/ha or Benlate (50% wp) 400 g/ha gives adequate control of leaf spot at 7-21 days intervals. Rust, *Puccinia arachidis* is difficult to control. We have not yet been able to suppress the infection.

EXPERIMENTAL RESULTS

Trials were conducted on sandy loam soils. The land was cultivated to a fine tilth using a rotavator and left flat. The experiments were hand planted with 150 kg per ha of a compound fertilizer (16:16:8) applied in furrows 4-6 inches from the seedling 4 weeks after planting. The experimental design was a complete randomized block of 4 replicates. Diphenamid 50w at the rate of 9 kg/hectare was applied with a knapsack immediately after planting.

VARIETY TRIAL

Four varieties were evaluated with each treatment having 4 rows 26 feet long. Planting was 4-6 inches in row by 18 inches between rows 1.5 to 2 inches deep.

Table 6. Result Variety Trial

Variety	In Row Spacing (cm)	Yield kg/ha	Per metre of row	
			yield (g)	Plants
Valencia	10	9763	439.42	11
Schulamit	15	5191	233.32	7
Florrunner	15	5178	232.75	7
RF 10	15	5235	235.30	7

Results were calculated from sampling one metre of row from each treatment per replicate.

SPACING TRIAL

Six spacing regimes were tried. Each treatment was approximately 8 metres long by 4 rows, spaced 45.7 cm apart. Results tabulated below were calculated from one square metre per treatment per replicate.

Table 7. Result Spacing Trial

Treatment	Seeds per rep.	Area (m^2) per rep.	Plants per m^2	Yield kg/ha
10 x 46 cm	324	11.04	33	1140
15 x 23 cm	216	5.52	35	954
10 x 41 cm	324	5.52	33	950
10 x 23 cm	324	9.84	55	1228
15 x 30 cm	216	7.20	28	827
10 x 30 cm	324	7.20	44	1190

Variety trial was planted 6th October 1977 and harvested on 16th January for Valencia and 1st February 1978 for the other three varieties. Diphenamid (9kg/ha) was used as a pre-emergence weedicide immediately after planting.

Throughout the experimental period two hand weedings were necessary to remove weeds. The dominant weed was nutgrass, *Cyperus rotundus*.

For the spacing trial Valencia variety was planted 14th September and harvested 20th December 1977. Weed control was as for the variety trial.

The results from those small experimental trials indicate not only the yield potentials of the local Valencia variety, but that as plant density increases over 330,000 plants per hectare yield progressively decreases.

Table 8. Groundnut and Groundnut Products Import into CARICOM States 1974 – 1975

Country of Origin	Antigua lbs	Antigua $EC	Barbados lbs	Barbados $EC	Dominica 1 lbs	Dominica 1 $EC	Grenada 1 lbs	Grenada 1 $EC	Guyana lbs	Guyana $EC
Antigua	–	–	–	–	–	–	–	–	600	4866
Barbados	–	–	–	–	–	–	–	–	15000	589
Guyana	–	–	120	417	–	–	–	–	–	–
Jamaica	–	–	7563	27980	–	–	2815	3406	60044	229272
St. Kitts	5000	6000	–	–	–	–	–	–	–	–
St. Vincent	–	–	10638	10270	–	–	–	–	127031	142852
Trinidad & Tobago	–	–	185591	408265	692	661	1110	1714	372	372887
French West Indies	–	–	–	–	762	218	–	–	–	–
France	–	–	–	–	80	16	–	–	–	–
USA	–	–	42619	47666	510	790	58	110	2	3
Canada	–	–	25430	63085	–	–	4496	1005	–	–
U.K.	–	–	16974	40242	9283	18678	8531	13076	2	6
Netherlands	–	–	–	–	–	–	698	1329	16610	18369
British East Africa	–	–	–	–	1943	1554	–	–	–	–
Ethopia	–	–	20300	16694	–	–	–	–	–	–
Kenya	–	–	–	–	–	–	–	–	104906	99127
Senegal	–	–	–	–	–	–	3740	3431	26180	22896
Zambia	–	–	–	–	–	–	–	–	7508	7940
Zanzibar	–	–	–	–	–	–	–	–	–	–
Egypt	–	–	89980	78196	–	–	935	824	42995	42634
Israel	–	–	26611	22929	–	–	–	–	–	–
India	–	–	–	–	–	–	1760	1461	382750	286388
Hong Kong	–	–	–	–	–	–	–	–	–	–
Malaysia	–	–	–	–	–	–	–	–	–	–
China	–	–	–	–	–	–	–	–	25234	28643
Brazil	–	–	–	–	–	–	3850	3112	22000	15413
Total	5000	6000	425826	715744	13270	21917	27993	38594	916240	985497

1 = Year 1974

Table 8. Cont'd

Country of Origin	Jamaica		Montserrat		St. Kitts		St. Lucia		St. Vincent		Trinidad & Tobago	
	lbs	$EC	lbs	$EC	lbs	$EC	lbs	$EC	lbs	$EC	lbs	$EC
Antigua	–	–	–	–	–	–	–	–	–	–	–	–
Barbados	–	–	–	–	–	–	1500	2100	–	–	–	–
Guyane	–	–	–	–	–	–	–	–	–	–	–	–
Jamaica	–	–	–	–	–	–	398	1497	–	–	3675	12495
St. Kitts	–	–	1680	2008	–	–	–	–	–	–	–	–
St. Vincent	–	–	–	–	–	–	–	–	–	–	1100	903
Trinidad & Tobago	1840	2805	–	–	4070	5206	4670	7996	4202	5664	–	–
French West Indies	–	–	–	–	–	–	1295	523	–	–	–	–
France	–	–	–	–	–	–	–	–	–	–	–	–
USA	1397033	1043265	200	281	1586	4622	41440	36357	70	177	3672972	2776930
Canada	–	–	–	–	270	736	1744	4140	1072	1887	49200	66496
UK	2061	2645	–	–	3051	8275	27575	52049	878	1407	8910	6785
Netherlands	–	–	–	–	–	–	–	–	–	–	–	–
British East Africa	–	–	–	–	–	–	–	–	–	–	–	–
Ethopia	–	–	–	–	–	–	–	–	–	–	–	–
Kenya	–	–	–	–	–	–	–	–	–	–	–	–
Senegal	–	–	–	–	–	–	–	–	–	–	–	–
Zambia	–	–	–	–	–	–	–	–	–	–	–	–
Zanzibar	–	–	–	–	–	–	2249	1928	–	–	159586	126319
Egypt	–	–	–	–	1650	1881	10136	10523	–	–	–	–
Israel	–	–	–	–	–	–	–	–	–	–	51371	42558
India	–	–	–	–	–	–	5294	4398	–	–	253605	225902
Hong Kong	–	–	–	–	–	–	–	–	–	–	405	566
Malaysia	–	–	–	–	–	–	–	–	–	–	1839	1989
China	–	–	–	–	–	–	11201	14400	–	–	66137	57901
Brazil	–	–	–	–	–	–	–	–	–	–	–	–
Total	1400934	1048715	1880	2289	10627	20720	107502	135911	6222	9135	4268800	3318844

Source: Caribbean Community Secretariat

STRATEGIES AND TECHNOLOGIES

Total import of peanuts in the CARICOM region for 1975 was about E.C. $6.3 million (table 8). The figures also indicate that of the total weight imported 7.3% was locally produced. However, the actual CARICOM production is even less as most of the preserved peanuts and peanut products were re-export within the region from external sources.

At the present rate of consumption it is estimated that the demand for peanut in the region for the snack trade will be 15 million pounds by 1980.

In St. Kitts yields of over 1120 kg per hectare is obtained in pure stands under commercial production while with small plot experimental conditions over 9641 kg per hectare was obtained.

It is known that the average pod yield per hectare for the U.S.A is 2815 kg and that certain regions in the U.S.A. frequently surpass 3363 kg to the hectare.

Observations in St. Kitts indicate that with improved technology and adaptation of an improved package of practices, yields can be dramatically increased. The present position can be summarised thus:

1. the local Valencia is potentially a very high yielding variety with a very competitive total growth period (90-110 days).
2. there is a need for improved land preparation to obtain fine tilth to a depth of 6 inches.
3. use of an efficient seeder so that stands of 280,000 to 330,000 plants per hectare can be obtained.
4. efficient weed control measures for the first 4-8 weeks of plant growth.
5. optimum water use for quick plant growth and uniform pod maturity.
6. mechanical harvesting for inverting and combining the plants.

The results of the experiments and observations under commercial production suggest continued applied research in the areas of water use; varietal assessment; weed control (cultural and chemical); plant protection; fertilizer requirements and bacterial inoculation. However, the package of practices using the local Valencia variety can improve both yield and cost of production as high density planting decreases the incidence of weeds.

REFERENCES

Forde, St. C.M., H.W. Payne and D. Walmsley, 1975. Fertility Assessment of some soils in Antigua, Montserrat, St. Kitts and Dominica from Maize *(Zea mays)* field trials. Department Report No. 18, Department of Soil Science, U.W.I.; St. Augustine, Trinidad. P. 100.

Feakin, S.D. 1973. Pest Control in Groundnuts. PANS MANUAL No. 2. Centre for Overseas Pest Research, Foreign and Commonwealth Office. Overseas Devel. Admin; London.

Lang, D.M. and Carroll, D.M. 1966. Soil and Land-use surveys No. 16. St. Kitts and Nevis. Soil Land-Use Section of the Regional Research Centre. Imperial College of Tropical Agriculture, University of the West Indies, Trinidad. W.I. P. 50.

NAME OF PAPER: Potentials and Problems of Peanut Production in St. Kitts
(K. Buckmire)
Questions by: John Hammerton
Country: Belize

QUESTIONS:

1. What is present small farmer practice in regard to:
   a. row spacing and intra row spacing.
   b. herbicides, insecticides and fungicides?

2. What are average yields of small farmers and average costs of production?

3. What additional inputs could, in your view, be made to increase yields economically?

ANSWERS:

1. Small farmers have no standard spacing practice but our extension services over the last year or so have begun to stimulate them to spacing of 3 to 6 inches in row and 18 inches between row. The normal practice is to plant 6 to 12 inches in row and 12 to 24 inches between rows. The farmers hill the plants. No herbicides, insecticides or fungicides are used by the small farmers. They do not have small sprayers and in most cases water is not available.

2. This is not known. A specific project will have to be done to as certain same. The chief constraint for not doing such work is man-power limitations.

3. Yields can be immediately increased per unit area by:
   a. planting only the local Valencia variety
   b. better preparation of lands so that precision seeding machines can give good stands
   c. using better lifting and windrowing techniques.
   For large scale production machines for inverting will increase the recovery of pods by at least 5% but in some cases up to 20% on dry lands.

Questions by: E. Soe Agnie
Country: Suriname

QUESTIONS:

1. Why a compound fertilizer with a low K_20 content is used? In my opinion potassium requirements of peanut are rather high.

2. Why there is a great difference concerning the yield per ha between the variety trial and the spacing trial? The variety used was the same (Valencia).

ANSWERS:

1. Work so far in the Caribbean indicates that response to NPK fertilizer is not apparent. Since there is a symbiotic nitrogen supply and phosphate fixation it is recommended that soil fertility can be maintained by the suggested amounts. Let we hasten to add that more fertilizer work is planned for 1979.

2. This we cannot explain. However the experiment (spacing) was just repeated and this may throw some light on the results.

PEANUT CULTIVATION IN SURINAME

R.P.S. Ahlawat and R. Samlal
Agricultural Experiment Station, Paramaribo

SUMMARY

In spite of the fact that research on peanut began 75 years ago and positive results were obtained, peanut cultivation in Suriname is still in its primitive form, which essentially means that a wide gulf exists between scientists/administrators and farmers. This gap needs be bridged by reorienting strategies and their effective implementation to equip the farmers with latest technology and resources in order to generate farmers interest in peanut cultivation.

INTRODUCTION

The peanut is recognized as one of the most important crop plants of the tropical and subtropical world. Suriname being in the equatorial zone has the climate most preferred by this crop plant. Now with it known that peanuts originated in tropical and subtropical South America, especially countries falling along the Amazon river to about 35^{o}S, it could be possible that peanuts grew in Suriname as well since centuries. However if peanuts were grown within the present limits of Suriname by its original inhabitants, the Amer-Indians, in pre-colonial times is not known, but we do have authentic reports of peanut cultivation during colonial period.

Prior to 1900, peanuts were grown in the country but on a small scale only as the inland peanut varieties were of long duration and low yielding.

Peanut in Suriname has been a crop of small land holders (± 2 - 4ha) especially javanese, whose families provide the needed labour. The bulk of the peanut farming is traditional and of a subsistence nature as the farmers, largely, follow the centuries old systems and practices as were inherited from their ancestors. The best examples are their land tilling tools which, barring few, are primitive. The area planted under peanut by these farmers is seldom more than one hectare. Up till now peanut is mainly used for butter and salted nuts.

GENERAL

Climate

Suriname owing to its situation (2^{o} – 6^{o} N latitude and 54^{o} – 58^{o} W longtitude) has a humid tropical climate. The average annual rainfall ranges between 2,000 – 2,500 mm spread over two seasons – one long season covering May to mid August (± 1,200 mm and a short season from mid November to mid February (± 900 mm). The main season never goes dry but varies in duration and intensity, however, the minor rainy season is comparatively less reliable (Ostendorf, 1957). The maximum temperature varies between 28^{o} – 33^{o} C average being 30.9^{o}C where as the average minimum temperature centers around 23^{o}C. The relative humidity all through the year remains very high (70 - 90%) except on a few days when it drops down to around 50% during 10.30 A.M. – 4.10 P.M. Besides, the climate is strongly influenced by North-East trade winds (Voets, 1959 a, 1959 b. 1960).

Peanuts are mainly grown just after the long rainy season but a considerable area is also planted in the short season.

Soils

Peanut is mainly planted on long ridges of medium drained light textured soils ranging from sand, very fine to sandy loams of the Young coastal plain. These soils are acidic in reaction (pH (H_20) ranging from 5,3 – 6,2), and of low natural fertility (Van Amson, 1958 – 1963).

The soil structure is very poor due to a low organic matter content (1,8%) and low clay content. As a result the soil becomes very hard after one or two rains.

Depending on the drainage conditions of the field, peanuts are planted on beds or on flat land without beds.

Area and Production trends

The figures on area and production (table 1) indicate a downward trend after 1966 the year of maximum production (827 t), although yield per hectare remaining the same (900 – 1,000 kg). The districts of Saramacca and Commewijne were the main peanut producers. The decline has been more sharp in the Saramacca district – from 485 ha in 1965 to 80 ha in 1972, followed by Suriname district – from 46 ha in 1965 to 14 ha in 1972.

It is dishearting to note that from the position of surplus production in the late fiftees and early sixtees, which earned Sf. 79,000 through export, we slumped in production so much so that at this moment an amount of Approx -- Sf. 1,000,000 is annually incurred on import of different peanut products to meet the home needs.

Table 1. Area and Production of Peanut

Year	Area (ha)	Production (ton)	Average (kg/ha)
1945	360	412	1144
1946	452	350	774
1947	657	480	734
1948	360	277	769
1949	391	322	824
1950	480	284	592
1951	661	463	700
1952	459	377	821
1953	338	272	805
1954	423	476	1125
1955	315	419	1330
1956	466	553	1187
1957	434	337	776
1958	598	625	1045
1959	328	325	991
1960	461	422	915
1961	449	443	986
1962	513	551	1074
1963	627	669	1067
1964	606	605	998
1965	648	628	969
1966	712	827	1160
1967	601	640	1065
1968	429	492	1147
1969	240	247	1029
1970	284	281	989
1971	220	215	977
1972	203	183	901

EXISTING MANAGEMENT PRACTICES

Peanut production level is below the economic level being 1000 kg/ha only, which is attributable to farmers attitude towards the crop and nature of farming being subsistence.

Crop rotation

The practice in vogue is monoculture cropping, however occasionally, it is rotated with vegetable.

Land Preparation

Peanut is traditionally planted on permanently laid raised beds. The land is tilled with a hoe or a digging fork, however, gradually farmers are switching over from subsistence tradional farming to mechanized farming by introducing 2 wheel tractors. The tilling is continued till the required tilth is obtained followed by little bit levelling.

Planting

The crop is planted in rows at a distance of 30 x 15 cm and depth of 3 – 4 cm with a drill stick.

Occasionally, pre-germinated seeds are sown in order to ensure good stand. Seeds used for planting is stored by farmers in the forms of pods, which are shelled just before planting and good kernels are selected.

The variety used is mostly Broll; although Matjan is also now planted by a few farmers.

Weed control

The practice consists of hand-weeding during the first month followed by hilling at 4 weeks stage.

Fertillization

The crop is generally grown without liming and fertilizer application. A few farmers have adopted fertilization, but they too apply a very low amount – mainly NPK mixture at hilling time.

Diseases and Pests

The peanut during growth is attacked by several pests, mainly caterpillars *(Spodoptora frugiperda* and *Stegasta basquella),* and diseases, *Cercospora* and rust being most common and deadly. However, no control measures, not even pre-cautionary measures like seed treatment and crop rotation are taken by the farmers.

Harvesting and stripping

Harvesting consists of pulling plants by hand and investing them to facilitate drying followed by hand-picking.

CONTRAINTS IN PRODUCTION

Soils

Low pH and depleted fertility limit the plant to exhibit its production potential (Van Amson, in Jaarverslagen Dept. Landb. Proefstation, Suriname, 1955 — 1957). Poor water management practices too reduce yield.

Cultural practices

Peanut after peanut (low yielding varieties) in absence of fertilizer use and disease control remarkably reduces the average yield.

Farm Size

The average farm size is 2 — 4 hectares. Recent experiments on mechanization did not make any impact owing to small farm size. Because of the soil pattern, the shape of the farm land and the limited man-power the area with peanuts on one farm generally covers less than 1 ha.

Economy

Peanuts are sold in bags to middle-men. The import of peanut is free. Consequently prices on the local market fluctuate strongly. Marketing co-operations are absent.

Social

A marked reduction in the agricultural labour and a migration of the majority of younger people to cities for better jobs compelled the farmers to cut down area under peanuts (Van Amson, 1975).

REVIEW OF RESEARCH

Plant improvement

Improvement of peanuts received consideratly more attention than other legumes or oil crops in the country by virtue of its higher oil content and industrial potential.

The work on plant improvement begins with introduction of plant material from other countries. The first such introductions were Rufisque, Barbados and Mauritions made as early as in 1904. The yield trials in 1905 and 1906 revealed Rufisque better over others including the indegenous in respect of yield (Jaarversl. Inspectie Landb. W. Indie, 1904 – 1907).

A few years later (1911, 12 and 13) curacaosche peanut was also put in trials but fared badly. However, there is no mention in the annual reports of the corresponding periods that any variety was released for cultivation. A mention was made that all the above peanuts were creeping types with long growing periods (4½ – 5 months) (Jaarversl. Dept. Landb., Suriname, 1911 – 1913).

It was late as in 1928 that an introduction from Indonesia known as Katjang Brol – a spanish, bunch type with sort growing season (95 - 100 days) proved markedly superior than the existing strains. It rapidly replaced the indegenous peanuts. Later in 1940 – 41, Valencia was tested against Brol but had to be rejected owing to its susceptibility to *Cercospora* and not an irregular marurity (Jaarversl. Dept. Landb. Econ. Zaken, 1940 – 1941).

In and about 1950, it came to be known that the peanuts grown as "Brol" were a mixture of various types. Schwarz and Hartley (1950) from Indonesia categorized the Surinam "Brol" into 3 seeded peanut and Bush Negro peanut and also reported mixture of Valencia type peanut. Later on Sauer and Widjanarko (Jaarversl. Dept. Landb., Veeteelt en Visserij, Suriname, 1949 – 1954), also from Indonesia confirmed the above findings and reported that Suriname Brol was not the same as Indonesian Brol variety. With these revealitions, the efforts to evolve a variety, which could replace Brol, intensified the first step being the farming of objectives of plant improvement program (1950). The principal objectives were:

1. yielding potential and stability of productivity over a reasonably broad range of ecological conditions;
2. uniform branching-preferably spanish type;
3. earliness (95 – 100 days);
4. large seed;
5. pink seed coat;
6. pods with slight constriction;
7. presence of distinct but short dormant period – not longer than 30 days;
8. disease resistence – mainly against *Cercospora, Sclerotium* rot, *Pseudomonas solanacearum* and rosette virus.

To achieve these objectives, large scale introductions were made from different countries. The most important varieties/strains were:
Schwarz – 21, Gadjah and Matjan from Indonesia (1948); Braz – 53; Roxo 54, Marokko and Indonesia from the Netherlands (1952); Samaru – 38, Kano 38, Kano 50 and Mj-374 from Nigeria (1952); Castle Cary from Ceylon (1952); B33, C12, C73 and NC4 from USA (1952); and CM2, C12 and C27 from R.F. Mexico (1957).

The breeding methods adopted were mainly Pure line selection using individual hill as starting point and partially mutation. Pure lines were developed out of the indegenous and introduced varieties/strains beginning with Schwarz-21 and Gadjah varieties in 1949, subsequently Matjan was also included (Mastenbroek), in Jaarversl. Dept. van L.V.V., 1949 – 1953). The first yield trial was conducted in 1952 to compare 6 lines raised from Schwarz 21 with original Schwarz 21, in which line 21/504 and 21/5012 yielded significantly more than Schwarz 21 (Jaarversl. Dept. van L.V.V., 1949 – 1953). In another trial (1952-2), Matjan was compared with Schwarz-21, Gadjah and Brol, and Matjan yielded significantly higher. Schwarz 21 yielded better than Brol and Gadjah but the differences were non-significant. Brol and Gadjah were at par (Jaarversl. Dept. van L.V.V., 1949 — 1953). Based on these results, a trial was planted at Mijnzorg and Ma Retraite locations in December 1952 to compare Schwarz 21/504, Schwarz 21/5012, original Schwarz 21, Matjan and Brol but the crops suffered from water logging and hence no conclusions were drawn. The above trial was, therefore, repeated in 1953 at Ma Retraite excluding Schwarz 21 and including Gadjah. In general the yields were low, however, Schwarz 21/5012, Gadjah, Matjan and Brol were at par and significantly better than 21/504 (Jaarversl. Dept. van Landb. Veeteelt en Vissery, 1949 — 1953). In another trial in the same year (1953-6-1) with Schwarz 21/5012), Matjan, Brol, C12/2, Spantex, G.F.A., Spanish 18-38 and Roxo 54 at Cultuurtuin, analysis of variance showed significant differences (P=1%) among enteries. Matjan with 24.29 kg/are yielded 4.81 kg more than the second best variety-G.F.A. The respective yields for Schwarz 21 and Brol were 17.84 and 18.85 kg/are.

In a similar trial but with other enteries (1953-6-2), improved Spanish with 18.47 kg/are yielded significantly better than Spanish 205 and Braz 53. Trial no. 1953-6-3 showed Schwarz 21/504 with 26-32 kg/are and Gadjah with 25.05 kg/are also having almost same yielding potential. Similar trials were conducted in 1954 with 10 enteries and in 1956 with 4 enteries but no statistical conclusions were drawn (Jaarversl. Dept. van Land. Veeteelt en Visserij, 1955 — 1957).

In a trial conducted at farmers field in 1951, Matjan yielded on an average, 3 kg/are more than Brol (Ter Horst and Mastenbroek, 1960). The line testing continued intensively till 1959 but none was found better than Matjan. Therefore, Matjan seed was multiplied and distributed among the farmers. Ter Horst and Mastenbroek (1960) while summarizing the results of the trials conducted till 1957 concluded that Matjan, Schwarz 21/504, Schwarz 21/LP5012 and Gadjah yielded constantly more than other enteries; but out of these four, Matjan met most of the requirements except: (a) jumbo sized seed, (b) presence of a dormant period and (c) resistance to *Cercospora,* although it was fairly resistant, and hence Matjan was released.

Bekendam of Wosuna (Jaarversl. Dept. van Landb. Proefstation 1958 — 1963) irradiated seeds of Matjan with or (control), 100, 2500 and 5000 of gamma rays to broaden the genetic variability. Most mutants showed variations in pod size, seed size, pod numbers, plant type and yielding potential. By the end of 1961 i.e. in 8 generations 16 best lines only were retained. In a yield trial with these lines and original Matjan, it was observed that mutants derived from seed treated with 1000 yielded up to 32000 kg/ha i.e. 30 — 40% more than Matjan (Huiswoud, (Jaarversl. Dept. van Landb. proefstation 1958 — 1963). A varietal yield trial conducted for three seasons (1962 — 63) with 3 introdctions from Africa viz. A124b, H3, 271A and Matjan mutant, Matjan and Engour Zang 270A; Matjan with 26.11kg/are stood first followed by A124b in the short rainy season; and 271A with 14.34 kg/are was first followed by 124b in the long rainy season. Two F.A.O. varieties named as Sape Roxo and FAO 11899 beat Matjan by a fair margin in a yield conducted in 1964 (Jaarversl. Dept. Landb. proefstation 1964-1966).
Likewise some more introductions were made and compared with Matjan for yield at CELOS during 1971-72. In both trials, Matjan clearly outyielded other varieties (Annual Rep. Celos, 1971 and 1972).

Mineral Nutrition

Peanut are generally planted on the very fine sandy ridge soils of the Young coastal plains. The maximum yields have been reported on the highest past of these ridges. (Ter Horst, 1961b). Recent experiments on sandy loam soils of Coebiti have given very good results (Wienk, in Annual rep. Celos, 1973). These soils are very acid, pH (H_2O) ranging from 5.3 – 6.2, highly leached, excessively permeable and of low natural fertility (Van Amson, in Jaarversl. Dept. van Landb. Proefstation, 1958 – 1963).

The first fertilizer experiments dates back to 1913 (Drent, 1913) in which patenkali, bone meal and lime were compared but the experiment was spoiled due to bad weather. the systemic research work on mineral nutrition began in 1951 with an orientation experiment at Peperhol (Ostendorf, in Jaarversl. Dept. van L.V.V., 1949 – 1953). The treatment consisting of 333 kg double super phosphate, 267 kg potassium sulphate, 13.3 kg/ha each of $CuSO_4$, Mn SO_4 and Zn SO_4 gave highest yield (12.4 kg/are) followed by 133 kg/ha potassium sulphate treatment with 10.1 kg/are. It was, therefore, informed that crop responded positively to the application of fertilizers mainly P and K and pastially to trace elements. Ostendorf (in Jaarversl. Dept. van L.V.V., 1949 – 1953) confirmed his earlier findings and reported that artificial inoculation had no influene either on the yield or quality. Verhoog (Jaarversl. Dept. van L.V.V., 1955-1957), in a permanent fertilizer cum rotation experiment conducted from 1952 to 1956 obtained significantly higher yields with 20,000 kg/ha FYM. Among the remaining treatments fertilizers combination in 5:10:10 yielded more but the differences were non significant. Smit and Mc.Gillavry (Jaarversl. Dept. van L.V.V., 1955 – 1957), reported K's effect more pronounced than P and N.

Ter Horst (1961b) from a Variety x Fertilizer experiment conducted at Tambaredjo (Saramacca) reported 44.5% increase in yield with 200kg of 5:10:10 fertilizer plus 50kg/ha kieseriet. He obtained similar results at Lelydorpplan (Ter Horst, 1961b) and Catharina Sophia (1958-60) but the increase was 17% only. Addition of lime @ 500 kg and 1000 kg/ha along with 200 kg of 5:10:10 fertilizer plus 50 kg Kieseriet increased yields by 34 and 47% respectively. Further experiments at Dirkshoop (Van Amson and Ter Horst, in Jaarversl. Dept. van Landb. Proefstation, 1958 – 1963). Dam Malang, Peperhol and Tijgerkreek (Ter Horst, in Jaarversl. Dept. van Land. Proefstation, 1958 – 1963) exhibited response up to 2000 kg/ha lime but maximum increase in yield was from first 500 kg.

In a demonstration trial at Saramacca-0 with zero, 200 kg of 5:10:10 fertilizer + 50 kg Kieseriet, and 1000 kg/ha lime, the yields were 8.9, 17.8 and 18.5 kg/ha respectively (Ter Horst, 1961b). These studies indicated a relationship between soil fertillity and soil pH.

Van Amson en Ter Horst (Jaarversl. Dept. van Land. Proefstation 1958 – 1963), measured pH of some selected peanut fields and found that lowest yields corresponded the lowest pH and vice versa. The main reason ascribed was low fertility status of low pH soils. On the basis of pH values, young coastal plains were divided in two fertility classes by an imaginary line running across in east-west direction, north of which soil pH (H_2O) ranged between 5.8 – 6.00 and in south from 5.2 to 5.4. It was, therefore, recommended that north of this line 500 kg and in south 1000 kg/ha ground calcic lime stone or shells be added with 200 kg of 5:10:10 fertillizer plus 50 kg of magnesium sulphate plus micronutrients mixture containing Zn and Mo. (Ter Horst, 1961).

As yet the research was concentrated on the traditional peanut growing areas. Results of liming experiments conducted in the interior also indicated response to liming.

Studies on time of application of phosphatic and potassium fertilizers (Wienk, 1974) indicated basal application better over splitting.

Management

Plant population

An optimum plant density and uniform stands are important yield contributing factors. In a experiment at Mijnzorg during 1948-49 on plant density, best results were obtained with 1111 plants/are (Jaarversl. Dept. van Landb. Econ. Zaken, 1940 — 1941), Mastenbroek and Smit (Jaarversl. Dept. van Landb. Veeteelt en Visserij 1949 — 1954) reported significantly higher yields in closer spacings (20 x 20 and 20 x 30 cm) over the wider spacing of 20 x 40 cm. Smit (Jaarversl. Dept. van Landb. Veeteelt en Visserij 1949 — 1954), obtained similar results at Sidoredjo (Saramacca). The spacing of 20 x 20 cm (2500 plants/are) yielded significantly more than 30 x 20 (1667), 40 x 20 (1250) and 60 x 12 (1389) spacings. Ter Horst (1959) reported that the population of 1009/are and above gave significantly higher yields than lower densities. The differences among 1009, 1667, 221 and 3330 plants/are were non-significant. The shelling percentage and 1000 kernel weight were comparatively higher in closer spacings.

In an experiment conducted at CELOS (Annual Rep. Celos, 1969), maximum LAI values recorded 79 days after sowing were 2.26, 3.07 and 4.22 ± 0.082 for 20 x 30 x 30 and 40 x 40 cm spacings respectively. The corresponding ripe pod yields were 3.99, 3.21 and 3.09 ± 0.311 t/ha. The net assimilation rate was comparatively higher in wide spacing.

Tillage

An experiment was conducted to compare rotorating, ploughing and minimum tillage (Van der Sar, in Annual Rep. Celos, 1974 in whiph ploughing gave the best yields followed very closely by rotorator. The yield in minimum tillage treatment was very low.

Weed Control

For results of weed control experiments, see Dumas and Ausan (1978).

Harvesting and Stripping

Most of the peanut crop is harvested by hand. This consists of pulling and inverting the plants to facilitate drying of pods (Ter Horst, 1961a). The real problem with the small farmers is that they cannot afford big tractors. A project on designing and testing of peanut diggers is already in progress.

Stripping operation is also labour intensive but two peanut strippers heavy and low duty designed and developed at CELOS (Van der Sar, (in Annual Rep. Celos, 1974)

Diseases

All the five major diseases common in tropical regions have been observed in Suriname as well in varying intensities but *Cercospora, Puccinia arachidis, Sclerotium rolfsii* and rosette virus are more serious.

Cercospora

The causal organisms are *C. arachidis – Cola Hosi* and *C. personata* Ellis and Everh. These organisms are dark brown to black spots surrounded by a yellowish ring and are found on both sides of the leaves. It appears through-out the year but is more severe in the short rainy season especially and of November to half December.

Control:

Control through host plant resistance was considered to be most practical method and hence was laid as a criteria for selection of a variety. Matjan was reported to be fairly resistance against *Cercospora* compared to other varieties (Mastenbroek, Jaarversl. Dept. van Landb. Veeteelt en Visserij, 1949 – 1954). The trials conducted in 1957 on screening of material with respect to their resistance to *Cercospora* revealed C-12, C37 and CM12 recieved from R.F.Mexico comparatively more resistant than Matjan. (Jaarversl. Dept. van Landb., Veeteelt en Visserij, 1955-1957).

The work on chemical control begin with Perenoxe (1%) @ 600 l/ha, which showed some preventive effect (Jaarversl. Dept. van Landb. Veeteelt en Visserij, 1949 – 1954). In 1953, two experiments – one with seven fungicides and another with Perenoxe (1%) were conducted but failed due to bad weather. Suchtelen and Del Prado conducted several experiments till 1957 with copper and sulphur fungicides and oils but the results were disappointing and erratic. In 1959, organic fungicides riz. Brestan (Triphenyltin acetate) gave the best results (Ter Horst, 1961a). In Subsequent experiments (CT 60-67, VP 238, VP 239 and VP 240) its dose and spraying shedules were worked out. The results indicated 1.5 – 2 gms Brestan per litre of water every 10 day beginning from 8th week gave good control.

Puccinia arachidis

This pathogen was reported in this area as early as 1911. The organism is found mainly on the lower surface of leaves, where it seems just, as necrotic flecks and later as yellowish spots on the upper surface. While these necrotic spots do not enlarge much, the infected leaves soon show burning and finally result in defoliation.

Control: Brestan 1.8.2.10 gms/litre gives good control. The number of sprayings depends upon the intensity of disease but 2-3 sprays are generally recommended (Ter Horst, 1961a).

Sclerotium rolfsii

The leaves of the affected plants first wilt and then turn brown, finally the plant dies.

Variety Matjan is resistent to this disease and hence negligible percentage of plants are found affected (Ter Horst & Mastenbroek, 1960).

Rosette Virus

It is characterized by a condensation of the whole plants. Petioles and internodes are shortened, giving the plant a typical rosette appearance.

Variety Matjan is resistant to rosette virus as well (Ter Horst & Mastenbroek, 1960)

Aflatoxin

A study was carried out to study the damage done by *Aspergillus flavus*. Poor treatment of the crop after harvest is of fundamental importance. Based upon the results of this study the farmers could be advised. Stripping and a dry treatment of the nuts are essential (Veltkamp and Samlal, 1976).

Insect pest

The peanut is attacked by several pests but most common are *Spodoptora frugiperda* and Caterpillar *Stegesta Basquella*. Effective control has been obtained with Dieldrin @ 3 litres/ha or Ditherane @ 3 gms/litre of water.

In the interiors ants also damage peanuts seriously. Aldrin 2% dust @ 1 kg per 100 Sq.m. of surface area of nest (Van Dinther, 1958) or mirex (Van Brussel and Van Vreden (in Jaarversl. Dept. van Landb. Proefstation, 1964 — 1966), give excellent control.

REFERENCES

Annual Report 1969, CELOS Bull. No. 9

Annual Report 1971. CELOS Bull. No. 16

Annual Report 1972. CELOS Bull. No. 18

Annual Report 1973. CELOS Bull. No. 28

Annual Report 1974. CELOS Bull. No. 31

Dumas R.E. and Ausan S. 1978. Research results and practical experiences regarding weed control in peanuts in Suriname-Proc. CFCS Vol. XV : 272 — 287.

Jaarverslagen 1904-7. Inspectie van de Landbouw in West Indie.

Jaarverslagen 1911-13. Dept. van Landbouw in Suriname.

Jaarverslagen 1928-30. Dept. van Landbouw Proefstation, Suriname

Jaarverslagen 1931-32. Dept. van Landbouw Proefstation, Suriname.

Jaarverslagen 1949-54. Dept. van Landbouw, Veeteelt en Visserij, Suriname

Jaarverslagen 1955-57. Dept. van Landbouw, Veeteelt en Visserij, Suriname.

Jaarverslagen 1958-63. Dept. van Landbouw Proefstation, Suriname.

Jaarverslagen 1964-66. Dept. van Landbouw Proefstation, Suriname.

Jaarverslagen 1967-69. Dept. van Landbouw Proefstation, Suriname.

Jaarverslagen 1974. Dept. van Landbouw Proefstation, Suriname.

Jaarverslagen 1975. Dept. van Landbouw Proefstation, Suriname.

Ostendorf, F.W. 1957. Our climate 8. Wet and dry periods. De Surinaamse Landbouw 5: 168-78

Sauer, G. and S. Widjanarko 1953. Historische Ontwikkeling van de *Arachis* Cultuur Landbouw 25:255-64

Schwarz, M.B. and C. Hartley, 1950. De selectie van Schwarz 21, een tegen slijmziekte resistente lijn van *Arachis hypogaea.* Landbouw 22:223-44.

South, F.W. 1911. Fungus disease of groundnut in the West Indies. West Indian Bull. No. 11: pl. 153-60

Ter Horst, K. 1958. Weed Control in Leguminous crops. De Surinaamse Landbouw 6:65-71.

Ter Horst, K. 1959a. Oil is of no use against the *Cercospora* leaf spot disease of peanut. De Surinaamse Landbouw 7:115-17.

Ter Horst, K. 1959b. The optimal spacing for spanish type peanut. De Surinaamse Landbouw 7:121-28.

Ter Horst, K. 1961a. Some experiments on the control of *Cercospora* leaf spot disease of ground nut. De Surinaamse Landbouw 9: 103-11.

Ter Horst, K. 1961b. Onderzoek naar de Bemesting van pinda in Suriname. Landbouwproefst. Meded. No. 27.

Ter Horst, and J.J. Mastenbroek, 1960 . Selection of pulses in Suriname. II *Arachis hypogaea.* Ground-nut. De Surinaamse Landbouw 8: 134-50.

Van Amson, F.W., 1961. Soil profiles of a hydromorphic sequence in a typical ridge sand. Agric. Expt. Station Bull. No. 78.

Van Amson, F.W., 1975. Agricultural potentials in relation to changing social patterns. De Surinaamse Landbouw 23:44-50.

Van Amson, F.W.; A.M. Sang A Jang; W.L. Asin; K.J. Lenselink, 1974. Bodemkundig en Agro-hydrologisch onderzoek. Gegevens het betreffende de kartering van de proeftuin, Coebiti. Landbouwproefstation Intern Rapport No. 234.

Van de Voorde, P.K.J., 1957. Soil conditions of the ridge land scape and the old coastal planes in Suriname. Landouwproefstation Bull. No. 74.

Van Dinther, J.B.M., 1958. Leaf cutting ants in Suriname and their control. De Surin. Landb. 6: 18-27

Van Drent, E., 1913. Bijlage behorende bij het verslag van de Landbouwleraar: verslag over het jaar 1913. Reptr. van den Landbouw in Suriname 48 en D.

Voets, B.A.D., 1959a. Meteorological records of Surinam 1958. De Surinaamse Landbouw 7:51-55.

-- 1959b. Meteorological records of Surinam 1959. De Surinaamse Landbouw 7:151-63.

-- 1950. Meteorological records of Surinam 1960. De Surinaamse Landbouw 8:57-63.

Veltkamp, H.J. and R. Samlal, 1976. De teelt van Pinda en het voorkomen van met Aflatoxinen besmette pinda bij kleinlandbouwers in het distr. Saramacca—Rapport No.23.(unpublished)

Wienk J. 1978. Ground-nut experiment at Coebiti in the period 1972-1975; A summary of results. Proceedings of the C FCS vol. XV : 218-235.

GEORGIA PEANUT PRODUCTION — A PACKAGE APPROACH

J. Frank McGill
Extension Professor of Peanuts
University of Georgia

It is a distinct honor and happy privelege to be invited to participate in this highly significant commemoration of Suriname's Agricultural Experiment Station's 75th Birthday and the 15th meeting of the Caribbean Food Crops Society.

We owe a depth of gratitude to South America for the peanut — one of nature's most nutritious food crops that probably originated in the eastern slopes of the Andes Mountains in Bolivia. Today in Georgia, peanuts rank as the number one cash crop with a farm value exceeding $300 million and with a peanut processing value exceeding $1 billion.

Peanuts are one of the three most important food legumes for mankind. In the world today, there are approximately 40 million hectares of soybeans, 17.2 MH of dry beans and 15.6 MH of peanuts. As a food crop, peanuts are still in their infancy. Greater emphasis upon its use as a food crop by your experiment station, the Caribbean Food Society and the U.S. Peanut Industry can and will cause it to make a greater food contribution for mankind in a protein deficient world.

U.S. is still one of the few peanut producing countries of the world that makes maximum use of the peanuts as a food crop. In most of the major peanut producing countries of the world such as India and China, where more than one half of the world's peanuts are grown, they are used mainly for oil instead of food use.

The chemical composition of the peanut, containing approximately 25% highly digestable protein and 50% oil makes it a natural for expanded use as a food crop. Since the protein is left in the meal or flour after the oil is expelled, there is the unlimited potential for using the peanut flour in human nutrition as bakery products and as meat substitutes or extenders. Such products or peanut flour will add a new dimension to the statue of the peanut as a food crop plant. Research in this important area has only scratched the surface, and there is more to come.

Peanuts currently rank 13th among the list of those crops standing between mankind and starvation. Peanuts will likely move forward on this list and gain prominence in proportion to their increased use for edible purposes instead of for oil.

U.S. peanut efficiency is among the highest in the world. By acreage, U.S. ranks 6th in the world but in total production they move up to third place, accounting for approximately 10% of the world's peanut production.

Georgia's peanut growers have achieved the highest average per acre yield of any state in the U.S. or of any other peanut producing country of the world except Israel. Georgia's 1978 average yield per acre is 3300 pounds of pods per acre compared to 2600 pounds for the U.S. and 800 pounds per acre for the world average.

Georgia's peanut production success did not occur by accident, but through a viable research program that has provided the "Package of Technology" and an agressive dynamic educational program that has resulted in its adoption by peanut growers.

A review of Georgia's per acre production reveals that there was very little progress achieved for a 20-year period from 1940-1960. During this period there was very little research and

Symposium on maize and peanut; Paramaribo
Nov. 13 - 18, 1978

extension effort placed on peanuts. However, during the past 20 years with increased research extension and industry effort the average yield of peanuts has almost trippled.

Peanut production in Georgia is based upon "A Package Approach". Peanuts are an ultra-sensitive crop plant from a cultural standpoint. For example, land preparation affects disease, weed and insect control. Therefore, a complete package of technology must be integrated and adopted by growers if they are to achieve maximum yield and quality of peanuts.

Land Selection

– Peanuts should not be planted on the same land more than one year out of three. Soil-borne and foliar diseases will be more severe. Also, if possible plant peanuts following a grass crop such as corn, small grains, sorghum or permanent pasture sod.

Land Preparation

Completely bury all surface litter and weed seed below 4 inches. Apply broadcast application or fertilizer if needed prior to land turning. Research results in Georgia have shown that this can best be accomplished by the use of a bottom plow equipped with trash covering devices. This also provides an ideal physical environment for peanut root development. The next step in land preparation is to apply soil incorporated herbicides to a depth of 3 inches and form precision – flat table top row beds.

Fertilizer and Lime

– Optimum soil pH for the peanut is 5.8 to 6.2. Peanuts usually respond better to residual fertility than to fertilizer directly applied. However, if soil is low in phosphous and potassium as indicated by soil test, a moderate rate of fertilizer should be directly applied. Broadcast to raise this to a medium level, preferably preceding final land preparation.

Planting

– Peanuts are usually planted in 2, 4 or 6 rows per tractor, 2-3 inches apart in 32 inch to 36 inch rows 3 inches deep. In planting, care should be exercised in not pulling back up any buried crop or weed residue and the planting profile should be left level, smooth and with a table top finish. This allows the peanuts to flower and develop normally and also reduces seedling soil-borne diseases.

The peanut is a highly efficient legume and will synthesize its nitrogen needs provided the correct fixation bacteria is either in the soil or added. Calcium is essential in the pegging zone and is the most common cause of "Pops" or "Black Plumule". Boron deficiency causes "Hollow Heart" and can be corrected by applying one-half pound of actual boron per acre.

Varieties

Florunner variety has out-yielded all other peanut varieties over a 5-year period of testing in Georgia. Likewise, Georgia peanut growers plant this variety on 98% of the State's peanut acreage.

Weed Control

— Consists mainly of a tank mixture of Vernam (2-3 pts.) plus Balan (3-4 qts.) per acre broadcast basis and incorporated 3 inches deep just prior to planting. This is followed by anyone of several mixtures of chemicals applied "at cracking" to further control any weeds which may have escaped pre-plant soil incorporated herbicides. Each chemical has its strong and week points, therefore, a "prescription" approach should be used in the selection of peanut herbicides. Post applications of dinitro are often advisable if weeds emerge following "at cracking" treatments to control weeds in the 2-leaf stage with little or no damage to peanut seedlings.

Disease Control

— Southern Blight *(Sclerotium rolfsii)* is the most serious soil-borne disease of peanuts in Georgia. Partial control may be obtained by rotation, land preparation and by chemical means. This organism is a saprophyte, therefore, thorough disposal of previous crop and weed residue below 4 inches is essential. If these organisms find food material in the soil surface, the disease can then attack the peanut plant. Disease control by chemical means is suggested only in severe problem fields as a supplement to the cultural control.

Cercospora leafspot is the most serious foliar disease of peanuts with both early and late strains causing serious defoliation problems if not controlled with fungicides. Bravo + Sulfur has been the most effective fungicide treatment for both strains of *Cercospora* and rust *(Puccinia)* when used on a 10-14 days schedule, closely followed by Duter and Sulfur.

Insect Control

— Lesser cornstalk borer *(Elasmopalpus lignosellus)* has been the most serious peanut soil insect attacking pegs and pods particularly on light textured soils during dry years. No chemical applied to the soil at planting has given control during mid to late season when the insects attack peanuts. (2.0 lbs./A of Parathion or Dyfonate) granules applied in an 18 inch band over the row when a damaging infestation is found has given the most effective control.

Foliage feeders consist mainly of corn earworm, velvetbean caterpillar and fall armyworms.

Water Use

— Although the peanut is quite tolerant to a moderate drought, irrigation has proven to be a profitable practice in Georgia on light textured soils. In spite of Georgia's 48-inch average annual rainfall, distribution is the problem. A three year test has shown an average yield increase of 600 to 800 pounds per acre from the use of carefully timed supplemental irrigation. Approximately 40% of Georgia's peanut acreage is under irrigation.

Maturity

— Peanuts of the Florunner variety should not usually be harvested until 70-80% of them are mature. "When to dig" is still more of an art than a science in spite of several new chemical techniques on peanut maturity that are in the research and development stages. There is no substitute for shelling out a representative sample of kernels to determine stage of maturity.

Harvesting

– Peanuts are mechanically inserted and left to partially dry in the sun for 2-3 days at which time the moisture percentage is reduced from 40% to approximately 20%. They are then combined and placed in drying wagons for artificial curing down to an average of 8½% moisture using temperatures not exceeding 915°F-100°F. Current emphasis is on using more forced air and less heat in reducing moisture for maximum peanut quality for seed or edible use.

NAME OF PAPER: Georgia Peanut Production – A package approach
(J.Frank McGill)

Questions by: Errol B. Whyte
Country: Barbados

QUESTION: Do you have a nematode problem on peanuts in Georgia – if so, what are the recommended nematicides?

ANSWER: Yes – On approx. 15% of Georgia's lighter sandier textured soils there are rootknot problems of sufficient magnitude to warrant preventive chemical control. They are *Meloidogyne arenaria* and *Meloidogyne hapla*. Some lesion nematodes *Pratylenchus sp.)* also infect peanut hulls and stems which probably opens the door for soil-borne fungi. However, the damage from these do not generally warrant a control recommendation.

P.S. Rec. nematicides are:
Soilbrom. 90 -1 -1.5 gal/row treatment or the lesser effective contact materials such as furadan or nemacur at 2.5 – 3.0 lbs. A.I./A on a 16" band incorp. over the row 3-6" deep.

Questions by: H. Payne
Country: Jamaica

QUESTIONS:

1. Do you agree that here is a need to express peanut yields in terms of pounds per acre per week of growth to standardize comparison of varieties?

2. In Jamaica – experiments have indicated a prolonged period for maturity from 105 days to 145 days with a change in elevation from 50 ft. to 1500 ft above sea level.
   What effect do you think that elevation would have on yield levels?

ANSWERS:

1. Yes – I agree with you particularly in Central America where you can use the soil 12 months in the year.

2. Regarding elevation, if temperatures are not excessively cool (below 60°F at night) I would expect to obtain a higher yield at the higher elevation, assuming water and disease control were comparable.

P.S. If you will make your request through A.I.D. I can probably give you some further assistance.

THE APPROPRIATENESS OF SPECIFIC PACKAGES OF TECHNOLOGICAL PRACTICES FOR WEED CONTROL IN PEANUT CULTIVATION IN JAMAICA

H. Payne

CARDI – U.W.I. – Mona

SUMMARY

In Jamaica, scarce foreign exchange makes it very important to examine carefully every aspect of technology employed in agricultural production to ascertain its appropriateness to local conditions and particularly its labour employment opportunity.

On small farms where a fraction of an acre is involved in peanut production it is most advantageous for optimum utilization of family labour to employ manual methods of weed control. In this way family income is optimized. Improved cultural practices and management involving maximization of land use would increase the efficiency and effectiveness of manual methods of weed control on small farms which collectively could supply Jamaica's needs for "ball park" peanuts.

Peanut industrial development in Jamaica however depends on expansion of the size of individual areas devoted to this crop. With increased size of areas, manual methods of weed control become less desirable. It would be disastrous, as far as efficiency is concerned, to depend on a large number of hired workers employing manual methods of hired workers employing manual methods of weed control only on individually large areas of peanut production. Economy and competitiveness of the final product will dictate a shift to a higher level of technology and capitalization involving the use of chemicals and fuel powered cultivators.

Although an integrated system involving all methods of weed control is essential for successful peanut production it would be unwise to specify any particular package of technological practices for weed control as the desirability of any practice or group of practices varies widely with circumstances and is determined by optimization of income, factor utilization and the satisfaction of well-being.

INTRODUCTION

An integrated system of all methods of weed control is essential in economic peanut production. Methods of weed control are best considered as occurring in one of the following distinct groupings:

Cultural
Chemical
Mechanical – the use of cultivators, powered by fuel
Manual – hand labour assisted by simple tools as the cutlass or hoe.

The role and thus the appropriateness of each of these methods either separately or in combination varies widely with circumstances. For example, in small farming where only a fraction of an acre is involved in peanut production, it would be advantageous to rely on manual methods thus better utilizing the excess labour usually available on the small farm. Only under these conditions a labour intensive approach to weed control is to be preferred to the more technological and capital intensive approach involving the use of chemicals and equipment, both of which might be outside of the skills and financial competence of the small farmer; hence manual methods of weed control are most appropriate on small farms. The accumulated effect of a labour intensive approach to weed control on small farms can have national significance in Jamaica in that there will be a savings of scarce foreign exchange that would otherwise have to be utilized for purchase of chemicals and equipment from abroad. However, as the individual areas to be devoted to peanuts are increased from a fraction of an acre, the need for improved technology and capitalization increases. No longer will it be possible for the farm family to carry out the required operations timely and efficiently. As the size of the peanut undertaking increases beyond an acre the cost of hired labour quickly becomes prohibitively high and efficiency would dictate an increase in the roles played by other methods of weed control if the final product is to remain competitive with the farmer obtaining the greatest benefit from his enterprise. Hence with increased size, labour intensive methods become less appropriate. Where extensive areas are involved in peanut production the advantages of chemical and mechanical methods of weed control come into their own although it is not possible to completely eliminate manual methods.

In Jamaica, very high prices are paid for "ball park" peanuts and on this market it is quite feasible for the sake of social benefit to make weed control and even other operations in peanut production labour intensive; however, if peanuts are required for processing into canned peanuts, butter or confectionaries or the numerous other uses of peanuts, there is an urgent need to increase mechanization and to improve the technology. Although such action would increase the foreign content of the industry, the shift cannot be avoided for efficiency. It must be realized that the cost of hand labour is high in terms of its productivity and for national survival, Jamaica must increase its productivity both per man and per acre and only in this context would peanuts play its proper role in the country's economy. Jamaica cannot subsidize inefficiency in any of its farming operations and expect to fulfill the aspirations of its people.

Cultural Methods

There are several operations carried on in peanut production that although not undertaken specifically for weed control have much significance in this regard and it is important to maximize the weed control benefits of these operations for success.

a. Thorough land preparation

Seed bed preparation usually commences with thorough clean-up operations of all plant remains and are followed by a number of tillage operations to provide a good tilth. Where tillage operations are suitably spaced with long intervals for weathering, the desiccating rays of the sun do much to reduce weed problems. Land preparation must not be hurried for good soil tilth alone but for maximum weed and other pest control benefits.

b. High plant populations

Spacing or arrangement of plants varies with variety grown – bunch or runner types,

system of planting involved — mechanical or manual and other factors but high plant populations are to be preferred. In Jamaica, with the local bunch type (Spanish) a 4 inch spacing in rows 18 inches apart have proven optimal under most circumstances. It is important to stress that cord lines should guide the establishment of straight rows. Any failure in this regard makes subsequent interrow cultivation and harvest difficult. High plant densities not only ensure higher yields but the shading effect of the crop is the most economical measure for weed control. All techniques such as placement of fertilizer about 1 inch below the depth of planting thus giving the crop a unique advantage for vigour can be considered as having special weed control merit.
Implementing seeding immediately after the final soil refinement operation allows the crop opportunity to get a good head start over weeds. Here also, careful selection and treatment of seed for protection against insect and disease damage combine with establishment on moist soil to give complementary benefits in the fight against weed growth.

c. Crop rotation and multiple cropping

Peanut production should be pursued as an integral part of the systematic development of the entire farm. Since peanuts is a clean cultivated crop that affords the soil little protection, it should be established only in flat or gently sloping areas or in areas that have been adequately protected from erosion losses through terracing. This factor makes site selections most important and it is wise to give special consideration to avoiding areas with weed problems — "prevention is better than cure". Continuous cropping is the most effective weed control measure and peanut being a legume has special merits as a rotational crop with a wide range of crops and its value as an intercrop is increasingly being realised. Infrequent cropping where the land is idle for protracted periods and/or permitted to go to bush fallow, aggravates weed problems. Bare fallowing, in areas of gentle slope where erosion is not a hazard, is to be preferred to bush fallow by virtue of its moisture conservation merits as well as avoidance of built up weed seed infestation.

d. Farm and field sanitation

Maintenance of clean hedge rows, suppression of weed growth on irrigation and drainage water ways and field intervals all have a vital role in peanut production of high quality. Collection and disposal of weeds eradicated from peanut fields form a part in the fight for maintaining good crop sanitation. The earliness of removal of weeds before their seeding is the key to success; indeed "a stitch in time saves nine".

Chemical Measures

Pre and post selective herbicides that would give effective weed control throughout cropping is a thing of the future. In Jamaica the use of Gesagard at 2 lb. a.i. per acre have given satisfactory control for about 6 weeks after planting under a wide range of conditions. It is important to stress that for effectiveness Gesagard must be applied to moist soil. Irrigating immediately after gesagard application reduces its effectiveness. Under circumstances of good seed bed preparation it has proven possible to eliminate any other control measure up to "closing in" of the rows planted at 18 inch intervals. In areas with a history of weediness, it has proven advantageous to reduce firstly the weed seed content of the soil before crop establishment. Either by awaiting a shower of rain but preferably by carrying out an irrigation on the thoroughly and completely prepared area, weeds are forced to germinate. The young weeds are then destroyed (burnt off) by an application of Gramoxone (at 1½ pints p.a.). After two days, the area is subjected to a final very light rotavation to no more than 2 inches depth. This operation creates a layer of soil relatively free of weed seeds and if planting occurs immediately thereafter gives the crop a good head start over weed growth from seeds buried at depth. Interrow cultivation carried out in the pegging crop can do much damage and is ineffective in any event for weed growth within the plant rows. It would therefore be a great technological break through if research could come up with a selective herbicide for application at this stage that would not produce phytotoxic effects on the crop but would ensure weed-free conditions to harvest.

Mechancial Methods

Under most circumstances, at least two interrow cultivations using shallow and wide cultivator sweeps will be necessary before closing of the plant rows. The use of "duck feet" tynes has given excellent control when the weeding operation is carried out early to allow the young crop to get a good head start. A shift over to spear shaped tynes for the final interrow operation is desirable at flowering and early pegging to provide the loose soil at moulding. Pegs that do not get under the soil do not form nuts; yet in the early stages of the crop soil should not be permitted to get on the leaves. Hence interrowing has to be carried out very carefully and the importance of absolutely straight rows in crop establishment cannot be over-stressed. A cord line should be used to guide the planting operations otherwise much damage can be caused by interrow cultivation.

Manual Methods

Hand eradication of weeds assisted by simple tools such as the cutlass or hoe has to be resorted to irrespective of what combination of other methods are employed. The use of a wheel hoe allows early control of weeds between rows with increased efficiency. It is possible for one operator to weed over an acre per day with this implement compared to merely two squares with the standard hoe. The wheel hoe operation however must be carried out at a particularly early stage of weed growth, actually at first emergence of weed seedings which is considerably prior to the stage of weed growth at which ordinary hoe weeding is normally implemented. The wheel hoe also has an advantage of creating less soil disturbance.

Hand eradication of weeds in the plant row will normally be required at least twice with the last operation occurring after closing in of the rows or at early pegging. The timing of this last operation is most important so that the peanut stand is free of weeds at harvest. Weediness at harvest causes difficulties in this operation and poor recovery of nuts.

RECOMMENDATIONS AND CONCLUSION

Satisfactory weed control in peanut cultivation calls for careful planning and timely execution of all operations. The cost of weed control can be considerably reduced by the proper implementation of a number of operations not specifically designed for weed control and maximizing these benefits are the essence of good husbandry.

The appropriateness of any technological package for weed control varies widely with circumstances particularly the size of the enterprise, the individual farmer's skills and his financial competence. For this reason it would be unwise to recommend a specific set of practices as a guide to all peanut farmers.

On small farms, labour intensive technology such as manual methods of weed control, optimizes farm family income in the absence of alternative employment. Such methods are therefore most appropriate as they make the best use of the small farmer's resources. Labour intensive technology however cannot be expanded efficiently through increased numbers of hired labour to cope effectively with the problems of large scale production on individually large areas. Large areas call for high levels of technology and capital investment if efficiency is to be maintained. Conversely, it will be inappropriate to apply capital intensive technology to small farms although much improvements in efficiency can be obtained by the use of small equipment such as the wheel hoe. For emphasis, it is the individual size of areas devoted to peanuts that largely determines the desirability of possible combinations of labour and capital intensive technology.

Increased emphasis on the role of cultural methods of weed control offers Jamaica the best opportunity for saving foreign exchange in its drive for self sufficiency in peanut production.

Small farm peanut production systems offer the greatest social benefits but needs to be supported by a high price market. For competitiveness, peanut industrial development must be supported by mechanized operations at every stage of its primary production. Only in this way would peanuts play its optimum role in the Jamaican economy.

NAME OF PAPER: The appropriateness of specific packages of technological practices for weed control in peanut cultivation in Jamaica (Payne)

Questions by: John Hammerton
Country: Belize

QUESTIONS:

1. What is the level of yield of small farmers growing peanuts in Jamaica?

2. What inputs do you consider would be most likely to increase yields?

3. Is "moulding-up" a common practice, and has any comparison be made of moulding versus no moulding?

ANSWERS:

1. Over the last 5-year period, average small farmers yield have increased from 200 to 300 level in 1972, 500 to 750 in 1974, 900 to 1200 lbs per acre in 1976. More recently levels of 1500-2000 lbs characterize levels of most peanut farmers. The better farmer obtains 2500 p/a.

2. Thorough land preparation in some areas; followed by increased population. For large scale plantings, improved harvesting by a peanut digger. Peanut threshing is costing over $200 per acre or 10c. per lb. to maximize return of yield.

3. Moulding is standard largely for weed control. Surface compaction is common on all the alluvial soils and shallow interrowing and moulding-up has been assumed to be advantageous for covering of the pegs but this has not been established formally.

RESEARCH RESULTS AND PRACTICAL EXPERIENCES REGARDING WEED CONTROL IN PEANUTS IN SURINAME

R. E. Dumas and S. Ausan

Agricultural Experiment Station, Paramaribo

SUMMARY

Crop information relevant to weed control and weeds prevalent in peanut plantings are mentioned. Pre-planting and post-planting weed control treatments are discussed. Prior to planting attention should be focussed on effective control of perennial weeds and proper soil cultivation in order to reduce potential weed regeneration. Subsequently an adequate pre-emergence herbicide treatment should be practiced in preference to mechanical control to combat weeds in the crop. However, no herbicide treatment has been found for season-long control under the prevailing weather conditions in Suriname. Of the herbicides tested alachlor (1.70 – 2.60 ≠[x]) has proven to be most appropriate. Very clean fields at harvest are obtained if hilling is practiced at about 4 weeks after sowing in addition to pre-emergence herbicide use. In general no adverse effects on the crop have been recorded, neither quantitatively nor qualitatively, following proper pre-emergence herbicide use. Compared with mechanical weeding, either by hand-hoe or machine equal or better yields have been obtained, the effect of hilling being slightly beneficial at best. Time recordings have shown that the total labour requirement for the traditional method of land preparation, weeding and hilling can be reduced from about 700 man hours/ha to 80-100 man hours/ha if small machines and herbicides are used.

[x]≠ : kg active ingredient per ha

INTRODUCTION

The first experiments with a pre-emergence herbicide were conducted in 1952. It was found that conventional hoeing could be replaced by pre-emergence spraying of 12.5 l Dow Premerge dissolved in 800 l water per ha provided moderate or heavy rains did not fall within 10-14 days from sowing (Ter Horst, 1958). In those days the treatment was frequently used in experiments with grain legumes.

Research on weed control in peanuts was resumed in 1967. Several herbicides were tested: linuron, cycluron, 2.4–DEP, diuron, 2,4–D amine and NPE. The best results were obtained with NPE (2.90 ≠) and 2.4–DEP (3.40 ≠). In combination with inter-row cultivation and hilling the treatments were effective for 2 months: they were more effective than inter-row cultivation and hilling only. Both chemicals caused temporary damage to the seedlings and showed reduced effectiveness under wet weather conditions (Groenendijk, 1967).

In 1972 it was found necessary to establish a weed control division at the Agricultural Experiment Station in order to do regular work on this subject. Up to now the division has

Symposium on maize and peanut, Paramaribo
Nov. 13 - 18, 1978

been mainly engaged in chemical weed control. Research on mechanical weed control is being carried out mainly by another institute which was founded in 1966, namely Celos (Centre for Agricultural Research in Suriname).Research results and practical experiences of both institutes are summarized in this paper. General information on peanut growing in Suriname has been reported elsewhere (Ahlawat and Samlal, 1978).

CROP INFORMATION

Matjan, the cultivar recommended in Suriname, belongs to the Spanish type. Compared with other Spanish type cultivars it has large leaves and large seeds (Wienk, 1978). The optimum plant density has proven to be about 110.000 plants per ha, both in the coastal plain (Ter Horst, 1978) and in the interior (Wienk, 1978). The growth duration is about 100 days. The seeds are usually sown at a depth of 3-4 cm. Seedling emergence normally starts 4-5 days after sowing. After emergence plants develop slowly until about 4 weeks after sowing (fig. 1). It is not known if this is a varietal characteristic or caused by environmental conditions. Flowering starts about 25 days after sowing and the first pegs appear 4 days later. At about this time the canopy starts to develop faster and at a plant spacing of 45 x 20 cm closing of the canopy takes place at 7 to 8 weeks after sowing. From this time on the crop should be able to suppress weeds properly. In a variety trial in the interior (Coebiti), using a plant spacing of 50 x 15 cm, it was found that Matjan provided a better ground cover than the other selections tested (Bink, 1976). Unfortunately Matjan proves to be very susceptible to *Cercospora* leaf spot and peanut rust *(Puccinia arachidis)*. Timely control of these diseases should be pursued in order to prevent premature defoliation which in turn could stimulate weed growth (Bink, 1975). Insect pests, e.q. *Stegasta basquella* (Dumas and Ausan, 1976) and the rate of liming (Muileboom-Muffels, 1975) were also encountered as factors which influence canopy closing. An experiment on a moderately fertile very fine sandy loam indicated that the critical period of weed competition in a wet growing season starts between 6 and 8 weeks after sowing (Oomkes, 1978). A significant yield reduction (54%) compared with the weed-free control was obtained in the case of no weeding only. *Digitaria spp.* and *Eleusine indica* were the predominant weeds. Light was supposed to be the main competitive factor Quantitative and qualitative effects of the weeding treatments on the yield in this experiment are summarized in table 6.

WEEDS

Coastal plain

More than 60 genera were found during a recent weed survey (Dumas and Ausan, 1978) carried out in peanut plantings of 60 farmers in the Saramacca and Commewijne districts where the important peanut growing areas are situated.

Ranked in decreasing order of occurrence *Digitaria spp., Phyllanthus spp., Jussieua spp., Eleusine indica, Alternanthera spp., Lindernia crustacea, Emilia sonchifolia, Eriochloa polystachya, Kyllinga spp.*, and *Fimbristylis spp.* appeared to belong to the first 10 most widespread weeds in the Saramacca district. Of these *Digitaria, Phyllanthus* and *Lindernia* prevailed more often than the other weeds.

A slightly different weed composition was encountered in the Commewijne district, probably because the peanut soils there are somewhat higher than in the Saramacca district. Here, again in decreasing order of occurrence, the following most widespread weeds were encountered:

Phyllanthus spp., Cleome spp., Alternanthera spp., Portulaca oleracea, Spigelia anthelmia, Eleusine indica, Digitaria spp., Commelina virginica, Croton spp., Emilia sonchifolia and *Kyllinga spp.* There were no obvious differences as to the frequency of predominance of the weeds.

— **Interior**

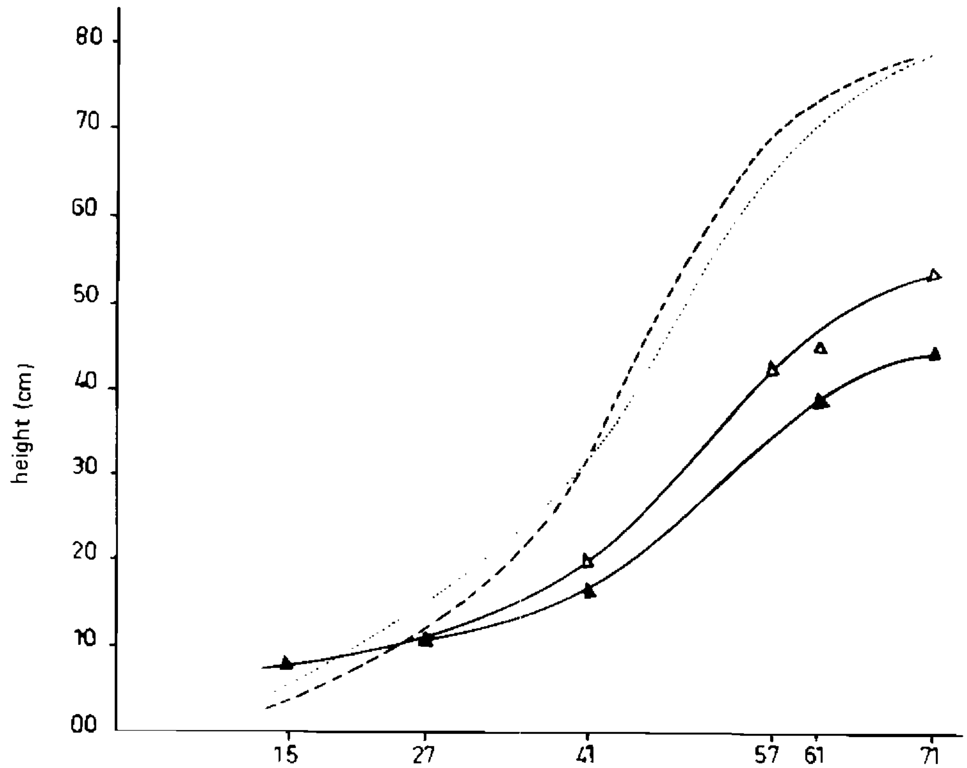
Bink (1975) reported the presence of *Cyperus sp., Digitaria horizontalis, Eleusine indica, Mariscus ligularis, Paspalum conjugatum, Alternanthera sessilis, Amaranthus dubius, Borreria latifolia, Croton miquelianus, Emilia sonchifolia, Euphorbia hirta, Euphorbia hypericifolia, Euphorbia thymifolia, Oldenlandia corymbosa, Physalis angulata, Portulaca oleracea* and *Vernonia cinerea* in a peanut experiment at the Coebiti Experimental Farm. *Eleusine indica* predominated within the group of grasses and sedges, whereas *Alternanthera sessilis, Borreria latifolia, Euphorbia hypericifolia, Euphorbia hirta* and *Physalis angulata* were predominant within the group of broad-leaved weeds. Budelman and Ketelaars (1974) reported the presence of *Lindernia crustacea, Jussieua erecta* and *Andropogon bicornis* at Coebiti as well. Recent information mentions *Eleusine indica* being by far the most predominant weed followed by both *Physalis angulata* and *Amaranthus sp.* (Wienk, 1978).

— **General remarks**

Most weeds found within the experimental area in the interior are common weeds in peanut plantings in the coastal plain. The predominant weeds differ from site to site within one area.

Of the weeds mentioned particular attention has to be paid to *Digitaria* and *Eleusine*, the two most widespread grasses in peanut plantings.

Due to their growth and rooting habit they should be considered most competitive to the crop and most troublesome at harvest. Fig. 1 shows that both grasses start overtopping peanut plants at 3-4 weeks after sowing.



Graphs showing the mean height of *Digitaria spp* (············), *Eleusine indica* (- -- - -) and peanut plants (*A. hypogaea* L. Gv. Matjan) in weed (▲——▲) and not weeded (△——△) plots at different times after sowing (Oomkes, 1978).

Of the broad-leaved weeds *Alternanthera* should be watched carefully. Although most probably less competitive it may infest fields quickly as it propagates easily, both vegetatively and by seed. Another weed with similar characteristics is *Aneilema* which infested the Tijgerkreek-West Experimental Farm badly within 3 years. *Amaranthus* may leave its modest position in the coastal plain as soon as liming is adopted by the farmers as a cultural practice.

WEED CONTROL TREATMENTS

– **Pre-planting**

- Mechanical

The traditional method of preparing the field usually starts with weeding by cutlass. Subsequently the debris is burnt, removed or worked into the soil during cultivation which consists of hand-forking. Mostly some kind of levelling is done by means of hand tools prior to sowing. It is estimated that 400-500 man hours/ha are needed for these operations.

Weeding by cutlass prior to soil cultivation is still practiced where a heavy vegetation is present although two-wheeled tractors, which are widely used now for soil cultivation, may be equipped with a rotary cutter. Vollebregt (1972) reported a very good performance of this implement, but Schipper (1972) mentioned that it failed on uneven land. The nett labour requirement for the use of the rotary cutter is supposed to be about the same as that for rotavating. According to Vollebregt (1972) the latter requires about 19 man hours/ha.

In practice most farmers rotavate their land 1-3 times to a depth of 5-7 cm. The second cultivation takes place 1 to 2 weeks after the first one, when weeds have emerged. The third cultivation is carried out mostly if weeds are not sufficiently destroyed. Use of an interval of about 10 days between two cultivations proved effective to control volunteer plants of previous crops (Van Der Sar, 1976).

Numerous data on the influence of the primary soil cultivation on weediness afterward. were compiled by Celos research workers.

As a rule it was found that initial weed regeneration decreased with increasing working depth (5 to 25 cm) of the primary soil cultivation. The effect was greater when the soil was turned (mouldboard plough) than when it was mixed (rotavator) (e.g. Kouwenhoven, 1973; Klay 1976; Vermeulen, 1975; Van Der Sar, 1976).

- Chemical

Instead of weeding by cutlass or mowing by machine the existing weed cover could be cleared chemically some time prior to soil cultivation.

Of the herbicides available to farmers paraquat is most popular. Experiences suggest that a slower but better killing effect is obtained if this herbicide is sprayed in cloudy weather or towards the evening. Further improvement of effectiveness has been experienced if 2,4-D was added to the spray solution.

Beside a better control of several troublesome grasses (e.g. *Eriochloa polystachya),* the mixture proved very useful to prevent climbers from becoming predominant which may happen after regular spraying with merely paraquat (Dumas and Schut, 1976). Disappointing results have been obtained with mixtures of paraquat and dalapon, probably due to reduced dalapon activity. Very satisfactory control of mixed weed populations has also been observed after the use of dalapon in conjunction with 2,4-D; the main disadvantage is that rain shortly after spraying washes off both chemicals.

Although very useful for perennial grass control, dalapon is by far not as appreciated by farmers as paraquat, since mostly 2 sprayings at a relatively short interval are needed. Moreover it may take a long time before it exhibits its killing effect. At present glyphosate is being introduced in Suriname. Due to its high price its use will probably be restricted to very troublesome perennial weeds. Proper chemical control of perennials prior to soil cultivation should be preferred to merely mechanical control if it is to be expected that they will be a nuisance in the crop. This also holds if a pre-emergence herbicide will be used later on.

Pre-emergence herbicides are in most cases not suited to control weeds which emerge from vegetative parts.

Minor attention has been paid so far to pre-planting use of pre-emergence herbicides. Benfluralin 0.75-2.25 ≠, trifluralin 0.50-1.50 ≠, nitralin 0.75 ≠, trifluralin 0.44 ≠ + 2,4-D amine 1.44 ≠, trifluralin 0.44 ≠+ linuron 1.00 ≠, trifluralin 0.44 ≠+ prometryne 1.00 ≠ and nitralin 0.75 ≠ + 2,4-D amine 1.44 ≠ incorporated into the soil immediately after application gave unsatisfactory weed control.

The labour requirement for spraying operations, excluding an allowance for personal needs, varies from 14-27 man hours/ha, dependent on knapsack sprayer characteristics, the way of spraying, etc.

– **Post-planting**

• Mechanical

The traditional method of weeding comprises hand-hoeing followed by hilling. According to Ter Horst (1958, 1959) 256 man hours/ha are needed of which 96 man hours are required for hilling.

In general a row width of about 50 cm is supposed to be adequate for control by machines. An experiment where interrow cultivation was carried out at 45 cm row width at 4 weeks after sowing by means of a two-wheeled tractor mounted with a two-row rotavator showed that weeds and peanut plants were too advanced resulting in poor weed control and some crop damage. A nett labour requirement of 16 man hours/ha was recorded for this operation. Better control was obtained where hilling was practiced in addition to inter-row cultivation although some grasses persisted in the plant rows. It should be stressed that hilling should be done at the proper time, i.e. when weeds are still small enough to bury them completely. In practice almost all peanut farmers still carry out hilling by hand-hoe at about 4 weeks after sowing, just after weeding. In order to cut the labour requirement efforts have been made by Celos research workers to mechanize this operation. Use of a two-wheeled tractor fitted with 2 ridgers required 13 man hours/ha (6½ machine hours/ha). The work being strenuous, 2 drivers were required. They relieved each other after about half an hour (Klay, 1975). Another approach was necessary to ease the driver's job.

This led to the construction of a multi-purpose toolbar with seat and wheels, which was fitted to a two-wheeled tractor changing it into a four-wheeled one (fig. 2). Rhebergen (1976) reported that the machine performed very well in practice. Hoeing in the third gear with duckfoot shares and angle blades in cowpeas required 5½ machine hours/ha. A minor degree of clogging was observed, however, if the fourth gear was used. A nett labour requirement of 4½ machine hours/ ha was recorded for hilling peanuts at 4 weeks after sowing, carried out in the fourth gear with 2 ridgers. The operation failed on too wet a soil.

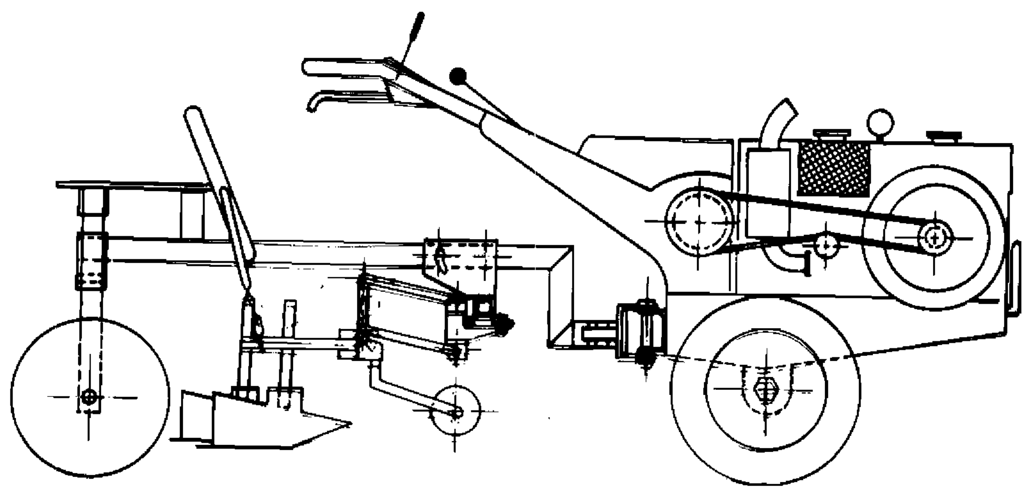


Fig.2. Multi-purpose toolbar with seat and wheels fixted to a two-wheeled tractor (After Rhebergen, 1976)

• Chemical

One of the objectives of the Weed Control Division of the Agricultural Experiment Station has been to find a herbicide treatment for peanuts which gives season-long weed control. In addition to the earlier mentioned pre-planting pre-emergence treatments the following post-planting pre-emergence treatments were tested:
alachlor 1.50-4.50 ≠, chlorthal 5.00-15.00 ≠, diphenamid 2.75-8.25 ≠, nitrofen 1.10-3.30 ≠, prometryne 0.50-1.50 ≠, propachlor 3.30-9.90 ≠, sulfallate 3.30-9.90 ≠, ametryne 2.40 ≠, linuron 1.00 ≠, methazole 1.00-1.87 ≠, ametryne 0.80 ≠ + prometryne 0.75 ≠ and linuron 1.00 ≠ + nitralin 1.50 ≠. The last mentioned treatment was tested in a very dry season only. Of the remaining treatments it can be said that none of them gave adequate season-long control under normal or wet weather conditions. Most screening work was done at the Tijgerkreek-West Experimental Farm on a fine sandy loam.

Information on the performance of the herbicides involved in prolonged experiments may be summarized as follows.

Alachlor. Up to now alachlor proved to be the best of all treatments tested. An application rate of 1.70-2.60 ≠ is recommended.

The chemical is spread very well by rain. It gives adequate control of both grasses and broad-leaved weeds under different weather conditions. Season-long control, i.e. without hilling or additional weeding, was obtained in a very dry season only. Normally an effective period of at least 6 weeks may be expected (table 1). Poor early post-emergence activity and the slightly too short a residual effect are the main defects of the chemical.

Table 1 – Mean visual scores for hand-hoeing and for several pre-emergence herbicide treatments with and without hilling at 4 weeks after sowing.

Sub-treatment	weeks after sowing	hand-hoeing					alachlor					diphenamid				methazole						prometryne				linuron + nitralin					
							+ 1.54	1.83	2.94	2.80	2.45	3.20	3.66	4.57	4.80	–	1.00	1.05	1.20	–	1.58	1.00	0.97	1.29	1.25	–	–	–	–	–	100 + 1.50
no hilling	4	–	–	–	4.4	4.9++	6.5	6.5	8.1	8.1	8.9	4.0	5.5	8.1	7.6	–	5.0	4.8	7.9	–	7.0	8.3	7.0	8.6	8.1	–	–	–	–	–	7.5
	5	–	–	–	8.9	–	6.5	–	7.6	7.6	–	3.0	–	4.8	6.8	–	4.0	–	7.3	–	–	6.5	–	7.9	7.3	–	–	–	–	–	–
	6	–	–	–	–	4.3	–	5.0	–	–	7.9	–	5.0	–	–	–	–	2.0	–	–	5.3	–	3.3	–	–	–	–	–	–	–	7.1
	8	–	–	–	7.3	4.3	5.0	5.0	7.0	6.3	7.4	–	3.5	4.3	5.4	–	2.8	2.0	5.8	–	5.3	6.5	4.0	7.1	5.6	–	–	–	–	–	7.3
plus hilling	4+++	–	–	4.3	4.6	4.7	8.5	6.5	8.1	8.4	9.1	4.0	5.5	6.1	7.7	–	5.0	4.8	7.9	–	8.9	8.3	7.0	8.6	8.1	–	–	–	–	–	7.5
	5	9.5	–	9.4	9.5	–	9.8	–	9.5	9.6	–	9.5	–	9.5	9.6	–	9.5	–	9.8	–	–	9.8	–	9.8	9.6	–	–	–	–	–	–
	6	–	8.8	–	–	7.9	–	9.5	–	–	9.5	–	9.3	–	–	–	–	8.8	–	–	8.7	–	9.0	–	–	–	–	–	–	–	9.3
	8	7.9	7.3	7.3	7.9	7.4	8.5	9.5	8.5	9.1	9.1	8.3	8.3	7.3	8.6	–	7.8	8.0	7.6	–	7.9	9.0	8.3	8.4	8.0	–	–	–	–	–	9.2

\+ herbicide rates in kg active ingredient per ha
++ score prior to inter-row rotavating (instead of hand-hoeing)
+++ scores prior to hilling by hand-hoe

Visual scoring: 1 = plot completely occupied
10 = plot completely weed – free

The former is being met by adding some paraquat to the spray solution.

Diphenamid. The chemical gave excellent control of grasses but poor control of broad-leaved weeds. This has also been experienced by Muileboom-Muffels (1975) who used the herbicide in the interior.

An application rate of at least 4.80 ≠ seems necessary to obtain reasonable control for nearly 6 weeks (table 1).

Methazole. Varying results were obtained but in general the herbicide proved to be usable. The appropriate rate for peanuts is 1.20-1.50 ≠, giving reasonable control for about 6 weeks (table 1).

Reduced effectiveness was observed under wet conditions. Grasses, particularly *Eleusine indica* and some broad-leaved weeds e.g. *Aneilema sp., Phyllanthus amarus* are poorly controlled. Experiences suggest that better control is obtained if methazole is used early post-emergence (but prior to crop-emergence) instead of pre-emergence.

Prometryne. As with methazole poor grass control and reduced effectiveness under wet conditions are the main defects, bug broad-leaved weed control is generally better than from the other herbicides mentioned. Under normal Surinam weather conditions a rate of 1.25 ≠ will give adequate control for about 6 weeks (table 1). Better control may be expected if prometryne is applied early post-weed-emergence but pre-crop-emergence as it then also kills weeds (e.g. *Eleusine indica),* which usually appear shortly after pre-emergence use.

Linuron + nitralin. The performance of this combination was observed in one (dry) season only, but the individual components were tested earlier under wet conditions. Linuron (1.00 ≠) gave poor grass control whereas nitralin (0.75 ≠) exhibited the reverse effect. The combination, using an increased rate for nitralin (1.50 ≠), performed well (table 1) and was almost equally effective as alachlor, the main difference being far better control of *Aneilema* by alachlor. However, the combination seemed to have a slightly better residual effect than alachlor, but this should be confirmed yet under normal and wet weather conditions.

- Chemical plus hilling

As mentioned earlier hilling is a common practice in peasant peanut farming. If done at the right time it has the advantage of controlling weeds effectively both within and between the plant rows. Moreover it seems to ease harvesting both by hand by peanut lifter. The hilling operation is time-consuming if done by hand-hoe but there are possibilities now to do it by machine. Experiments and observational plantings where hilling was practised as an additional weeding treatment at about 4 weeks after sowing showed that weed control effectiveness was considerably improved (table 1). Strikingly clean fields at harvest were obtained where the use of a good pre-emergence herbicide was followed by hilling.

EFFECTS ON THE CROP

– Seedling emergence

As to the main pre-emergence herbicide treatments no effect was noticed on seedling emergence using not pre-germinated seed and a sowing depth of about 5 cm. Results of two field experiments are given in table 2. Figures are treatment means of 4 replications.

Table 2 — Percentage emergence 8 days after sowing.

Treatment	Experiment no. TK 75	Experiment no. TK 103
no herbicide	90.1	84.2
alachlor 2.80 #, 2.45 #	88.4	84.6
diphenamid 4.80 #	89.0	—
methazole 1.58 #	—	84.2
prometryne 1.25 #	87.9	—
linuron 1.00 # + nitralin 1.50 #	—	84.9

Muileboom-Muffels (1975) who applied prometryne (1.25 ≠), diphenamid (5.60 ≠) and paraquat (0.5% spray solution) pre-emergence in the interior found no appreciable differences in seedling emergence under wet conditions after the use of not pre-germinated peanut seed at a sowing depth of 3-4 cm.

Research on the influence of sowing depth with use of alachlor is still in progress. The results of two field experiments with peanuts have been mentioned in table 3. Figures are treatment means of 5 replications. Alachlor was applied not later than one day after sowing.

Table 3. Percentage emergence as affected by sowing depth and alachlor under dry and wet weather conditions.

sowing	dry conditions						wet conditions					
depth	no herbicide			alachlor 2.58 #			no herbicide			alachlor 2.58 #		
	5+	12	19	5	12	19	5	14	19	5	14	19
2.5 cm	15	29	39	12	31	40	55	81	81	56	77	77
5.0 cm	28	69	80	22	68	77	37	82	82	24	67	68

+ days after sowing

Alachlor did not affect seedling emergence significantly at both sowing depths under both weather conditions. The figures suggest that there might be a slight depressive effect if wet conditions prevail following deep sowing and the use of alachlor. However, this supposition is not confirmed by earlier results from a weed competition experiment (Oomkes, 1978) where alachlor had been used under similar conditions. The above mentioned figures demonstrate clearly how seedling emergence is influenced by both sowing depth and weather conditions. In this experiment the depressive effect of deep sowing under wet conditions disappeared at 9 days after sowing. It is worth reminding that in practice peanut farmers use a sowing depth of 3 – 4 cm.

— **Visual damage**

Normally no damage to the plants should occur where alachlor is used pre-emergence at the recommended rates.

Shorter plants were observed where wet weather conditions prevailed immediately after application of the highest rate recommended. Other damage symptoms such as yellowing and scorching of the leaf margins, particularly along the leaf top as expressed by e.g. cowpeas (Dumas and Ausan, 1977) usually are rare. In most cases normal or better developed peanut plants may be expected following the use of alachlor.

Pre-emergence use of methazole at 1.58 ≠ caused yellowing of the older leaves at about 2 weeks after sowing. Yellowing and some stunting of the plants were observed after pre-emergence application of 1.87 ≠ during wet conditions. Damage is usually temporary at the highest rate recommended.

Crop injury was also noticed at about two weeks after sowing where linuron 1.00 ≠ plus nitralin 1.50 ≠ were used pre-emergence. The symptoms were restricted to the older leaves exhibiting yellow spots, local curling and die-back. The injury was short-lived.

No visual damage was observed after pre-emergence use of prometryne or diphenamid at the rates applied.

— **Yield**

Compared with mechanical weeding, either by hand-hoe or machine, equal or better yields were obtained where pre-emergence herbicides had been applied. The results from two split-plot experiments where hilling at 4 weeks after sowing and no hilling at all had been arranged as sub-treatments, have been summarized in table 4. Figures are treatment means of 4 replications.

Table 4 — Pod yields (kg/are) from two weed control experiments in peanuts.

main weeding treatment	Exp. TK 75* hilling		Exp. TK 103++ hilling	
	—	+	—	+
hand-hoeing at 4 weeks	19.6	20.0		
inter-row rotavating at 4 weeks			16.8	19.9
alachlor 2.80 ≠ and 2.45 ≠	20.8	22.7	30.8	29.9
diphenamid 4.80 ≠	22.0	23.2		
methazole 1.58 ≠			19.9	24.8
prometryne 1.25 ≠	20.4	22.0		
linuron 1.00 ≠ + nitralin 1.50 ≠			26.1	26.2

* sun-dry pods
++ pods at 12% m.c.

In both experiments hilling tended to be beneficial (significant at the 10% level) irrespective of the main weeding treatment. Muileboom-Muffels (1975) found no significant yield differences following pre-emergence use of prometryne, diphenamid and paraquat (+ weeding at 3 weeks) in the interior (table 5). She recorded a slight beneficial effect of hilling only where prometryne was used (significant at the 10% level). It was supposed that this might be due to the relatively high percentage of inter-row space covered by weeds at this herbicide.

Table 5. Quantitative and qualitative data on yield (12% m.c.) from a weed control experiment in the interior (Muileboom-Muffels, 1975).

herbicide		yield (kg/ha)	pods/plant	out-turn (%)	1000 kernels (g)	pods per kg total	partly filled	pops
prometryne	–*	2350	18	74	582	745	59	14
(1.25 #)	+	2650	19	74	616	733	98	18
diphenamid	—	2590	20	74	585	764	97	9
(5.60 #)	+	2700	19	75	606	719	57	21
paraquat	–	2650	20	74	591	752	95	18
(0.5% sol.)	+	2540	18	75	603	701	59	10

* — not hilled
+ hilled

As to the effect of hilling on pod yield variable results have been obtained so far. In two earlier experiments in the coastal plain (Cultuurtuin) Van Dijk and Huiswoud (1966) and Van Dijk (1968) found a small but significant effect on yield, whereas Van Slobbe and Wienk (1973) working in the interior (Coebiti) found no effect, neither quantitative nor qualitative. No weed problem was encountered in the latter case as the experimental area had been reclaimed only recently (1969). The most plausible explanation for these results is that if hilling is carried out in time its effect becomes more pronounced as the level of weed competition increases.

The results from two earlier mentioned experiments are available as to the qualitative effects of the pre-emergence herbicide use on yield. The figures in table 5 are means of two replications, those in table 6 are means of four replications. Alachlor was used here to accomplish a weed-free check.

There were no significant differences, neither between the three herbicide treatments nor between alachlor pre-emergence and the traditional method of hand-hoeing at 4 weeks. Above all the figures in table 6 show the effects of postponing the first weeding treatment in a wet season.

Table 6. Quantitative and qualtitative data on yield (12% m.c.) from a weed competition experiment in the coastal plain (Oomkes, 1978).

treatment	yield (kg/ha)	pods/5 pl	out-turn (%)	1000 kernels (g)	completely filled pods (%)
alachlor 2.58 #	1553	88	64	364	83
1st weeding at 2w.	1578	81	63	363	85
1st weeding at 4w.	1509	82	67	382	82
1st weeding at 6w.	1594	72	65	409	89
1st weeding at 8w.	1220	57	71	399	87
no weeding	708	40	69	395	90

Note: plots were kept as clean as possible from the 1st weeding on up to 8 weeks after sowing.

DISCUSSION

The traditional method of peanut growing is time-consuming requiring about 1500 man hours/ha. Of these about 700 man hours are needed for land preparation, weeding and hilling by hand-hoe. Time recordings have pointed out that the labour requirement for these operations can be reduced to 80 – 100 man hours/ha if small machines and herbicides are used. Machines are particularly valuable for land preparation whereas pre-emergence herbicides should be preferred for weed control in the crop as machines may cause mechanical damage to the peanut plants allowing fungi (e.g. *Aspergillus niger)* to enter and/or may help to spread diseases (Feakin, 1973). An important factor to be considered in Suriname is that the main peanut area is situated in the coastal plain where raised beds are usually necessary for drainage. Use of machines in an established crop on beds is rather unpractical. Peanut growing on the free-draining soils in the interior is still in an experimental stage. However, experiences up to now have pointed out that weed control by merely mechanical means was far from satisfactory (Wienk, 1978).

The effort to suffice with one pre-emergence herbicide treatment without additional weeding or hilling failed under normal and wet weather conditions. The residual effect of the herbicides and herbicide combinations tested was slightly too short resulting in too weedy fields at harvest. It will be interesting to find out if the ultimate aim may be attained by combining pre-emergence herbicide use with a closer plant spacing e.g. 30 x 20 cm, which approximates the plant spacing used by peanut farmers (Veltkamp and Samlal, 1976). An earlier closing peanut canopy might help to suppress weed growth more effectively. Moreover better filling of the kernels might be expected if table 6 is considered more closely. As soon as season-long control is obtained with one herbicide treatment hilling can be omitted, even if it needs only a few hours to do it by machine. In general hilling is not recommended abroad (Feakin, 1973) as it creates favourable conditions for the development of *Sclerotium rolfsii*, a fungus which also occurs in Suriname.

However, up to now no significant differences in the number of plants per plot have been found at harvest in "hilling vs. no hilling" experiments in the coastal plain and in the interior.

Alachlor has proven to be an attractive herbicide for Suriname as it controls most grasses and broadleaved weeds commonly found on regularly cropped land under different weather conditions. There are good prospects to use this herbicide in other crops. This is an important factor to be taken into account in Suriname because of the relatively modest area under cultivation, making it unattractive for commercial enterprises to import a wide variety of herbicides. The more so as they are bound to fixed minimum orders. As the introduction of a herbicide to farmers proceeds slowly (Veltkamp, 1978) one can imagine that kind co-operation of the representing firm will be indispensable.

In order to prevent the build-up of a resistent weed flora as a result of one-sided use of alachlor some more herbicides should be found with comparable or better qualities. These herbicides should be active on different ranges of weeds in order to be able to rotate them as effectively as possible.

The yield figures of the weed competition experiment indicate that rather a post-emergence than a pre-emergence treatment should be applied on peanuts as weed competition starts in the second half of the growth cycle. Moreover peanut fields should be as clean as possible at harvest. Application of a post-emergence treatment implies that the herbicide should be selective and soil-acting as part of the weeds will be protected at spraying by the peanut foliage. Experience on this subject is lacking in Suriname, but the literature (Feakin, 1973) indicates that the number of herbicides available (2,4-DB, 2,4-D ester, MCPB, dinoseb) is far less numerous than for pre-emergence herbicides. This probably means that peanut plants are less tolerant to post-emergence herbicide treatments.

REFERENCES

Ahlawat, R.P.S. and R. Samlal, 1978. Peanut cultivation in Suriname. Proceedings of CFCS Vol. XV: 250 – 260.

Bink, J.P.M., 1975. Een cultuurmaatregelenproef bij aardnoot, *Arachis hypogaea* L.cv.Matjan; de effecten van bemesten, bespuiten tegen bladvlekkenziekte en wieden op de opbrengst. Celos rapp. no. 110.

Bink, J.P.M., 1976. Een rassenproef met aardnoot, *Arachis hypogaea* L. Celos rapp. no. 118.

Budelman, A. and J.J.M.H. Ketelaars, 1974. Een studie van het traditionele landbouwsysteem onder de boslandcreolen. Celos rapp. no. 96

Dijk, A.H. van and R.R. Huiswoud, 1966. Cultuurmethodeproef met pinda. Proefverslag CT 37. Landbouwproefst., Paramaribo, Suriname.

Dijk, A.H. van, 1968. Cultuurmethodeproef met pinda; Effect van aanaarden op produktie. Proefverslag CT 55. Landbouwproefst., Paramaribo, Suriname.

Dumas, R.E. and B. Schut, 1976. Preliminary results of ring-weeding in young dwarf coconuts. De Surin. Landb. 24(1): 30-41.

Dumas, R.E. and S. Ausan, 1977. Tolerantie van een aantal peulgewassen voor enige pre-em. herbiciden op twee grondsoorten en de reactie van enige direct ingezaaide groentes als volggewas. Intern Rapport no. 30 (APO), Landbouwproefst., Paramaribo, Suriname.

Dumas, R.E. and S. Ausan, 1978. Onkruiden in pinda-aanplantingen in de Surinaamse kustvlakte. Intern Rapport no. 33 (APO), Landbouwproefstation, Paramaribo, Suriname.

Dumas, R.E. and S. Ausan, 1976. Onkruidbestrijding. In: Jaarverslag 1976. Landbouwproefst., Paramaribo, Suriname.

Feakin, S.D., 1973. Pest control in groundnuts. Pans Manual No. 2, Centre for Overseas Pest Research, London.

Groenendijk, E., 1967. Praktijkverslag. Landbouwproefst., Paramaribo, Suriname.

Horst, K. ter, 1958. Onkruidbestrijding bij peulvruchten. De. Surin. Landb. 6(2):65-71.

Horst, K. ter, 1959. Het optimale plantverband voor pinda van het ras Matjan. De Surin. Landb. 7:121-128.

Klay, M.C., 1975. Grondbewerking gericht op de permanente teelt van droge eenjarige gewassen in Suriname. Proef Coebiti; Occupatie III. Celos rapp. no. 102.

Klay, M.C., 1975. Grondbewerking gericht op de permanente teelt van droge eenjarige gewassen in Suriname; proef Celos-terrein (Occupatie X). Celos rapp. no. 104.

Kouwenhoven, J.K., 1973. Grondbewerking gericht op de permanente teelt van droge eenjarige gewassen in Suriname. Landbouwkundig Tijdschrift 85(2): 63-72.

Muileboom-Muffels, T., 1975. Een cultuurmaatregelenproef bij aardnoot *(Arachis hypogaea* L.cv. Matjan). Celos rapp. no. 105.

Oomkes, A., 1978. Onderzoek naar de kritieke periode van onkruidkonkurrentie bij pinda *(Arachis hypogaea* L.cv. Matjan). Intern Rapport no. 32 (APO), Landbouwproefst., Paramaribo, Suriname.

Rhebergen, W., 1976. Mechanisatie-mogelijkheden bij de pinda-cultuur. Celos rapp. no. 117.

Sar, T. van der, 1976. Grondbewerking gericht op de permanente teelt van droge eenjarige gewassen in Suriname; proef in de Stipris - proeftuin te Coebiti (Occ. IV t/m VI). Celos rapp. no. 115.

Schipper, R.A., 1972. De tweewielige tractor. Celos rapp. no. 72.

Slobbe, W.G. van and J.F. Wienk, 1973. Peulvruchten onderzoek in de Stipris-proeftuin Coebiti. Verslag over de periode dec. 1972 – mei 1973, Celos.

Veltkamp, H.J. and R. Samlal, 1976. De teelt van pinda en het voorkomen van met aflatoxinen besmette pinda bij klein-landbouwers in het distrikt Saramacca. Rapport no. 23 (AGO), Landbouwproefst., Paramaribo, Suriname.

Veltkamp, H.J., 1978. Awareness and adoption of chemical weed control in peanut farming in Suriname. Symposium on Maize and Peanuts, Paramaribo, Suriname.

Vermeulen, G.D., 1975. Een vergelijkend onderzoek bij de grondbewerking met de spitmachine, de risterploeg en de schijvenploeg. Celos rapp. no. 109.

Vollebregt, N.G.J., 1972. Bepaling van de technisch mogelijke rijafstand van gemechaniseerd geteelde paprika in de grote natte tijd en de toepassingsmogelijkheden van polyethyleen mulch. Celos rapp. no. 62.

Wienk, J.F., 1978. Personal communication.

Wienk, J.F., 1978. Groundnut experiments at Coebiti in the period 1972-1975; a summary of results. Proceedings of the Caribbean Food crops Society vol. XV : 218 – 235.

AWARENESS AND ADOPTION OF CHEMICAL WEED CONTROL IN PEANUT FARMING IN SURINAME

H.J. Veltkamp
Agricultural Experiment Station, Paramaribo

SUMMARY

Awareness and adoption of chemical weed control in peanut farming and the use of communication channels among peanut cultivating farmers was studied. One and a half years after its introduction 17% of the farmers had adapted this innovation. A large group was still not aware of the innovation. Lack of knowledge was the major constraint to its adoption. A description is given of the process by which information on improved farm practices goes from the source, in this case the Agricultural Experiment Station, to the farmers. Constraints which may have hindered a more effective flow of information to the farmer are discussed.

INTRODUCTION

In 1977 in Suriname 282 ha were cultivated with peanuts. The production was 338 tons of unshelled air-dried nuts. Moreover 406 tons of shelled peanuts were imported. Area, and, in consequence production, has dropped very much in the last ten years. In 1965 the area was still 648 ha. Because of the very labour intensive character of peanut cultivation when all activities are done by hand the cultivated area has decreased enormously. The introduction of labour saving techniques may increase the cultivation of peanuts.

Research of the possibilities of chemical weed control was considered one possible way to reach this objective. Mechanical weed control with a Kubota PC tractor fitted with a spiral plough gave disappointing results (de Wit, 1974). Of the herbicides tested for several seasons, Lasso (alachlor, 43% a.i.) proved to be the best one (Dumas & Ausan, 1978).

Based on those results its utilization by farmers was recommended in April 1976 (Veltkamp, 1976). One and a half years after its introduction a study was made of the rate of awareness and adoption and the use of communication channels on this subject by peanut cultivating farmers. The results of this study are presented in this paper.

THE DIFFUSION OF INFORMATION ON IMPROVED METHODS OF CULTIVATION TO THE FARMER

The Agricultural Experiment Station is the main source of recommendations for cultivation of crops in Suriname. Dissemination of research data from the Agricultural Experiment Station to the farmer is a task of the Agricultural Extension Service. This service also belongs to the Ministry of Agriculture and has offices in all rural districts. The headquarter is located in Paramaribo, the capital of Suriname.

Already in 1967 meetings were held to discuss the possibilities to come to a better communication between the Agricultural Extension Service and the Agricultural Experiment Station in order to accelerate the dissemination of research results to the farmer. Interviews with extension agents held in 1970 by Kalshoven showed "that personel of the lower echelons, who visited the farmers most regularly received little information from their own agency, either by written or by oral communication" (Kalshoven, 1977).

Since 1974 the dissemination of research results to extension agents is carried out by division of the Agricultural Experiment Station called Contacts-with-the-Extension Service. For the dissemination of information to extension agents the division Contacts-with-the-Extension Service uses different communication channels:

* The issue of pamphlets for extension agents.
* Method and result demonstration meetings and field days at a demonstration garden of approx. 3.7 ha.
* Group discussions at meetings of extension agents in some districts.
* Farm visits together with extension agents.
* Office calls and visits.

Of these communication channels the issue of pamphlets and the meetings at the demonstration garden are the most important ones. Furthermore information is disseminated to farmers via participation in the weekly radioprogramme of the Ministry of Agriculture in collaboration with the Agricultural Publicity Service. Finally in 1976 the issue of leaflets on different agricultural topics for farmers was initiated again.

The most important organization for contacts on agricultural affairs with farmers is the Agricultural Extension Service especially via personal visits and – to a much lesser extent – farm demonstrations.

The organizational structure of the Agricultural Extension Service has been described by Kalshoven (1977). Leaflets for farmers are mainly distributed via the Agricultural Extension Service. Extension agents also participate in a number of radio programmes of the Ministry of Agriculture in collaboration with the Agricultural Publicity Service. At present the pamphlets for extension have an average circulation of 250-300. All extension agents obtain one of each issue. A number of copies go to different divisions of the Ministry and of the Agricultural Experiment Station and to representatives of seed, fertilizer and crop protection products companies in the country. A stock is hold for visitors (farmers, students and others) at the office.

THE DIFFUSION OF INFORMATION ON CHEMICAL WEED CONTROL IN PEANUT FARMING

Information on chemical weed control in peanut was disseminated as stated before in general terms. In April 1976 a pamphlet was issued on this subject. This pamphlet of 4 pages contained technical information on the recommended herbicide (Lasso), the way to use it, the time to spray it, the recommended dose, the preparation of the spray solution, and so on.

In February, June and September 1977 meetings were organized at the demonstration garden to show the effect of Lasso on weed and peanut growth. Detailed information on this can be found in a report of Veltkamp, Veldkamp & Darmohoetomo (1978).

In two radiobroadcasts of the Ministry of Agriculture attention was paid to the possibilities of chemical weed control in peanut.

Furthermore a leaflet for farmers on this subject was issued in March 1977 (Anonymous, 1977). It was sponsored by the importer in Suriname. The circulation amounted to 750. Extension agents held farm demonstrations on chemical weed control in peanut cultivation in one district. It is unknown to what extent extension agents gave information to farmers during personal visits. On an agricultural exhibition in one district also attention was paid to chemical weed control in peanut cultivation.

Last but not least the private activities of the foreman of the demonstration garden should be mentioned who worked temporarily also as a shopkeeper for agricultural products under which Lasso.

CHEMICAL WEED VERSUS HANDWEEDING IN PEANUT CULTIVATION

The time required for handweeding averages 205 hours/ha, while about 30 hours/ha are needed for spraying (Ter Horst, 1958). Labour costs are at present approx. Sf 1.75 per hour (1 Sf = US$ 0.55). Initially 6 l Lasso per ha was recommended, but this quantity has recently been lowered to 4 l/ha based on results in practice. Herbicide costs are at the moment Sf 11.25/l). The calculated financial advantage of chemical weed control with Lasso over handweeding is approx. Sf 280/ha (labour costs for spraying included).

Yields from Lasso sprayed peanut fields are at least of the same order as the yields of handweeded peanut fields (Dumas & Ausan, 1978) (see also table 1).

Table 1. Yields of peanut (kg air-dried unshelled nuts/ha) for two weed control methods in different demonstration fields

Demonstration field	Date of sowing	Yield	
		Handweeding	Chemical weed control with Lasso (6 l c.p./ha)
TK Dem 1977-3A	14 Jan. 1977	1360	1370
TK Dem 1977-3B	19 May 1977	1790	1700
TK Dem 1977-25	29 Aug. 1977	2610	2790
Average		1920	1950

AWARENESS AND ADOPTION OF LASSO IN PEANUT AMONG FARMERS

Methodology

In the period October 1977 – January 1978 peanut cultivating farmers in the principal peanut growing districts were interviewed about their awareness or adoption of chemical weed control in peanut cultivation. This was done by questionnaire. A total of 66 farmers with at least 0.04 ha peanut on their field were interviewed. The enumerators were officers of the division Contacts-with-the Agricultural Extension Service of the Agricultural Experiment Station. They were accompanied in the field by an extension agent of the districts concerned. The interviewed farmers cultivated 19.3 ha with peanuts.

CHARACTERISTICS OF THE FARMERS

Of the interviewed farmers 58% was full-time farmer. The others had another main profession (Government's service or something else). 53% of the farmers had received no schooling at all. Only 3% had the certificate of the elementary school. There were no farmers who had attended a secondary school. Among the farmers a rather low level of literacy was found: 56% could not read, whereas 24% could read reasonable or good. 58% of the farmers was over 50, 40% over 60 years of age. Farm size varied from 0.2 – 36 ha. Most farms (81%) sized less than 5 ha. The area cultivated with peanut varied from 0.04 – 3.0 ha. The average was 0.29 ha. 86% of the farmers cultivated in the period that the study took place 0.4 ha or less with peanut.

All farmers possessed a radio. 52% was not aware of the weekly radioprogramme (10 minutes) of the Ministry of Agriculture. The majority of the others who were aware of it listened more or less accidentally to the programme. 69% of them did not know exactly when the programme is broadcasted.

78% of the farmers never read a daily newspaper. Only one farmer had a subscription on a newspaper.

FINDINGS

Adoption of chemical weed control in peanut

One and a half years after its introduction chemical weed control in peanut cultivation with Lasso had been adopted by 17% of the peanut cultivating farmers, equalizing 24% of the area cultivated with peanut.

57% of the interviewed farmers was not aware of "somewhat" for the control of weeds in peanut. 20% of the farmers had heard about it but not adopted it, whereas 6% had sprayed Lasso in one season but did not continue.

Adopters

For all of them it was the first time that they used Lasso in their peanut field. 73% had not sprayed the whole peanut area. The adopters cultivated 4.6 ha with peanut of which 3.6 ha (78%) had been sparyed with Lasso. 91% of the adopters was fully content on the effect of Lasso on weed growth. One farmer (9%) had had a good control of annual grasses but not *Phyllanthus amarus* (gripe weed) ("fini bita"). The cause of it will be presumably the low quantity that was used (2.5 l c.p./ha).

None of the adopters had made a test before spraying Lasso to see how much spray solution was needed per hectare, in order to calculate the needed amount of Lasso per l water, as is recommended.

Disadopters

Four farmers (6% of the total interviewed persons) had used Lasso once for the control of weeds in peanut but did not use it in the next season again. Reasons they called for no further use were respectively: lack of money, lack of labour just after planting, had rotavated his area twice and did not expect much weeds and it rained rather much just after planting and he thought that it could not be used under such weather conditions.

Reasons for non-adoption

Lack of knowledge accounted for 76% of all non-adoption reasons and formed the major constraint to adoption (table 2).

Table 2. Non-adoption reasons for chemical weed control in peanut

Non-adoption reasons	% Farmers (N = 55)
Lack of knowledge	76
Lack of money	7
Lack of materials	2
Lack of labour	2
Lack of conviction	4
Sufficient labour	2
Others	7

Media of information

First information

For the group of 27 farmers who had at least heard of Lasso the extension agents of the Agricultural Extension Service, the demonstration garden of the division Contacts-with-the-Agricultural Extension Service of the Agricultural Experiment Station and the foreman of the demonstration garden in his function of extension agent/shopkeeper were the most important first information sources (table 3). 17% of the farmers had received first information from mass media (radio or farmers' leaflet).

Table 3. First information source on chemical weed control in peanut

Information source	% Farmers (N = 27)
Extension agents Agric-Ext. Serv.	18
Foreman demonstration garden	18
Demonstration garden Agric. Exp. St.	18
Farmers leaflet	12
Radio	5
Family/friends	15
Other farmers	7
Demonstration plot Agric. Ext. Serv.	7

Further information

The 27 farmers who had heard at least of Lasso for chemical weed control in peanut mentioned totally 68 information sources; an average of 2.5 information source was called per farmer. The extension agent of the Agricultural Extension Service was cited most (table 4).

Table 4. Classification of information sources cited for chemical weed control in peanut

Information source	Number	Percentage
Radio	8	12
Farmers' leaflet	10	15
Daily newspaper	0	0
Family/friends	5	7
Foreman demonstration garden (local shopkeeper)	8	12
Other farmers	7	10
Demonstration plots Agric. Ext. Serv.	6	9
Extension agent Agric. Ext. Serv.	13	19
Demonstration garden Agric. Exp. St.	9	13
Shopkeeper (in town (Paramaribo))	2	3
Total	68	100

Most important information source

The farmers who had adopted Lasso were asked from whom or what they had obtained the most important information. Five of the eleven adopters answered a meeting at the demonstration garden, three the foreman of the demonstration garden acting as a local shopkeeper and further the farmers' leaflet, another farmer and an extension agent were all called once as the most important information source.

DISCUSSION AND CONCLUSIONS

Research data on the diffusion of information on improved farm practices in Suriname are scarce. Kalshoven (1977) focussed on environmental factors that accelerated or retarded the adoption of innovations by small rice farmers. Oomkes (1977) studied the diffusion of information on the control of the banana weevil *(Cosmopolites sordidus)* among plantain cultivating farmers. It regarded a recommendation given in 1956. To obtain reliable data on the channeluse at the different adoption stages was not possible. Comparable studies carried out in other countries do not breathe a word of similar problems. Katz et al. (1963) put a note of interrogation on the assumption that people can be asked to recall the channels of information and the influence of the decision to adopt an innovation or not. When the innovation is of recent date as in our study such problems will be of much less extent.

Information on chemical weed control in peanut has been spread on a number of ways (leaflet, demonstration fields, personal visits, radio, advertisements in daily newspapers). In spite of that 57% of the farmers had never heard of chemical weed control in peanut. Lack of knowledge and lack of conviction accounted for 80% of all non-adoption reasons (table 2). The questions to be answered are why are farmers not aware of the innovation and why are those who are aware not convinced to adopt it. The group of farmers belonging to this last group was however only small.

To answer the question why farmers were not aware of the innovation in study several reasons can be mentioned:

— Till the end of 1976 there existed problems concerning the distribution of the pamphlets for the Agricultural Extension Service. Somehow the pamphlets remained within the Agricultural Extension Service and did not reach the extension agent in the field. Since the end of 1976 each extension agent receives a copy of each newly issued pamphlet personally by which this problem could be banished.

— Serious shortage of well-trained extension agents of the Agricultural Extension Service. Training on improved farm practices needs much more attention. Joint discussions on new information presented in pamphlets for the Agricultural Extension Service are not held systematically or not at all by most extension agents in the various districts. Visits at the meetings in the demonstration garden of the Agricultural Experiment Station need also much improvement (Veltkamp, Veldkamp & Darmohoetomo, 1978).

— Part of the farmers does not receive information on improved farm practices from extension agents. In our study 30%. It was 44% among a group of plantain cultivating farmers (Oomkes, 1977). Visits of farmers to the offices of the Agricultural Extension Service were limited; 91% did never go to the office.

— Only a low percentage of the farmers listened regularly to the radio programme of the Ministry of Agriculture. Of those who had heard of it 69% could not remember correctly when the programme was broad-casted.

— A rather high percentage was illiterate. Although 15% answered that they knew the farmers' leaflet on chemical weed control in peanut it remains a question what they have learned of it. In a study carried out in May 1977 among 28 peanut cultivating farmers who had received the farmers' leaflet on chemical weed control in peanut which had been distributed under pupils of a secondary school it appeared that two months after its distribution only 21% knew that "somewhat" was available for the control of weeds in peanut, 8% knew the correct needed amount per ha, 13% knew the correct time of spraying and no one knew the working period of the herbicide (Veltkamp, unpublished results).

It is possible that in reality the percentage of adopters is somewhat lower than the mentioned 17% in this study. This will be caused by the fact that no random sample of all peanut cultivating farmers could be taken on an easy way and the interviewed farmers were partly selected by extension agents.

REFERENCES

Anonymous, 1977. Chemische onkruidbestrijding in pinda. Handboekje No. 6. Min. LVV in Suriname, 10 p.

Dumas,R.E. & S.Ausan,1978. Research results and practical experiences regarding weed control in peanuts in Suriname. Proceedings of the Caribbean Food Crops Society Vol:XV:272-287.

Horst, K. ter, 1958. Onkruidbestrijding bij peulvruchten Surin. Landb. 6: 65 – 71.

Kalshoven, G. 1977. Patronen van communicatie en hun organisatorisch verband bij de landbouwvoorlichting in Suriname. Thesis Landbouwhogeschool Wageningen, 182 p.

Katz, E., H. Hamilton & M.L. Levin, 1963. Traditions of research on the diffusion of innovation. Amer. Soc. Rev. 28: 237-252.

Oomkes, A., 1977. Het gebruik van kommunikatie media door landbouwers in de distrikten Commewijne, Suriname, Saramacca en Para. Rapport No. 131 Afd. Gewasonderzoek, Landbouwproefstation, Paramaribo, 93 p.

Veltkamp, H.J., 1976. Chemische onkruidbestrijding in pinda. Pamflet voor de Voorlichting No. 13, Landbouwproefstation, Paramaribo, 4 p.

Veltkamp, H.J., H. Veldkamp & R. Darmohoetomo, 1978. Eén jaar demonstratietuin Tijgerkreek-West; 1976 – 1977.
Rapport No. 37 Afd. Gewasonderzoek, Landbouwproefstation, Paramaribo, 90 p.

Wit, Th de, 1974. Economic aspects of partly mechanized groundnut production in Surinam. Surin. Landb. 22 (2/3): 45-51.

MICRO-ECONOMIC ASPECTS OF PEANUT PRODUCTION IN SURINAME IN RELATION TO IMPORT – SUBSTITUTION

A.W. Graanoogst

INTRODUCTION

In Suriname peanut is grown as a regular crop: small plots of 0.04–0.20 ha are planted 2 (sometimes 3 times) a year on the sandy ridges of the coastal plain.
Main production areas are the Saramacca district and the Commewijne district. Total acreage planted amounted 242 ha in 1976 with a production of 290 tons dry pulses. Production is used for preparing salted and unsalted peanuts and peanut-sauce: a small part is manufactured into peanut-butter. As local production still does not meet national demand an amount of 446 tons of shelled peanuts are imported mainly for the peanut-factories (in 1977).

PRODUCTION TECHNIQUES AND PRODUCTION COSTS

Although the planted plots are of a small acreage the used practices show a shifting from the traditional system where all operations (were done by hand and simple implements) to a lightly mechanized system.
Seed-bed preparation of the greater part of the acreage is done by 2-wheel tractors.

All further field operations such as seeding, ridging, weeding and pulling are done by hand and simple implement: sun-drying is generally practiced. Recent experiments on weedcontrol by spraying with herbicides has shown to be succesful.
Efforts are undertaken by extension to get peanut-farmers aquainted with this new system of weed control thus enabling a further decrease of total labor costs in peanut growing.
Still the lack of harvesting equipment adjusted to their conditions is felt as the main constraint for further accres of acreage by most farmers.

Field trails in the interior has up to now showed the possibility of achieving higher yields on the Coebiti-soils. A project for the further research of peanut-growing on these soils is being carried out for the present.
Production costs for the completely hand-operated cropping system are calculated to amount Sf. 3.275,–/ha resulting in a cost-price of Sf 2,25 per kg dry pulses.

A cropping system with mechanized seedbed preparation, fertilizing chemical weed-control would enable a reduction of this figure to Sf. 1,75 per kg dry pulses.

COST OF PRODUCTION IN RELATION TO IMPORT SUBSTITUTION

Import prices for whole, graded peanut-kernels amount Sf. 2,25 (including 42% import taxes) with production prices of Sf. 1,70 for dry pulses that is a cost price for whole graded kernels of app-Sf. 2,85 per kg*, it is not likely that import-substitution will have a chance unless special measures are taken.

* hereby it is assumed that the costs of shelling, greading, bagging and transport are made up by the proceeds of broken kernels.

PEANUT PRODUCTION THROUGH PROJECT–DEVELOPMENT

Generally speaking the problems concerning an increase of local peanut production are believed to be of less complex nature than those for maize. Small farmers are eager to increase their plots if the necessarry machines are available. Their special interest is focussed on machinery for seedbed preparation, pulling and stripping.

As in the case of maize a special role should be played by nuclear farms in the main production areas providing these equipment to surrounding farmers, preferably in an outgrower setting. As a result of the expected decrease of farmers acreage provisions should be made for artificial drying of peanuts.

Contrary to maize, it is also believed that total import substitution can be achieved without large-scale farms; small-and eventually middle-scale peanut production in the coastal plain might prove to be the polution.

Table 1. Regional division of peanut acreage and production* (1973/1977)

Districts		1973	1974	1975	1976	1977
Commewijne	(ha)	117.4	139.4	131.3	124.2	73.6
	(ton)	109.0	122.7	121.9	77.7	51.4
Coronie	(ha)	5.1	8.9	0.3	8.9	1.4
	(ton)	6.6	10.5	0.8	10.5	2.3
Marowijne	(ha)	11.9	–	7.5	3.4	10.1
	(ton)	12.0	–	7.4	2.2	9.7
Suriname	(ha)	12.8	20.8	24.8	7.9	14.2
	(ton)	12.5	13.3	10.9	3.7	10.6
Saramacca	(ha)	137.9	148,4	161.7	96.5	–
	(ton)	107.0	104.0	113.3	50.4	–
Para	(ha)		0.6			
	(ton)		0.5			
Totaal	(ha)	285.1	318.1	325.6	241.4	99.3
	(ton)	344	382	391	290	338

* dried pulses

Source: Ministery of Agriculture
Agro-Economic Division

Table 2. Imports of peanuts (kernels)

1975	331 tons	value	Sf.	662,000
1976	427 tons			965,000
1977	446 tons			1,248,000

US$ 1.00 = Sf. 1.77

Source: Min of Agriculture
Agro — Economics Division

Table 3. Production costs traditional system

seedbed preparation	43 mandays	
planting and plant replacement	31 ,,	
weeding and ridging	32 ,,	
pulling	24 ,,	
stripping	55 ,,	
total labor for	185 mandays =	Sf. 2,775,—
seed		560,—
tools and bags		15,—
total production costs		Sf. 3,350,—

Total yield: 1500 kg dried pulses

Source Min. Agriculture
Agro— Economics Division

Table 4.

	Labor costs	machinery	materials	total costs
seedbed preparation		Sf. 375.—		Sf. 375.—
planting and plant replacement	Sf. 465			Sf. 465,—
weedcontrol	45,—			Sf. 45,—
fertilizing and earthing	120,—			120,—
pulling	360,-			360,—
stripping	825,—			825,—
seed			Sf. 420,—	420,—
herbicides			70,—	70,—
fertilizer			300,—	300,—
tools and bags			25,—	25,—
Total production costs				Sf. 3,005,—

Total yield: 1800 kg dried pulses

MISCELLANEOUS

EFFECT OF SPREADING DISTILLERY WASTE IN OPEN FIELD[1]

J. and M Gautheyrou, J.F. Turenne

INTRODUCTION

A substantial amount of effluent is obtained from the rum and sugar factories in the French West Indies. Their discharge in river or the sea lead to significant pollution which becomes worse during dry years, due to the low flow of the rivers. Chemical and biological oxygen requirement of the distillery wastes are high and their degradation and their transformation upset the environment by removing an important part of dissolved oxygen. The low pH. high temperature, and high organic matter content are sources of nuisances.

For many years these effluents have been spread in the field in various geographical regions: particularly in Brasil, they are rationally applied as fertilizers providing to the plant useful nutrients.

In particular case of insular ecosystems as Martinique and Guadeloupe, experiments has been conducted to control the effect of field application of distillery wastes at different doses. This study does not consider only the fertilization aspect of waste application but aims at evaluating eventual modifications that may take place at the organic level. The experiments are here briefly presented and thė results about the dynamics of major elements are discussed.

MATERIAL AND METHODS

Soils

The experiment, was carried out by the Technical Centre for Sugar Cane in two different environments.

In Martinique, the experimental plots were established on intergrade ferrallitic/fersialitic soils, down slope; soil compaction is important, with a clay content of about 60% mixture of kaolinite and montmorillonite. Cation exchange capacity is high (35-45 me) and exchangeable cations content is 25 to 35 me., with a high saturation level. In the low lying plots some hydromorphy was observed.

In Guadeloupe, the experimental plots were established on vertisols: the clay content is about 60-70% mainly montmorillonite with a Cation exchange capacity also high (50 me). The absorption complex is saturated with Calcium (presence of calcareous sands), the pH is of about 7.5 to 7.8, locally 6.3 at surface, and 8 in deep horizons. The difference between water-pH and KCl-pH is 1 unit. These soils are more or less deep, 60 to 120 cm. All the plots are planted with sugar-cane.

1. Work done in contract with Centre Techniques de la Canne et de Sucre de Martinique et Guadeloupe, with financial participation of Ministére de la Culture et de l'Environnement, service de l'environnement industriel.

Experimental design

The experimental design is adapted to each situation: the common disposition being the storage of the distillery waste in a pond, digged in the soil. This induces the rapid neutralization of the effluent in Guadeloupe.

The spreading is realized by sprinkler (Guadeloupe), the topography not permitting an irrigation system by running water, and during the night, on a plot of about 8 ha.

The principal experiment in Martinique is done on 9 plots of 100 m2 with irrigation by flooding in the furrow.

The distillery waste is spread with 2 variables, crude or neutralized, at different levels.

The distillery waste (vinasse)

The composition of the distillery waste is variable, following the nature and the management of treatments in the factory (Vasseur et. al. 1977, Robert et. al. 1978): the quality is different according to the origin, from molasses or from cane juice.

One notices the high content in K, in N, and in organic matter. The distillery wastes have also an appreciable content in iron, copper, manganese, coming from the corrosion of pipes: these elements could be used as marks for evidence of water sheet pollution.

The mixture which is spread after storage in the ground is somewhat different from the factory waste: (table 1b). There is an important lowering of chemical requirement in oxygen,

Table 1. Composition of effluents

		Suspension DCO (mg/l)		DB05	pH	N (mg/l)	P (mg/l)	K (g/l)	Ca (g/l)	Dry matter (g/l)
Martinique										
Effluents of Molasses	1a	2.200	50.000	26.000	3.2	227	13.9	3.8	1.5	53
Effluents of Cane	1a	5.700	18.000	8.000	3.5	100	22.5	1.2	0.2	11
Spread Mixture	1b	1.700	13.500	8.200	3.4	371	137	1.42	–	6.63
Effluent after Aeration			200		8.7	23	217	3.81		
Guadeloupe										
Effluents of Molasses	1a		45.000		3.27	315				36
Effluents of Cane	1a		14.000		3.22	164	67	0.438	0.2	13.9
Spread Mixture (pond)	1b		992	288	7.1	66	36	0.598	0.364	6

Source: Centre Techniques de la Canne et du Sucre Martinique et Guadeloupe.

an increase in N-NH4 content, a decrease in total N, a relative concentration in K. Vasseur and Montreau (1977) advise a passing through a "lit bactcerien" (lagunage) (aeration on columm), before storage and spreading, when natural neutralization as in Guadeloupe cannot be obtained (table 1, Effluent after aeration).

Application modes

The irrigation in Martinique is managed in order to satisfy the water requirement of the sugar-cane in correlation to water deficit and with the distillery waste coming out of the pond, crude (pH 3,5) or neutralized (pH 7). The doses were 12, 5 mm each 15 days from 7-04-76 to 30-05-76, 25 mm each 15 days from 30-05-76 to 30-06-76 and 50 mm/15 days from 30-06-76 to 30-09-76. 3000 cubic meters were spread at all, and 3 plots received double dose (5500 m^3). Neutralization required 4 kg of lime/m^3 of effluent, and must be added just before spreading, the pH going back to 3,5, if stored 24 hours after neutralization (F. Montreau, in Vasseur, op. cit.). The fertilizer (1 ton of 12-8-24) was normally added.

In Guadeloupe, irrigation tends to supply the fertilizer necessary to the plant (P_2O_5, 60 to 80 kg; K_2O 160 to 180 kg or 25 to 34 kg of P, 130-150 kg of K for 1 hectare.

The mixture is spread by sprinkler, during the night, with the naturally neutralized effluent during its storage in a pond digged in the soil. It represents 22 mm during 6 months (220 cubic meters/ha). The experiments then are situated between the mean of experiments in other regions (200 to 500 cubic meters) or are superior in quantity to the doses proposed by brasilian authors (1000 m^3/ha/year) (Da Gloria, 1975).

Sampling

Sampling is done at different periods (1) 0 time, before spreading, (2) 3 months, (3) 6 months, and (4) at the end of harvesting (12 months). In Guadeloupe, sampling is effectuated at (a) 0, (b) 6, (c) 12 months (table 2)

Results represent a mean of 15 samples in Martinique, 6 samples in Guadeloupe. In this island, a folliar analysis is done at 6 months.

RESULTS

If the irrigation by sprinkler, during the day, with non neutralized effluent induces burns on the leaves, the same operation, during the night, with neutralized effluents, does not induce any damage (table 2).

Physical properties

Due to their heavy texture, and presence of montmorillonite, the physical properties of the soils in experiment are naturally bad. No significant variation in stable agregates ratio is observed after treatment with the effluent: this ratio remain constant or increase slightly, in the first time of spreading. The decrease of stability noticed at the end of harvesting is less pronounced on the plots with effluent: the high level in effluent quantity (5500 m^3/ha) (an), does not affect the stability, in respect to a cultivation cycle of one year. The water retention capacity remains constant.

Table 2. Agricultural Results

	pH water	pH KCl	C ‰	N ‰	C/N	AF C(‰)	AH C(‰)	AF MHT	K^+ me%g	CEC me%g	SAT %	N&A N(‰)	Ag (%)
						FURROW IRRIGATION							
CRUDE EFFLUENT													
1	6.0	4.9	21.93	1.90	11.5	6.65	2.47	72.9	0.39	33.8	77.1	.182	38.73
2	5.7	4.9	19.77	1.91	10.3	5.93	2.29	72.1	0.56	35.0	79.6	.280	38.51
3	5.9	5.0	21.01	1.93	10.8	6.38	2.33	73.2	0.49	34.2	75.8	.322	40.22
4	6.2	4.9	19.51	2.18	8.9	5.72	1.87	74.7	1.12			.364	37.80
EFFLUENT pH 7													
1	6.1	4.9	21.69	1.84	11.7	6.45	2.19	74.6	0.44	32.3	77.7	.224	40.87
2	5.7	4.9	18.96	1.81	10.5	5.90	1.92	75.4	0.48	33.0	73.0	.182	40.67
3	5.9	5.1	21.44	2.10	10.2	6.45	2.53	71.2	0.60	34.6	79.0	.280	40.51
4	6.1	4.9	19.87	2.05	9.7	6.07	1.98	75.4	0.83			.392	36.88
EFFLUENT pH 7 (x 2)													
1	6.2	5.0	21.62	1.94	11.1	6.51	2.53	71.9	0.44	32.6	87.0	.252	40.30
2	6.0	5.0	21.55	1.98	10.9	6.34	2.23	74.0	0.58	35.5	78.0	.182	42.30
3	6.0	5.2	20.81	1.94	10.7	54.5	2.19	74.6	0.89	35.6	74.6	.224	42.63
4	6.1	4.8	18.65	2.04	9.2	6.04	1.71	78.0	0.77			.364	37.11
WATER													
1	5.9	5.0	18.07	1.71	10.5	3.33	1.65	67.0	0.42	30.0	79.4	.294	35.76
2	5.8	4.9	18.15	1.70	10.7	3.87	1.59	70.0	0.44	30.0	80.2		33.73
3	5.8	5.1	19.37	1.75	11.1	4.02	1.50	73.0	0.37	31.5	80.2	.252	33.22
4	5.8	4.6	18.79	2.17	8.7	5.71	1.77	75.5	0.70			.252	31.4
CONTROL													
1	5.6	4.7	22.25	1.96	11.3	3.78	1.62	68.5	0.39	34.0	71.7	.224	39.76
2	5.9	4.7	20.23	1.85	11.0	4.38	1.56	73.7	0.34	33.5	77.6	.210	39.55
3	5.6	4.8	20.23	1.75	11.5	3.81	1.89	66.8	0.18	34.0	70.0	.196	36.12
4	5.9	4.5	21.09	2.20	9.6	6.37	2.43	72.4	0.42			.252	38.7
						SPRINKLER IRRIGATION							
EFFLUENT pH 7													
a	7.8	6.9	21.3	2.30	9.3	3.2	5.7	35.9	0.35	50.6	Sat		47.1
b	7.6	6.9	24.0	2.70	8.8	4.0	4.8	45.5	1.18	49.7	Sat		44.1
c	7.6	6.9	23.4	2.60	9.0				1.13	51.3	Sat		
CONTROL													
a	8.0	7.2	23.4	2.50	9.3	3.5	6.0	36.8	0.54	45.2	Sat		37.2
b	8.0	7.2	21.7	2.40	9.0	4.3	5.9	42.0	0.55	47.1	Sat		41.2
c	7.9	7.1							0.57	47.6	Sat		

1 – Before spreading 07/04/76
2 – After spreading 09/07/76
3 – After spreading 10/10/76
4 – End of harvest

a – before spreading
b – at 6 months
c – at 12 months
(x2) – double dose

AF – Fulvic acids
AH – Humic acids
N & A – Aminated nitrogen
AG – Stable aggregates

The pH

In plots irrigated by the effluent, one can notice the light but systematic decrease, in the difference water-pH, KCl - pH. Although non significant, this difference would indicate a salt effect already mentioned: there is a slight but apparent increase of KCl-pH.

Adsorbing complex

The Cation exchange capacity remains constant in both cases. During the irrigation by flooding (Martinique), one can observe the increase of Potassium in surface horizon (0,35 to 0,45 me) the higher increase corresponding to the plot with double dose of neutralized effluent at pH 7 (0,44 to 0,89 me) (fig. 1). The control plots irrigated by water, or not, do not show any significant differences.

On the contrary, there in a clear increase at the end of spreading in the sub-surface horizons (40-60 cm) and a lowering at the end of harvest, after rainy season: it appears that in irrigation by flooding in the furrow, a great part of Potassium, and of elements supplied by the effluent, is susceptible to migrate deeply.

After irrigation by sprinkler (Guadeloupe), at low doses, the level of exchangeable K is multiplied by 3.

Magnesium does not show any variation in a complex saturated by Calcium. There are no variations deeply.

Organic matter and phoshorus

NITROGEN

In the experiments, there is an increase of total nitrogen. The lowering of C/N ratio in the effluent irrigated plots (11.5 towards 10.5) can be due, for a great part, to this increase. However, Robert and Gautheyrou (1978) point out that the balance determined by foliar analysis reveals a non complete utilization of nitrogen (low foliar diagnostic index).

The analysis of nitrogen forms shows a clear increase of hydrolizable aminated forms in the effluent irrigated plots.

This is of a particular evidence in the plot receiving crude effluent. The aminated N/total N ratio is changing from 11.2, 11.4%in the control to 17.8, 19.1, 16.7% in treated plots.

(fig. 2.) The spreading of the effluent contributes to a transformation of nitrogen products in α - aminated forms.

CARBON

The organic carbon remains constant or slightly increase in sprinkler irrigation.

In the case of irrigation by flooding, there is a general increase of extraction rate for fulvic and humic acids, increase correlated to the high level of humidity maintained by the irrigation followed by the rainy season: the extraction rate is the higher for plots receiving double dose of neutralized effluent (pH 7); in these plots too, ones notices the higher ratio of fulvic acids in extracted fraction (78%).

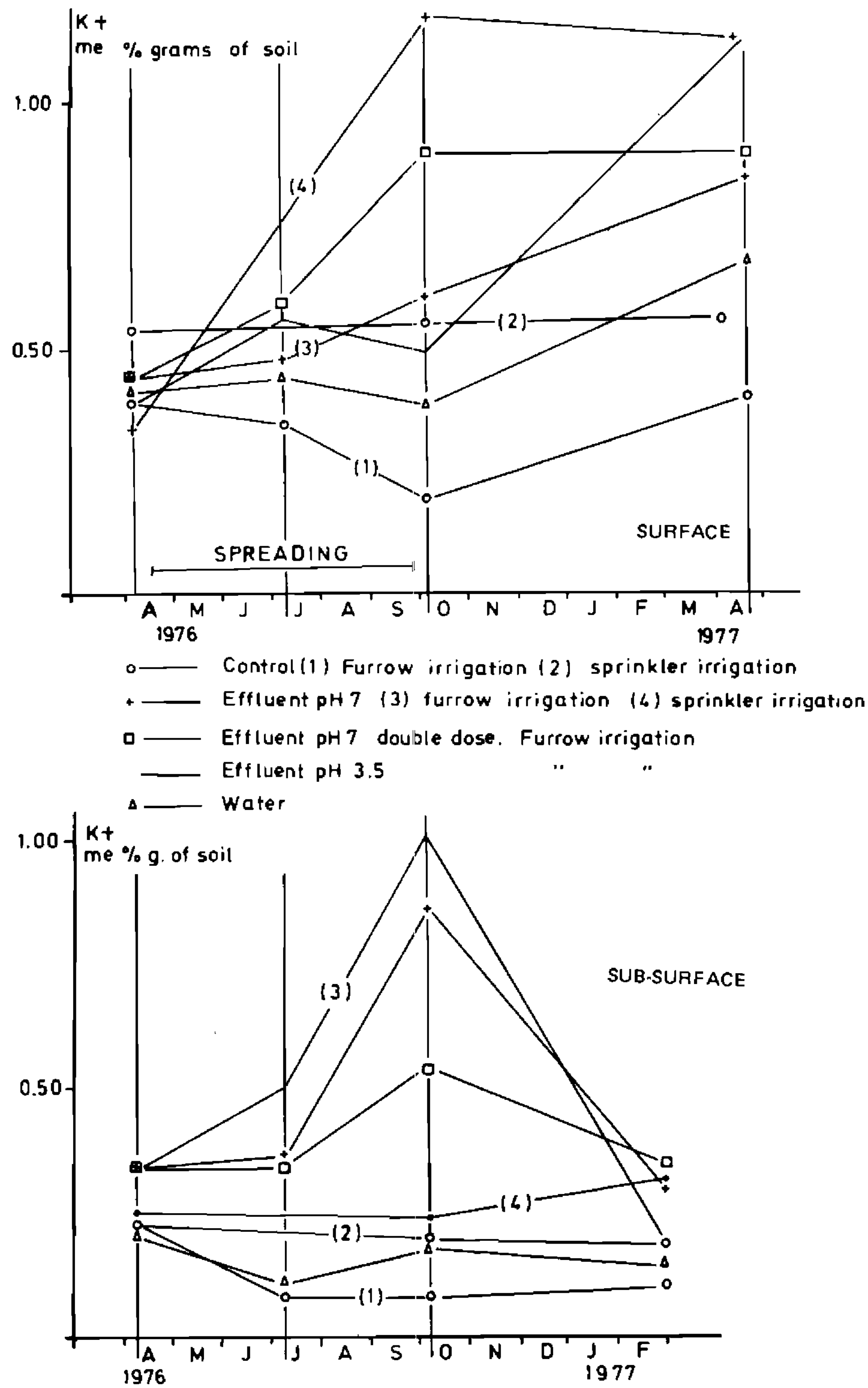


Fig. 1. Variation of potassium content at surface (0 - 20 cm) and at sub - surface (40 - 60 cm)

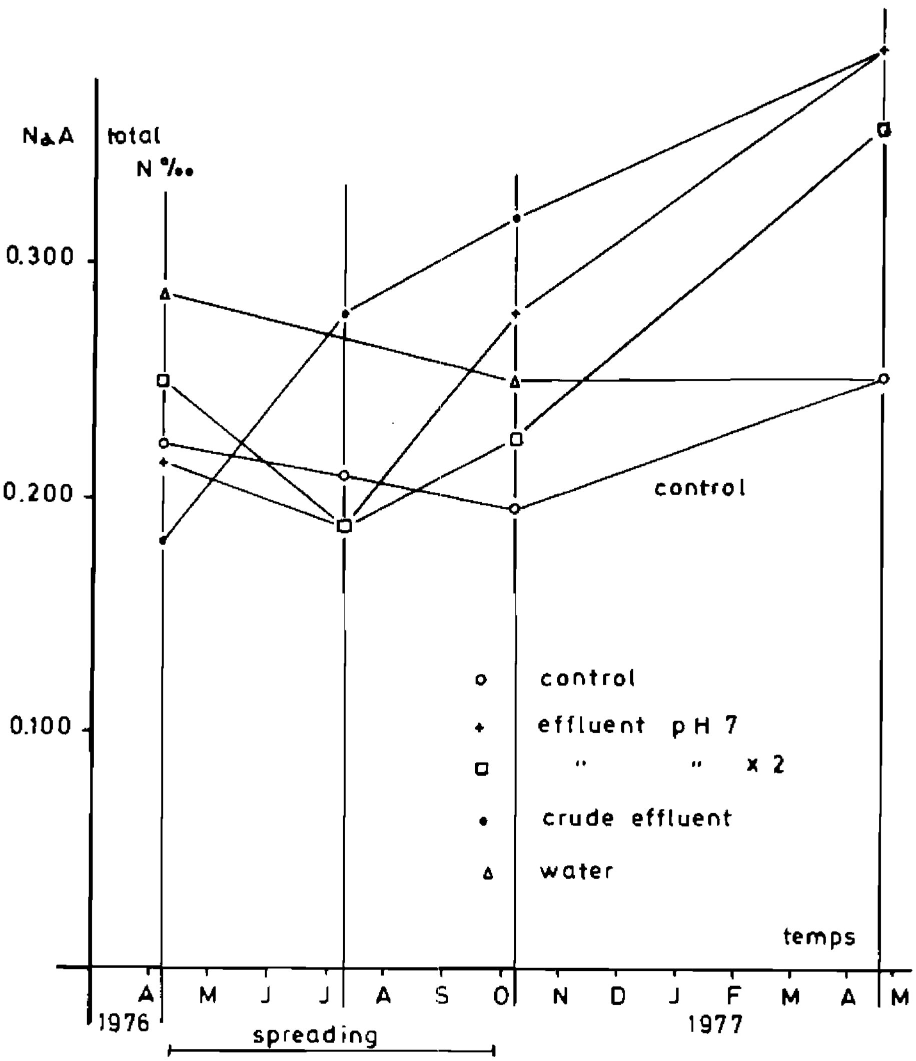


Fig. 2. Course of aminated nitrogen content

During sprinkler irrigation, the fulvic acid ratio in total organic matter does not vary.
The optical density analysis of the humic extracts (alcalin extract), and the comparison of extinction ratio at 400, 500, 600 nm (EQ 400/500 EQ 500/600, Salfeld J. Chr. H. Sochtig, 1974), emphasize the existence of two families of products, and reveals a lowering of the condensation of humic substances, in the following order (fig. 3): irrigated plots by pH 7 effluent, irrigated plots by pH 3.5 effluent.

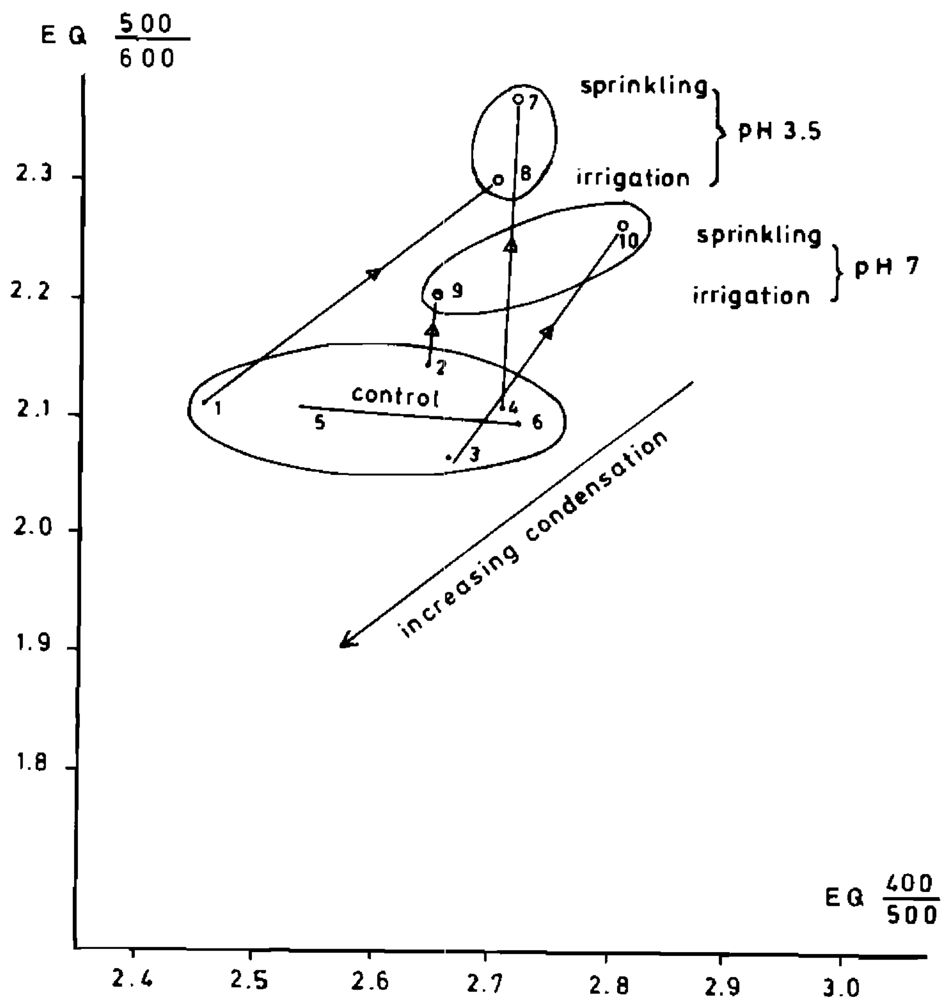


fig. 3. Optical characteristics of humic extracts.

The decrease of condensation is the higher with pH 3,5 effluent.

The persistent humidity all during the year participates to the increase of fulvic acid, and lowering of humic fractor condensation. The persistence of a high level of fulvic acids in the soil is susceptible in the long run to alterate the structural stability and to induce a leaching in the depth of complexed elements. The better use of the effluent seems to be in a neutralized form, at fertilizer doses, spread by sprinkler.

PHOSPHORUS

There is an increase of total P_2O_5 in the soil, exceeding the response level necessary for the sugar cane in these soils (before spreading control: 73.3 mg/100 g; 80.3 mg/100 g after spreading, at 12 months control, 70.3, irrigated plots 118.4) (Robert et al, 1978).

DISCUSSION

The observations done at harvest show in the irrigated plots a higher yield with an increase of 20t/ha (effluent irrigated plots 96t/ha, control 76t/ha), without a lowering in sugar content. The foliar analysis, at 6 months, in irrigated plots, give the following results:

	N	P	K
Sugar cane (mean)	1.879	0.225	1.411
Standard (Technical Centers)	1.9-2.1	0.18-0.20	1.12-1.22

The standard adopted for well balanced nutrient status is exceeded, considering Phosphorus and Potassium, inducing extra consumption.

The excess of Potassium does not affect fermentation in distillery but may be an inconvenience for sugar production.

Nitrogen content does not reach the minimum standard, and this has to be followed in case of repeated irrigation.

The important contribution in K and P is emphasized, as well as the need of a nitrogen complementation within a short time. This complementation can be balanced through an increase of nitrogen in biodegradable aminated forms.

The analysis of qualitative variations of organic matter shows however some modifications: they are useful index of possible unfavourable changes in soil system in case of repeated spreading, particularly with crude effluent; the lowering of condensation of humic substances can in fact act on structural stability and elements complexation.

REFERENCES

Nadir A. Da Gloria, 1975. Utilizacao agricola da vinhaça. Brasil Açucareiro, n°5 pp. 397-403.

Planal Sucar, Rapport annuel, 1976. Programa nacional de melhoramento da cana de açucar.

Robert G., Chofardet, D., Gautherou J.M., 1978. Etude d'épandage a la Distillerie Damoiseau Bellevue – Grande-terre (Guadeloupe) Année 1977. Orstom Antilles. 31 p. multigr. annexes.

Salfed J. and Chr. and H. Sochtig, 1974. Proposals for the characterization of soil organic matter as an approach to understand its dynamic. FAO. ROME.

Vasseur J.G. and Montreau, F.R., 1977. Les effluents des industries sucrieres et rhumieres aux Antilles. Centre Technique de la canne et du sucre, Martinique. 30 p. annexes, multigr.

PRELIMINARY RESULTS OF SUGAR CANE EXPERIMENTS ON THE SANDY LOAM SOILS OF THE "ZANDERIJ" FORMATION.

I.E. Soe Agnie

Agricultural Experiment Station, Paramaribo

SUMMARY

In three field experiments conducted at the experimental farm of Coebiti the effects of nitrogen, phosphorus, potassium and lime on the growth and quality of sugar cane were studied for the past two years.

Phosphate and potassium had significant positive effects on the leaf content, but not on the yield. Nitrogen did not influence both the leaf content and the yield. Liming raised the leaf content and the yield significantly, but reduced the sugar content, on the other hand. The effects of rock phosphate from Curaçao, which raised the soil pH, were similar to those of liming.

From the results of the first two years it was decided to lower the levels of the nitrogen, phosphorus and potassium dressings.

INTRODUCTION

Up till now sugar cane is planted in the young coastal plain on very heavy clay soils. Chemically these soils are good, but the physical conditions are very poor. Due to the low permeability and the flat topography the field drainage is unsatisfactory. That's why a cambered bed system is required. Because of this bed system, the high water holding capacity of these soils and the lack of a defined dry season, mechanization of harvest is not possible so far. For this reason, and within the scope of the soil productivity research on the so called "Zanderij" soils in the interior of Suriname, some sugar cane fertilizing trials were started in December 1975. Some analytical data of these soils are presented in table 1. More detailed information is given by Schroo (1976).

Table 1. Soil analytical data sandy loam Coebiti topsoil (0-25 cm)

Analysis		Value
pH – H_2O		5.0
pH – KCl		4.0
C (Walkley-Black) %		0.7
C.E.C.	me %	3.0
Base saturation	%	20
Exchangeable Al me %		0.7
Total N	%	0.08
Total P205	ppm	55
Total K20	ppm	60
Available P205	ppm	6
Available K20	ppm	15
Available CaO	ppm	100
Available MgO	ppm	15
Available SO4	ppm	30
Available Moisture (per 50 cm topsoil) mm		60
% Sand (2000-53 mu)		81
% Silt (53-2 mu)		4
% Clay (less than 2 mu)		15

The experiments are carried out on a coarse sandy loam (with sandy clay loam in the subsoil). As can be seen from table 1 these soils are very poor. Field drainage is good, however, so mechanization is quite possible. Because of the low available moisture content the sugar cane might suffer from water shortage during long dry periods. Root studies showed, however, a root development to a depth of two meters, if the cane was planted in the wet season (Parsan, 1976).

Because of the low nutrient status of these soils three fertilizing trials were designed. The object of the first trial is finding the optimum levels for nitrogen, phosphate and potassium. In the second trial the effects of lime, magnesium and sulphate are studied, whereas in the third trial rock phosphate of Curaçao (Curaçao phosphate), which is relatively very cheap, is tested. This rock phosphate contains 16.7% P205 and reacts basic, so it can also be used as a liming material.

EXPERIMENTAL PROCEDURE

Experiment 1

This experiment was set up as a confounded (3x3x3)– factorial design with two replicates. Nitrogen was applied as Calcium Ammonium Nitrate (CAN); phosphate as Granulated Triple Super Phosphate (GTSP), and potassium as Muriate of potash (KCl). The nitrogen levels (N1, N2, N3) were 75, 125 and 175 kg N per ha, the phosphate levels (P1, P2, P3) 90, 135 and 180 kg P205 per ha, and the potassium levels (K1, K2, K3) 120, 150 and 180 kg K20 per ha. All plots were limed at a rate of 5 tons per ha. Dolocal (finely ground dolomitic limestone) was used as the liming material.

Phosphate was applied in the planting furrow just before planting and for the ratoon cane just after sprouting as a side-dressing. Nitrogen and potassium were given as side-dressings in three split doses at 1, 8 and 14 weeks after germination or sprouting. Liming took place before planting by broodcasting, followed by ploughing-in to a depth of 25 cm.

Each plot consists of 6 plant rows 6½ meters in length with an interrow spacing of 1½ meters. The cane variety used was D 141/46, obtained from Marienburg Estate. Selected cane tops were cut into three-eye pieces, about 25 cm long. Every 65 cm two pieces were placed in the planting furrow and covered with soil. Earthing up took place after the NK split-dressings. Weed control and crop protection were carried out, if necessary.

Experiment 2

This experiment was set up as a 5x5 — latin square design. The 5 treatments are:

A: Only N,P and K; no lime, no magnesium, no sulphate
B: A, plus lime
C: A, plus sulphate
D: A, plus lime and sulphate
E: A, plus lime, magnesium and sulphate.

Nitrogen was applied as Calcium Ammonium Nitrate (treatments A and B) and Sulphate of Ammonia (treatments C, D and E); phosphate as Granulated Triple Super Phosphate, and potassium as Muriate of potash.
Liming took place with aragonite (treatments B and D) and dolocal (treatment E).
Fertilizer levels were: 125 kg N, 135 kg P205 and 150 kg K20 per ha.
Lime amounts were: 7 tons aragonite and 5 tons dolocal per ha.

As for the rest the experimental procedure is equal to experiment 1.

Experiment 3

The design is the same as for experiment 2. The 5 treatments are:

F: no Curaçao phosphate
G: 500 kg Curaçao phosphate per ha
H: 750 kg Curaçao phosphate per ha
I : 1000 kg Curaçao phosphate per ha
K: 1250 kg Curaçao phosphate per ha

All plots received 125 kg N (as sulphate of ammonia), 150 kg K20 (as sulphate of potassium and magnesium) and 90 kg P205 (as granulated triple super phosphate) per ha. The latter gift can be considered a phosphate starter dose and was applied only before planting.

Curaçao phosphate was applied by broadcasting just before planting, followed by ploughing-in to depth of 25 cm.

As for the rest the experimental procedure is equal to experiment 1.

Measurements

Length measurements were made at 4, 6 and 8 months after planting or sprouting. Length of stem was measured between the seed piece and the top visible "dew-lap" (TVD), according to Schroo (1954). All stems of six selected cane stools per plot were measured and the average was determined.

Leaf analysis

Leaf analysis was carried out at 4, 6 and 8 months after planting or sprouting, together with length measurements. Leaf sampling always took place in the early morning. Of each plot 12 cane stools along the diagonals were selected. Of each stool two leaves were taken from two well -- developed stems. The uppermost leaf showing a "dew-lap" (TVD-leaf) was selected. The upper halves were cut off and discarded, the mid-ribs were stripped out and the remaining laminae, about 30 cm long, were oven-dried and powdered in a hammer mill (Schroo, 1954; Poidevin & Robinson, 1964). After wet digestion nitrogen, phosphate, potassium, calcium and magnesium were determined, according to Legger (1975).

Reaping and milling the cane

The stems were fully trashed and the stools cut off at seed piece level. The cane tops were also discarded (40 cm below TVD-leaf) and the remaining "net millable cane" was weighed. Of each plot 20 stems were selected and sent to the Marienburg Estate, where they were crushed in a laboratory mill and the weights of juice were noted. The juice samples were analysed for "degree Brix", "pol percent" and "purity". From these data the sugar content was calculated.

RESULTS AND DISCUSSION

The results of the leaf analyses are presented in tables 2-4. Leaf nitrogen content was not influenced by nitrogen, phoshorus and potamsium dressings at the chosen levels. Phosphate had a positive effect of leaf phosphate content (significant at the 5% level). Leaf potassium content was positively effected by potassium applications (significant at the 5% level). Negative effects of nitrogen and potassium have been found on leaf calcium content and leaf magnesium for plant cane (table 2).

Table 2. Results of leaf analysis experiment 1 for plant cane (upper half) and first ratoon (lower half)

	% N			% P			% K			% Ca			% Mg		
	a*	b*	c*	a	b	c	a	b	c	a	b	c	a	b	c
N1	2.37	2.04	1.70	0.22	0.21	0.17	0.77	1.12	0.99	0.64	0.43	0.31	0.27	0.20	0.16
N2	2.34	2.07	1.73	0.22	0.21	0.17	0.82	1.08	1.03	0.57	0.42	0.31	0.25	0.20	0.16
N3	2.36	2.05	1.74	0.22	0.21	0.17	0.80	1.13	1.02	0.57	0.43	0.31	0.24	0.19	0.15
P1	2.32	2.04	1.70	0.21	0.21	0.16	0.79	1.12	1.00	0.58	0.42	0.30	0.25	0.20	0.16
P2	2.35	2.06	1.70	0.22	0.21	0.17	0.82	1.15	1.03	0.59	0.42	0.30	0.26	0.20	0.16
P3	2.40	2.06	1.77	0.23	0.21	0.18	0.78	1.07	1.00	0.61	0.43	0.32	0.26	0.20	0.16
K1	2.38	2.09	1.74	0.22	0.21	0.17	0.71	1.04	1.01	0.63	0.43	0.32	0.27	0.21	0.16
K2	2.35	2.05	1.74	0.22	0.21	0.17	0.82	1.16	0.98	0.56	0.42	0.30	0.25	0.20	0.16
K3	2.33	2.02	1.70	0.22	0.21	0.17	0.86	1.14	1.05	0.59	0.42	0.30	0.25	0.19	0.16
mean	2.36	2.06	1.72	0.22	0.21	0.17	0.80	1.11	1.01	0.59	0.42	0.31	0.26	0.20	0.16
N1	2.22	2.06	1.63	0.23	0.22	0.20	1.11	1.29	1.15	0.40	0.36	0.36	0.18	0.19	0.19
N2	2.22	2.00	1.64	0.23	0.22	0.20	1.14	1.25	1.14	0.38	0.35	0.36	0.17	0.20	0.18
N3	2.25	2.04	1.66	0.23	0.22	0.20	1.15	1.31	1.13	0.38	0.37	0.37	0.17	0.19	0.19
P1	2.22	2.04	1.65	0.21	0.22	0.20	1.12	1.28	1.18	0.37	0.37	0.37	0.17	0.19	0.19
P2	2.23	2.03	1.66	0.23	0.23	0.20	1.12	1.29	1.12	0.39	0.36	0.37	0.18	0.19	0.19
P3	2.24	2.02	1.63	0.24	0.22	0.20	1.16	1.30	1.11	0.39	0.35	0.35	0.18	0.19	0.19
K1	2.24	1.99	1.66	0.23	0.22	0.20	1.09	1.24	1.08	0.39	0.36	0.37	0.18	0.19	0.19
K2	2.22	2.04	1.62	0.23	0.22	0.20	1.15	1.31	1.15	0.38	0.36	0.36	0.18	0.19	0.19
K3	2.23	2.06	1.65	0.23	0.23	0.20	1.16	1.31	1.18	0.38	0.36	0.36	0.18	0.20	0.18
mean	2.23	2.03	1.64	0.23	0.22	0.20	1.14	1.29	1.14	0.38	0.36	0.36	0.18	0.19	0.19

* a = 4 months after germination or sprouting
b = 6 months after germination or sprouting
c = 8 months after germination or sprouting.

The results from table 3 clearly show the very positive effects (significant at the 1% level) of liming with aragonite on leaf calcium content. Liming with dolocal also positively influenced leaf calcium content, but to a lesser extent. The effect of dolocal on leaf magnesium content was very positive.

Table 3. Results of leaf analysis experiment 2 for plant cane (upper half) and first ratoon (lower half)

	% N			% P			% K			% Ca			% Mg		
	a*	b*	c*	a	b	c	a	b	c	a	b	c	a	b	c
A	2.23	2.05	1.63	0.17	0.19	0.14	0.82	1.03	1.03	0.36	0.32	0.24	0.15	0.13	0.11
B	2.23	2.11	1.67	0.19	0.19	0.14	0.85	0.96	1.05	0.60	0.50	0.41	0.18	0.14	0.12
C	2.19	2.00	1.63	0.16	0.17	0.13	0.86	1.09	1.05	0.34	0.26	0.20	0.16	0.13	0.12
D	2.24	2.05	1.67	0.18	0.19	0.14	0.73	0.99	1.01	0.66	0.53	0.39	0.18	0.13	0.11
E	2.26	2.09	1.70	0.19	0.20	0.15	0.76	0.94	1.00	0.46	0.40	0.31	0.27	0.20	0.20
mean	2.23	2.06	1.66	0.18	0.19	0.14	0.80	1.00	1.03	0.48	0.40	0.31	0.19	0.14	0.13
A	2.14	2.01	1.46	0.21	0.20	0.18	1.12	1.12	1.15	0.29	0.25	0.24	0.11	0.13	0.12
B	2.18	2.05	1.54	0.21	0.21	0.18	1.11	1.10	1.04	0.45	0.49	0.43	0.13	0.15	0.14
C	2.13	2.01	1.45	0.20	0.20	0.17	1.08	1.12	1.09	0.22	0.22	0.23	0.11	0.13	0.13
D	2.21	2.12	1.46	0.21	0.20	0.18	1.11	1.04	1.04	0.45	0.50	0.41	0.11	0.13	0.12
E	2.17	2.06	1.50	0.21	0.21	0.18	0.97	1.02	0.95	0.32	0.37	0.31	0.20	0.24	0.21
mean	2.17	2.05	1.48	0.21	0.20	0.18	1.08	1.08	1.05	0.35	0.37	0.33	0.13	0.16	0.14

* a = 4 months after germination or sprouting
b = 6 months after germination or sprouting
c = 8 months after germination or sprouting.

Table 4. Results of leaf analysis experiment 3 for plant cane (upper half) and first ratoon (lower half)

	% N			% P			% K			% Ca			% Mg		
	a*	b*	c*	a	b	c	a	b	c	a	b	c	a	b	c
F	2.18	1.95	1.54	0.17	0.18	0.14	1.01	1.25	1.17	0.29	0.24	0.20	0.19	0.14	0.12
G	2.19	2.01	1.61	0.20	0.20	0.14	1.00	1.20	1.12	0.31	0.24	0.22	0.18	0.15	0.14
H	2.20	2.02	1.68	0.20	0.21	0.15	1.07	1.26	1.17	0.31	0.24	0.25	0.18	0.15	0.14
I	2.26	2.11	1.69	0.22	0.22	0.16	1.04	1.29	1.17	0.33	0.28	0.22	0.18	0.17	0.15
K	2.30	2.08	1.62	0.23	0.23	0.16	1.02	1.32	1.16	0.34	0.29	0.23	0.20	0.17	0.14
mean	2.23	2.04	1.63	0.20	0.21	0.15	1.03	1.26	1.16	0.31	0.26	0.22	0.19	0.15	0.14
F	1.99	1.89	1.25	0.14	0.14	0.13	1.23	1.25	1.20	0.23	0.26	0.21	0.13	0.16	0.12
G	2.08	1.87	1.22	0.15	0.15	0.13	1.25	1.20	1.11	0.25	0.24	0.20	0.12	0.16	0.10
H	2.13	1.96	1.42	0.17	0.17	0.15	1.32	1.25	1.21	0.28	0.29	0.26	0.13	0.16	0.14
I	2.20	1.93	1.43	0.17	0.17	0.15	1.26	1.20	1.12	0.28	0.30	0.28	0.14	0.18	0.15
K	2.10	2.03	1.39	0.18	0.19	0.16	1.32	1.21	1.28	0.27	0.32	0.27	0.15	0.16	0.14
mean	2.10	1.94	1.34	0.16	0.16	0.14	1.28	1.22	1.18	0.26	0.28	0.25	0.13	0.16	0.13

* a = 4 months after germination or sprouting
b = 6 months after germination or sprouting
c = 8 months after germination or sprouting.

From table 4 it can be concluded that Curaçao phosphate had positive effects on both leaf phosphate and leaf calcium content. Comparing the results for plant cane and for ratoon cane, we can see that leaf nitrogen content is slightly higher in plant cane, whereas leaf potassium content is slightly lower. There is also a decrease in leaf nitrogen content when the plant matures, both for plant cane and for ratoon cane. Especially after 6 months nitrogen content dropped considerably. This relation also was found by Evans (1961).

The results of the length measurements, yield determinations and juice analysis are given in table 5 and 6. Unfortunately it was not possible to determine yield and to make juice analysis of the first ratoon, because of heavy lodging of the cane, causing much damage. This lodging was caused by very strong winds, together with heavy showers, which occurred in July 1977.

Tabel 5. Results of length measurements, yield determinations and juice analysis for plant cane and of length measurements for the first ratoon (last columns): Experiment 1

	Stem	Length (cm)	M.C**	Rend.	Sugar	Purity	Pol %	Brix	Stem	Length (cm)	
	b*	c*	kg	%	kg	%		o	a*	b*	c*
N1	203	264	696	7.34	51.2	86.7	15.47	17.85	146	212	235
N2	204	262	684	7.34	50.2	87.8	15.63	17.80	145	212	240
N3	203	261	715	7.35	52.6	86.6	15.41	17.79	146	210	240
P1	202	262	701	7.34	51.5	87.6	15.65	17.86	145	212	239
P2	202	262	706	7.35	52.0	86.9	15.50	17.84	146	212	241
P3	206	264	688	7.34	50.6	86.6	15.37	17.73	146	210	238
K1	203	262	672	7.40	49.8	87.0	15.61	17.94	147	211	243
K2	203	262	715	7.42	53.1	87.5	15.57	17.79	145	211	241
K3	204	263	708	7.21	51.3	86.5	15.32	17.71	145	213	234
mean	203	262	698	7.34	51.4	87.0	15.50	17.81	146	211	239

* a = 4 months after sprouting
b = 6 months after germination or sprouting
c = 8 months after germination or sprouting

** M.C. = net millable cane.

The results from table 5 show that there were no effects at all of nitrogen, phosphate and potassium at the chosen levels. On the contrary, there were very positive effects of liming on stem length during growth and on yield. This is also true for application of Curaçao phosphate. These positive effects, however, were leveled by negative effects on juice quality (purity, pol %, brix). For this reason sugar yield (rendement x cane yield) was not influenced by liming and application of Curaçao phosphate (table 6).

Table 6. Results of length measurements, yield determinations and juice analysis for plant cane and of length measurements for the first ratoon (last columns): Experiment 2 and Experiment 3.

	Stem	Length (cm)	M.C**	Rend.	Sugar	Purity	Pol %	Brix	Stem	Length (cm)	
	b*	c*	kg	%	kg	%		o	a*	b*	c*
A	177	229	680	8.29	56.4	89.9	17.31	19.26	141	199	254
B	195	249	730	7.88	57.8	89.0	16.10	18.11	152	219	269
C	172	222	646	8.77	56.4	91.6	17.73	19.53	140	204	256
D	197	250	699	7.88	55.2	88.7	16.35	18.42	147	214	261
E	205	268	734	7.16	52.7	87.5	15.53	17.74	154	226	259
mean	189	244	698	8.00	55.7	89.3	16.60	18.61	147	212	260
F	185	244	729	8.40	61.3	90.5	17.03	19.02	112	164	221
G	194	254	798	8.01	63.9	88.5	16.73	18.88	123	175	227
H	199	260	840	7.72	65.0	87.8	16.53	18.81	132	197	245
I	202	266	883	7.25	64.0	86.5	15.64	18.06	139	203	255
K	211	274	855	6.84	58.5	85.9	15.15	17.64	143	213	251
mean	198	260	821	7.64	62.5	87.9	16.22	18.48	130	190	240

* a = 4 months after sprouting
b = 6 months after germination or sprouting
c = 8 months after germination or sprouting

** M.C. = net millable cane.

Summarizing the following can be concluded from these experiments:

1. The chosen levels of nitrogen, phosphate and potassium fertilizers were too high and for this reason the levels will be lowered for the second ratoon.
2. Liming did not influence sugar yield in plant cane, but this has to be studied also for ratoon cane.
3. Curaçao phosphate had similar effects as liming. Moreover, this fertilizer makes it also possible to grow at least one ratoon crop without applying water soluble phosphate.

REFERENCES

Evans, H., 1961. A guide to the interpretetion of nutritional diagnostic analyses of sugar cane in British Guiana. Sugar Journal 23:8-16.

Legger, D., 1975. Gewassenanalyse methoden. Unpubl. res. Agric. Exp. St.

Poidevin, N. le & L.A. Robinson, 1964. Foliar analysis procedures as employed on the Booker Group of sugar Estates in British Guiana. Part 1: Sampling and analytical techniques. Fertilité 21:3-11.

Schroo, H., 1954. The use of pot tests in research on the fertility of sugar cane soils. Paper VI: The effect of the increasing dressings and various methods of placement on the phosphate status of Red Ferruginous clay and on the growth of cane. Trop. Agric. 31:327-341.
Schroo, H., 1976. Soil productivity factors of the soils of the "Zandery formation" in Suriname. De Surinaamse Landbouw 24:68-84.

ACKNOWLEDGEMENT

I am much indebted to Mr. Schroo, who in 1975 started the three experiments at Coebiti. Mr. Schroo was attached to the Soil Productivity department of the Agricultural Experiment Station for a one year period as Consultant of this department.

Preliminary results of sugar cane experiments on the sandy loam soils of the "Zanderij" formation.
(I.E. Soe Agnie)

Question by: J.H. van Eyck
Country: Suriname

QUESTION: It is not clearly stated in the paper (see table 6) at what age of the cane the juice analysis were performed.

ANSWER: The age of the cane was about 12 months.

ANATOMY OF TUBER AS AN AID IN YAM BIOLOGY STUDY

L. Degras and P. Mathurin (+)

SUMMARY

In spite of the part played by the Yam tuber in the clone perennity and economical value, its anatomy remains insufficiently studied. A simple study of *D. alata, D. trifida, D. cayenensis, D. esculenta* and *D. transversa* sets up characters which enlighten tue species biology. In *D. alata* a very specific sclerenchymatous zone is interpreted as transfusion tissue. In all the species, cellular blocks, within the inner cortical parenchyma, make up the organizing poles of the tuber part set germination.

INTRODUCTION AND LITTERATURE

In spite of the fundamental value of the underground tuber of Yam for its economic interest and its biology, relatively few studies concern its anatomy. Ayensu (1972) himself who mentionned this fact in his own anatomical monography considers but 18 species for their tuber out of the 67 he studied.

So, for a synthetic as well for many specific views of the Yam tuber anatomy, the best information has to call for the old thesis of Queva (1894). The normal and general types of *Dioscorea* can be thus described under four organogenetic cases (fig. 1):

A. Several *Dioscorea* with perennial tubers

Only cambial layers which come from secondary tissues hypertrophy; no sub-apical meristem.

B. *D. alata, D. bulbifera* and *D. pentaphylla* for instance

Cambial layers for the outer cortex and sub-apical meristem of which primary tissues relay the secondary tissues hypertrophy and make the essential tuber tissues. Delayed multiplicating layers are seen in the inner cortex.

C. *D. esculenta* and D. *opposita* for instance

A primary tissue hypertrophy is relayed by the sub-apical meristem and the cambial layer giving the outer cortex. Delayed multiplicating layers are seen in the inner cortex.

We must underline that Queva's observations rely upon germinating sexual seeds as well as on adult tuber from vegetative origin, the classification of the species which are quoted here from homology with the adult tuber of sexual origin of *Tamus* (A), *Helmia* (B), and *D. kita* (C) (see Burkill (1960) for Queva's botanic terminology.

(+) Institut National de la Recherche Agronomique (INRA)
Station d'Amélioration des Plantes
Domaine Duclos

Petit-Bourg (Guadeloupe)

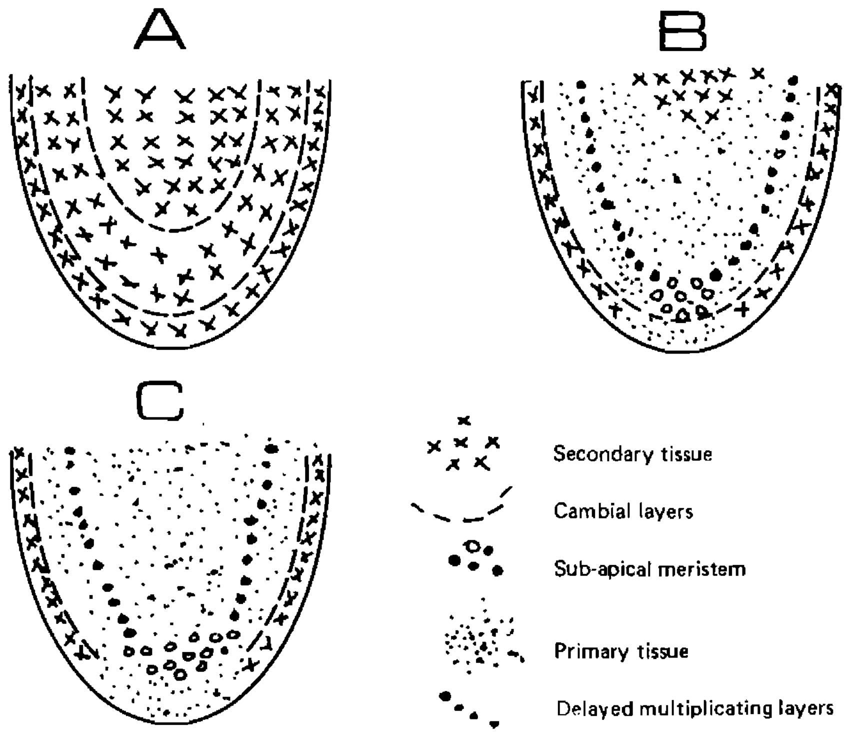


Fig. 1 – The three types of *Dioscorea* apex from the data of QUEVA (1894)

Apart from this general classification, we can find in Queva (1894) some details concerning *D. alata* and *D. esculenta* which will be discussed with our own observations.

Winton and Winton (1935) published a detailed account of *D. alata* structure and cell types, using the "Red Barbados" Yam.

Ayensu (1972), as we have seen did not give to tuber anatomy all its importance and this is again reflected in the fact that the gives a unic description for the whole *Enantiophyllum* section which contains *D. alata, D. cayenensis (x), D. opposita (= D. batatas)* and *D. minutiflora,* this last one being a tuber perennial species. So its description is vey general. As well, we might use it as the general frame of Yam tuber anatomy. The more so that the section *Macrogynodium,* which hold *D. trifida,* does not bring great variations. From the periphery to the center, the following structures are seen:

- a primary tissue outer cortex of irregular suberified cells
- a secondary tissue outer cortex of numerous suberified layers in more or less radial rows
- a fundamental inner cortex tissue of parenchymatous cells sometimes in radial or stratified series
- a fundamental central amyliferous parenchyma where collateral (stem type) vascular bundles are dispersed.

Raphids and tannin cells are seen.

(x) We use the Flora of West Tropical Africa (Miege, in Hutchinson, Dalziel, Hepper, 1968) terminology, where we have *D. cayenensis sp.* comprising ssp. *cayenensis* and ssp. *rotundata.*

Occasionnal anatomical tuber data has been met in litterature, the most interesting and recent of which are those of Onwueme (1973) and Mantell, et al. (1977). Sharma (1974) alone, published a detailed contemporary study of tuber anatomy, but of a wild *Enantiophyllum* species, *D. Glabra.*

As could be foreseen from a so limited interest in tuber anatomical study, many observations remain superficial and lead to many discrepancies either by lack of specification of given or by speculative description of the same structure. The most exemplary case is the *D. alata* one, in spite of the outstanding position and dispersion of the Great Yam in the whole tropical area.

Ayensu (1972) speaks of the "striking uniformity of the general anatomy". So he never mentionned the lignified structure of the inner cortex which for Mantell et al. (1977) is quite distinctive of *D. alata* one from that of *D. cayenensis,* in spite of their *Enanthiophyllum* grouping. Queva (1894) holds for oblical suberified layers in the *D. alata* cortex and for indifferentiated bunldles among an inner cortex layer of thick wall cells and Winton and Winton (1935) for a pericycle of stones cells filled with an oxalate crystal. None of these authors localised the "meristematic layer" of Onwueme (1973) from which neoformed buds are rising in the common seed pieces in which most cultivated yams are cut for plantation.

The general investigation we conduct of the Yam tuber fragmentation effects (Mathurin, Degras, 1974, Degras, Mathurin, 1975) has to take account of the anatomical structures and evolution which permit the bud germination and growth. And, as can be seen from the present review, no sound data could be obtained from the litterature. Hence the following observations.

MATERIAL AND METHODS

Cultivars

We first observed the cultivars used in the quoted investigation; *D. alata* cv "Pacala" and "*D. trifida* pv "INRA 25", then in front of the surprising differences, we extended our observations to *D. cayenensis, D. esculenta* and *D. transversa* cultivars. Here are some traits of them.

D. alata cv "Pacala" is known from Guadeloupe. Its African secondary origin may be related to the Pakalla community of Ivory Coast. Similar clones are known in Dominica. The tuber is more often cylindro fusiform, rarely finger-tipped, white-fleshed, with a rather midly cracked corky bark. It has a relatively long storage ability (Degras et al. 1972).

D. trifida cv "INRA 25" is an hybrid clone selected from a cross done in Guadeloupe in 1966 and released in 1971 (Degras et al. 1971). The pyriform tubers may reach as much as a fifty per plant and a mean weight of 100-250g per tuber. The flesh is white and of high cooking grade. The skin is rather thin with thickened and cracked transversal corkly lines. The storage ability is very short (Degras et al. 1971, Martin and Degras, 1978a).

D. cayenensis ssp. rotundata cv "V17-2" has been introduced from West Africa (may be Cameroon) about the year 1964 by IRAT, (x) and pass to INRA collection in 1966. The clone as a flesh creamy whitish colour which should place it not far from a ssp. *cayenensis.* It is of early first harvest and, as usual, this first tuber is not stored very long. It was our material.

D. esculenta cv "Pas-possible" is a "Chinese yam" introduction of the end of the last century from Indo-China peninsula. Like "INRA 25" the underground tubers are clustered but their peduncle is thin and the tuberized part is cylindroid with a smoother and thinner corky bark. They can be stored for a longer time than "INRA 25" but less than "Pacala".

D. transversa cv "Waël" has been introduced in 1969 from New Caledonia under the false name of *D. nummularia.* This minor species, at the world level, is highly appreciated in its country (Bouret, 1973) and appears susceptible of a wider dispersal (Martin, Degras, 1978b). Its tubers are several per plant, with a long neck, and covered with rootlets; the skin is thin and cream coloured, the flesh white at the center under a slight pinky-purple peripheric zone. It is of fair cooking behaviour and good taste. It keeps easily in the soil and seems able of a long growth while it is of a long growth while it is of very short storage aptitude, mainly through bruising accidents.

Methods

In this preliminary approach, only adult and normal but rather small tubers has been observed. It follows different tuber weight, respectively 150 to 400g, for *D. trifida, D. esculenta* and *D. transversa* but 500 to 800g for *D. alata* and *D. cayenensis.*

Transversal middle section has mostly been used with a limited numbers of radical and tangential sections at the same tuber level.

We used the classical anatomical technique: elimination of the cell content with sodium hypochlorite, clearing in dilute acetic acid and water, colouring with alumned carmine and iodine green. Mounting was done in glycerine. Examination was conducted with an optic Leitz microscope under a 12,5 eye-piece x 3,5 objective, giving a magnification of about 150.

OBSERVATIONS

They are presented in a growing complexity order and description goes from periphery to center.

Dioscorea transversa cv "Waël" (fig. 2 and 3)

(x) IRAT = Institut de Recherches Agronomiques Tropicales.

Fig. 2 — ***Dioscorea** transversa* Transversal section of the tuber

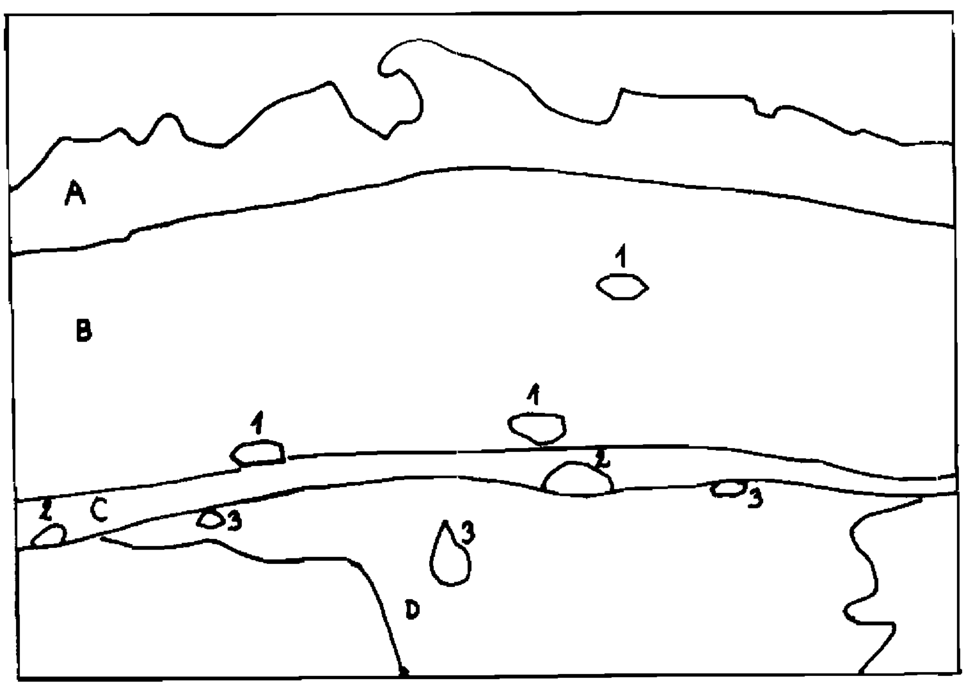


Fig. 3. — ***Dioscorea transversa.*** Analytical drawing of fig. 1. A: cork; B: cortical parenchyma C: Inner cortex procambial zone; D: central amyliferous parenchyma; 1: raphid cell; 2: multiplicating cell blocks; 3: vascular bundle

–5-6 layers of suberified cells, mostly irregularly disposed and isodiametric, sometimes stratified and in radial series; so, primary tissue seems prevalent in the outer cortex;

– 1-2 poorly differentiated layers

– 10-15 layers of smaller parenchyma cells rather regularly and tangentially elongated; greater cells are filled with raphids;

– 5-8 layers of even smaller but less differentiated cells are also well disposed and tangentially elongated; from place to place they are interrupted by cells blocks of more or less meristematic appearance like proto phloem zones;

– ground amyliferous parenchyma with isodiametric cells growing in size towards the center and holding stem type vascular bundles evenly dispersed.

Dioscorea cayenensis cv. "V 17-2" (fig. 4 and 5)

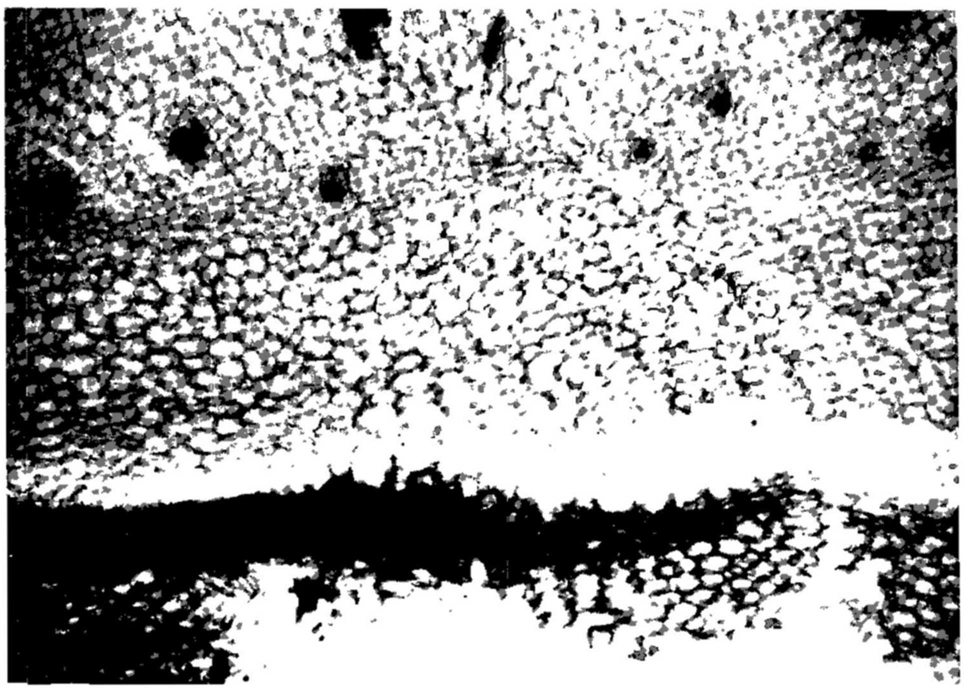


Fig. 4 – *D. cayenensis.* Transversal section of the commercial tuber.

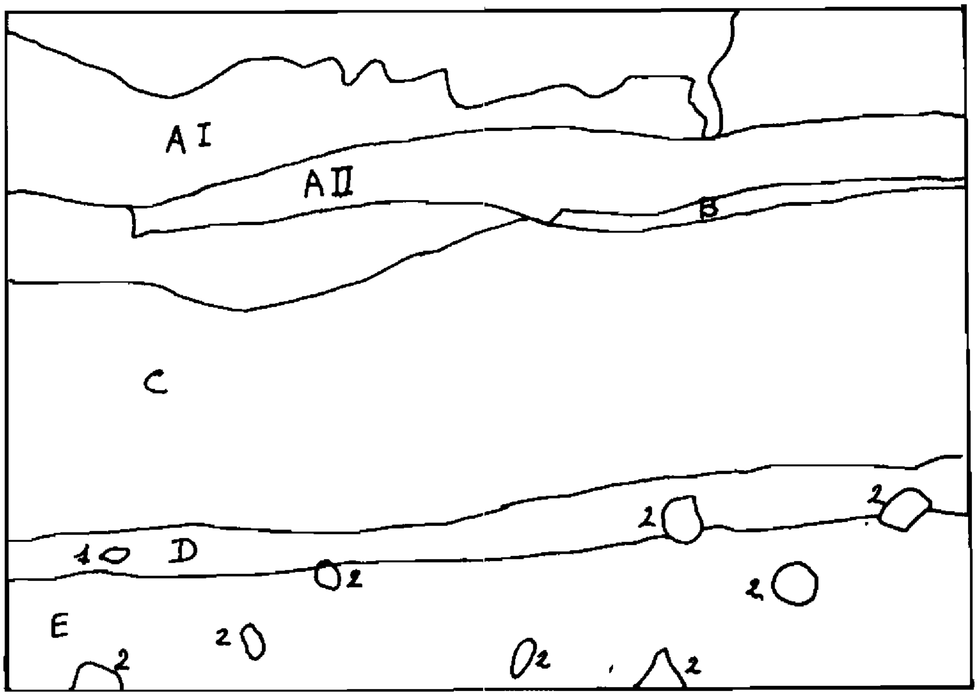


Fig. 5. — *D. cayenensis.* Analytical drawing of fig. 4.
AI: primary cork, AII: secondary cork;
B: cambium; C: cortical parenchyma;
D: inner cortical procambial zone; E: central amyliferous parenchyma; 1: cell blocks; 2: vascular bundle

The same succession as the precedent is observed with the following differences:

— cells are generally smaller

— the suberified outer cortex has

— 4-5 layers of primary tissue

— 5-6 layers of secondary cork tangentially elongated and disposed in radial series, the inner layers being often densely compacted against a basic cambial layer

— the meristematic cell blocks seem less frequent

— associated cells in the parenchymas result in secretory chanels features.

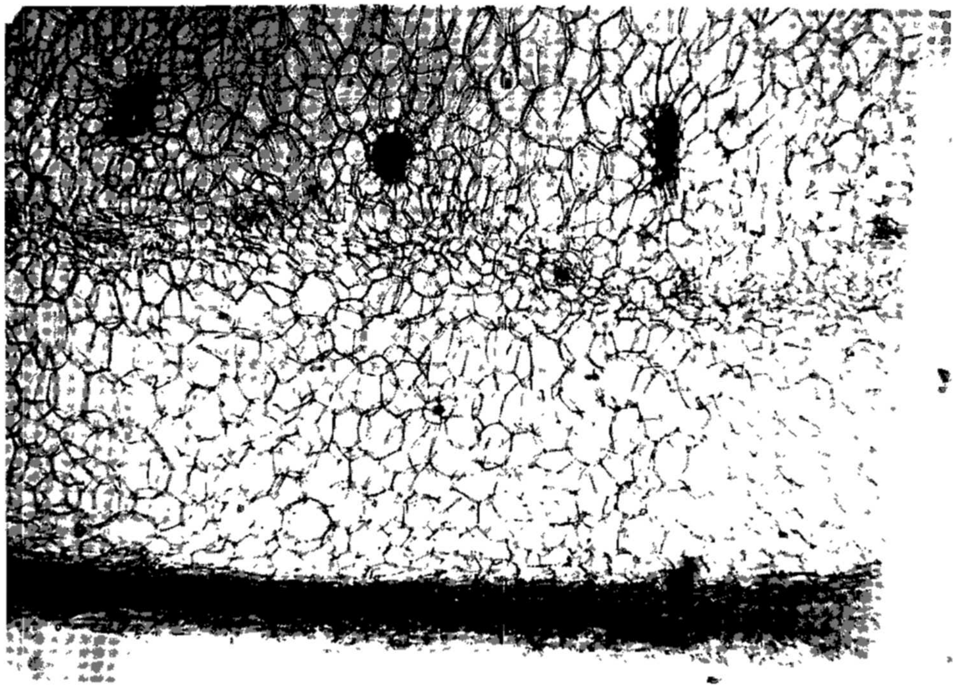


Fig. 6. *D. esculenta*; transversal section

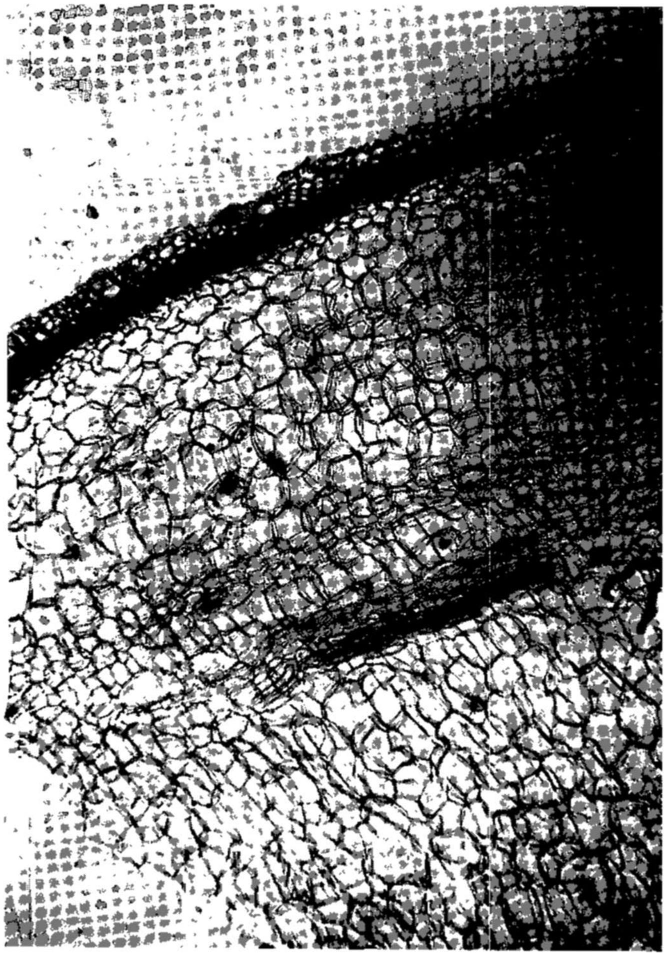


Fig. 7

D. esculenta;

longitudinal section

Dioscorea esculenta cv "Pas possible" (fig. 6 and 7)

– Suberified more or less isodiamteric cells layers partly exfolating

– Suberified tangentially elongated cell layers with thick walls resulting in unconspicious cellular content for the inner layers.

– 1-2 cambial layers

– cortical parenchyma with greater isodiametric cells.

– 3-4 layers of quite undifferentiated small cells interrupted by scattered young cell blocks;

– amyliferous parenchyma with vascular bundles.

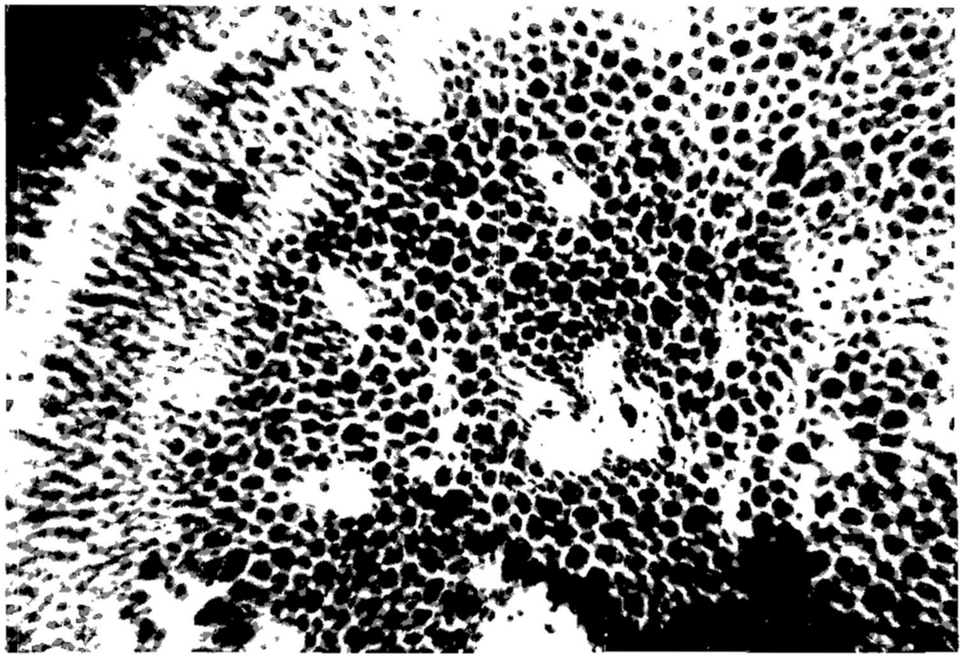


Fig. 8. — *D. trifida;* transversal section general view of a tuber section

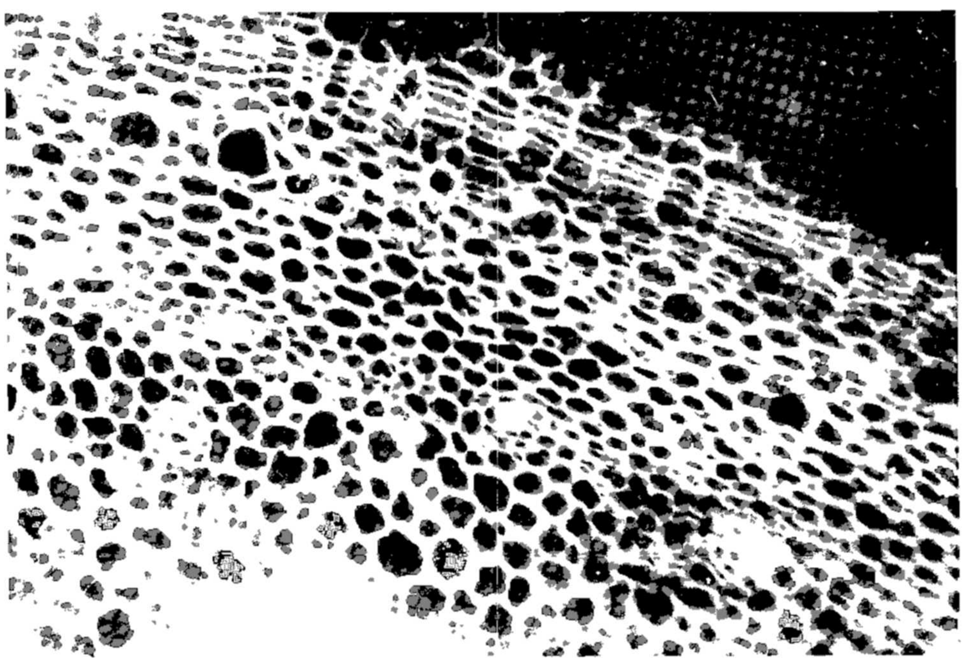


Fig. 9. — *D. trifida;* transversal section.

Detailed view of the peripheric zones of the tuber

Dioscorea trifida cv "INRA 25" (fig. 8 and 9)

– Suberified primary layers widely exfoliating

– 5-7 suberified secondary layers in well ordered radial series;

– 1 cambial layer linked to the suberified cells;

– 6-8 layers of cortical parenchyma with tangentially elongated cells but rarely radially associated to the precedent cambium; greater cells giving raphids or secretory systems;

– 3-4 layers of small rather isodiametric cells, interrupted by young cells blocks;

– amyliferous parenchyma with vascular bundles all cells growing in size towards the center

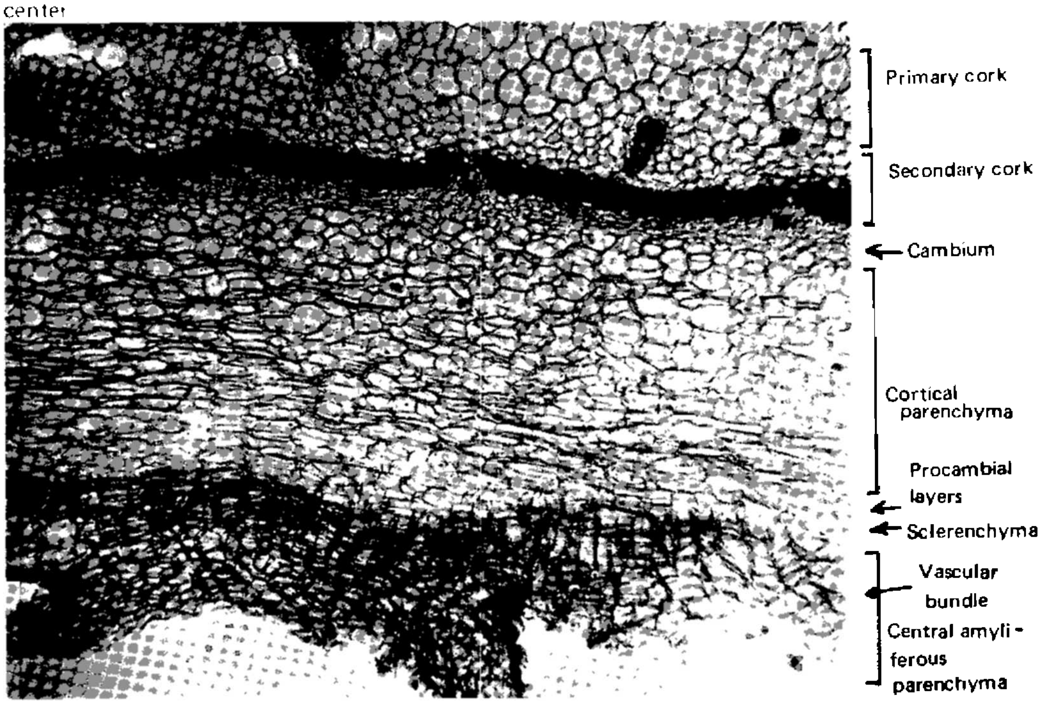


Fig. 10. *D. alata*. Transversal section of a tuber; general view of the peripheric zones.

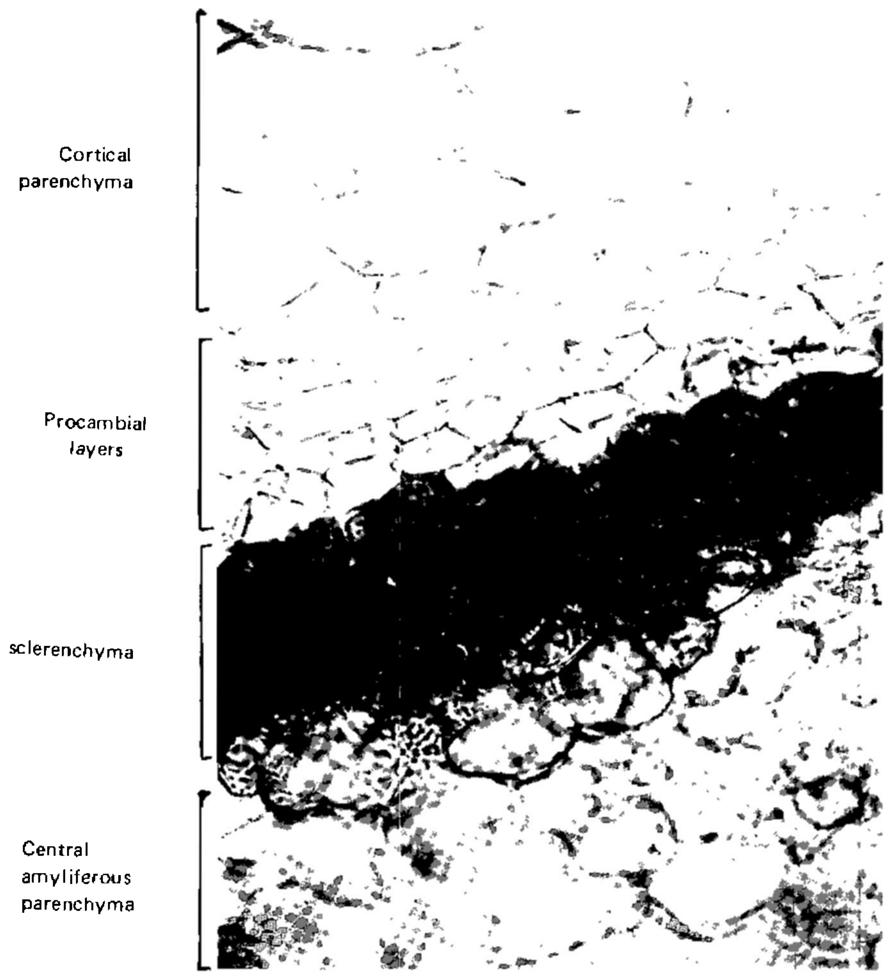


Fig. 11

D. alata transversal section; detailed view of the sclerenchyma area.

Dioscorea alata cv "Pacala" (fig. 10 and 11)

– 5-6 primary layers of large sized suberified cells

– secondary suberified layers of similarly wide cells but radially organized and squeezed on the inner side;

– 1 cambial layer associated to the secondary cork;

– 2-4 young parenchymatous layers with isodiametric cells under the cambium;

– cortical parenchyma with more or less tangentially elongated cells, rarely in radial succession; it contains secretory and raphids cells.

– 4-5 layers of small quite undifferentiated cells either isodiametric or tangentially elongated with by place young cells blocks which sometimes go in the inner tissue;

– 3-5 layers of large polyhedric sclerenchymatous cells, giving way by place to young small cell blocks which reach the central parenchyma; these sclerenchymatous cells are mostly with thick walls surrounding and excentered crystal, but several on the inner side in general, have relatively thin walls punctuated in the horizontal direction.

– an amyliferous parenchyma with vascular bundles of the same characteristics as the precedent ones.

The essential traits

Over the five species we have:

– A cortex with – outer corky layers
– mid parenchymatous layers holding raphids when they exist
– inner young small cell layers

– A ground amyliferous parenchyma holding stem-type vascular bundles.

An outer cambial layer might occur under the cork. But it is rather conspicious in some cases like *D. transversa* when the cork seemed mainly of primary nature. This leads to the variations between species.

At the cork level, besides the primary versus secondary tissue nature contribution, we notice the cell wall thickness relative variation. With consideration of the cell size it grows from *D. trifida, D. alata* and *D. esculenta.* The number of cell layers seems to increase from *D. transversa* to *D. trifida,D. esculenta* and *D. alata.*

The inner cortical layers of *D. esculenta* are thinner. And this level is achieved in *D. alata* on its singular sclerenchymatous layers.

The structural identity of the ground parenchyma through the five species is remarkable in view of the structural specific diversity of the cortex. But, it is the reverse as for the final development of each part. While the cortex, (obviously thinner towards young tuber sections) never outpass 2mm, the ground parenchyma, depending on tubers and varieties, goes from 5 to 20 cm in diameter.

INTERPRETATION

Let us consider now the contribution which could be infered, from the anatomical structure, to the tuber functions which are accumulation, protection and re-utilization of stored biological food.

Food storage: central and cortical parenchyma

Starch grains are numerous the more so the amyliferous cells are near by the vascular bundles, which determines a macroscopic granular appearance of the ground parenchyma, the grana being the best filled cell areas. Starch grains are very few in the cortical parenchyma. Other products are mostly accumulated by this one. Raphids of calcium oxalate and tannin cells may be seen. Calcium oxalate monocrystal are filling the sclerenchyma cell lumen in *D. alata*. Are they properly food storage seems questionnable (see further).

Food storage protection: corky and sclerenchymatous layers

These layers play a protection part through different degrees of cell size and degrees of cell wall modification. And the respiratory and hydric economy of food stores as well as their mechanical protection reach different levels with each species.

The less suberified and mostly primary cork layers added to the generally thin cell walls of *D. transversa* are in accordance with the easy post-harvest decay and the relatively extending growth of its tuber. The thin cell walls of *D. trifida,* though with secondary suberified layers may be faced with the poor post-harvest conservation of its tuber, while *D. esculenta* may be more efficiently protected through the seeming high cell wall suber density of a corky cortex which is not thicker in total.

The thickness of the primary and secondary suberified layers of *D. alata* in good accordance with the rather good post-harvest conservation of its tuber. Moreover, with the sclerenchymatous layers this species may have not only a stronger mechanical protection and rigidity for deeper underground growth, but also something like the „transfusion tissue" (Boureau, 1954) which play a part in water keeping. Their cell wall punctuation and the vascular bundles vicinity are good features of that.

Food stores utilization: cortical parenchyma and indifferentiated cell block

The organogenetic area for the tuber buds is known to be at the inner cortex layer level (Onwueme, 1973, Mathurin, 1977). This area can be considered as a procambial meristem in (Boureau, 1954) sense with its sheath situation between two parenchyma (x), the frequent lengthening of its cells and its seemingly high participation in the conducting tissue.

The individual cell blocks appear as the initial multiplication site for any tuber piece outside the "head" one. This process needs energy from the food stores available. If this energy would directly come from the starch stored, the parenchyma cortex may not be adapted. Here raises the possible contribution of the calcium oxalate. At a time it was seen as only a refuse or waste product. Then data has been produced for a possible part in osmotic pression balance (Wattiez and Sternon, 1942). Others mentionned also its ability to modify the respiratory quotient (Binnet and Brunel, 1968). Now it seems to certify a detoxication process (Zinsou, 1978). Whatever may be, it apppars to be linked with a high metabolic activity. This is clear from the multiplication of raphids in the growing zones (Mathurin, 1977).

Individual cell blocks seem to function as organizing poles which structure and determine growth and morphogenesis. Their nature may be enlighted through a comparison with the undifferentiated l embryo of some seeds, and in the main part of the tuber, between harvest and germination, could exist a kind of embryonic dormancy.

(x) True procambial meristem are mostly surrounded by meaters parenchyma while we have here rather polyhedric parenchyma.

DISCUSSION – CONCLUSION

These preliminary observations appeal for more sound research. Among needed complementary studies must be mentionned:

- comparative varietal studies within each species
- longitudinal sections
- section in tubers related to their age
- relation between cell content, mitotic activities and cell wall lignification

Nevertheless the following points can be retained as strong basis for further investigation:

1. The clones anatomy has specific value; this comes from the fact that our data permit a comprehensive view of those of the other authors on *D. alata*. It is now clear that this species has original hard cell inner cortical layers named by Queva: thicken cell wall layer, by Winton and Wintony: stone cells layers, by Mantell et al: sclerenchyma, and which, with its seeming transfusion tissue character may be one of the determinant wide adaptative factor of this species unic pan-topical dispersion.

2. The general presence of generative cell blocks offers histological basis for the structural and dynamic analysis of the tuber multiplication.

3. The tuber functionning (and, for essential aspects the whole plant functioning) can be understood through its anatomy, in spite of the limited transversal sections: the relative independance of the successive areas in transversal sections refers to the tuber apex (sub-apical) morphogenetical predominance, a fact which appears to emerge from perennial toward the most evolved annual types (Queva, 1894).

ACKNOWLEDGEMENT

Thanks are due to Dr. Portecop (Centre Universitaire des Antilles et de la Guyane) and Dr. Zinsou INRA, Antilles Guyane) for their fruitful criticisms and suggestions.

REFERENCES

Ayensu E.S., 1972. In Anatomy of the Monocotyledons (C.R. Metcalfe ed.) VI Dioscoreales, 182 pages, Clarendon Press, Oxford.

Boureau E., 1954. Anatomie végétale, T.I, 330 pages, P.U.F, Paris.

Bourret D., 1973. Etude ethnobotanique des Dioscoreacées alimentaires. Igname de Nouvelle Calédonie. Thèse de Doctorat 3è cycle. Spécialité: Biologie Végétale. Paris. 135 pages.

Brunet P. and Brunel J.P, 1968. Physiologie végétale, Doin, Paris. Tome III (p. 796-1156).

Burkill, I.H. 1960. The organography and the evolution of *Dioscoreaceae,* the family of the Yams. J. Linn. Soc. Bot., 5, 6, 367, 319-412.

Degras L., Mathurin P. and Suard C., 1975. New results in Yam multiplication, 13th Ann. Meet. Proceed. Carib. Food Crops Soc. Trinidad.

Degras L., Arnolin R., Suard C. and Poitout R., 1971. New information about *Dioscorea trifida* Cush-cush yam selection. 9th Ann. Meet. Proceed. Carib. Food Crop Soc. Guyana.

Degras L. Arnolin R. and Poitout R., 1972. Principal yams introduced and grown in the French West Indies. 10th Ann. Meet. Proceed. Carib. Food Crops Soc. Puerto-Rico.

Mantell S.H, Mohamed N., Haque S.Q. and Phelps R.H. 1977. Virus diseases of Yams in the Commonwealth Caribbean, ODEM Yam Virus Project, Technical Report n° 3, CARDI, UWI, Trinidad.

Martin F.W. and Degras L., 1978a. Tropical Yams and their potential. Part 5. *Dioscorea trifida,* Agric. Handbook, USDA, USAID, INRA Washington. 26 pages.

Martin F.W. and Degras L., 1978b. In Tropical Yams and their potential. Part 6. *Dioscorea* minor species., Agric. Handbook, USDA, USAID, INRA (sous presse) Washington.

Martin F.W. and Ortiz S., 1963. Origin and anatomy of tubers of *Dioscorea floribunda* and *D. spiculiflora,* Bot. Gaz. 124, 6, 416-421.

Mathurin P., 1977. Données pour l'étude de la multiplication végétative de l'Igname *(Dioscorea spp.).* Anatomie due tubercule, fragmentation et essai d'activation de la germination. Mémoire d'étude I.T.A., Dijon. Archives INRA Guadeloupe.

Onwueme I.C., 1973. The sprouting process of Yam *(Dioscorea spp.)* tuber pieces. J.Agric Sci Camb. (1973), 81:375 – 379.

Queva C., 1894. Recherches sur l'anatomie de l'appareil végétatif des Taccacées et des Dioscorées. Mém. Soc. Sci. Agric., Lille, Sér. 4, 20, 457p.

Wattiez N. and Sternon F., 1942. Eléments de chimie végétale, Masson, Paris, 844 p.

Winton A.L. and Winton K.B., 1935. The structure and composition of foods. Vol. II, 137-141, Wiley, London

CITRUS PLANTMATERIAL IMPROVEMENTS

W.E. Fung-Kon-Sang and J.A. Kromodimedjo*
Agricultural Experiment Station, Paramaribo

INTRODUCTION

Research has been aimed at raising production capacity of high quality fruits by combining genetic potentials and by application of disease-free (especially virus-free) and footrot-tolerant plantmaterial. Rootstock trials and extensive evaluation of clones and/or cultivars that have been conducted disclosed some dramatic potentials of different stock-scion combinations. Soil type imparts a significant role on yield and fruit quality. With respect to production and fruit quality, the clay soils are preferable to sandy soils; however tree life is believed to be shorter on clay soil, due to poor drainage conditions.

ROOTSTOCKS FOR ORANGES

With regard to rootstock effect, a distinction should be made between combinations with a virus-free and combinations with a virus-infected top. When budded with virus-free Alidjan budwood, Rangpur lime induced the highest (accumulative) yield, followed by Troyer and Rough lemon, while Sour orange was the least productive, (fig. 1). In the combinations with virus-infected Kwata budwood, the relatively highest productions were totalled by King, Surino and Cleopatra. Moreover these stocks attain the same level of production either with virus-free or virus-infected budwood as top. Consequently, these stocks are tolerant to the virus-complex and can be used with either type of budwood.

The sandy soils of the interior are being explored, for their potentials. Both table 1 and 2 display preliminary results of rootstock performance in that area. The Rough lemon types induced the largest trees, but also low fruit quality with low percentages of juice. Yuzu is a recently imported stock and performs almost equal to Rangpur lime. Soil moisture retention of these sandy soils is low and probably resulted in bad performance of Troyer in contrast to its behaviour in the coastal clays. (Fung-Kon-Sang, E. and T. Nanden Amattaram, 1975).

Production has been discontentedly low in 1978 after a good start in the previous year, for reasons unknown.

* Landbouwproefstation (Agricultural Exp. Stat.) P.O. Box 160

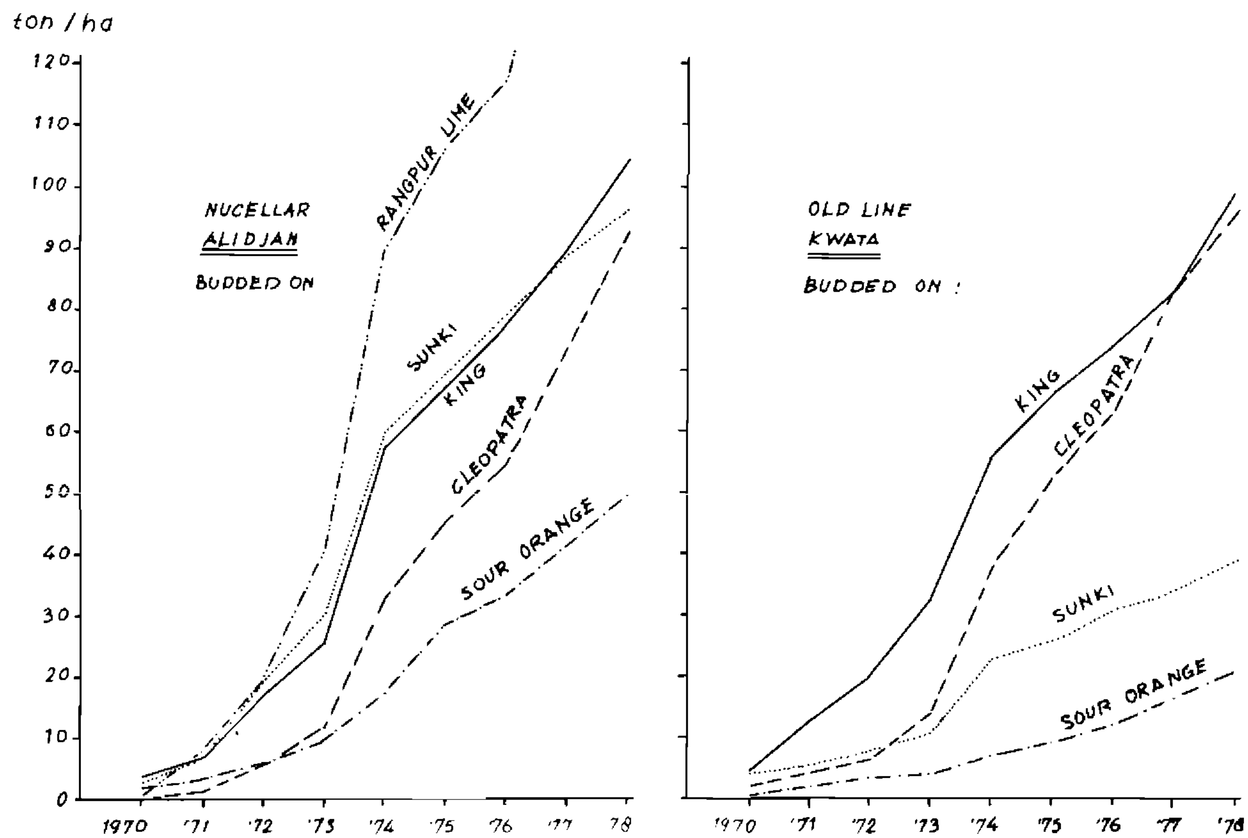


Fig. 1. Accumulated production of different orange combination

Table 1. Relative tree-size of Valencia (47-14 ex BH) in combination with different rootstocks in sandy soil at Coebiti. Planting date: jan. 1972. Observation: Jan. 1978.

Valencia budded on:	Trunk circumf. (cm)		Tree height (cm)	Fruits p. tree	
	stock	scion		(1977)	1978
Volkameriana	51	50	451	123	11
Red Rough lem.	44	43	433	47	12
Estes Rough lem.	45	42	431	48	5
Rough lem. Fla	45	44	424	68	3
Rough lem. -A	42	39	407	51	6
Rangpur lime	44	41	384	49	8
Yuzu	41	39	398	66	10
Orlando tangelo	41	39	375	20	2
Sunki mand.	39	36	353	41	3
Troyer citr.	34	29	286	16	2

Table 2. Fruit characteristics of Valencia (47 – 14 ex BH) in combination with different rootstocks in sandy soil at Coebiti.
Observation: Sept. 1977

Valencia budded on:	Fruit wt. (g)	juice (%)	acid (%)	brix (°)	seeds p.fru.
Volkameriana	208	46.0	1.70	9.2	7.0
Red Rough lem.	206	48.3	1.33	9.1	6.9
Estes Rough lem.	194	50.1	1.52	9.2	6.6
Rough lem. Fla	228	42.7	1.59	8.8	6.1
Rough lem. -A	238	42.3	1.25	8.9	5.5
Rangpur lime	221	48.1	1.43	9.2	6.6
Yuzu	212	51.3	1.56	8.8	6.6
Orlando tangelo	246	48.3	1.20	8.9	7.2
Sunki mand.	235	48.9	1.35	9.5	4.9
Troyer citr.	283	51.0	1.02	10.0	4.9

Rootstocks for grapefruit

Sunki, King and Troyer were the most productive stocks for Hooghart grapefruit in clay soil, when expressed in number of fruits. (Fung-Kon-Sang, E, 1977).

Relatively, Cleopatra induced the lowest yield, but when given sufficient time this stock might have gained. After 10 years in the field, this experiment was discontinued after that excessive rainfall followed by extreme drought in 1976 caused the death of many trees. Since 1973 a larger number of stocks have been put under test in sandy soil, of which update results are presented in table 3. Planted in 1973 these trees still produced no substantical amount of fruits. Volkameriana, a Rough lemon type induced the largest trees, while Sour orange again occupied the last place.

Table 3. Relative tree size of Marsh grapefruit in combination with different rootstocks in sandy soil at Coebiti
Planting date: May 1973; Observation: May 1978.

Marsh budded on:	Trunk girth (cm) stock	scion	Tree height (cm)
Volkameriana	51	48	465
Rangpur lime	49	48	463
Sunki	41	40	409
Amblycarpa	42	38	381
Yuzu	38	36	377
Cleopatra	38	35	376
Troyer	37	32	368
Caipira	35	34	347
Surino	37	33	346
(Rode) King	35	30	340
Citrumelo	30	22	293
Sour orange	25	23	265

Scion varieties

Oranges

Quite a number of orange cultivars have been observed especially with regard to fruit quality. Locally selected Kwata orange was solely propagated, because sufficient knowledge of the potentials of other cultivars was lacking. In general, fruits of early cultivars are susceptible to granulation and they lose their flavour when stored too long on the tree. Hamlin orange for example is totally unacceptable under all soil conditions for it even granulates when the fruits are still greenish. Navel orange performs slightly better but suffers moreover from oversized fruit when kept too long on the tree. Parson Brown is not ideal but is now considered the most acceptable early cultivar.

The mid-season and late varieties are better suited to the tropics. The first mentioned group is represented by Kwata orange, while Valencia will be added in order to extend the season. Some recently imported varieties (e.g. Westin) will be observed for their potentials.

Grapefruits

Since almost all grapefruit is cultivated for export where Marsh seedless is preferred, there is little or no need for varietal tests. Multi-year comparison of Marsh and a local selection called Hooghart proved the latter to be indistinguishable from Marsh. However there are indications, that red-fleshed grapefruit is gaining popularity, reason why recently the Star Ruby grapefruit was acquired from Texas. An observation plot will be established soon.

Miscellaneous

The local market has shown trends toward a diversification and especially toward mandarins and their hybrids. 'Gele King' tangor 'Curacaosche oranje' mandarin and 'Minneola' tangelo are already high in demand; all with excellent flavour and easy peelable.

Some new introductions as Ponkan, Dancy, Clementine, Mexerica de Rio and Robinson mandarins, Ortanique and Murcott tangors are being observed and await fruit analysis. Ortanique looks promising, while Mexerica de Rio, Robinson and Murcott, although delicious, have small fruit sizes. Also attention is given to the so-called 'pompelmoes' *(Citrus maxima)*, a variety with high heat requirement and thus almost confined to the warm and humid tropics.

REFERENCES

Fung-Kon-Sang, W.E. & T. Nanden-Amattaram. Citrus rootstock performance with old and nucellar orange tops on heavy clay soils of the coastal plain in Surinam. De Surinaamse Landbouw, vol. 23 (1975) : 109 – 119.

Fung-Kon-Sang, W.E. Rootstocks for grapefruit in the coastal clays of Surinam. De Surinaamse Landbouw, Vol. 25 (1977): 14 – 20.

NAME OF PAPER: Citrus Plantmaterial Improvements (Fung Kon Sang)

Questions by: S. Hilario
Country: Dominican Rep.

QUESTIONS:

1. To what do you attribute the low yield of the sour oranges here?
2. Of what origin is the used material in sour oranges?

ANSWERS:

1. Low production is because of drainage problem, diseased plant material and poor cultivation methods.
2. Orange material of sour orange probably from South Europe.

Questions by: Ferdinand Klas
Country: Suriname.

QUESTIONS:

1. Neither from your paper nor from your presentation it became clear what virus you were talking about in the case of virus infected kwata or virus free Alidjan?
2. How have you proved that the kwata material was really infected with any viruses?
3. Have you conducted those experiments with virusfree kwata. Did you compare production of virusfree kwata on the mentioned rootstocks with virusfree Alidjan on these rootstocks?

ANSWERS:

1. Kwata is infected with psorosis, exocortis and xyloporosis (cachexia).
2. That Kwata is infected with viruses, was proved by:
   Kraayenga D.A. See: De Surin. Landb. 1963 11 — (page 46-51) for exocortis.
   For tristeza see: Kraayenga, D.A. In: Congress Agric. Research in the Guiana's 1963 bull. 82 (1964) 65 – 69.
   For psorosis: idem as with triseza.
   For xyloporosis. See: Childs, J.F.L. Observations on citrus culture and problems in Surinam.
   Dutch Guyana II. De Surin. Landb. 14 (1966): 136 — 142.

3. Experiments with virusfree Kwata are running now.
Differences between virusfree Alidjan and virusinfected Kwata are probably not varietal, since production on King and Cleopatra stock were similar with either type of budwood.

Questions by: C. C. Weir
Country: Jamaica

QUESTIONS:

1. What was the source of the Nucellar planting material you used?

2. Is the quality of the Ortaniques grown in Suriname good? What areas in Suriname are best suited for ortanique growing?

ANSWERS:

1. The source of the nucellar planting material was a seedling tree and very similar to Valencia orange.

2. External quality of Ortaniques in Suriname is not too good, because of scab.
We have not enough experience with different areas for Ortanique growing.

PAPAYA RESEARCH IN SURINAME

F.W. Soerodimedjo;
Agricultural Experiment Station, Paramaribo

SUMMARY

Papaya has 3 sexual forms: hermaphrodite, female and male. Only the first two mentioned forms bear fruits. Therefore male plants are not prefered at a plantation, because of the fact that hermaphrodite plants give enough pollen for fruitsetting. By controlled hand (self and cross) pollinations male progenies could be eliminated. In Suriname the seed seemed to be tenable only 2-3 years. After this period the germinal potential was reduced to 50%. All plantations in Suriname are set up with hand pollinated seeds.

In experimental fields with poor drainage 35% of the young seedlings are infected by *Phytophthora species.* The pathogenic *Corynospora cassiicola,* that causes the St. Croix decline has been observed for only one year on infected plants in Suriname; many plants died. At the same time the dieback disease appeared on several experimental fields after a period of extreme drought, followed by an exceptional wet season.

The nematodes *Rotylenchus reniformis* and *Meloidogyne sp.* which cause serious damage at Trinidad and Hawaii (Anon. 1970) were only found in Suriname in very small and unharmful numbers.

At a planting distance of 3 m between the rows and 2-2.5 m in the row yields of 15-80 tons per ha per year were obtained in Suriname, depending on the condition of the crop and the fruit-type. Yields of 38 kg per plant per year of the selection Waimanalo, with small fruits, were obtained in Suriname. The Surinam selections, which have large but tasteless fruits, have a production of about 50 kg per plant per year. To obtain large, sweet fruits, crossings are made between the Surinam and Solo selections. The results of this first experiment were very good.

INTRODUCTION

In Suriname papaja *(Carica papaja* L.) has been known for centuries. Large scale cultivation started in 1963 with an experimental garden of the Agricultural Experiment Station at Santo Boma. Various seeds were planted. In 1970 the selections studies started. By self-pollination of good starting plants 9 selections were finally created which seemed to be homogeneous even after two generations of inbredlines. Besides, 4 Solo and the Puna selections were imported from Hawaii; these are observed and compared with the Surinam selections. The intention was to observe the Surinam and foreign selections with regard to growth, fruit-bearing, production and fruit-quality. A number of trials were prematurely stopped because of the poor condition of the crop as a result of waterlogging. Of these trials no results are known.

The Surinam selections have large (1 kg), but tasteless fruits. The foreign Solo selections have small, sweet fruits. Because people in Suriname prefer large fruit, the reciprocal crossings were made from Solo's with some Surinam selections.

MATERIAL AND METHOD

The Surinam selections in the F_1 and F_2-generations were observed on different experimental fields at Ma Retraite with sandy and clay soils. Because of poor drainage, three of the trials on clay soils failed.

The two trials that were planted on the higher located soils produced significant results. The selections used in the trials were: Santo 2, 3, 4 and 7 and Boma 2 and 3 in the oldest (1972) plantation and the selections Santo 2, 3, 4, 6, 7 and 10 and Ma Retraite 2, 4, 6, 7, 8, 9, 10, 11, 12 and 13 in the plantation of June 1973. In the latter some Hawaiian selections Waimanalo, Kapoho Solo, Red Solo, Line 8 Solo and Puna were also introduced. In the trial at Jarikaba with heavy clay soil, three foreign Solo selections (Waimanalo, Red Solo and Line 8 Solo) were used with the selections Ma Retraite 13 and Santo 4. Also 12 reciprocal crossings (F_1-generation) between the foreign and Surinam selections were made.

At Jarikaba 8 Surinam and 1 foreign selections are also planted, namely Santo 7, Ma Retraite 13, La Poule, Victoria 6, Victoria 9, Kwattaweg, Weg naar Zee, Saramacca and respectively Puna (Peru). The waterlevel in this area was constant at a depth of 90 cm.

The experiment on the inland laterite soils had to be stopped prematurely because of growth stagnation in an early stage. The planting distance in both trials at Ma Retraite was 2,5x2,5 m. All later trials at Ma Retraite and elsewhere had a planting distance of 3,00 m between the rows and 2.20-2.50 m in the row with the possibility of mechanization.

For drainage a bed system has been used. The beds were approximately 6 m wide. All plants originated from hand-pollinated seeds of hermaphrodite plants. The self-pollinations were realized by wrapping up of the unopened, but full-grown hermaphrodite blossem. Afterwards self-pollination starts in this flower. The crossing-pollinations (F_1) took place as well as on a full-grown but not opened emasculated hermaphrodite flower. On this flower the pollen of a male flower originating from a hermaphrodite fatherplant was brought on the stigma. Afterwards the pollinated flower was wrapped up to prevent open pollination and pure male progenies, which never bear fruit. Also by vegetative propagation male progenies can be eliminated. This method gives too little planting material and seemed to have only 40-50% success. Propagation by seeds is more practicable. Already after 2 weeks germination begins and the percentage of success is high; about 90%. With the use of open-pollinated seeds the possibility of male progenies is high. The seeds stay in good condition for 2 to 3 years in a seed room (20^{o}C), though the rate of germination is reduced by 50 percent.

The difference of the fruitform of female and hermaphrodite plants occurs; fruits of female plants are round-roundoval; those of the hermophrodite plants ovalround-oblong. It is known that from the progenies of the following crossings no male plants are expected:

Crossings	Expected progenies
	♀ : ⚥
♀ x ⚥	1 : 1
⚥ x ⚥	1 : 2
⚥ x	1 : 2

The fertilization for all trials was about the same. At planting 5 g of Terracur (or 30 g of Nemacur) to prevent nematodes and 300 g of Renophosphate (or 300 g of Emkal) were placed in the planthole. If available 5 of farmyard manure was also used.

Afterwards 240 g NPK (13-13-21 or 15-15-15) was used for each plant in the first 6 months of the first year divided into 4 applications. Furthermore every other two months an application of 150 g of NPK (13-13-21) was used for each plant on sandy soil and 100 g of NPK (13-13-21) for each plant on clay soil. During the second year 1.2 kg of NPK (13-13-21) on the sandy soil and 0.8 kg on the clay soil was applied at 4 different times. In the third year the application was about 1.8 kg and respectively 1.0 kg. In two experiments at Ma Retraite (1972-1973) several groundwater level-pipes were placed to check the height of the groundwater level during the experiment.

RESULTS AND CONCLUSIONS

Production

In several experiments no difference during the early blossem stage was observed. About 5,5-6 months after sowing the Surinam and foreign (Waimanalo and Red Solo) selections were in bloom and production. The foreign selections Line 8 Solo and Kapoho Solo were a month later in bloom. The average percentage of hermaphrodites was about 68 which did not differ from the expectation (66,7%) at the crossing ⚥ x ⚥ . The plantations were started from hand-pollinated seeds. No male plants were observed. The height of the stem on which the first fruit was formed is also a selection criterion. The height of the first fruit seems to differ between selections. The selections Santo 3,4 and 7, Waimanalo, Red Solo produced fruit which was lower on the stem (90-100 cm). The Ma Retraite selections started to produce fruit that was more than 100 cm on the stem, while the Boma selections, Line 8 Solo and Kapoho Solo produced fruit at still a greater height. (table 1).

Table 1: Average height (cm) of the first production of a number of selections at different locations

	Ma Retraite		La Poule	Jarikaba
Selection	1972	1973	1976	1977
Santo 3	85	100	124	–
Santo 4	94	110	100	99
Santo 7	99	129	97	–
Ramaining Santo	115	124	–	–
Boma	135	118	–	–
Ma Retraite 8	–	129	–	–
Ma Retraite 13	–	121	–	102
Remaining Ma Retraite	–	138	–	–
Waimanalo	–	96	98	87
Line 8 Solo	–	137	133	141
Red Solo	–	103	98	80
Puna (Peru)	–	–	–	126

In order to obtain a yield impression, the number of fruits were counted monthly for one year. In table 2 and fig. 1 a synopsis is given of the average number of formed fruits per plant.

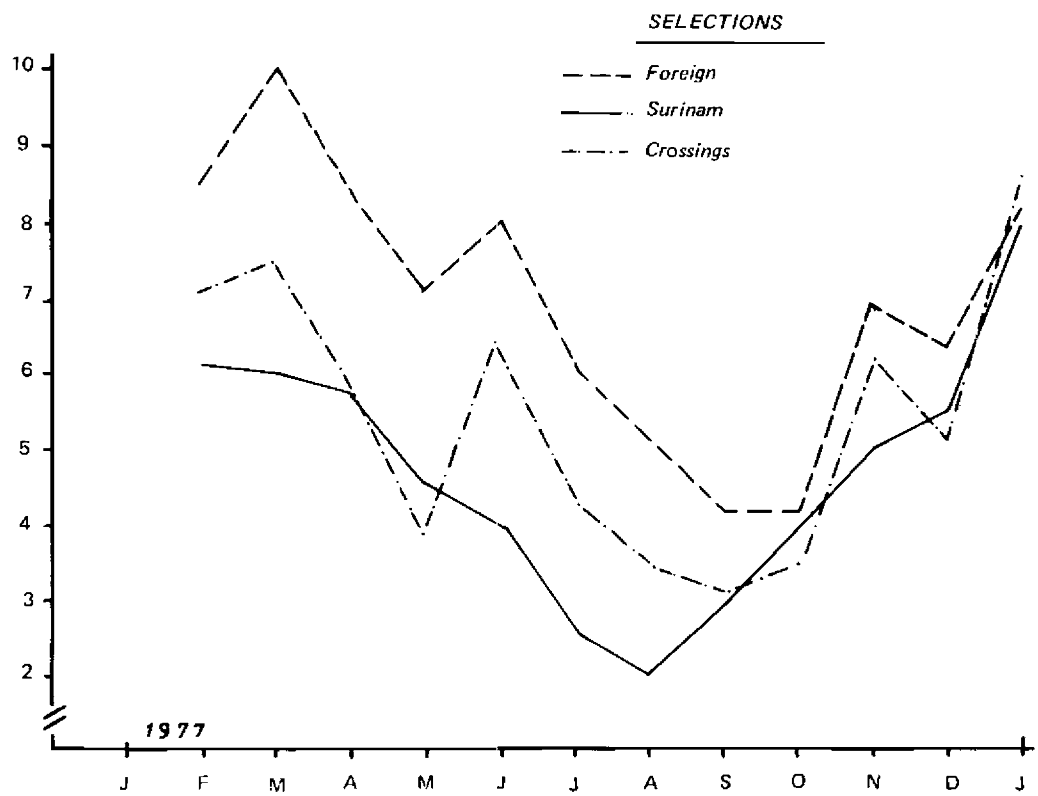


Fig. 1. Number of fruits formed per plant/month

Table 2: Number of formed fruits per plant during the first production per year for 4 different plantations

Selection	Ma Retraite 1972	Ma Retraite 1973	La Poule 1976	Jarikaba 1977
Santo 3	88	72	35	–
Santo 4	79	59	30	65
Santo 7	63	66	35	–
Remaining Santo	67	52	–	–
Boma	49	47	–	–
Ma Retraite 8	–	37	–	–
Ma Retraite 13	–	37	–	58
Remaining Ma Retraite	–	46	–	–
Waimanalo	–	46	41	72
Line 8 Solo	–	93	49	74
Red Solo	–	80	51	95
Puna (Peru)	–	–	–	28

When tested, the number of fruits formed per year did not differ with the Duncan Range Test for both the Santo and Boma selections. However, the number of fruits per year of the Santo selections was significantly higher ($p = 0.01$) than the Boma selections. It seems that the Boma selections 2 and 3 had many bare parts on the stem (without fruits) in comparison to the Santo 3, 4 and 7 which almost continually formed fruits. Santo 2 showed moderately bare parts on the stem.

The most yielding selections seemed to be Santo 3 and 4 with a production of about 100 kg per plant per year, followed by Santo 2 with 89 kg/plant/year. The rest of the selections produced 62-76 kg/plant/year. At the plantation with 1600 plants per ha (planting distance 2.5 x 2.5 m) the yield should have been from 99-174 tons/ha/year for the different selections. According to the calculation all plants are fully producing, but actually only 50% produced fully. The rest often fails because of poor drainage or strong winds. The actual yields is then about 30-80. tons/ha/year.

It is known, that papaya responds heavily-to-weather condition in relation to fruitbearing. If conditions are too dry or too wet, sterility appears (fig. 1). At both plantations of the Ma Retraite selections large barren parts were observed; this was due to sterility. On the selections Santo 3, 4 and 7 and Ma Retraite 8 and 13 and also on the foreign selections Waimanalo and Red Solo or less barren parts appeared. It seems that these selections are less sensitive to weather conditions. These good selections, observed at La Poule and Jarikaba, appeared sterilite after a monthly rainfall of more than 250 mm and less than 50 mm. Table 2 indicates that the number of formed fruits on the plantations suffering from waterlogging, as is the case at La Poule and Ma Retraite (1973), became month after month less productive compared to the well drained experimental fields (Jarikaba and Ma Retraite 1972).

The fruits could be harvested 5-6 months after fruitset. The little (Solo) selections ripened approximately 2 weeks before the big selections. The plantations at Ma Retraite were supervised by the Agro-Company "Ma Retraite". The fruits were harvested by the Company. Unfortunately no yield data are known. Some fruits were weighed per selection. Production was valued on fruitweight (g) per selection (table 3) and the number of formed fruits. The actual yields should amount to approximately 2/3 of the potential.

On the plantation of 1972 a potential yield of the good producing selections (Santo 3 and 4) was calculated to more than 100 tons/ha/year. However, real yield of the whole plantation amounted to approximately 70 tons/ha/year. That of the inferior plantation of1973 amounted to approximately 50 tons/ha/year. At La Poule and Jarikaba the number of harvested fruits of the plantations were counted and weighed, monthly. Through premature falling, too late harvesting, and probably robbery, the number of harvested fruits amounted to less than the number formed.

In table 3 the average fruitweight (g) is mentioned.

Table 3. Average fruitweight (g) per selection

Selection	Ma Retraite 1973	La Poule 1976	Jarikaba 1977
Santo 3	855	982	–
Santo 4	1099	1069	1062
Santo 7	930	612	–
Remaining Santo	1356	–	–
Boma	1583	–	–
Ma Retraite 8	1212	–	–
Ma Retraite 13	1279	–	1476
Remaining Ma Retraite	1276	–	–
Waimanalo	602	568	556
Line 8 Solo	425	350	377
Red Solo	300	359	401
Puna (Peru)	–	–	1638

The yields of La Poule and Jarikaba were 6 and 50 tons/ha/year respectively. The very low yields of La Poule were primarily caused by the poor condition of the crop due to waterlogging; many plants (40%) died.

The remaining plants had few leaves and bare parts on the stem. During the rainy season (January-July 1976) few or no flowers and fruits were formed. Secondly, 50% of the plantation consisted of foreign selections, which had a lower fruitweight (300-600 g) than the Surinam ones (1.0-1.5kg). Though the Solos produced a greater number of fruits than the Surinam ones, this number cannot compensate for the lower fruitweight. The average yields per plant per year amount to 50kg for the Surinam selections and 25kg for the Solos.

Consequently, the F_1-crossings at Jarikaba were made to yield big fruits with the Solo selection taste. The results of this first experiment were satisfactory. The production per plant of the reciprocal crossings seemed to be significantly higher ($p = 0.05$) than that of the foreign parent and exceeded in some cases even that of the Surinam one. This high yield with regard to the Solo selection was not initially caused by a great number of formed fruits (only Red Solo had a significant greater number ($p = 0.05$)), but greater fruitweight, which equaled or sometimes exceeded that of the Surinam parents. In table 4 a synopsis is given of the characteristics of the crossings.

Table 4. Average height (cm) of the first production, number of formed fruits per plant in the first production year, fruitweight (g) and production (kg) per plant

Crossings	height 1st prod. (cm)	Average number formed fruit/pl. (12 mth)	Average weight/ fruit (g)	Average prod./pl. kg (6 mth)
Wai-San	89	61	1223	41.8
San-Wai	95	76	817	15.4
Red-San	95	78	811	26.6
San-Red	87	72	995	39.1
Red-Vic	84	61	1130	31.9
Vic-Red	79	86	942	31.3
Wai-Vic	95	62	1499	43.4
Vic-Wai	101	52	1439	24.4

The crossings Wai-San, Wai-Vic and San-Red seem to produce the highest yield per plant: 41.8, 43.4 and 39.1 kg respectively.

Besides, they were also good in height (first production) and fruitbearing. All of these selections have yellow pulp. Of the two selections with red pulp, namely Vic-Red and Red-Vic, Vic-Red seem to have the best characteristics.

Fruit analysis

To determine the fruit quality, the fruits were analysed for sugar-content (^{o}Brix) and pH; the extradition was also determined.

Table 5. Average values of the quality analysis of 3 Solo selections and 2 Surinam ones and 10 reciprocal crossing

Selection	^{o}Brix	pH	extradition
foreign	13.4	5.1	68.8
surinam	11.7	5.2	79.0
crossings (F_1)	12.4	5.1	73.5

It appears that from both the organoleptic and chemical determinations (^{o} Brix) that Solo selections are sweeter than the Surinam ones. Also the crossings were found organoleptic sweeter, although this was not always found in the Brix value. Owing to the fact, that the foreign selections are much smaller than the Surinam ones, the surface is larger with regard to the content, through which the extradition is of course lower.

The consistency of the Solo selections seemed to have lesser quality than that of the Surinamese. The pulp became soft quickly as a result of damage and overripeness. The consistency of the crossings had been found intermediary. However, this finding has been established visually. The fruits can be stored for 6 days at room temperature (27^{o}C) without loss of quality, if they are harvested when the tip of the fruit initially changes colour.

As yellow pulp is dominant over red pulp, the colour of most of the crossings is yellow. Only the crossings Red Solo x Ma Retraite 13 and Red Solo x Victoria 9 (both have red pulp) have red-coloured fruits. These 2 crossings have, though not the best ones, good plant and fruit properties. These selections will be maintained in the collection.

Soil and manuring

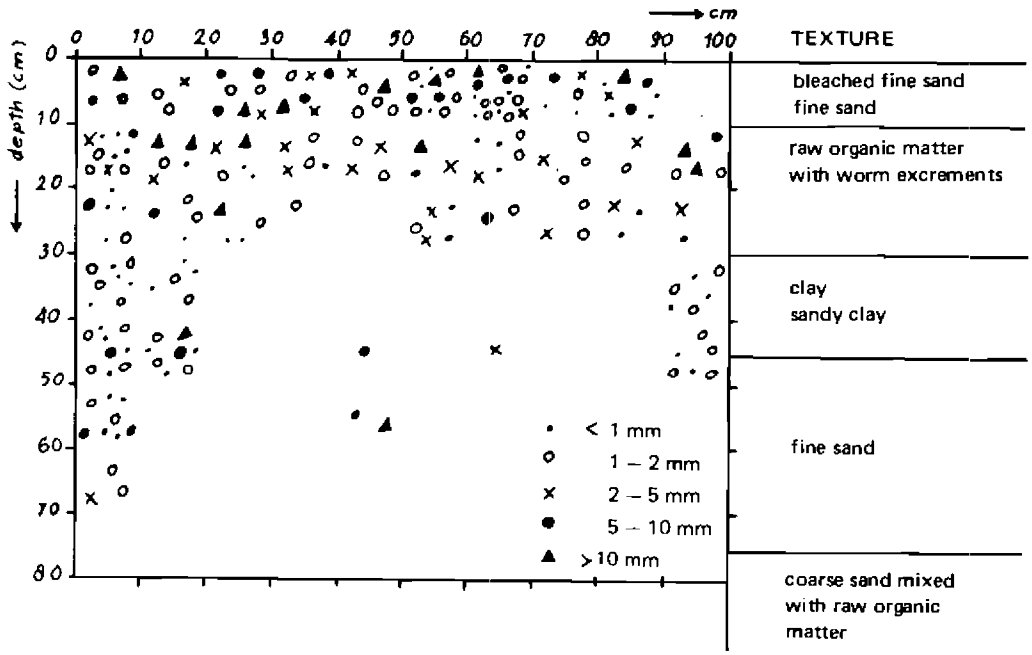


Fig. 2. Root profile of papaya (Ma Retraite)

Papaya is very sensitive to even a minimum of waterlogging. A study of root development (fig. 2) has been made by the Agricultural Experiment Station. When the soil is well drained, the roots grow to a depth of about 80 cm. However, most of the roots are in the upper 30 cm. In trials at Ma Retraite groundwater level-pipes were placed. On well drained sandy soils the water was 85-130 cm, while on the clay soils it was about 50 cm below the surface. Many plants died on the clay soils. To protect the soil, the beds have been planted with cover crop; except at Jarikaba where a grass cover existed. At Jarikaba half of the beds were planted with kudzu; the other half with mixed grasses. The plants on the kudzu-planted beds had a more vigorous appearance than those with grass, which resulted in differences in number of formed fruits, yield per plant etc. In table 6 the data are summarized.

Table 6. Influence of cover crop on papaya yield

	Kudzu	Grass
number of formed fruits/pl. (12 months)	79	61
number of harvested fruits/pl. (6 months)	37	22
height first production (cm)	94	95
average fruitweight (g)	1032	907
yield (kg)/plant	37.7	19.5

In relation to the growth and production differences, soil- and leaf samples were taken from the various beds. These were analysed for soil, chemical, and physical properties. In tables 7 and 8 the results are presented.

Table 7 Average N,P,K, Ca and Mg content (%) of leaf stalk and leaf from plants growing on kudzu and grass beds

	leaf stalk		leaf	
Content (%)	grass	kudzu	grass	kudzu
N	0.91	0.97	4.68	4.90
P	0.19	0.17	0.42	0.37
K	3.32	3.65	2.75	2.70
Ca	0.54	0.66	0.80	0.90
Mg	0.52	0.55	0.91	0.84

Table 8. Chemical soil data related to healthy and diseased plants

Analysis	healthy		diseased	
	0-25 cm	25-50 cm	0.25 cm	25-50 cm
pH H_2O	5.4	5.3	5.2	5.2
pH KC1	3.9	3.8	3.8	3.7
EC 2½ (mmho)	0.10	0.14	0.16	0.16
C (WB) %	2.30	0.94	1.85	0.94
N %	0.31	0.31	0.26	0.12
P-Truog (dpm)	45	10	16	12
available K_2O (dpm)	185	155	320	190
available CaO (dpm)	2090	1450	1780	1440
available MgO (dpm)	1890	1830	1630	1730
available SO_4 (dpm)	120	100	80	140

The soil samples were taken at a depth of 0-25 cm and 25-50 cm.

The fertilization for all trials was about the same. At planting 300 g of Renophosphate or 300 g of Emkal and 40 g of NPK (13-13-21 or 15-15-15) were placed in the plant hole. If available 5 kg of farmyard manure was also used. Afterwards 240 g of NPK (13-13-21 or 15-15-15) per plant was applied in the first year during the first 6 months.

Plant protection

– Pests

These hardly form a problem in Suriname. Once in a while damage from the white fly *(Aleurocanthus woghuni)*, which had been active on several plantations, occurred. However, the damage was limited; control did not seem necessary. Scales and mealy bugs were repeatedly found on the stem and fruits. Treatment with Gusathion (2,5 cc/1) resulted in good control. It is known, that the nematodes *Rotylenchulus reniformis* and *Meloidogyne* can do serious damage to papaya. Therefore soil and root samples are taken at regular time intervals in the experimental gardens. However, the number of nematodes, which has been found (10-20 per 100 g soil) was of no great concern.

– Diseases

In Suriname diseases form a serious threat for the majority of crops. Papaya plantings also suffer from several diseases. In a poor drained area *Phytophthora species* (footrot) paused many failures particularly with seedlings. At the same time, the so-called dieback disease appeared in december 1976 at the two remaining experimental gardens, Jarikaba and La Poule. The first symptoms were a bended growing point and light-green younger full-grown leaves. At a later stage rotting at the flower stalk and leaf basis made its appearance. Finally a bare stem remained which rotted from top to bottom. Up till now the cause of these diseases is not known. Physical and chemical analysis of soil samples, taken at diseased and healthy plants, do not show any difference in chemical fertility. Neither did the soil differ in physical properties around diseased and healthy plants. Infected plants were spread over the whole experimental area. About 20% tions was infected. It seemed, that the disease did not spread from plant to plant, and is consequently not caused by a pathogen, but probably has a pedological cause. Topping off the infected plants to about 50 cm above the ground level prevent further rotting.

Most of the topped plants again sprouted without dieback symptoms. Half a year after outbreak of the disease no new infected plants were seen.

The plantation at Jarikaba had been seriously infected by another disease (50%). Particularly on the grass-planted beds approximately 50% of the infected plants died. On the other hand the infected plants on the kudzu-planted beds recovered. In this case the disease spread from plant to plant. Only the foreign selections and some crossings and not the Surinam ones were infected. It is not exactly known, which pathogent caused the disease. Although in some cases the fungus *Corynospora cassiicola* is isolated from stalk and stem, it cannot be concluded that this was the St. Croix decline. The symptoms of this disease corresponded with those which were found at Jarikaba: crumpled yellow older leaves. At a later stage the leaves fell off and a tapering stem remained. Especially during the wet weather conditions fruitrot was confirmed on the ripened fruits. In most cases the fungi *Colletotrichum gloeosporioides* and *Phytophthora species* appeared as pathogen.

REFERENCES

Anon; 1970. Papayas in Hawaii Coop. ext. Serv. University of Hawaii circ. 436.

Barke, R.E. 1974. Papaw Dieback and Calcium Deficiency, Queensland Agricultural Journal; 100, (7) 316.

Bass, L.N. 1975. Seed Storage of *Carica papaya* L. Hort-Science: 10 (3), 232.

Bharath, S. 1969. Cultivation of Papaw in Trinidad and Tobago. Crop Bulletin, Ministery of Agriculture Land and Fisherries no. 15, 17 pp.

Colan-Covas, G. 1977. Effect of plant Population and Fertilization on Growth and Yield of Papaya *(Carica papaya* L.) Journ. of Agric. Univ. Puerto Rico: 61 (2), 152-160.

Jindal, K.K. & R.N. Singh 1976. Sex Determination in Vegetative Seedlings in *Carica papaya* by phenolic Tests. Scientia Horticult. Vol. 4 (1) : 33 – 39.

Krochmal, A 1974. Some Common Diseases of Papaya. Cuba 18, 19-31.

Nakasone, H.J. & M., Aragaki 1973. Tolerance of *Phytophthora* Fruit and Rootrot in *Carica papaya* L. Proceeding of the Tropical Region of the American Society for Horticultural Science 176, 176-185.

Norse, D. 1973. A stem and fruit Disease of Papaya in Barbados Caused by *Corynespora Cassiicola.* Plant Disease Reporter: 57 (5), 404-6.

Simmonds, J.H. 1965. Papaw Disease. Queensland Agricultural Journal 91 666-678.

GRASSLAND

A.R. Tjong A Hung
Agricultural Experiment Station, Paramaribo

Grassland research in Suriname started in the early 50's when an agronomist made an inventory of local grasses and studied their ecology and production levels. Introduction of grasses however started before research was initiated.

A collection of various imported grass species was established at the Agric. Exp. Station from where the better quality grasses were released to the farmers. One of these was *Digitaria decumbens* which was also distributed in the caribbean area and the tropical zone of the U.S.A. In the late 50's an unkonwn disease, called Pangola Stunt Virus (PSV), was described in Suriname. The PSV caused reduced production or even destruction of the *Digitaria decumbens.*

Expeditions were therefore organized to the land of origin to collect new cultivars of this very palatable and nutritive *Digitaria* grass. Some of these new collections and their hybrids were obtained and planted at our Exp. Station for observations on PSV infection. The "OAK" collection and lately the hybrid collection from the University of Florida, U.S.A., are still maintained and observed at regular intervals. Among these collections some cultivars have shown no signs of PSV over the years of observation while some have been diseased as off the first month of growth. A couple of these "resistant" cultivars were planted on a larger scale and are being observed under grazing conditions.

In the meantime other grasses as *Brachiaria decumbens, B. ruziziensis* and *B. species* USDA PI 299498, were introduced. These have found a welcome place in pasture land in Suriname and animal performance is satisfactory under proper management.

The annual yield is between 80-100 tons fresh material per ha with a cutting interval of 4-8 weeks. The yield in nutrients is however still inadequate to meet the animals daily requirements especially in protein and energy. Rice-byproducts in Suriname are a good source to meet these deficiences. However the availability is insufficient to meet local demand. Other possible sources are maize and sorghum. As already stated in previous papers, the better location to grow these crops is the well drained soil of the interior of Suriname where mechanization is possible. These soils are also known to be very poor in organic matter. Consequently, grassland with its high production in organic matter is being studied in order to find a proper grass/crop rotation system. This programm (zero grazing or grazed) contains a study for 1, 2 or even 3 crop yields. One of the main criteria for grassland in this respect is the regrowth of the grass after crop harvest. The establishment of pasture in Suriname is carried out through vegetative material which is frequently planted by hand and therefore very costly.

The grass/crop rotation study started last year and the first experience is that about six year stand of *Digitaria swasilandensis* showed an excellent, aggressive regrowth after a maize crop. *Brachiaria species* USDA PI 299 498 on the other hand demonstrated a longer regrowth period which demands weed control.

It is obvious that the growing of sub-soil level producingcrops will be a problem in a pasture of *D. swasilandensis* since the rootsystem of the grass in known to be very intense. The *Digitarias* are also low growing or creep-type grasses while *B. decumbens* and *B. ruziziensis* grow up to a height of 60-75 cm. Considerations should therefore be given in the proper grass/crop selection.

The production of a short-growing crop to increase the farmers income will be a welcome alternative to the livestock industry.

Symposium on maize and peanut, Paramaribo
Nov. 13 - 18, 1978

CURRENT STATUS OF BANANA PEST CONTROL RESEARCH IN JAMAICA

K. Ittyeipe,
Research and Development Department
Banana Board, Kingston Jamaica W.I.

SUMMARY

Plant parasitic nematodes, banana borer weevils and various peel-scarring pests together cause an estimated 40% reduction in the yield of bananas in Jamaica. Current research has shown that both nematodes and borers may be adequately controlled by using Mocap. Primicid and Nemacur may be used in the specific control of borers and nematodes respectively. Among the unregistered, candidate pesticides screened, Miral was found to be effective against both borers and nematodes whereas Tokuthion was found to be as effective as Primicid in the control of borers. Of the various pesticides screened in the laboratory, Primicid, Miral and Mocap were found to be more lethal to banana borers than other chemicals.

Of the peel-scarring pests, crickets, grasshoppers, trash worms, *Platynota,* caterpillars and slugs may be adequately controlled by sleeving. Locally manufactured, non-insecticidal sleeves were found to be satisfactory substitutes for the imported, insecticidal sleeves. Sleeving also improved bunch weight and fruit quality.

Though both Phosvel and Malathion reduced percentage of thrips damage, the use of the former is now considered unsafe while the latter is uneconomical. However the removal of up to two distal hands from two to three week-old bunches reduced the percentage of thrips-damaged fingers without significant reduction in bunch weight.

Slug baits were found to be more effective when placed in the 'throat' of 'shooting' plants than when placed on the ground.

Both laboratory and field investigations on eight cultivars have shown that Valery was the least preferred whereas the tetraploids T 3405-1 and T 168-12 were the more preferred as borer hosts. On the other hand, Valery suffered most damage from flower thrips while tetraploid cultivars suffered the least.

INTRODUCTION

The world market demand for high-quality, blemish-free bananas together with strict governmental restrictions on pesticide use has increased the importance of banana pest research. Plant parasitic nematodes, banana borer weevils and peel-scarring pests together reduce the marketable yield of bananas in Jamaica by about 40%. This paper summarizes the current pest control research work carried out by the Research and Development Department of the Banana Board in Jamaica.

CONTROL

Dual control of nematodes and borers

Radopholus similis Cobb and *Helicotylenchus spp.* are the major species of nematodes affecting bananas in Jamaica. Until recently they were being adequately controlled by D.B.C.P.

(= Nemagon, Shell) injection. However, Nemagon has been withdrawn from the market in 1977 as it has been found harmful to humans.

Since 1972 the insecticide kepone (= chlordecone, A.C.C.) has been used widely in Jamaica for the control of banana borer weevils (*Cosmopolites sordidus* Germar). This product also has been found hazardous to humans and due to adverse press reports and public concern its use is no longer recommended.

Consequently, priority was given to the search for chemicals that could replace both Nemagon and Kepone and a completely randomized block design experiment was carried out to see whether both the nematodes and the borers could be controlled by the use of a single chemical.

The compounds tested were: Furadan (= carbofuran, Shell), Mocap (= ethoprop, Mobil), Nemacur (= phenamiphos, Bayer) and Vydate (= oxamyl, DuPont). In addition, Kepone and Nemagon were included for comparison of efficiency. 50g of Furadan 5G, 30g of Miral 10G, 40g of Mocap 10G, 30g of Nemacur 10G and 30g of Vydate 10G were sprinkled around the mat in approximately 18" (46 cm) radius every 4 months. 40g of Kepone 5D were placed immediately around the corm every 9 months and 8 ml Nemagon 75 EC diluted to a 20% aqueous solution was injected around the mat every six months.

The pre and post-treatment borer population indices in the various treatments and control are given in table 1. The indices are the mean number of borers/trap caught during the pre and posttreatment trappings (Harris, 1947; Hord and Flippin, 1956). The percentage change in the post-treatment borer population indices in the various treatments from the pre-treatment and control means are also given in table 1.

The number of nematodes recovered from 100 5-root samples in each treatment and the observed change from the mean number of nematodes in the control and in the various treatments are given in table 2.

Results indicate that the mean number of borers trapped in plots treated with Furadan, Miral, Mocap, Kepone and Vydate were significantly lower than the pre-treatment means (table 1). A comparison of the various post-treatment means with the control means indicates that the borer populations were significantly reduced in plots treated with Furadan ($P < 0.05$) and Kepone ($P < 0.002$).

Expressing the population change as a percentage of the pre-treatment level, the greatest decrease was in treatment with Kepone (77.7%) closely followed by treatments with Mocap (68.4%) and Furadan (68.0%) (table 1).

Table 1. Change in borer population indices, expressed as mean number of borers/trap in the various treatments and control

Treatments	Pre-treatment borer population indices	Post-treatment borer population indices	% change in post-treatment population indices when compared to pre-treatment indices	Significance of the change in borer population indices	% change in population indices in various treatments when compared to the control	Significance of the change in treatments compared to control
Control	1.83	1.73	− 5.46	P > 0.10	–	–
Furadan	2.44	0.78	− 68.0	P < 0.01	− 54.9	P < 0.05
Kepone	2.06	0.46	− 77.7	P < 0.002	− 73.4	P < 0.002
Miral	2.39	0.82	− 65.7	P < 0.01	− 52.6	P < 0.10 P > 0.05
Mocap	2.56	0.81	− 68.4	P < 0.002	− 53.2	P < 0.05
Nemacur	1.78	1.04	− 41.6	P < 0.10	− 39.9	P > 0.10
Nemagon	1.83	1.84	+ 0.5	P > 0.10	+ 6.4	P > 0.10
Vydate	2.83	1.07	− 62.2	P < 0.01	− 38.2	P > 0.10

Table 2. Mean number of nematodes recovered from 100g roots and the observed change from control mean as a result of treatment

Sampling Occasion	Control	Furadan	Kepone	Miral	Nemacur	Mocap	Nemagon	Vydate
Pre-treatment	1050	1400	1933	333	233	400	433	1933
Post-treatment samples								
1	2500	100	766	66	833	500	833	233
2	1350	100	366	66	366	233	66	400
3	5100	666	866	133	–	233	933	1400
4	2000	3466	2133	33	166	–	666	4433
5	5000	1966	6266	1133	2666	3200	2666	3433
6	550	1233	2500	966	900	1700	900	433
7	4100	6166	3633	3033	–	3700	–	3400
Total	18600	13697	16530	5430	4931	9566	6064	13732
Post-treatment mean	2655	1957	2362	776	986	1594	1011	1962
Observed change from control	–	– 696	– 293	– 1879	– 1669	– 1061	– 1644	– 693

From the data presented (table 2) it can be seen that Miral, Mocap and Nomacur gave better nematode control than Nemagon. As a suitable alternative Miral would be best but it is still in its experimental stage and cannot be recommended. Nemacur is a suitable nematicidal alternative but because of its low insecticidal activity, Mocap is a more suitable nematicidal/ insecticidal treatment for both nematode and borer control.

Specific control of banana borers

In a completely randomized block design experiment, the efficiency of Belt (= chlordane, Velsicol), Heptachlor (= Hoptagran, Volsicol); Primicid (= pirimiphos — ethyl, I.C.I.), Surecide (= cyanofenphos, Sumitomo) and Tokuthion (Bayer) in controlling banana borer weevils were compared with that of Kepone. Rates of application were 40g each of Primicid 10G, Tokuthion 5G, Belt 50 and Kepone 50, 60g of Heptachlor 2.5D and 80g of Surecide 1.5D per mat placed immediately around the corm. Primicid 50 EC, at the rato of 2.5 litres/acre diluted with water to make 20 gallons (91 litres) was applied as a spray close to the base of the pseudostem to give 3 ml/mat.

The pre and post-treatment borer population indices for the various treatments and control are given in table 3. The indices are the mean number of borers/trap caught during the pre and post-treatment trappings. The percentage change of the post-treatment indices in the various treatments from the pre-treatment and control means are also given in table 3.

Results presented in table 3 indicate that there was a general decline in the post-treatment number of borers caught/trap in all the treatments including control, when compared to the pre-treatment numbers. This could be due to the effect of chemicals being leached into the control plots during periods of excessive rain. The post-treatment number of borers/trap was significantly less than the pre-treatment means in all except control, Chlordane and Surecide treatments. However, the decrease in numbers was highly significant in plots treated with Primicid (both 10G and 50 EC, $P < 0.001$ and $P < 0.002$ respectively) followed by treatments with Kepone ($P < 0.02$) and Tokuthion ($P < 0.05$ table 3).

Duncan's Multiple Range analysis of the post-treatment borer population indices indicated that control was most effective in Primicid (both 10G and 50 EC), and Tokuthion treatments, all three performing at a level not significantly different from Kepone. However, Tokuthion is not yet registered for use in bananas and therefore cannot be recommended.

Sensitivity of banana borers to various chemicals under laboratory conditions.

As there is no accurate means of assessing the borer population density in the field, the absolute effectiveness of a chemical in terms of percentage mortality cannot be measured. Hence a number of chemicals were screened in the laboratory for their efficiency in killing borers.

The chemicals tested included the technical materials of Basudin (=diazinon, Ciba — Geigy), Chlordane, Heptachlor, Lannate (=methomyl, DuPont), Lindane (=gammexane, Chevron), Miral, Mocap; Nemacur, Nemagon, Phosvel (=leptophos, Velsicol), Primicid and Thiodan (=endosulfan, Hoechst).

Table 3. Post-treatment banana borer population indices expressed as mean number of borers/trap in the various treatments and control compared to one another and with the pre-treatment means

Treatments	Pre-treatment borer population indices (Mean No. of borers per trap)	Post-treatment borer population indices (Mean No of borers per trap [1])	% change in post-treatment population indices	Significance of the change in borer population indices [2]
Control	1.39	0.96 ab [3]	– 30.9	$P > 0.10$
Chlordane	3.59	1.40 a	– 61.0	$P < 0.05$
Heptachlor	3.33	1.02 ab	– 69.4	$P < 0.05$
Kepone	3.05	0.71 bc	– 76.2	$P < 0.02$
Primicid 50 EC	4.89	0.45 c	– 90.8	$P < 0.002$
Primicid 10 G	3.00	0.26 c	– 91.3	$P < 0.001$
Surecide	1.55	1.07 ab	– 31.0	$P > 0.10$
Tokuthion	1.33	0.39 c	– 70.7	$P < 0.05$

[1] Means of monthly assessments

[2] $P > 0.10$ means difference not significant at 10% level
$P < 0.05$ means significance at 5% level
$P < 0.001$ means significance at 0.1% level

[3] Mean figures followed by the same letter are not significantly different at 5% level.

Duncan's Multiple Range Test.

Five percent solutions of each chemical were applied topically using a hand micro-applicator (Arnold, 1967) and a droplet (size 5) of the chemical solution was administered to each individual borer. The percentage mortality of borers in the various treatments was corrected, for control mortality by using Abbott's formula (Finney, 1947):

$$P = \frac{pi - c}{100 - c} \times 100$$

Where P = corrected percentage mortality
pi = observed mortality
c = control mortality

Results presented in table 4 indicate that Primicid, Miral and Mocap caused mortalities not significantly different from each other ($P > 0.10$) in each case) and were also more effective than all other chemicals tested. Heptachlor, Lannate and Lindane also caused mortalities equal to or higher than 50%.

Table 4. Comparison of percentage mortality caused by the topical application of 5% solutions of different insecticidal compounds on banana borer weevils

Insecticides	Corrected % mortality at 2 days	
Basudin	48.5	de[1]
Chlordane	36.0	c
Heptachlor	55.1	ef
Lannate	55.0	ef
Lindane	50.0	de
Miral	63.0	fg
Mocap	59.0	fg
Nemacur	38.5	c
Nemagon	2.0	a
Phosvel	43.5	cd
Primicid	65.0	g
Thiodan	14.0	b

[1] Figures followed by the same letter are not significantly different from each other at 5% level (Duncan's Multiple Range Test)

Table 5. Comparison of maturation period, bunch weight and peel scarring in 60 each of sleeved and unsleeved bunches

Treatments	Mean time to maturity (in days)	Mean bunch wt. (lb)	Percentage of fingers scarred by Leaves	Slugs	Grass-hoppers	Crickets	Rats	Total % of scarred fingers
Sleeved	120.5	37.23	1.532	1.445	0.557	0.035	0.156	3.725
Unsleeved (control)	128.2	33.25	3.576	4.514	3.131	0.190	0.756	12.167
Significance[1] of difference	$P > 0.10$	$P < 0.01$	$P < 0.01$	$P < 0.05$	$P < 0.001$	$P < 0.05$	$P < 0.05$	$P < 0.01$

[1] $P < 0.05$, $P < 0.01$ and $P < 0.001$ indicate significant difference between treatments at 5, 1 and 0.1% respectively.

Control of peel-scarring pests by sleeving

Based on a field trial carried out in Jamaica (Bond, 1974) and on reports from elsewhere (Berrill, 1956; Kuhne and Kritzinger, 1964; Cann, 1965; Perumal and Adam, 1968; Phillips 1971 and Turner and Rippon, 1973), the Research and Development Department of the Banana Board had recommended the use of 3% blue tinted, 1% dursban – impregnated 0.05 mm thick polyethylene sleeves for the improvement of bunch weight and fruit quality of bananas (Ostmark and Whyte, 1975).

The results of an experiment carried out to study the effect of bunch sleeving on improving the external appearance, bunch weight and maturation period of bananas are given in table 5.

It was found that when bunches were covered with blue, dursban-impregnated polyethylene sleeves, there was a significant increase in bunch weight ($P < 0.01$) and less peel-scarring by insects (crickets, grasshoppers, trashworms and *Platynota)* ($P < 0.001$); slugs ($P < 0.01$); rats ($P < 0.05$); and leaf rubbing ($P < 0.01$) than when unsleeved. However the decrease in maturation period of the sleeved bunches was not significant.

The results of another experiment carried out to compare the efficiency of locally manufactured, non-insecticidal bunch sleeves with the imported, dursban-impregnated ones, is given in table 6.

It was found that the local sleeves were satisfactory substitutes, except that more of them split under field conditions. Although the insecticidal sleeves offered better protection from peel scarring pests than the non-insecticidal ones ($P < 0.001$ for percentage scarring), there was no significant difference between them in mean bunch weight, mean time to maturity and percentage of fingers scorched by sun. The thicker sleeves reduced the incidence of leaf scarring ($P < 0.001$) and when untinted they also increased the bunch weight significantly ($P < 0.001$).

Control of banana flower thrips

Flower thrips *(Frankliniella parvula Hood)* enters the inflorescence just before it emerges or possibly even before and damages the peel of the young fruit by oviposition.

The comparative efficiency of single applications of 0.15% Malathion (=carbophos, American Cyanamid), Phosvel and Sevin (carbaryl, Union Carbide) to the 'throat' of banana plants at flowering was evaluated. Results presented in table 7 indicate that treatments with both Phosvel and Malathion reduced thrips damage significantly, Phosvel being more effective than

Table 6. The effect of covering bunches with six different types of sleeves compared with unsleeved bunches

Parameters Measured	Unsleeved control	Imported insecticidal		Locally manufactured, non insecticidal			
		0.05 mm blue	0.05 mm untinted	0.05 mm blue	0.05 mm untinted	0.075 mm blue	0.075 mm untinted
Mean bunch weight (in lb)	31.9	40.3	40.4	37.2	39.5	38.6	44.6
Maturation period (in days)	95.6	92.3	97.3	97.9	92.4	93.0	94.9
% of fingers scarred by insects	18.63	2.70	2.03	4.27	5.03	3.63	4.07
% of fingers scarred by leaf rubbing	1.27	0.77	0.57	0.73	0.87	0.39	0.33
% of fingers sporched	0.13	0.19	0.00	0.00	0.07	0.00	0.00
% of sleeves split	Not Applicable	1.87	0.97	12.50	27.45	11.83	25.04

Table 7. Percentage of fingers scarred by thrips in the three treatments, control and in the pre-treatment sample

Parameters measured	Pre-treatment[1]	Control	Treatments per 60 plants		
			Malathion	Phosvel	Sevin
Total no. of fingers	3,234	7,140	6,886	6,465	6,389
No. of fingers scarred by thrips	346	684	559	341	565
% of fingers scarred	10.41	9.58	8.12	5.36	8.90
Significance[2] of difference between control and other treatments	$P > 0.10$	–	$P < 0.05$	$P < 0.001$	$P > 0.10$

[1]Pre-treatment assessment was done on 30 plants only

[2]$P < 0.05$ and $P < 0.01$ indicate significant difference at 5 and 1% respectively

Malathion. However, the use of Phosvel has since then been suspended in Jamaica by health authorities and treatment with Malathion was not economical. Sevin was found to be ineffective against thrips.

However, the result of another experiment given in table 8 shows that the removal of up to two distal hands from two to three week-old bunches reduced the percentage of thrips damaged fingers without significant reduction in bunch weight. This is because thrips damage is more prevalent in the distal hands of the bunch. This operation also resulted in an increase of mean length and girth of fingers.

Table 8. Effect of removing distal hands of bunches after emergence of the last hand, on bunch weight finger length and girth and thrips scarring

No of hands on bunch at emergence	No. of hands removed	Mean bunch weight (in lb)	Mean finger length (in inches)	Mean caliper girth 1 inch = 32 units	% of fingers scarred by thrips
	0	28.5	7.4	35	14.1
	1	27.8	7.6	37	11.5
6	2	26.2	7.9	38	10.2
	3	22.4	8.1	40	12.4
	0	33.4	7.5	37	12.3
	1	34.3	7.6	39	8.4
7	2	32.8	7.9	41	8.7
	3	29.2	8.3	43	2.6
	0	39.9	7.8	38	17.1
	1	38.5	8.1	41	11.5
8	2	35.8	8.2	42	14.7
	3	30.1	8.3	44	11.2
	0	46.4	7.8	40	20.2
	1	47.3	8.0	44	14.7
9	2	43.6	8.3	43	12.6
	3	39.5	8.5	45	10.3
	0	51.3	8.0	40	18.9
	1	50.1	8.3	42	15.8
10	2	50.6	8.6	44	13.8
	3	42.2	8.9	46	8.0
	0	57.8	8.1	44	22.8
	1	56.1	8.5	45	14.1
11	2	55.3	8.9	47	16.3
	3	46.7	9.3	48	6.5

Table 9. Percentage of fingers scarred by slugs in the various molluscicidal treatments and control

Parameters measured		Treatments per 30 plants			
	Metaldehyde-coir dust bait at base	Metaldehyde – coir dust bait in 'throat'	Mesurol at base	Mesurol in 'throat'	Control
Total no. of fingers on bunches	2,537	2,699	2,586	3,056	2,844
No. of fingers scarred by slugs	739	189	853	303	910
Percentage of slug scarring	29.13	7.00	32.98	9.91	31.99
Significance[1] of difference from Control	$P > 0.10$	$P < 0.001$	$P > 0.10$	$P < 0.001$	–

[1] $P < 0.001$ indicates significant difference at 0.1%
$P > 0.10$ is not significant

Control of slugs

Two species of slugs – *Vaginulus* sp. and *Veronicella* sp. damage bananas by feeding on the pool. The traditional metaldehyde bait placed around the pseudostem base does not satisfactority control slugs unless applied repeatedly and over the entire field.

The efficiency of 5% metaldehyde – coir dust mixture and 4% methiocarb (mesurol, Bayer) pellets in the control of slugs when placed in the 'throat of plants with newly emerged bunches was compared with that of same baits placed around the pseudostem base.

Results presented in table 9 show that both 'throat' treatments were significantly more effective than the ground treatments ($P < 0.001$ in both cases). Metaldehyde bait en the 'throat' was found to be more effective and economical than the other treatments and therefore may be recommended.

CONCLUSION

The decline of the Banana Industry in Jamaica has been attributed to a number of causes of which drought, labour shortage and poor management are the ones often mentioned. These are no doubt legitimate contributory factors but the low yield in Jamaica (3.5 tonnes per acre) is in a large messure due to lack of proper pest management efforts. Pests pose a serious problem to banana production in Jamaica. The problem will continue unless the growers take a more active part in pest management. Efforts will continue towards finding safer and more economical methods of pest control in bananas.

REFERENCES

Arnold, A.J. 1967. Arnold Hand-operated applicator. Lab. Practice 16 (1): 56-57

Berrill, F.W. 1956. Bunch covers for bananas. Qd. Agric. J. 82: 435-440

Bond, W.B. 1974. Bunch sleeving trial. Ann. Rep. Banana Board, Jamaica 53-62.

Cann, H.J. 1965. Banana growing plantation practices. Agric. Gaz. N.S.W. 76: 672-678

Finney, D.J. 1947. Probit analysis. A statistical treatment of sigmoid response curves. Cambridge Univ. Press 389 pp.

Harris, W.V. 1947. The banana borer. E. Afr. Agric. J. 13: 15-18

Hord, H.H.V. and Flippin, R.S. 1956. Studies of banana weevils in Honduras. J. Econ. Ent. 493: 296-300.

Kuhne, F.A. and Kritzinger, H. 1964. Polyehtylene sleeves for banana bunches. Farming S. Afr. 40: 37-52

Ostmark, H.E. and Whyte, E.B. 1975. Banana peel-scarring pests. Bulletin No. 8, Research Dept., Banana Board, Jamaica.

Perumal, A. and Adam, A.V. 1968. Bagging of Giant Cavendish banana stems in Honduras. Trop. Agric. (Trin.) 45: 109-112

Phillips, C.A. 1971. The effect of polyethylene bunch cover on growth and quality of Robusta bananas. Proc. 2nd. Ann. Conf. ACORBAT, 80-88.

Turner, D.W. and Rippon, L.E. 1973. Effect of bunch covers on fruit growth and maturity in bananas. Trop. Agric. (Trin.) 50: 235-240.

NAME OF PAPER: Current status of Banana pest control research in Jamaica.
(K. Ittyeipe)

Questions by: R. Segeren-v.d. Oever
Country: Suriname

QUESTIONS:

1. Can you give us some more information on the chemical product Miral?

2. Did you ever observe Mocap is more easily leached than other nematicides? Of course this depends on soil type too.

ANSWERS:

1. Miral is an Organo phosphate insecticide/nematicide from CIBA-GEIGY. It is experimentally used in many crops including bananas. It is very effective against soil insects and nematodes. Please refer to Thompson (1977), Agricultural chemicals, Volume III on insecticides — a CIBA-GEIGY product manual for details of LD_{50}, formula — uses precautions.

2. Mocap is less soluble than Vydate but is more soluble than Nemacur. Mocap appears to move vertically in soil than horizontally, exept where there is soil wash and erosian as on hill slopes. The vertical movement maybe greater in Sandy Soil. Usual vertical movement is not more than 10 inches (25 cm in loamy soil.

Reprinted from:
Proc. Caribb. Food Crops Soc., 15:370-374. 1978.

LIST OF INSECT PESTS OF CULTIVATED PLANTS IN FRENCH GUYANA

M. Remillet

The author gives a survey of the main insect pests of cultivated plants in French Guyana. Fifty six species are counted. These insects were collected during a succession of observations carried out from March 1976 till March 1978.

It is the first time that such a study is done in this country.

We are very grateful to the Landbouwproefstation of Paramaribo which has helped us for our determinations and, in particular, we thank here Dr.J.B.M. Van Dinther and Mr.P.Segeren.

For each species we have mentioned the attacked plant, the place of the damages, the period of the attacks and the extent of these damages.

Liste des ravageurs des cultures de la Guyane Française

Nous présentons, sous forme de tableaux, les principaux ravageurs des cultures guyanaises, mis en évidence à ce jour. Cinquante six espèces ont été recensées. Les insectes ont été recueillis au cours d'une série d'observations réalisées de Mars 1976 à Mars 1978.

Un tel inventaire est le premier du genre pour la Guyana Française.

Cette étude est redevable, dans une large mesure, de l'aide prodiguée par la Station de Recherches Agronomiques de Paramaribo, et plus particulièrement par le Dr. J.B.M. van Dinther et par Mr. P. Segeren que nous tenons à remercier vivement.

Pour chaque espèce nous indiquons la plante attaquée, la localisation des dégâts, l'importance de ces dégâts, symbolisée pas des croix, et enfin la période où se situi le plus haut niveau de dégâts.

Questions by: Errol B. Whyte
Country: Barbados

QUESTIONS:

1a. Of the three pest category a. borers; b. nemacur; c. peel scarring Pests, which is the most important?

b. If nematode is, which chemical would you recommended.

2. Regarding table 6 – Is the average banana wt – marketable bunch wt – or is it gross wt?

ANSWERS:

1. Nematodes are the most important pests of
   a. bananas in Jamaica –
   b. Nemacur (phenaniphos)

2. Gross weight of fruits that is weight of hands above (excluding stalk weight and weight of false hands.

Questions by: De Gras
Country: Guadeloupe

QUESTION: What about biological control research in Banana crop in Jamaica?

ANSWER: There where 4 separate attempts to control bananas borer weevil *(Cosmopolites sordidus)* using *Pleasius javamus* from Fiji, in the 40th and early fifties. However these where of no consequence, though the predatory beetles were estabished in Jamaica. Their histerid beetles are still present in Jamaica but they do not offer any measure of control. Plans are being made to import a large number of *Plesisius javanus* from Fiji and try again.
It is thought that the small samples (less than 50) brought in earlier did not include the total gene-pool of the species.

: COLEOPTERA

INSECT	FAMILY	PLANT	PERIOD	PLACE	DAMAGE
Acalymma bivittata H.	*Chrysomelidae*	*Cucurbitaceae*	III, IV	Leaves	+
Carpophilus mutilatus Er.	*Nitidulidae*	Guava	Permanent	Fruits	+
		Maize	VII, VIII,	Ears	+
			VII, VIII,	Flowers	+
Cerotoma variegata F.	*Chrysomelidae*	Beans	VI, VII, VIII,	Flowers	++
			Permanent	Leaves	++
Colaspis glabrata Oliv.	*Chrysomelidae*	Cassava	Permanent	Leaves	++
Cosmopolites sordidus Germ.	*Curculionidae*	Banana	IV, V,	Corms	++
Diabrotica sinuata Oliv.	*Chrysomelidae*	Cowpea	Parmanent	Flowers	+
		Maize	III,	Flowers	++
		Rice	Permanent	Flowers	+++
		Soya-bean	III,	Leaves	+++
Ligyrus spp.	*Scarabaeidae*	Taros		Tubers	+
Metamasius hemipterus L.	*Curculionidae*	Banana	VII, VIII, IX, X	Corms	++
Omothyphus morosus Clark	*Chrysomelidae*	Taros	VI,	Tubers	++
Oryaephilus surinamensis L.	*Cucujidae*	Stored products	Permanent		++
Pachymerus nucleorum F.	*Bruchidae*	Coconut	Permanent	Seeds	+
		Palm	Permanent	Seeds	++
Rhynchophorus palmarum L.	*Curculionidae*	Coconut	Permanent		++
Strategus aloeus L.	*Scarabaeidae*	Coconut	Permanent	Trunks	+
Systene s-littera L.	*Chrysomelidae*	*Solanaceae*	III,	Leaves	++
Trechyderes succinctus L.	*Cerambycidae*	Beans	I,	Husks	++
Tribolium spp.	*Tenebrionidae*	Stored products	Permanent		++

LEPIDOPTERA

INSECT	FAMILY	PLANT	PERIOD	PLACE	DAMAGE
Agraulis vanillae L.	*Heliconiidae*	*Passifloraceae*	Permanent	Leaves	+
Brassolis sophorae L.	*Brassolidae*	Coco-nut	Permanent	Leaves	+++
		Palm	Permanent	Leaves	++
Castnia dedalus Cr.	*Castniidae*	Coconut	Permanent	Trunks	++
		Palm	Permanent	Trunks	++
Castnia licus Drury	*Castniidae*	Banana	Permanent	Trunks	+
		Sugar-cane	Permanent	Stems	+
Diaphania hyalinata L.	*Pyralidae*	*Cucurbitaceae*	Permanent	Fruits	++
				Leaves	+
Diatraea saccharalis F.	*Pyralidae*	Rice	Permanent	Stems	++
		Sugar-cane	Permanent	Stems	+++
Erinnys alope Drury	*Sphingidae*	Papaw	Permanent	Leaves	+
Erinnyis ello L.	*Sphingidae*	Cassava	I,	Leaves	+
Hedylepta indicata F.	*Pyralidae*	Beans	I,	Leaves	+
		Soya-Bean	I,	Leaves	+
Mocis latipes Guen.	*Nectuidae*	Herbage	Permanent	Leaves	++
		Rice	Permanent	Leeves	+
Othreis materna L.	*Noctuidae*	Citrus	IX,	Fruits	+
Papilio anchisiades Esp.	*Papilionidae*	Citrus	Permanent	Leaves	+
Papilio andregeus Cr.	*Papilienidae*	Citrus	Permanent	Leaves	+
Phoenicoprocta spp.	*Amatidae*	Cassava	I, II,	Leaves	+
Protoparce spp.	*Sphingidae*	Tomatoes	Permanent	Leaves	+
Pseudoplusia oo Cr.	*Noctuidae*	Tomatoes	VI,	Fruits	+
				Leaves	+
Spodoptera frugiperda J.E. Smith	*Noctuidae*	Herbage	Permanent	Leaves	++++
		Maize	Permanent	Ears	+
				Leaves	++
		Rice	Permanent	Leaves	+++
Utetheisa orna Krix L.	*Arctiidae*	*Crotalaria spp.*	Permanent	Husks	+

List of insect pests of cultivated plants in French Guyana

HOMOPTERA

INSECT	FAMILY	PLANT	PERIOD	PLACE	DAMAGE
Aeneolamia flavilatera Urich	*Cercopidae*	Sugar-cane	II,	Leaves	+
Aphis gossypii Glov.	*Aphididae*	Citrus	Permanent	Leaves	+
Coccus spp.	*Coccidae*	Citrus	Permanent	Branches	+
Icerya spp.	*Margarodidae*	Pigeon Pea	Permanent	Stems	++
		Citrus	Permanent	Branches	++
				Twigs	++
				Leaves	++
Lepidosaphes spp.	*Diaspididae*	Citrus	Permanent	Branches	++
				Leaves	+++
				Fruits	++
Peregrinus maidis Ashm.	*Delphacidae*	Maize	VII,	Leaves	+
Pseudaulacaspis sp.	*Diaspididae*	Papaw	II,	Leaves	++
				Fruits	+
		Pimento	II,	Stems	+
Saccharicoccus sacchari Ckll.	*Pseudococcidae*	Sugar-cane	Permanent	Stems	++
Saissetia spp.	*Coccidae*	Citrus	Permanent	Branches	+
Toxoptera aurantii Fonsc.	*Aphididae*	Citrus	Permanent	Flowers	++
				Leaves	++
Toxoptera citricida Kirk.	*Aphididae*	Citrus	Permanent	Flowers	++
				Leaves	+++
				Shoots	++

DIPTERA

INSECT	FAMILY	PLANT	PERIOD	PLACE	DAMAGE
Anastrepha spp.	*Trypetidae*	Guava	Permanent	Fruits	++
latrophobia brasiliensis Rubs.	*Cecidomyidae*	Cassava	Permanent	Leaves	+
Liriomyza spp.	*Agromyzidae*	Salads	Permanent	Leaves	+
		Cucurbitaceae	Permanent	Leaves	+
Lonchaea sp.	*Lonchaeidae*	Cassava	Permanent	Shoots	+

HETEROPTERA

INSECT	FAMILY	PLANT	PERIOD	PLACE	DAMAGE
Holymenia histrio F.	*Coreidae*	*Passifloraceae*	Permanent	Fruits	+
Mormidea spp.	*Pentatomidae*	Rice	Permanent	Seeds	++
Oebalus poecilus Dall.	*Pentatomidae*	Rice	Permanent	Seeds	+

HYMENOPTERA

INSECT	FAMILY	PLANT	PERIOD	PLACE	DAMAGE
Atta spp.	*Formicidae*	Citrus	Permanent	Leaves	+
		Rice	Permanent	Leaves	+
		Sugar-cane	Permanent	Leaves	+
Trigona spp.	*Apidae*	Beans	I, II, III,	Husks	++
			I, II, III,	Flowers	+
		Citrus	Permanent	Flowers	+
				Leaves	++

MATURE PLANT RESISTANCE OF COWPEA LINES TO COWPEA SEVERE MOSAIC VIRUS IN SURINAME

Ferdinand E. Klas
Agricultural Experiment Station, Paramaribo

SUMMARY

Local and imported cowpea lines have been tested for their susceptibilities to the cowpea severe mosaic virus (CSMV). Only 12 lines, obtained from the IITA in Ibadan (Nigeria), showed resistance to the virus. On the other hand some of the lines, which were resistant to the nigerian cowpea yellow mosaic virus (CYMV), revealed susceptibility to isolates of the surinamese cowpea severe mosaic virus; in various extents, however.

In order to find a way to let the crop escape infection, mature plant resistance experiments were carried out. These experiments showed that in the greater part of the susceptible lines mature plant resistance started at the age of 28 to 35 days.

INTRODUCTION

Cowpeas *(Vigna unguiculata* (L.) Walp.) are grown throughout the tropics and subtropics and are the most ancient vegetables of human food. In India cowpeas were known already in Sanskritic times and the old Romans grew it under the name *'Phaseolus'*. Nowadays they provide food for millions of people in India, Africa and the West — Indies.

In Suriname only four varieties of *Vigna sinensis* were known at the beginning of this century: capucijner, djaripesie, botropesie and black eye-pesie (Ter Horst, 1961). To improve and expand this small collection and to substitute the red kidney bean, experiments were conducted with local and imported lines. The first import took place in 1912 from the United States of America (Ter Horst, 1961).

At present cowpea lines are obtained from the IITA (International Institute for Tropical Agriculture) in Ibadan (Nigeria). They are to be tested for their growth, production and susceptibility to virus diseases under surinamese conditions.

In this paper attention was focused on screening of the different lines for their susceptibility to the cowpea severe mosaic virus (CSMV) and on mature plant resistance tests.

The objective the last-mentioned tests was to find a way for the susceptible lines (with good qualities to production, growth etc.) to escape CSMV-infection.

MATERIALS AND METHODS

The Cowpea *(Vigna unguiculata* (L.) Walp.) lines, TVu 3629, TVu 4557, TVu 1502, TVu 157, TVu 1267, TVu 1190-E, TVu 1977, TVu 2616 P, TVu 1987, TVu 201, TVx 1836 P, TVx 1836, TVx 30, TVx 2112, TVx 1630, TVx 876, VITA 4 and TVx 66-2 H have been used in the experiments. TVu 1267, a selection of the Agricultural Experiment Station in Paramaribo, served as a control.

Symposium on maize and peanut,
Paramaribo Nov. 13 - 18, 1978

The cowpea severe mosaic virus isolate was obtained from severily infected *Vigna sinensis* Cv. 'Sesquipedalis' plants which showed green blisters on the leaves, leaf malformation and reduction of leaf size.

From each line 80 plants were sown. Subsequently the carborundum-dusted primary leaves of each 10 plants of each line were inoculated at the ages of 3, 7, 14, 21, 28, 35, 42 and 56 days, respectively. Since at the ages of 42 and 56 days the primary leaves were mostly dropped already, trifoliate leaves were inoculated at these ages.

4 to 6 days after the inoculations the first reactions of the different lines were recorded. Three weeks later a second series of readings were made to make sure that the number symptoms did not vary any longer.

RESULTS AND DISCUSSION

All of the tested lines mentioned in the previous section have shown to be susceptible to the CSMV isolate. The most susceptible one was TVu 1977, from which the infected plants

Table 1. Susceptibility and mature plant resistance of cowpea lines.

Cowpea lines	Susceptibility to CSMV			Mature plant resistance							
	Reaction to CSMV incoluation	Sequence of symptoms		Age of plants (in days)							
		prim. leaves	trif. leaves	3	7	14	21	28	35	42	56
				Numbers of infected plants							
TVu 3629	HS	l (chl)	vy→mo→lm	8	3	5	3	1	0	0	0
TVu 4557	S	l (chl)	vy→mo→lm	7	–	8	5	4	0	0	0
TVu 1502	S	l (chl)	vy→mo→lm	6	9	8	8	3	6	2	0
TVu 157	S	l (chl)	vy→mo→lm	3	9	7	7	6	2	0	0
TVu 1267	S	l (chl)	vy→tn+lm	2	8	8	5	4	1	0	0
TVu 1190E	S	l (chl)	vy→mo	10	7	6	5	7	3	1	0
TVu 1977	HS	l (chl)	vy→mo→tn	10	3	2	3	2	1	1	0
TVu 2616P	S	l (chl)	vy+mo→lm	10	3	10	5	7	0	1	0
TVu 201	S	l (chl)	vy+mo→lm	10	7	3	8	0	5	2	0
TVu 1987	S	l (chl)	vv→mo→lm	10	10	3	2	10	2	0	0
TVx 1836	S	l (chl)	vy→byf	2	4	8	4	3	1	3	0
TVx 1836P	S	l (chl)	vy→mo	10	9	2	3	4	4	1	0
TVx 30	S	l (chl)	vy→mo+lm	10	1	5	4	1	0	1	0
TVx 2112	S	l (chl)	vy→mo+lm	10	5	7	3	4	1	1	0
TVx 1630	S	l (chl)	vy→lm	10	4	10	10	10	2	1	0
TVx 876	S	l (chl)	vy→mo+lm	9	–	6	5	3	1	1	0
VITA-4	HS	l (chl)	mm→ld+tn	10	10	10	10	9	8	6	0
TVx-66-2H	S	l (chl)	vy→mo→lm	10	10	5	10	10	4	0	0

S: Susceptible
HS: Highly Susceptible

l (chl) : local chlorotic lesions
vy : vein yellowing
mo : mosaic
mm : mild mottling
byf : bright yellow flecks
lm : leaf malformation
ld : leaf drop
tn : top necrosis

showed severe mosaic, dwarfing, malformed leaves and top necrosis. However, when virus was introduced in 7-days old plants and older the amount of infected plants reduced drastically; as is to be seen in table 1.

Line TVu 3629 was also highly susceptible; top necrosis, was absent, however. With all of the lines symptom expression started with local lesions on the primary leaves, followed by a systemic vein yellowing, which most frequently turned into mosaic and sometimes into leaf malformation (TVu 1630), top necrosis (TVu 1267) or bright yellow flecks (TVx 1836).

From table 1 it can be concluded that the amount of infected plants is decreasing the older the plants were when inoculated. Although each line has to be viewed separately for the occurrence of mature plant resistance, there exist a general tendency that with most of the lines the resistance started at the age of 28 to 35 days.

The term of mature plant resistance was first used by Bercks (1951, 1952), when studied this phenomenon in detail for potato virus x.

Since it is known now to what extent mature plant resistance occurs in the cowpea lines mentioned in this paper, advantage can be taken of it to protect the crop from infection with this virus.

From the experiments of Van Hoof (1962) it became clear that the virus can be transmitted by the beetles *Cerotoma variegata* F., *Diabrotica sp.* (probably *laeta* F.) and *Diphaulaca sp.* (probably *meridae* Barber). It is no use to spray against these beetles since they do not transmit the virus circulatively. Covering the crop with gauze for the first 35 days would be better. By doing so infestation and, as a consequence, infection is prevented.

However, cross pollination by insects will be prevented too. Fortunately we are dealing here with a self-pollinating crop. What the yield and the quality will be, still needs investigation.

Another solution of the problem would be breeding or selection of resistant lines. In the course of the experiments 12 lines have been found resistant to the virus: TVu 4554, TVu 2480, TVu 3901, TVu 3900, TVu 113, TVu 408-2, TVu 410, TVu 274, TVu 1948, TVu 612, TVu 2331, TVu 6666. They will open new perspectives for the future.

REFERENCES

Bercks, R., 1951. Weitere Untersuchungen zur Frage der Altersresistenz der Kartoffelpflanzen gegen das X-Virus. Phytopath. Z. 18: 248-269.

Bercks, R., 1952. Fortgeführte Freilanduntersuchungen über die Altersresistenz von zwei Kartoffelsorten gegen das X-Virus. Züchter 22:85-92.

Ter Horst, K. 1961. De selectie van peulvruchten in Suriname. De Surinaamse Landbouw 10(1): 19-26.

Van Hoof, H.A., 1962. De overbrenging van het 'Cowpea mosaic virus' in Suriname. De Surinaamse Landbouw 11: 131-137.

THE ROOT-KNOT NEMATODE PROBLEM OF RICE

R. Segeren-van den Oever
Agricultural Experiment Station
Paramaribo

Root-knot nematodes have been observed in rice in Suriname for the first time in 1964. In 1972 it became a problem in parts of the rice growing area Nickerie.

Rice is grown on the heavy clay soils of the coastal plains of Suriname. Land is empoldered continuously although irrigation-water becomes a limiting factor. Because of that the nematode problem will probably grow worse as this nematode becomes most severe at places in the rice fields which are just saturated or with only a shallow waterlayer.

When fields are not leveled sufficiently at tillage, nematodes reach harmful densities at the higher spots within the fields. Usually many galls are formed in the root system. Affected plants become stunted and tillering is reduced.

Many insecticides and herbicides are applied during the growing season with drainage of the field sometimes. These practices with possible side-effects of fytotoxicity and the availability of other pests with similar symptoms, make recognizing the presence of root-knot nematodes by above ground symptoms difficult. Sometimes a large number of larvae is found in roots without root galling, which hinders detection in the field even more.

Many rice weeds are good hosts of this nematode. Many larvae have been found in the roots of weeds of the families *Gramineae, Cyperaceae* as well as in *Sphenocleaceae.*

When the nematode population was followed during a growing season in three infested fields at higher and lower spots in the field, the number of root-knots at the higher spots always exceeded that of the lower spots. The same applies for the number of larvae and females per plant. Numbers of root-knots and nematodes per sample spot were fluctuating sharply during the season, although a maximum was clearly observed 35-40 days after sowing. A reduction in plant length of 10-20 cm was observed in plants of the higher spots compared to that of the lower spots. Yields were significantly lower at the higher spots too, but weeds also badly influenced crop production, so it was difficult to assess the percentage of reduction caused by nematodes. The size of the root-knots, containing nematodes varied from 1x2 mm to 7x3 mm. Up to 50 females per root-knot could be detected.
Egg-masses did contain 75 up to 800 eggs. The hatching percentage of eggs, collected in the field and left in the laboratory, varied from 5 to 78%. The mean hatching percentage (n=20) was lower in eggs collected 103 days after sowing that 50 days after sowing. The mean number of eggs per eggmass (n=20) at 103 days after sowing exceeded the number at 50 days after sowing.

We are dealing with a new *Meloidogyne species, M. oryzae* (Maas et al., 1978), morfologically and ecologically different from other *Meloidogyne spp. M. oryzae* is distinguished by the second stage larvae, which have a length of 500-615 microns, a tail length of 70-90 microns and a dilated rectum. Its closest relative is *M. graminicola,* which does not reproduce on tomato (cv. Rutgers). Besides of rice *M. oryzae* reproduces on tomato (cv. Rutgers and Moneymaker), wheat and potato. Morfologically the same species was found on plantain at Lelydorp in sandy soil, however in one field only. In other plantain crops in the area the common *M. incognita* or *arenaria* was found. By making cross inoculations we observed that *M. oryzae* from plantain reproduces on rice too. Root-knots are somewhat similar although more proliferation of roots and root-knots is caused by *M. oryzae* of plantain.

In Panama and Costa Rica root-knot nematodes are a problem of rice too. The ***Meloidogyne* sp.** is of the Hypsoperine type, females with ventrally located necks and posterior protuberances. Roots and roots-knots containing this nematode are twisted and root-knots have a J or O shape. This ***Meloidogyne* sp.** does not reproduce on tomato and the number of chromosomes (2n=36) is different from that of M. oryzae from Suriname (2n=30 or 32). Crop losses caused by this nematode are more heavy and in certain areas rice growing is abandoned.

In future experiments under more controlled conditions will be started within the framework of the just started research project on rice. First of all economic thresholds have to be determined to see at which densities and in which crop stage this nematode is really harmful.

The available rice varieties and rice weeds have to be tested for their susceptibility. Influence of the waterlayer on nematode development has to be investigated, because flooding may be the most effective way of controlling if water is available, together with proper tillage of the soil.

Applying a nematicide at sowing is impossible at the moment because of application of the herbicide propanil, 15 days after sowing. This herbicide is not compatible with most of the available nematicides, especially carbamates.

THE ECONOMICS OF AGRICULTURE IN SURINAME

(the need for an alternative strategy)

W.R. Caldeira
Ministry of Agriculture, Animal Husbandry
and Fisheries, Paramaribo

A BIT OF HISTORY

Agriculture has played an important role in bringing the majority of the Suriname population (92%) together, especially from Africa and Asia, under the old colonial system. Since 1873 (abolition of slavery) the Negroes abandoned agriculture in great numbers and the descendants of immigrants from India and Indonesia (Java) who took their place did the same since 1950. The latter was mainly the result of the colonial power shifting its interests to the more and lucrative bauxite sector. After World War II Surinam also became an "Equal" partner within the Netherlands Kingdom opening emigration possibilities for approximately 150,000 ex-Surinamers now living in Holland, while around 400,000 remained Surinamers. Together with the absence of a development strategy for sustained growth and development of the agricultural sector, this resulted in a sharp decline of agricultural production except for paddy (rice) and oilpalm, especially in the years 1970-1977 (see tables 1 and 2).

Agriculture's share in domestic product fell from 14 to 9% from 1955-1974 and direct employment fell from 50% to 18% of the working population.

MAIN FEATURES AND RECENT TRENDS

1. Suriname's agricultural sector contributes only 9 to 10 percent to the Gross National Product and 12 percent to exports, with 18 percent of the population directly employed and around 10 percent indirectly in agro-industries, transport, petty trade and other services. Unemployment (disguised unemployment) is relative high due to most of the 16,000 peasant farms being too small (2 to 6 hectares) for mechanized operations (see tables 5 and 9) and other modernized farming systems saving labour.

2. Farmers are very progressive, willing and able in adopting modern technologies (applying new varieties, fertilizers, chemicals, mechanization and labour saving technologies especially in tillage, (heavy tractors), harvesting (combines) and even in applying fertilizers seed, pesticides etc. by airplane in rice, bananas).

3. Land is available as an abundant resource base, potentially over 4 million hectares of which less than 1 percent is under agricultural cultivation (see table 4).
   Irrigation water is no constraint except for rice, since rain fall amounts 2500 mm per year.
   Drainage is a severe problem for most crops, especially annual crops other than rice, making "bed culture" necessary. Suriname faces no calamities like floods, hurricanes, severe droughts and the like.

4. Only food crops are produced. Paddy (rice) dominates with 67% of total crops value, 81% of planted acreage and 60% of agricultural exports.
   Oilpalm, sugarcane, bananas, vegetables and citrus take the second line.
   Mays and peanut are still minor crops, though potentially important (see tables 1, 2, 3).

5. Agricultural production is mainly for marketing through agro-industries in rice, sugar, oilpalm, shrimps for exports (rice, oilpalm, bananas, sugar, shrimps, citrus) and local consumption (rice, oilpalm, sugar, citrus, vegetables, meat, milk, fish etc.).
   Agriculture in Suriname is not a traditional way of life but highly commercial with an intensive use of modern systems (inputs). The organization of marketing however is rather poor and inefficient leaving small farmers at the mercy of brokers and middle-men, creating inefficiencies in the use of irrigation water and expensive imported machines (tractors, combines) because of time-peaks in paddy production, especially for small farmers.

6. Agricultural production except for oilpalm, is concentrated in the coastal area on clay soils with scattered fragments of ridges these heavy soils call for bed-cultivation, except for rice to meet drainage problems. The bed-system hampers mechanization. Oilpalm is grown in the southern areas on lighter soils. Rice production is concentrated in the Nickerie district (95% of production) in the North-West.

7. Land, Manpower and Capital are no constraints to agricultural development. The main constraint is the agricultural policy giving the agricultural sector a marginal role. The actual development strategy, emphasize capital intensive bauxite and related industries and hydro-electric power works. The employment needs were met by emigration to the Netherlands and expansion of the Government sector having 33% of employment (see tables 9 and 10).

PROBLEM AREAS AND NEEDED COUNTERS

1. Food imports (see table 7) amount over 10 percent of total imports with a negative agricultural balance of payments. Deficit in national balance of payments and government budget is yet solved by aid from the Netherlands and EEG 925% of total government budget). This will definitely come to an end around 1990. Import substitution in maize, meat products, fish products, milk products and vegetables have great possibilities. Still export promotion in rice, oilpalm, sugar, alcohol, citrus is of more importance.

2. Government participation (see table 6) in agricultural production mostly on large scale operations is frequently inefficient with bureaucratic constraints, in stead of supporting modern organized farmers to achieve economies of scale through cooperative systems, nucleus units with outgrower-systems, decentralizing away from the bureaucratic inefficient apparatus in Paramaribo. Governments normal budget allows for only 3.6 percent of funds for the agricultural department. Around 20-25% of development aid goes to agricultural projects.

3. Diversification in crops (not only rice and oilpalm) and regional spreading of activities (also other districts than Nickerie) are urgently needed.
   Maize, peanuts and other pulses are of great significance in both respects.

4. Urbanization needs a counter in approving living conditions in villages in rural areas by creating sufficient facilities (potable water, electricity, schools, health centres), guaranteed reasonable prices for products and more back up services to farmers (credit, nucleus service units) etc.

5. The urgent need for a development through people's involvement, with decentralized decision making per district by farmers, especially concerning land policies and the like.

6. Excecution of the 15 years Long Range Agricultural Development Plan of over Sf 900 millions (US$ 500 millions) runing from 1977-1992, which has to get started but still meets ethnical and other political constraints (see table 8). Adaption of the Plan, in meeting the basic needs of farmers and consumers, is necessary in this respect.
   For more information see tables 1-10.

Table 1. Suriname: Acreage of principal crops, 1970 – 1977 (hectares) (1970 = 100)

	1970	1971	1972	1973	1974	1975	1976	1977
Paddy								
Area planted (ha)	39,132	40,153	37,409	44,985	44,353	47,500	48,400	49,700
Index	100	103	96	115	113	121	124	127
Oilplam								
Area planted	50	330	840	1,215	1,435	1,640	1,710	1,880
Index	100	660	1,680	2,340	2,870	3,280	3,420	3,760
Other crops								
Area planted (ha)	10,051	9,263	9,390	9,584	9,444	9,684	9,398	9,540 1)
Index	100	92	93	95	94	96	94	95
All crops								
Area planted (ha)	49,683	49,746	47,639	55,784	55,232	58,824	59,508	61,120
Index	100	100	96	122	111	118	120	123
Small-scale farming								
Area planted (ha)	28,245	25,430	21,215	26,763	25,400	24,344	24,431	23,993
Index	100	90	75	95	90	86	86	85
Large-scale farming								
Area planted (ha)	21,438	24,316	26,424	29,021	29,832	34,480	35,071	37,127
Index	100	113	123	135	139	161	164	173

Source: Ministry of Agriculture, Animal Husbandry and Fisheries (LVV)
Agro-Economic Division

1 hectare = 2.54 acres

1) of which in 1977:

mays	110 hectares
peanuts	282 hectares
sugarcane	2188 hectares
bananas	1870 hectares
citrus	2000 hectares
coconuts	1100 hectares

Table 2. Suriname: Production of principal crops, 1970 – 1971
(Physical production in metric tons)

	1970	1971	1972	1973	1974	1975	1976	1977
Paddy								
Production	145,399	136,290	122,968	164,063	162,147	174,845	172,500	202,866
Index	100	94	85	113	112	120	119	140
Vegetables								
Production	3,370	2,740	2,966	3,106	2,016	2,230	2,704	3,165
Index	100	81	88	92	60	66	80	94
Sugar								
Production	12,011	10,075	11,082	8,961	8,535	9,577	8,391	6,370
Index	100	84	92	75	71	80	70	53
Alcohol								
Production	3,863	3,828	4,052	2,476	2,789	2,422	2,067	1,371
Index	100	94	105	64	72	63	54	34
Bananas								
Production	39,749	49,255	42,000	38,811	39,605	43,095	41,425	31,568
Index	100	124	106	98	100	108	104	79
Palmoil and rel. prod.								
Production	–	–	–	–	160	766	1,630	2,291
Index	–	–	–	–	100	479	1,018	1,432
Citrus								
Production	59,311	64,100	73,887	74,560	66,100	61,900	58,650	67,650
Index	100	108	125	126	111	104	99	115
Other crops								
Production	16,406	12,558	12,141	13,739	8,478	9,765	9,368	10,203 1)
Index	100	77	74	84	52	60	57	64
All crops								
Production	287,668	283,871	275,182	311,932	295,745	310,327	302,129	330,008
Index	100	99	96	108	103	108	105	115

Source: Ministry of Agriculture, Animal Husbandry and Fisheries (LVV)
Agro-Economic Division

1) of which
mays 230 metr. tons
peanuts 238 metr. tons

Tabel 3. Suriname: Value of agricultural production, 1970 — 1977 (In thousands of Suriname Guilders)

	1970	1971	1972	1973	1974	1975	1976	1977
Value of all crop production	30,626	29,334	31,272	44,156	49,106	58,547	60,038	78,775[1)]
Value of all livestock and poultry production	15,263	17,897	19,340	20,967	24,583	32,349	33,558	34,541
Value of all fishery production	6,446	7,656	9,791	10,930	13,081	21,589	46,134	49,961
Total	52,335	54,887	60,403	76,053	86,770	112,485	139,730	160,277

Source: Ministry of Agriculture, Animal Husbandry and Fisheries (LVV)
Agro-Economic Division

US $ 1.00 = Sf 1.77

1) of which in 1977:

paddy	Sf 52,542,000.—
bananas	Sf 5,976,000.—
citrus	Sf 6,734,000.—
mays	Sf 207,000.—
peanuts	Sf 1,301,000.—

Table 4. Suriname: Land use pattern, 1969

	Hectares	Percent
A. Land in farms, total	93,833	
1. Agricultural land	47,002	0.29
Areable land (crops)	38,172	
Natural grassland	6,470	
Cultivated grassland	2,360	
2. Yard and yard crops	2,062	0.01
3. Other land[1)]	44,769	0.27
B. All other land in Surinam	16,306,167	99.43
Total country area	± 16,400,000	100.0

Source: For A: Third Agricultural Census. Nov. 1969, pp. 44-45
For B: LVV estimates, Agro-Economic Division

1) other land for agricultural purpose but not in production mostly estates in private property or long lease.

Table 5. Suriname: Legal status of agricultural holders, by size of holdings and by District in 1969

	Private person estates		Government		Private Corporation		Other[1]	
	Number	Hectares	Number	Hectares	Number	Hectares	Number	Hectares
A. By size of holdings								
1. Holdings under 20.0 ha	15,702	44,283	15	31.9	–	–	10	20.2
Less than 0.48 ha	1,455	405	2	0.6	–	–	4	1.3
0.48 – 5.0 ha	11,884	24,869	12	25.8	–	–	5	6.1
5.0 – 20.0 ha	2,363	19,009	1	5.5	–	–	1	12.8
2. Holdings over 20.0 ha	309	18,344	13	6,211.8	15	13,836	14	11,105.5
20.0 – 50.0	252	7,073	2	67.0	–	–	3	81.0
50.0 – 100.0	27	1,738	1	60.0	–	–	–	–
100.0 – 200.0	15	1,738	3	384.8	2	1,243	2	218.7
200.0 – 500.0	11	3,644	3	875.0	5	1,613	1	206.0
500.0 – 1.000.0	2	1,300	3	1,645.0	6	4,556	2	1,331.8
1,000 and over	2	2,850	1	3,180.0	2	7,424	6	9,268.0
Total	16,011	62,627	28	6,247.7	15	13,836	24	11,125.7
B. By District								
Paramaribo	41	81.9	–	–	–	–	–	–
Nickerie	2,867	13,386.7	3	1.095.8	2	1,185	13	9,594.5
Coronie	525	2,060.1	1	0.6	1	100		
Saramacca	1,561	10,899.1	6	726.5	–	–		
Suriname	7,494	22,823.5	6	615.8	4	3,272		
Para	925	3,962.4	2	3.4	–	–	3	16.8
Commewijne	2,245	8,705.0	8	3.191.6	8	9,279	7	3.4
Marowijne	315	535.3	1	550.0	–	–		
Brokopondo	38	173.4	1	60.0	–	–	1	1,511.0
Total	16,011	62,627.4	28	6,243.7	15	13,826	24	11,125.7

Source: Third Agricultural Census, Nov. 1969. pp. 36 – 37

1) Agricultural Societies, foundations, and cooperatives.

Tabel 6. Suriname: Government participation in agricultural production, 1978

Type and name of enterprise	Government participation	Area (ha)	Activity
A. COMPANIES (profit)			
1. Tropica N.V.	100% *	–	Processing of fruits
2. Dairy Factory N.V.	100% *	–	Production of dairy products
3. Agricultural Bank N.V.	100% *	–	Provision of agricultural credit
4. Victoria N.V.	72%	1.650	Oil palm production
5. Marienburg SOM B.V.	100%	2.200	Sugar production
6. SURLAND N.V.	100%	1.800	Bananas and rice production
7. SUGAM N.V.	51%		Shrimps fishing (19 vessels)
8. Phedra[1] N.V.	100%	800	Oil palm production
9. Patamacca N.V.	100%	5.000	Oil palm production
10. SUCA N.V.	100%		Processing fruit etc.
B. GOVERNMENT FOUNDATIONS (non-profit)			
1. SML Wageningen	100%	10,000	Rice production
2. SEL (Experimental Agric.)	100% (	500	Rice production (comme)
	(	300	Citrus & beef cattle production
3. Small Fishery Operation (STIVI)	100%		Fishing processing
4. STIPRIS	100%	60	Research facilities (several)
5. STICOS	100%	18	Research on coconut
C. GOVERNMENT ENTERPRISES			
1. Alliance	100% *	300	Citrus production
2. LAK (Landsbedrijf Agr. (Kern bedrijf)	100% *	250	Vegetable production
3. State Livestock Farm (Landsboerderij)	100% *	400	Livestock production

Source: Ministry of Agriculture, Animal Husbandry and Fisheries.
Agro-Economic Division (August 1978)

Table 7. Suriname: Imports of agricultural products also produced in Suriname, 1969 — 1973
(Metric tons)

	1969	1970	1971	1972	1973	1977
Maize	11,000	11,500	12,000	13,000	28,030	23,000
Peanuts	n.a.	n.a.	n.a.	n.a.	203	446
Cabbage (sauerkraut)	130	80	110	100	170	n.a.
Tomatoes (processed)	390	410	340	520	60	n.a.
Other vegetables (processed)	1,020	870	550	860	880	n.a.
Sugar	110	2,070	1,790	2,440	1,900	
Cocoa	120	90	110	90	90	n.a.
Beef	920	990	960	1,060	950	n.a.
Pork	n.a.	475	432	456	n.a.	n.a.
Chicken	636	581	513	647	191	n.a.

Source: Ministry of Agriculture Agro Economic Division
November 1978

Table 8. Suriname: Area increase in crops and livestock 1976 — 1992 (15 Year Plan) (Hectares)

Crops	1976	1992			Area increase 1992 over 1976
		"Autonomous farming"	"Planned farming"	Total	
Rice	27,000	26,300	45,250	71,550	44,500
Dairy cattle	7,750	800	3,120	3,920	
Beef cattle		2,250	6,830	9,080	5.250
Fodder crops	100	100	6,900	7,900	6,900 1)
Citrus	850	1,400	830	2,230	1,380
Horticultures	1,820	700	2,220	2,920	1.100
Coconut	630		6,000	6,000	5,370
Oilpalm	1,600	2,000	5,800	7,800	6,200
Bananas	1,800				
Sugarcane	2,280	2,280	720	3,000	720
Other	560	560	—	560	
Total hectares	44,390	36,390	77,670	114,060	69,670
Index	100	82	175	257	(+ 157%)

Sources: Ministry of Agriculture, Long-range Agricultural Development Plan. Several tables of main report.

1) of which located around:

Paramaribo	1800 hectares
Saramacca	2000 hectares
Commewijne	1600 hectares
Tibiti	1500 hectares
	6900 hectares

Table 9. Suriname: Gross domestic product and employment per sector 1973 – 1975

(%) – percentage of employment	1973	1974	1975
Sectors:		(In millions of Surinam guilders)	
Agriculture and fisheries (18%)	51	62	72
Forestry and wood processing (2%)	11	11	12
Mining and bauxite processing (6%)	198	182	179
Manufacturing (10%)	44	34	45
Gas, water and electricity	16	15	18
Construction	12	13	15
Trade, restaurants and hotels (21%)	84	100	124
Transport and communications	20	21	32
Banking and other financial institutions	17	23	30
Housing	26	32	34
Government (33%)	117	136	159
Other social and personal services (10%)	13	15	18
Total GDP at factor cost	609	644	738
Total GNP at factor cost (Gross National Product)	545	597	724

Existing jobs, working force and unemployment 1975

	Year 1975 (december '31)	
Existing jobs	97,200	persons
Potential working force	117,500	persons
Actual working force	86,900	persons
Unemployed	30,600	persons
Percentage of unemployment	26%	

Source: General Bureau of Statistics (ABS)
National accounts 1975
Suriname in cijfers No. 79, July 1977

Table 10. Development Investment through aid from the Netherlands and E.E.C. 1954 – 1974 (x Sf 1000)

Sector	1954 – 1964 Ten Year Plan	1964 – 1974 1st x 2nd 5-year Plan	Total
Agricultural sector	43,419 (24%)	42,383 (18%)	85,802 (21%)
Forestry sector	10,640 (6%)	29,303 (13%)	39,943 (10%)
Infrastructure [1)]	50,326 (28%)	57,556 (25%)	107,882 (26%)
Industry	16,828 (10%)	3,086 (1%)	19,914 (5%)
Surveys [1)]	21,656 (12%)	46,225 (20%)	67,881 (17%)
Social sector	19,471 (11%)	9,673 (5%)	29,144 (7%)
Education sector	8,107 (4%)	5,665 (3%)	13,772 (3%)
Electricity, water, gas	1,557 (1%)	1,381 (–)	2,938 (1%)
Govt. organization	6,428 (4%)	33,344 (15%)	39,772 (10%)
Total	178,432 (100%)	228,616 (100%)	407,048 (100%)

Source: Planning Bureau of Surinam (Stichting Planbureau Suriname)

1) Infrastructure and surveys were mostly allocated to the mining sector, creating lucrative investment possibilities for foreign companies (bauxite etc.)

NAME OF PAPER: The Economics of Agriculture in Suriname (W.R. Caldeira)

Questions by: Horacio Stagno
Country: Dominican Rep.

QUESTION: Why the 1977-92 Agricultural Sector Plan does not seem to be running very well? Is it a financial type problem?

ANSWER: Finance is not the problem, since the agreement with the Netherlands Kingdom allows for approximately Sf 750 millions of funds on a fonds perdu term for the agricultural sector until 1990.
The Long Range Agricultural Plan doesn't run well because of the actual policy with a development strategy giving agriculture a marginal role to play. Our development strategy emphasizes economic growth through the mining sector instead of a basic need approach with development through people's involvement.

A STRATEGY FOR THE DESIGN AND LAYOUT OF FIELD EXPERIMENTS IN THE CARIBBEAN REGION

A.C. Brewer and F.B. Lauckner*

Caribbean Agricultural Research and Development Institute

Cave Hill, Barbados

SUMMARY

Nearly all field experiments on food crops which are conducted in the Caribbean region employ techniques of design and layout which have been developed by biometricians in temperate countries in North America and Europe.

These techniques have been very successful for field experimentation in the countries in which they were developed. However they have not been so successful in tropical regions.

This is partly due to the fact that often the land used for experimentation in the tropics is not uniform which means that great care has to be taken to ensure that each block is laid down so as to eliminate most of the variations due to non uniformity of land. Again the type of factorial arrangements often chosen include treatment combinations which are not really of interest to the experimenter. Researchers are therefore urged to adopt a flexible approach to the design of their experiments so as to include only treatment combinations in which they are interested and also to give extra replication to treatments which are of special interest such as control treatments.

Another problem regularly faced by experimenters is to decide on the size and shape of their plots. Some suggestions are made to help in choosing the optimum plot size and the advantages of various plot shapes are also discussed.

INTRODUCTION

There has been a United Kingdom Ministry of Overseas Development funded biometrics project in existence in the Caribbean region since 1972, which has had as its objectives the development of more efficient statistical techniques for the conduct of field experiments in the region. This project was originally set up due to concern over the high variation which most experimenters in the region experienced in their field trials and it was hoped that the development of new techniques would help to reduce this variation to an acceptable level. This project is shortly due for completion and this paper has been prepared to present the findings of this project to the region's agricultural research personnel. The authors are confident that the implementation of their findings will lead to a realization of the objectives of the project. The findings amount to a fairly radical new approach to the problem of field experimentation in the region, involving a different strategy from that which is practiced in the main at present, and encompasses questions concerning the choice of treatments and their levels of replication, experimental design and analysis and field layout.

*Both authors seconded on technical assistance by the United Kingdom Ministry of Overseas Development.

CHOICE OF TREATMENTS AND NUMBER OF REPLICATIONS

The only treatments on which it is necessary to experiment are those which are likely to produce an optimum result plus one or more control treatments. An optimum result does not necessary mean the highest yield of a crop as economic considerations should be taken into account and the treatment which gives the highest yield may not be attractive to farmers if the cost of inputs is high. Control treatments are usually in the form of present farming practice or present recommended practice and should be included even if they are not likely to produce an optimum result as they provide a standard by which the other treatments can be judged. However, zero or null treatments need not be included unless these are present farming or recommended practice or in the unlikely event of being thought to be optimum. Thus in a fertilizer experiment a treatment of no fertilizer is not necessary unless it is present practice. In fact zero treatments of this kind can create problems. For example in an insecticide trial the infestation in an untreated plot can be so high as to spread to neighbouring plots.

If a factorial design with complete replication is chosen then all possible treatment combinations for the levels of factors chosen are included whether they are likely to produce optimum results or not. This approach is quite satisfactory if resources such as land and labour are plentiful, but in the limited resources conditions of experiments in the Caribbean it can be a very wasteful approach. Experiments with a factorial design in factional replication have the disadvantage that the treatment combinations are determined by the experimental design and not by the experience and knowledge of the experimenter.

Another popular misconception about experimental design is that all treatments must have equal replication. There is no need for this if experimental circumstances, such as the number of blocks available, make this difficult. Also some treatments may be in short supply and it is not possible to give them as many replications as other treatments. Again we are generally interested in comparing the control treatments with the other treatments and this is achieved with greater precision if the controls are given extra replications. As a general rule the greater the number of replicates of a treatment the more precisely can its effect be estimated. So treatments such as controls and any others in which there is special interest should be given extra replication. If a treatment is in short supply and we cannot give it many replications then we cannot estimate its effect with any great precision, but it is better to include it with a few replications rather than to leave it out entirely as this will not allow us to estimate its effect with any precision at all.

PURPOSE AND PRINCIPLES OF BLOCKING

Almost all field experiments employ the technique of blocking. The idea of blocking is to reduce error from factors other than those being investigated in the experiment and consequently each block should contain uniform experimental material. This means placing blocks on areas of uniform soil and environmental conditions and to achieve this aim the researcher must become familiar with the site on which the experiment is to be conducted, taking into account such factors as soil type, site history, topography and climatic conditions. Because of the layout of diagrams in text books on field experimentation, it is often thought that different blocks in an experiment must be equal in size and shape. This is only desirable however, if it achieves the aim of making the experimantal material within each block uniform. If not then blocks of different shapes and sizes will have to be employed. Blocks of very unequal sizes can cause problems in the statistical analysis because of the unequal variances of the treatment means and should only be used when experimental circumstances make it absolutely necessary. However, designs with blocks of slight or moderate inequality only lead to small differences in the variances of the treatment means and in many circumstances they lead to much better experiments than designs with equal block sizes. Again there is a misconception that blocks have to be geographically compact units, but again this is not a necessity. For example if two small areas in a field are badly drained and prone to flooding then if soil and climatic conditions are similar and the separate areas are individually too small for separate blocks without introducing very unequal block sizes, then it would make sense to use the two areas together as one block. If however, the two areas have different soil or climatic conditions then they will have to form two separate small blocks.

There is a growing tendency in the Caribbean to perform experiments on farmer's fields because findings in the idealised environment of an experimental station do not always apply to commercial crops grown on small farms. These farmers fields on which experiments are performed are frequently sloping and different parts of the field have sometimes been under different crops prior to the experiment. In cases like these if blocks of equal size and shape are laid down in geographically compact units then it is unlikely that each block will contain uniform experimental material. Even on research stations on flat, well drained land, different parts of a field chosen for an experiment sometimes have different soil types, climatic conditions and previous cropping history. Again uniform blocks will not be successful and the result will be a high coefficient of variation. Great care should be taken to choose blocks on uniform areas bearing in mind the principles outlined above.

BLOCK CONFIGURATIONS

It has been seen in the previous section that the primary purpose of blocking in field experimentation is to split the experimental area into "uniform" areas of land in which the plots within each area can be expected to perform in a similar manner. Uniform here has been put in inverted commas since it is obvious that there exists no such thing as a uniform area of land since this would imply, for instance, that identical clones of a species grown in such an area would all grow to the same height and yield exactly the same amount, and this of course never happens. What is actually meant by uniform is an area of land in which an experimenter, prior to planting out the experiment, cannot determine by observation or inference which portions of that land are likely to produce better or worse yields of the crop than others, except perhaps for knowledge that one particular direction of the land is likely to produce greater graduations in yield than other directions (directional variation). This may be inferred, for instance, from slopes in the land or a known fertility gradient. It is possible that the entire experiment is conducted on only one such area, though this can have disadvantages if the results of the trial are meant to apply to a range of conditions. Once these areas have been determined, there remains the problem of laying out plots and blocks within them.

We are greatly aided in this respect by knowledge of a property which is true of all such areas of land and was described in a paper presented at the previous meeting of this society (Brewer 1977) and this is that points of the land closer together are more similar than those further apart. This means that areas of land are in general more dissimilar the further they are away from each other. This is a direct result of the fact that the levels of the various environmental factors which influence the response of a crop are likely to be more closely related at points in the field that are near to one another. This effect can and has been investigated in a formal manner but it should be obvious that a direct result of this is that in order to form blocks of highly homogeneous land, these blocks should be both compact and small in size. Suitable arrangements of plots within them will be discussed in the next section.

Blocks are kept compact by making them square in shape, or nearly so, especially in the case where there is no directional variation present. There are far too many experiments in the Caribbean region laid down straight out of a text book with blocks formed as long strings of plots laid side by side.

Those are two ways of keeping down block size, firstly by using small sized plots which is discussed in the next section, and secondly by keeping the number of plots per block small. This second requirement is the source of one of the great disadvantages of the widely used randomized complete block (RCB) designs, which stipulates that the number of plots per block must necessarily be at least as large as the number of treatments in the experiment. The alternatives to this may be an unbalanced or partially balanced block design or confounded designs when the treatment structure is factorial, and these possible alternatives should be considered very seriously, especially when there are a large number of treatments involved. It should be pointed out that unbalanced or partially balanced designs can in these days be analysed just as easily as RCB designs once computer facilities are available. The best and most objective approach to experimental design is to form the blocking system in accordance with the nature of the land comprising the experimental site without any reference to the number of treatments to be investigated in the experiment. This may not lead to neat designs such as the RCB but if it leads to a highly accurate experiment, then we have achieved the whole point of the exercise.

A class of designs which have hitherto been somewhat underestimated in their usefulness is the row and column designs. By eliminating variation in two directions they often compensate well for the general property of field variation described earlier. The standard design of this class is the latin square which is not too often used because of its rigid structure, and it also suffers from the same kind of disadvantages as RCB designs. However, any contiguous grid of plots within the experiment can be used as a row and column structure, and this may lead to an experimental design which is unbalanced or partially balanced. These are again easy to analyse when computer facilities are available. Situations in which row and column designs can prove effective are listed below.

1. The classical situation in which they are used is when there are two factors likely to cause directional effects in the crop transverse to one another (e.g. a slope and a wind direction across the slope).

2. They can be used when contiguous grids of plots that are to form the experiment are not easily split into compact blocking units, e.g. if an area of land is used in an experiment on which it is convenient to place, for example, a 5 x 6 grid of plots, there may be no sensible way in which compact blocks can be defined on this area, and thus a row and column arrangement would be a superior design.

3. Even on land with no directional variation row and column designs of small dimension are often superior to block designs in eliminating environmental variation. In support of this contention, it has been generally observed, for instance, that latin squares of size 4 x 4 to 8 x 8 are often superior to an RCB design of the corresponding size. (Fisher 1942, p. 69).

4. In the situation where there is directional variation but for cultural reasons the plots have to be elongated transverse to this direction. This will be further explained in the next section.

It is thus evident that row and column designs are useful in a wide variety of situations. When plots in the experiment are arranged in rectangular grids then these designs should always be considered as one of the possible alternatives as long as the experiment is big enough to leave sufficient degrees of freedom for the estimation of experimental error.

When an experiment entails the use of an unbalanced design there are methods of determining a suitable or optimum allocation of treatments to the blocks or rows and columns. For reasons of length these cannot be included in this paper.

PLOT SHAPES AND SIZES

It has been shown in the previous section how the general property of "uniform" areas of land affect the best allocation of blocking systems upon it, and it will be seen here that it also determines the best arrangement of the plots within these blocks. Bearing in mind that it is the between plot variation which contributes the most to the experimental error, whilst within plot variation contributes relatively little, it is evident that plots within the same block should not be remote from one another, and individual plots should be spread out as much as possible to absorb the maximum amount of variation existing within the land which comprises the block. Although perhaps not quite as obvious as the implication on block shape, these desirable properties lead to the following optimum arrangements and plot shapes:

1. Where there is no directional variation, form long narrow plots side by side in any direction to form compact blocks.

2. With directional variation present form long narrow plots corresponding to this direction and lay them side by side to form blocks (form long narrow plots down a slope for instance).

3. When directional variation is suspected to be present but its actual direction is unknown, it is safest to form square plots in compact blocks to avoid laying long plots the wrong way.

4. Row and column designs allow the use of square plots since variation is eliminated in both directions.

5. When long plots have to be laid transverse to a direction of greater variation for cultural reasons, they should if possible be formed into a contiguous grid and a row and column design used. This enables the rows to eliminate the large variation in one direction, and the columns to correct for the remoteness of plots in the same row.

Of usually greater importance than plot shape is plot size. This is often the question which experimenters are uncertain about and sometimes ask biometricians for a solution. There is in fact a statistical method perporting to calculate the best plot size for any particular crop (Fairfield – Smith, 1939) and has been widely used in the past. However, the best plot size for any experiment is a function of the variability inherent in the crop itself (i.e. planting material), errors of observation, and the nature of the environmental variation of the land, and of these the latter is the most important factor. It is therefore erroneous to recommend a "best plot size" for a particular crop under any conditions, and preferable to set out general guidelines for determining a good plot size in any particular situation.

In essence this guideline is to keep to a minimum plot size, since this enables block size to be kept small and will also in many cases allow greater replication with the same resources. Viewing the choice as larger plots with less replication as against smaller plots with more replication the latter alternative is never worse than the former, and will normally be considerably better in terms of statistical precision, though of course it will generally require more work in general management and data recording. Indeed, it has been shown (Brewer,1977) that larger plot sizes even with the same amount of replication, can under certain conditions result in less precision due to the nature of the environmental variation. By minimum size is meant a size which is just large enough to allow the plot to give a representative reading of the treatment applied to it, and this is dependent upon the nature of the treatments and the objectives of the experiment. This allows for different plot sizes to be used for, say, a preliminary screening trial as opposed to an investigation of a treatment's performance in commercial practice.

The practice of planting guard areas around a plot has an obvious modifying effect on every recommendation given in this section. Firstly a small experimental plot area has a greater ratio of guard plants to protect it, and secondly rectangular plots have a greater ratio of guard than do square plots. This creates conflicting objectives of optimizing the economics of a plot with its shape and size as opposed to gaining maximum statistical precision. An experimenter in this situation needs to assess the particular case on its merits, and should attempt to decide upon a minimum economic plot size based on what proportion of his planting material he is prepared to use as guard area.

CONCLUSION

Some of the methods described here have been recently developed and have not been extensively employed in field experimentation in the region whilst others have been used in experimental work. They are all, however, based upon statistical investigation and logical reasoning and each should help to produce more efficient field experiments. The methods are here brought together as an integrated approach and as such form a sound scheme for achieving greater efficiency. It remains to fully implement the approach in the research work of the region.

REFERENCES

Brewer, A.C. (1977)·Beyond the randomized complete block; new statistical concepts for the design and analysis of field experiments. Proc. 14th Meeting C.F.C.S. (in press)

Fairfield-Smith, H. (1938)·An empirical law describing heterogeneity in the yields of agricultural crops. A. Agric. Sci. 28, 1-23

Fisher, R.A. (1942). The design of experiments. Oliver and Boyd, Edinburgh.

WORKSHOP

SOIL MANAGEMENT

Chairman; N. Ahmad.

QUESTIONS:

a. What soil is preferable for the growth of maize and/or peanuts: Coebiti or Tijgerkreek West?
b. What are the limitations and economic measures which have to be taken to promote production?

The time allowed did not permit exhaustive consideration of all aspects of these two important questions; we did give more attention to maize than to peanuts for example.

Maize/peanuts on Young coastal plain:

The group felt that in the case of the sand ridge soils, the areas were to small, irregular in occurrence, variable in soil properties for mechanized maize cultivation. It did not rule out the suitability of these soils for peanut. The clays are considered to have very serious soil drainage problems for maize to be cultivated without very elaborate land layout. The use of the cambered bed as for sugar cane was decided to be too limiting for use of machines, it did not adequately solve the drainage problem for maize. Essentially flat beds up to 30 meters wide with box drains and moles across the bed at close intervals as presently being tried in Guyana were considered a layout well worth studying both for drainage and irrigation. The use of the very acid, toxic peaty and acid sulphate, clay soils of the Young coastal plain was considered unsuitable in view of the very costly amelioration that would be required.

The brown sandy loams as at Coebiti were considered as having several advantages over the Young coastal plain soils for commercial maize and/or peanut production. Land clearing and reclamation were not as much of a problem, and tillage was easier and maximum use is made of the total land surface for the growing of the crop. The fertility problem was, however, severe. Attention was given to ways of solving this soil infertility and measures such as kind of fertilizer, method and time of application, crop rotation system were thought very important. The question of tillage was also discussed. No definite recommendations could be given on these matters at this stage, due to inadequate research.

With respect to method of application, it was concluded that band placement would result in better fertilizer utilization, would restrict root development which could have adverse effects in water stress situations. What amounted to optimum tillage was a wide open question. Too much tillage could lead to rapid soil deterioration, on the other hand some tillage was necessary to incorporate fertilizer and lime into the subsoil to allow root development. Initial fertilizer application at the time of seed drilling was considered adequate and side-dressing could eventually be done aerially. This technique would combine the benefits of box band placement and broadcast applications.

Some form of crop rotation probably involving long or short term legume crops and/or grass fallow was considered as essential in fertility maintenance. Some reservations were expressed to rearing of cattle as part of the cultivation system.

Kinds of fertilizers used would leave to consider handling properties as well as cost. Conceivably, if sufficiently large scale operations were to be developed, application of N as anhydrous ammonia may be feasible initial. Broadcast applications of fairly large dressings of ground rock phosphate may be a sound and even economic proposition in supplying P and combating Al toxicity.

At all stages of operation economic considerations should be given. For example, in the application of lime, it has to be decided whether one large application every 3 or 4 years is better than smaller annual applications. In the case of the farmer, the succeeding crop in the rotation could be selected with respect to their requirements of calcium status in the soil.

CROP PROTECTION **Chairman: T.L. Hammerton**

I. The first question was:
"What is recommended for *Spodoptera* control?
Chemical or Biological control?"

After a lengthy discussion, we agreed upon an intregrated approach — but one embracing the entire area of crop production.

In new area opened up to corn, it was stressed that chemical control was essential initially until parasites and predators could be established. These needed an opportunity to build up their numbers to an effective level.

For corn in established areas we felt that an integrated approach, using chemical and biological control was needed, but further research was necessary to establish certain procedures and economic threshold levels.

The components can be learned as follows:

1. Adequate fertilizer and water to ensure rapid growth and to enable the crop to recover from *Spodoptera* damage and to grow away from such damage.

2. Seed dressing with a systemic insecticide to confer early resistance and control of *Spodoptera*. Furadan was mentioned but research is needed on this and alternative materials.

3. A simple monitoring procedure, based on a study of economic threshold levels, to enable the farmer to ascertain when chemical control was necessary.
   Such a study would need to be within a time frame, since young corn plants are less able to tolerate a given level of caterpillar infestation than older plants.

4. An insecticide spray, using an insecticide that would cause minimum fatalities to natural enemies of *Spodoptera*. Dipterex approved to be satisfactory. It was stressed that we should avoid and discourage insurance spraying — the routine application of insecticide regardless of infestation level.

5. Further monitoring to determine if one (or more) additional spray(s) were necessary. The need for research on this topic has already been emphasized. In addition continuing work on parasites and predators, and on the economics of spraying, would be necessary.

II. The second question was:
"Is chemical control of weeds in peanuts to be preferred to mechanical control?

The simple answer was YES, but with certain reservations. It was agreed that weed control must start before planting in the course of land preparation. This should include burial of weed seeds and weed propagules by ploughing, or the one of herbicides such as paraquat and glyphosate to reduce weed infestations.

Minimal disturbance of the soil was considered important to avoid damage to plants and to the elongating pegs particular on certain soils however — perhaps on the Tijgerkreek soil — cultivation might be useful to break surface crushing. Timing of the cultivation is critical since peanuts may start flowering relatively early.

In general chemicals were to be preferred, but the divertion of weed control by herbicides was not always adequate. Close spacing to enhance by competition, suppression of weeds was emphasized, as well as fertilizer usage to encourage rapid early growth and care of the ground. Research on varieties and spacing was considered necessary to find those combinations of variety and spacing that best suppressed weeds.

We felt that satisfactory post-emergence herbicides for peanuts were urgently needed. No candidate chemicals could be named, but the use of a circulating sprayer was mentioned as a possible means of controlling weeds growing well above the crop canopy. Glyphosate was a suitable material for use in circulating sprayers.

MISCELLANEOUS **Chairman: G.A.M. van Marrewijk**

Let me start saying Mr. Chairman that we had a vivid discussion in our group about many subjects. But the fact that we were really a miscellaneous group, including crop husbandries, breeders, biometrists, engineers, economists and even a social welfare worker made that each single problem was discussed by a small number of persons only.

With respect to the three final questions for which we were labeled to find an answer it must be stated that there was no consensus about question 1, whether Surinam should start an own breeding program or rely on breeding stock from abroad.

The one opinion was that we should not start an own breeding work before maize growing has become more established in the country. Others on the contrary advanced the idea that apart from testing of varieties, developed elsewhere, we should start at least a smallscale programme ourselves to get types adapted to specific Surinam conditions and problems. This might fairly well be based on "prebred" material from CIMMYT or elsewhere. It was stressed that cooperation with other institutes in our region is necessary. We did not discuss question 2, because of the reasons mentioned by you.

With respect to question 3 asking whether other peanut varieties than Matjan should be tried out, Dr. Wienk, in a one-man show came to a positive answer as-alongside with some attractive features — Matjan is susceptible to *Cercospora* leaf spot and has a growing type not allowing high density plantings.

But all cultivars tried out so far suffered from specking of the seed coat, of which the causal agent still has to be detected. We finally started discussing question 1 of the soil group. It was stated that the answer to this question also depends on the goals aimed at (apart from the technical aspects mentioned by Prof. Ahmad). Though on the long run it is possible and might probably be advisable to expand activities to the interior, within the agricultural development plan 1978 — 1992 aiming primarily at import substitution and not at export, for the moment groundnut growing should be stimulated in the coastal area.