CARIBBEAN FOOD CROPS SOCIETY

PROCEEDINGS

ELEVENTH ANNUAL MEETING

TABLE OF CONTENTS

CARIBBEAN FOOD CROPS SOCIETY ELEVENTH ANNUAL MEETING

The Eleventh Annual Caribbean Food Crops Society Meeting was held in Barbados as a result of an invitation from the Government of Barbados.

This meeting was organised in Barbados with Mr. W. deCourcey Jeffers as President and Mr. Ronald A. Baynes as Vice-President. The Caribbean Food Crops Society acknowledges the assistance of the Government of Barbados, the University of the West Indies, U.S.I. West Indies Limited and the several other organisations and individuals too numerous to mention, who in any way contributed to the successful organisation of the Eleventh Annual Meeting.

MINUTES OF 11TH ANNUAL BUSINESS MEETING CFCS, CAVE HILL BARBADOS

The business meeting was called to order by the President, Mr. deCourcey Jeffers at 11:50 a.m. at the University of the West Indies, Cave Hill, Barbados on July 6, 1973.

The minutes of the previous meeting in Puerto Rico in 1972 was read and approved. The treasurer's report was read and approved.

Old Business: None reported

New Business:

1. Mr. H. A. D. Chesney, Guyana, suggested that the CFCS Newsletter be used to make known who are members of the CFCS.

2. Dr. C. Walters, Antigua, moved that copies of minutes of the business meeting be made available to members at time of registration. Seconded Mr. T. Fergusson. Passed.

3. Dr. C. Walters, Antigua, moved that the agenda of the business meeting be circulated one day previous to the meeting. Seconded Mr. C. Frazer. Passed.

4. Mr. H. A. D. Chesney, Guyana, moved that there should be an audit report of the accounts of the Society. Seconded Mrs. C. Frazer. Passed. Dr. C. Walters, Antigua, proposed that the CFCS constitution be amended to include a manditory auditors report of the accounts of the Society. The Board of Directors to appoint the auditors. The matter shall be placed for the next meeting in order to comply with the by-laws of the constitution.

5. Mr. T. Fergusson, UWI, moved that the Board of Directors appoint a 3-man committee to determine the feasibility of setting up a permanent secretariat for the CFCS. Said committee shall submit to the Board of Directors a report within 4 months. The Board of Directors

shall meet in January 1974 to consider the report. The final recommendations shall be submitted to the members at the 12th Annual meeting. Seconded Mr. H. A. D. Chesney. Passed. Selected for this committee were V. Sargeant, T. Fergusson, and H. Miller.

6. Mr. A. G. Naylor presented Jamaica as the proposed site for the 12th Annual Meeting CFCS in 1974. The gracious offer was unanimously approved by the members.

7. Proposed sites for the 13th Annual Meeting CFCS in 1975 were St. Vincent, St. Lucia, and Grenada. Mr. R. Baynes shall determine which of these sites might be available.

8. The Nominating Committee presented their recommendations for the officers of CFCS for 1973–74. There were as follows:

President of the Board	Mr. deCourcey Jeffers	Barbados
Board of Directors	Mr. G. Anais	Guadeloupe
	Mr. R. Baynes	Barbados, UWI
	Mr. H. Beckford	Jamaica
	Mr. H. A. D. Chesney	Guyana
	Mr. L. Cross	Trinidad
	Dr. C. Walters	Antigua
President	Mr. Hugh Miller	Jamaica
Vice-president	Mr. A. G. Naylor	Jamaica

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

9. Dr. C. Walters, Antigua, moved that the outstanding Proceedings of the CFCS for 1970, 1971, 1972 be edited, published, and distributed by December, 1973. Seconded G. Anais. Passed.

10. Mr. H. A. D. Chesney, Guyana, moved that a vote of thanks on behalf of all CFCS members visiting Barbados for the meeting be

extended to the President, vice-president, and all peoples on the local committee who worked so hard to make the 11th Annual Meeting an outstanding one. And also for their hospitality apart from official acts. Seconded Mr. A. G. Naylor. Passed.

There being no further business, the meeting was adjourned.

ADDRESS OF WELCOME BY THE HON. A. DaC. EDWARDS, MINISTER OF AGRICULTURE, SCIENCE AND TECHNOLOGY, AT THE OPENING CEREMONY OF THE ELEVENTH ANNUAL MEETING OF THE CARIBBEAN FOOD CROPS SOCIETY HELD AT MARINE HOUSE, HASTINGS, CHRIST CHURCH BARBADOS, ON 2ND JULY, 1973

Mr. President, Honourable Ministers, Distinguished guests, delegates, ladies and gentlemen:

Nine years ago, Barbados had the honour of hosting the Second Annual General Meeting of the Caribbean Food Crops Society. A similar honour has fallen to this country at the Eleventh Meeting.

It is fortunate that the Society was formed some years ago, and not at the 'eleventh hour', in order to meet the crisis with which we are faced. The main objective of the Society was, and still is, to advance Caribbean food production and distribution in all their aspects, with the end in view of improving the levels of nutrition and standard of living in the Caribbean.

I note from the Agenda for the technical sessions, that a variety of items will be discussed. Papers will deal with crops such as tomatoes, cabbage, cucumber, red peas, peanuts and so on. Perhaps, you will excuse me if I single out the full title of one paper: it is "Increases in sweet potato yields by soil fumigation." I have done this, because, here in Barbados, it had recently been found necessary to import sweet potatoes from a neighbouring island, and the price has been a very high one per pound. Agricultural Ministers throughout the world are under heavy fire; but, the truth of the matter is, that there is a shortage of food crops throughout the world, to meet the demand of an ever-increasing population.

It is very distressing to read that there are millions of people who, in what we like to call a progressive world, are suffering from malnutrition or actually dying from hunger. Some of those numbers live around us in this Caribbean Region.

If we forget politics and view the problem from humanitarian grounds, we will realise that the task is ours – you, the members of the research team of this Society, and persons administering Governments – to endeavour to find solutions to the problems facing this area, and also wider afield.

A man can work hard, save and borrow money to build a house and buy other material goods. He can take his time to acquire these things – many years in some cases – but not so with food. It must be taken daily. It is therefore very appropriate that serious study be made of the food situation, both from the technical and policy-making angles.

It is not in my place this morning, at this particular meeting, to make grandiose policy statements; but, I must mention that, throughout the Caribbean, there is a moving away from working the land, and that is why so many items of food are so scarce and costly. You, researchers, must exchange material and information on the various aspects of food production, processing and marketing in this area, in order to save duplication of effort and waste of time.

We are well aware of the present difficulties in obtaining enough supplies of grain, animal feed, rice and so on, throughout the region, and so I am pleased to see that you intend to discuss subjects dealing with soils, climate and water situation, which are so vital to the good production of any crop.

We all speak of import substitution, but we have to face facts, However we try, the older developed countries find a way to keep ahead of us. We must find a way to prevent too great a lead on our first innings. This coming together of people from all over the Caribbean, with the purpose of working towards the co-ordination of research and development programmes in the field of food crops, is a good start.

Food is a common link between many organisations, whether in private enterprise or in Government. For instance, Agriculture, Trade, Industry, Tourism, Education, Health, are Ministries which must interest themselves in this subject: therefore, although there may be a tendency towards political independence, we are forcibly reminded, in times like these, of our common heritage.

The countries in Europe are working together; we in the Caribbean, must follow likewise. Shortly, we will have our own version of a common market; therefore, it is essential that we have something worthwhile to place in that market. For too long now, we have been dependent on others to tell us what to do for ourselves. It is to be hoped that an Organisation such as the Food Crops Society, will help the area to be more self-sufficient. We must pay particular attention to nutrition, for us to produce citizens with healthy bodies and healthy minds. With the sugar industry in the present precarious position, we in the Caribbean, must take stock of our natural facilities, and with the help of science, exploit them to the fullest benefit of all.

The time has come when Agriculture must NOT be any longer considered an Industry of Subsistence. In other words, the time has come when the Agricultural Worker should no longer be expected to work for subsistence wages. The gap between the wages paid to Agricultural Workers and those paid to general workers in other fields of endeavour, MUST BE closed, and this would stem the tide of the general drift away from working the land.

I do not consider that it is my duty, on this occasion, to try to score points by saying, for instance, that Barbados has benefited from these research meetings, and has been in recent years producing good onion crops, and that we have also introduced processed yam. It is too serious a period in the history of the area, to rest on our laurels, or for that matter, to sit back and hope that a 'mother country' is going to come running to help us out of a jam. We must each do our bit and pool our knowledge and expertise.

It would not be amiss for me to mention here, that shortly, an Inter-American Development Bank team from Israel, will be visiting Barbados to advise on rural development. The matter of Agrarian Reform will also be touched upon, and if the Barbados Government agrees that there should be such a reform, I, personally, visualise agriculture in Barbados having a new orientation.

Farming must be made to pay. The old-time association of hard work and low pay, must be eliminated, not only in Barbados, but in the whole Caribbean Area, if we want to advance economically. During your deliberations, you must therefore pay special interest to this thought, and see the Agricultural Worker in a new perspective.

Ladies and Gentlemen, when I earlier mentioned the word 'crisis', I did not do so lightly. We can no longer act like the ostrich, but we must face the problems of the agricultural industry in the Caribbean Area. In this matter, no one can stay aloof, big and small territories, rich and poor; technicians; administrators and politicians, private enterprise; must all join together to promote better conditions in the agricultural sector.

Mr. Chairman, I understand that the Dean of Agriculture of the University of the West Indies, is to give the feature address; therefore, I must refrain from making too lengthy my words of welcome.

However, I would like to highlight a few points here, at the opening of this Society's Meeting, which I shall dub as the beginning of "operation – Import food substitution for the Caribbean Area".

(1) We should pool our resources and rationalize agriculture, so that if any one country/island has a comparative advantage in the production of any food item, then let that territory produce that item in sufficient quantities that the area as a whole will be self-sufficient in that commodity.

(2) At Agricultural Marketing Protocol Meetings, there should not be undue haggling over prices. In recent budgetary proposals,

the Governments throughout the area have put high tariffs on goods coming from outside the Region, in order to stimulate production within the region: therefore, if it is found sometimes that an item locally produced costs two or three cents more than the imported one, we should buy the item in order to keep the money circulating within the region, and to give encouragement to our local farming industries. In due course, a reduction in the price of such items will inevitably come about. And I say this, because I am convinced, that NOW is the time for farmers in the region to be encouraged to produce more food. I am also convinced that our low level of production is a result of the lack of encouragement given to the farmer, because of the low price structure. With a better price structure, yields will be increased, and at such a level, the desirable interplay of Supply and Demand will play a prominent role, and prices will therefore find their true level.

(3) Researchers should make use of the political climate, and try to develop high yielding crop varieties of good nutritional value, to ensure that total demands are adequately met. Towards this end, throughout the area, there will have to be an up-dating of planting, harvesting, processing and marketing equipment and techniques.

(4) We in the Caribbean, have the tendency to prefer items produced overseas, even at a higher cost than locally produced substitutes. Sometimes, the canned products have been processed from items grown in our region, and sold to us at high prices, when, in fact, similar products can be made locally. A Caribbean Food Nutritional Institute Survey carried out about five years ago, pointed to the fact that the bulk of our protein needs is imported, when, in fact, we have the potential to produce the same requirements in this area. A more recent survey carried out here in Barbados by the same Institute indicates that the amount and quality of food intake need improvement in at least one-third of the homes, while in another one-third, the very

quality of the diet needs improvement. I believe that a similar survey in any territory in the region will show similar results. The fact of the matter is that the protein imported from overseas, is usually high-priced animal protein obtained from meat, and because of its cost, it is not obtained by some income groups. But it should be noted that these costly protein foods can be substituted by vegetable protein at a much cheaper price locally. In other words, we want more beans, peas, pulses and legumes grown, and more animals reared in the region.

(5) In order to encourage local production, there will have to be more economic incentives, especially good farm gate prices to reflect not only the cost of production, but the risks and uncertainties involved in agricultural pursuits. In this respect, many acres of land now unutilised and under-utilised throughout the Caribbean, should be brought back into full production, in order to produce more food crops for human consumption and more feed crops for animals.

(6) I can divulge to you now, that we in Barbados are engaged in looking into certain aspects of modernising agricultural credit and marketing facilities, increasing the technical staff and farming incentives. I urge you to encourage your several Governments to do likewise, and help them by submitting schemes which you consider will be beneficial to the area as a whole, and wage the campaign of the operation against importing goods from outside the region, when we can produce locally, items just as good.

(7) I now come to the most crucial constraints to Agricultural Production within the area. In this respect, I refer to processing and marketing of our agricultural produce. One can attempt to take a leaf out of the Book of Venezuela, which has gone a long way in making itself almost self-sufficient in foodstuffs. This is mainly due to the establishment of processing plants for all types of agricultural produce, and a most

up-to-date marketing policy. The farmer in that country is considered a most important person, and all sorts of incentives are given to encourage increased production. A guaranteed market is provided, and there is little wastage of agricultural produce, because of the existence in that country of all sorts of agro-industries. I exhort all of you to come out of this Conference with firm recommendations and commitments for the establishment of similar aforementioned facilities.

It is good to see that representatives from many islands have found it possible to attend this meeting. The local delegates and agriculturists know how strongly I feel on this matter of 'agriculture', but I hope I have allowed some of my zeal to be seen by the visitors, and that on their return to their homeland, they will bear in mind the challenge which the Caribbean faces, and try to do something useful about it.

I welcome all the delegates, but a special welcome goes out to those visiting Barbados for the first time, and those renewing acquaintances. I am sure that you will enjoy yourselves, in spite of the heavy programme which lies before you during the next few days.

Mr. Chairman, ladies and gentlemen, I have much pleasure in declaring open the Eleventh Annual Meeting of the Caribbean Food Crops Society.

PROGRAMME OF SESSIONS

AND

INDEX OF PRESENTATIONS

Monday 2nd July, 1973, 2.00 p.m. – 5.00 p.m.

BARBADOS BACKGROUND PAPERS

1.	The Role and Structure of Agriculture.	E. C. Pilgrim
2.	Contribution of Agriculture to Barbados' Economy.	J. Mayers
3.	The Soils of Barbados.	N. Ahmad
4.	The Climate of Barbados.	B. Rocheford
5.	The Water Situation in Barbados.	W. A. Johnson

TECHNICAL PAPERS

Tuesday 3rd July, 1973.

1.	An Investigation on the Yield Response of two Tomato Varieties to Different Levels of Nitrogen and Potash Fertilizer and to a Dry Grass Mulch Cover.	L. Smith
2.	Tomato Varieties, Training and Cultural Practices for the Caribbean.	G. Anais & P. Daly
3.	Investigation on the Effect of Different Frequencies of Harvest on the Yield of String Beans.	L. Smith
4.	Effects of Fertilizer on Growth Yield and Leaf Mineral Contents of Pigeon Peas. *(Cajanus Cajan* (L.) MILLS P).	J. L. Hammerton
5.	Effect of Planting Date on Soyabean Oil and Protein in Trinidad.	R. A. I. Brathwaite

Tuesday 3rd July, 1973

6.	A Yellowing and Die-back Syndrome of Pigeon Pea *(Cajanus Cajan* (L.) MILLS P). ...	...	J. L. Hammerton
7.	Red Pea Variety Testing in Guadeloupe.	...	F. Kaan & C. Suard
8.	The Response of Plantains to Magnesium Fertilizers in Puerto Rico ...	...	G. Samuels, E. Hernandez & S. Torres
9.	Yam Planting Density Trials in Guadeloupe.	..	R. Arnolin, R. Poitout & L. Degras.
10.	Studies of Pangola Grass *(Digitaria Decumbens* Stent) in Barbados. 1. Effect of Level of Nitrogen Fertilization and Frequency of Cutting on the Yield, Chemical Composition and *in vitro* Cellulose Digestibility.		R. C. Quintyns & E. Donefer.
11.	Attempts at Mechanical Harvesting of Root Crops in Barbados.		W. O'N. Harvey & J. P. W. Jeffers.
12.	A Solar Crop and Seed Drier.		O. St.C. Headley & B. G. F. Springer
13.	The Analysis of an Arrangement Designed for Limited Resources. ...		F. B. Lauchner & B. G. F. Springer

Wednesday 4th July, 1973. All Day Field Tour

Thursday 5th July, 1973

14.	The Contribution of Plot Characteristics to the Design of an Experiment.		A. C. Brewer & B. G. F. Springer

Thursday 5th July, 1973.

15.	A System of Project Registration Designed to Facilitate Information Retrieval. ...	R. F. Barnes & B. G. F. Springer
16.	Plant Parasitic Nematodes Associated with Vegetable Crops in Antigua ...	C. W. D. Brathwaite
17.	Effect of Plastic Mulch and Plastic Canopy on Nematode Population and Southern Blight of Tomato.	N. D. Singh & M. S. Sandhu
18.	Studies on the Agromyzid Leaf-miners in Barbados.	B. Munir
19.	Pigeon-Pea Pod Borers in the Caribbean.	S. Parasram
20.	The Effect of Local Climate and Soil Factors on Irish Potato (Solanum Tuberosum) Yields in St. Lucia.	F. S. Leonce
21.	A Simple Technique of Continuous Irrigation for Hydroponic Sand Culture ...	J. Brochier
22.	Evaluation of Chemicals for the Control of Nematode Population in Cabbage. ...	N. D. Singh
23.	A Greenhouse Trial of the Efficiency of Vitamon d and Enmag as Slow Release Fertilizers using Pangola Grass.	B. R. Cooper
24.	Measurement and Estimation of Evapotranspiration in French West Indies	R. Bonhomme & C. V. Grancher

Friday 6th July, 1973.

34.	Evaluation of Cucumber *(Cucumis sativus)* Varieties in the Leeward Islands.	St.C. M. Forde
35.	The Influence of Plant Density on Sweet Pepper (Capsicum annum) Yields in St. Kitts. ...	St.C. M. Forde
36.	A Preliminary Report on the Development of Avacado as a tree Crop and on Factors Affecting Yield in Barbados.	R. D. Lucas
37.	The Pepper Flower Bud Moth in the Caribbean (an evaluation).	S. Parasram
38.	Possibilities of Onion Bulb and Seed Production in the French Caribbean	G. Anais

With a view to improving the quality of the Proceedings of the Caribbean Food Crops Society, an Editorial Committee consisting of the following members was established for one year.

W. deCourcey Jeffers – Chairman
R. A. Baynes – Secretary
E. G. B. Gooding
V. A. L. Sargeant

The following persons assisted the Editorial Committee in editing the numerous papers :–

J. Mayers	R. Phelps
N. Ahmad	D. Walmsley
H. A. Sealy	J. P. Jeffers
L. H. Smith	B. Williams
Omawale	R. Pierrs
L. Campbell	R. Barrow

TECHNICAL PAPERS – *(Cont'd.)*

Thursday 5th July, 1973.

25.	Some Aspects of Avocado Propagation and Diseases Associated with Nursery Seedlings in Barbados.	R. D. Lucas.

Friday 6th July, 1973.

26.	Onion Blast Studies I. A Preliminary Report on Onion Blast Disease in Barbados. ...	L. W. Small
27.	Onion Production, imports, exports and Research for Puerto Rico.	G. C. Jackson.
28.	Onion Production in Barbados 1967 to 1973.	B. W. Eavis & W. deC. Jeffers
29.	A Preliminary Report on the Comparative Performance of Some Southern Type Varieties and Hybrids of Onions in U.S. Virgin Islands. ...	R. Shulterbrandt & D. S. Padda.
30.	Onion Growing in Jamaica.	J. H. Donaldson
31.	Primary Evaluation of new Unregistered Pre-emerge Vegetable Herbicides. ...	G. C. Jackson & C. Sierra
32.	System for Field Measure of Erosion, run off, and Oblique Drainage in Ferrallitic Soils on Granitic Matrices in French Guyana. ...	P. Blancaneaux.

RESEARCH NOTES

The following papers upon recommendation by the editors have been included in the proceedings under Research Notes.

33.	The Evaluation of Cabbage *(Brassica oleracea* var capitata) Varieties in the Leeward Islands. ...	St. C. M. Forde

ADDRESS BY THE PRESIDENT OF THE CARIBBEAN FOOD CROPS SOCIETY MR. W. DeC. JEFFERS AT THE OFFICIAL OPENING OF THE ELEVENTH ANNUAL CONFERENCE AT MARINE HOUSE, HASTINGS, BARBADOS ON MONDAY 2ND JULY, 1973.

Hon. Minister of Agriculture, Science and Technology, Mr. DaCosta Edwards, Colleagues sharing the platform with me, Delegates to this Eleventh Annual Caribbean Food Crops Society Conference, and Guests, I mentioned when introducing our first speaker that one of my functions as President of this Society was to perform the duties of Chairman to this official opening session. There is also another function which, as President, I have to perform, and those of you who are familiar with the Constitution and By-Laws of this Society will know what I mean. For those who are not familiar with the Constitution and By-Laws I will quote the relevant section. Article S, Officers, Section 3, President, reads "The President shall be the chief executive officer of the Society and shall be *ex officio* a member of the Board of Directors. He shall have the general powers of supervision and management usually vested in his office subject, however, to the right of the Board of Directors to delegate any specific power or powers to any other officer or officers of the Society. *The President shall deliver an address at the Annual Meeting of the members* and shall perform such other duties and have such other powers as may be prescribed by the Board of Directors, any duly constituted committee, or the by-laws.

I trust you will pardon the detail but I have done this specifically to let you know, that in fact, it is not a love of mine to give addresses, but as I have taken pains to point out, it happens to be mandatory that I should address you.

This is not particularly difficult since for the most part I am flanked on either side first by my own Minister of Agriculture, Colleagues and friends on the platform, and I am facing an audience made up primarily of Caribbean Food Crops Society Members from abroad and from Barbados; local Agriculturists and Farmers; and other prominent members of our Barbadian Society. In other words I feel fairly well at home in the present company.

Secondly, apparently because of a general food shortage and rising prices looking at us full in the face, there appears to be a very sudden awakening to the fact that there is a profession called Agriculture, and at the moment there is a tremendous amount of lip service paid to all aspects, phases and sections of agriculture. Had these problems not descended upon us, Agriculture might well have remained as obscure as it always has, so that in fact, this food shortage might well turn out to be a blessing in disguise for all those engaged in the various agricultural enterprises.

Our daily paper on June 28, 1973 is quoted as saying "Apathy towards agriculture on the part of young people is evident in the Caribbean. Production is inefficient and marketing arrangements often fall flat, because supply cannot match demand as and when it is required." The question I raise here is the mention of 'Apathy towards agriculture on the part of young people'. In my opinion this apathy appears to spread from older people down to the young, and if the reasons for this were carefully examined and analysed, I am inclined to feel that frustration, inadequate storage, insecurity, lack of firm guarantees, difficulty in obtaining credit and other factors have all added up to turn interested persons to more secure rewarding and guaranteed enterprises.

It appears obvious to anyone travelling through the Caribbean that Agriculture is in fact facing difficult times. One cannot help but notice the drastic reduction in cultivatable land in just about all of these islands, and this at a time when food is becoming less and less, and as a result prices are going up and up. I am mindful of a statement recently quoted in the local papers purported to have been made by the Carifta Secretary General, Mr. William Demas while addressing a Rotary Convention in St. Kitts. The statement reads as follows:— "We in the Caribbean today are making a very serious mistake in turning our backs on Agriculture and not giving it sufficient attention, because we cannot have a soundly based economy until Agriculture is developed." Ladies and Gentlemen I can only say that I fully endorse that statement. However I further add, that it is going to take a lot more action, real assistance, and less talk to properly develop agriculture in our area.

Some of you will probably be asking the question right now, how can this Caribbean Food Crops Society play a role in the future development of agriculture in the Caribbean? I could probably best answer such a question by quoting from the objectives of the organisation which reads as follows:—

"The objectives of the Caribbean Food Crops Society are: to advance Caribbean food production and distribution in all their aspects to the end of improving levels of nutrition and standards of living in the Caribbean through:—

(a) facilitating exchange of material and of information on all aspects of food production, processing and marketing in the Caribbean area.

(b) stimulating and presentation of information available on food crop production, processing and marketing of food crops in the Caribbean area.

(c) assisting in the general dissemination of information on the production, processing and marketing of food crops in the Caribbean area.

(d) provide a regional consultant service in food crops for the Caribbean area.

(e) maintaining close contact with research problems and progress in the fields of food crops production, processing and marketing.

(f) working towards the coordination of research and development programmes and the optimum use of the resources available in the Caribbean area stimulating the development of joint projects of research or development where such projects can be of value to the region as a whole.

(g) cooperation with organisations dedicated to the fostering of cooperation between countries of the Caribbean area."

Ladies and gentlemen these are all laudable objectives, no one can deny. It must however be remembered that every member has in many cases more than one job to perform, and can therefore devote only a limited time to the business of this organisation. This is where some of the business organisations in the area can assist. Provision is made for sustaining membership. Sustaining membership shall consist of individuals or organisations contributing to the support of the Society. The annual subscription is One Hundred Dollars U.S. This kind of support will help us to accomplish some of our objectives as set out. I should add here that Barbados is one of the few Caribbean Governments that is a sustaining member and has paid the annual dues regularly, I would like to see other Governments do likewise, it would certainly help the Society.

I am also quite concerned over the fact that this Caribbean Organisation should in fact be far more useful to the smaller Caribbean Territories than it has been. In these Territories General Agriculturists in many cases are expected to perform as jack of all trades. The moment food production intensifies so also do the disease problems Nematode problems, Virus problems, Insect problems etc. etc. It seems to me that to involve these Generalists with the appropriate specialists could only result in tremendous benefit to the Generalists. I therefore would urge more representation from the smaller territories. This does not mean however that the larger territories should usurp the organisation, in my opinion the personal contact of research workers permits for an exchange of views, a comparison of programmes etc. etc.

I am aware that smaller territory representation is very often governed or dependant upon finance. Again in my opinion it is likely to be far more beneficial for smaller territories representatives to become more familiar with other Caribbean Agriculture, than Scottish, English, Canadian or United States Agriculture. Where there is a will there is a way, and a source of funds should be found so that these smaller territories can obtain some benefit from these Annual Meetings, by being able to attend.

Mr. Minister, Delegates, Guests, I have performed by function, I have delivered my address. Before taking my seat I must resume as chairman and introduce the next speaker, who will in fact be giving the feature address. Before the introduction however I must join with my Minister in extending to you a cordial welcome and I trust that your stay in Barbados will be fruitful, rewarding and enjoyable.

REFLECTIONS ON AGRICULTURAL EXTENSION IN THE COMMONWEALTH CARIBBEAN

by

C. K. ROBINSON

(Dean, Faculty of Agriculture, St. Augustine)

INTRODUCTION

According to the Food and Agriculture Organisation of the United Nations, "Agricultural Extension is essentially an informal educational process and its purpose is to change attitudes and practices of the people with whom work is done. It makes available to rural people scientific and other factual information".

In the United States where perhaps it has been most highly developed[1] "Cooperative Extension work in agriculture is a partnership undertaking between each State Land-Grant College and University and the United States Department of Agriculture, in cooperation with local governments and local people. Extension is a unique service of three levels of government permitting maximum flexibility and adaptation to local conditions and needs while carrying out a hard core of purposes, objectives and focus.

"The major function of the Cooperative Extension Service, as stated in the Smith-Lever Act, is 'to aid in diffusing among the people of the United States useful and practical information on subjects relating to agriculture and home economics, and to encourage the application of the same'. This broad charter clearly identifies Extension's function as education. This is not education in the abstract, but education for action. It is education directed to helping people solve the various problems which they encounter from day to day in agriculture, home economics, and related subjects."

1. Miller, P. A. *et* al: *The Cooperative Extension Service Today: a statement of scope and responsibility.* USDA, Washington. 1958.

This educational work has been called agricultural extension in some countries while in others it is known as agricultural advisory work or, in a broader sense, as community development, rural construction or reconstruction, fundamental education, or mass education. Broad programmes of community development, etc. include agricultural extension as well as nutrition, health, sanitation, literacy and cooperative development.

Paul Leagans[2] of Cornell University has pointed out that "the entire theory and practice of education extension in the United States appears to hinge on ten central or normative concepts which can be rather precisely stated:

"1. The supreme and central function of the extension service is to promote the development of people economically, socially and culturally by means of education.

2. The essential purpose of extension teaching is to facilitate among people a grasp of the meaning of knowledge, to help them see its connection to their problems, and to help them to develop skills needed to apply useful knowledge to their problems.

3. The extension service must be understood, conducted and judged as an educational instrument.

4. The extension service must be organised to provide educational services for large numbers of people who need them and to respond to their needs without restriction, to the extent of their resources.

5. The extension service must be operated in close continous mutual relationship with the people it serves.

2. **Leagans, J. Paul: *Developing Professional Leadership in Extension Education.* Cooperative Extension Publication No. 3, Cornell University, New York.**

6. The extension service must seek to achieve its purpose by initiating, stimulating and guiding the process of education.

7. The extension programme must be oriented and organised to deal with the current practical problems of people and also with those of a long-term nature.

8. The extension service must be an institution in which those whom it serves derive satisfaction from their participation.

9. The county extension staff must be viewed as occupying the central position in the organisation and conduct of extension work.

10. The programme of training for extension workers must be designed to develop competent technicians who are effective educators."

It is a truism that "extension work grew out of a situation. It has come to be a system of service and education". It would be useful to take a quick look at how it developed in various countries relevant to the situation in the Caribbean.

EVOLUTION OF AGRICULTURAL EXTENSION SERVICES

EUROPE

A Working Party[3] appointed by the Organisation for European Economic Cooperation (OEEC) in 1950 stated that "in several European countries the origin of Agricultural Advisory work dates back over one hundred years. In its initial phases it was not organised in accordance with present day concepts but was concerned largely with the efforts of outstanding and progressive individuals. From 1840 onwards, travelling teachers of agriculture were found in many countries. Organised Advisory Services were initiated in most cases after the beginning of the present century and came into being largely through the intervention of governments or farmers' organisations. Their advent was due to a recognition of the economic need to bring scientific advances in agriculture into farm practice. This marked the change from the pre-scientific to the scientific age in the field of agriculture and rural welfare".

The term "Extension Education" was used to describe a particular educational innovation by Cambridge University as early as 1873. This innovation was to take the educational advantages of the university to ordinary people where they lived and worked. Within a decade or so the movement had spread to other institutions in Britain, the United States of America and elsewhere. The first grants to the extension movement from public funds, in this case from the English County Councils, were for extension lectures in agricultural science.[4]

The Agricultural Advisory Services established in most European countries at the beginning of this century differ in regard to organisation,

3. **Working Party of Experts: *Agricultural Advisory Services in European Countries*. O.E.E.C., Paris. 1950.**

4. **Farquahar, R. N.: *Comparative Agricultural Extension, Melbourne*. C.S.I.R.O., Australia. 1962.**

field of activities, staff and efficiency.[5] The services in the different countries have been very much affected by historical, economic and social conditions prevailing at the time. Two different systems of organisation can be distinguished, namely, a system entirely managed and directed by the government, as in the case of England and Wales, and a system managed by growers organisations and agricultural societies as in the case of Denmark; transitional systems between the two being found in several other countries.

Agricultural extension in England and Wales is the responsibility of the National Agricultural Advisory Service* which was established in 1946 in the Ministry of Agriculture and Fisheries. The NAAS has connection on the one hand with the Research Centres and on the other with the Agricultural Education Service of the Local Authorities. Research in England and Wales is mainly financed and coordinated nationally, but the actual research is entrusted to grant-aided universities and other institutions. The Agricultural Research Institutes are grant-aided institutions organised on a subject-matter basis: horticulture, plant breeding, plant pathology, etc. The NAAS also maintains Experimental Husbandry Farms and Experimental Horticultural Stations to test out under various soil and climatic conditions the results obtained at the Research Institutes and to incorporate them into practical farming.

Agricultural advisory work first received financial support from public funds in 1910 and universities and local education authorities both supplied services, the universities and agricultural colleges supplying provincial specialist services and the local authorities general advisory services. The Luxmoore Committee in 1943 severely criticised both the county and the provincial services and recommended the establishment of one national agricultural service for England and Wales. It proposed that a

5. *Methods of Agricultural Extension.* Training Centre organised by the International Agricultural Centre in collaboration with FAO and the Natural Security Agency. *Wageningen, the Netherlands.* 1953.

* Since May 1971 renamed the Agricultural Development and Advisory Services, with some services removed and development functions added.

"district" of not more than 1,000 farms or 100,000 acres should be the primary unit, each with a "general practitioner" district advisory officer having a sound knowledge of basic sciences and farm practice including farm management and farm accounting. The county was the next unit with a general county officer to coordinate the work of the district officers with the aid of county specialists. The specialist services continued to be based on the province. A recommendation that all agricultural educational and advisory programmes be placed under a National Council for Agricultural Education was not accepted and agricultural education was treated as part of further education generally, a responsibility of the local authorities.

At present, the NAAS has to cover the whole of England and Wales and to provide a nearby point of contact for every farmer and grower. The majority of the 1,500 members work in countries and regions. An adviser can expect to spend several years at each of a number of different NAAS centres. The Director, Deputy Director, and senior advisers are stationed in London but do a good deal of travelling.

There are seven Regional Offices and three sub-centres, each region having at its head a Regional Director, a deputy and a large staff of subject-matter specialist officers in the various applied science fields, husbandry, horticulture, and farm and horticultural management, as well as a number of officers who give technical help on demonstrations, experiments, and in regional laboratories, but are not engaged in advisory work. The services of the specialists are available as consultants to all advisory staff in the counties of the region and they travel all over the region to investigate problems on the spot in response to requests for advice.

In each county, there is a Senior Agricultural Adviser, usually a general agriculturist, a deputy and a number of specialist advisers, all based in the county office. The county is divided into a number of districts, each under a District Agricultural Adviser who may be based in the County Office or an Area Office. The average size of a district is about 500 holdings of over 15 acres each. The District Adviser is in direct contact with the farmer and is the main channel for NAAS advice and through him the contributions of the various specialists can be integrated and the farmer given a coherent plan.

The NAAS undertakes a large experimental programme as a basis for its advice, with two main fields of activity: experimental centres and regional and county investigations. There are twenty odd experimental husbandry and horticulture stations in different parts of the country. These conduct long-term and detailed crop and livestock experiments and investigate local problems. With the help of cooperating farmers, the NAAS carries out many experiments and trials on commercial holdings in the county. Regional specialists have their own investigational plots at the regional centres and both specialists and advisers collaborate in planning the experimental work for each region. The results are printed and made available to every member of the NAAS.

The various groups of specialists keep in touch with university research workers as well as with the various Agricultural Research Council Institutes.

Although the NAAS is part of the Ministry of Agriculture, it does not act as an advocate of Government policy and all members are given full freedom to give the technical and economic advice they think best suited to the circumstances of the particular farm or holding. However, the Ministry looks to the Service for technical help in connection with various grant-aided schemes. They are responsible for a number of regulatory and statutory schemes such as bull and boar licensing, the Milk and Dairies Regulations, the Small Farm (Business Management) Scheme, the Farm Business Recording Service and the Farm and Horticultural Improvement Schemes.

UNITED STATES OF AMERICA

The Morrill Act of 1862 ushered in a new era in American agricultural education. This Act provided land grants to each state for the endowment, support and maintenance of at least one college where the leading object should be to teach agriculture and mechanic arts. The programme was revolutionary in that it added subjects to the curriculum never before considered worthy of university education; it was designed to provide higher education and training for the industrial classes and it involved a new conception of the function of higher education in society.[6]

This was followed in 1887 by the Hatch Act which established the Agricultural Experiment Station system. Then, as research accumulated which was not being put to practical use by farmers, the Cooperative Extension Service came into being with the passage of the Smith-Lever Act in 1914. This Act established the base for what has become the world's greatest agricultural extension programme.

According to M. O. Watkins, Director, Florida Extension Service, it was found through trial and error over the period 1862 to 1914 that there must be the closet coordination and working relationships between Teaching, Research and Extension and to the present time no substitute for this close tie has been found.[7] The Smith-Lever Act requires the Extension Services to be attached to and form a basic part of the university system. In the University of Florida, the extension subject-matter specialists are members of their subject-matter departments and are partially responsible to a department Chairman who heads Teaching, Research and Extension and one of whose major responsibility is to ensure that the information being taught by the classroom teacher and distributed by the extension specialist is consistent with the research results obtained on the Experiment Station.

The close working relationship between specialists and research workers makes possible an exchange of information between the researcher and the extension worker. The extension specialist communicates with the researcher as problems are encountered in the field for which no research information is available and the researcher

6. Farquahar, R. N.: Op. cit. p. 113.

7. Watkins, M. O.: Paper presented at the Caribbean Agricultural Extension Conference, University of the West Indies, 1966. p. 1.

keeps the extension specialist informed, not only on new research, but also on research in progress and the indicated results. In this way, there is no lag in time between the release of new information and its dissemination by extension specialists to local extension agents and, in turn, to the users of the information, i.e. the producers. In Florida, it is considered extremely important that the extension subject-matter specialist be as highly trained as his counterpart in research or in teaching. The minimum requirement for an extension specialist is the M.Sc. degree and seldom is one employed without a Ph.D. In this way, there is no barrier between research and extension in the communicating of knowledge, no feeling that the extension specialist is not academically prepared to analyse the information and to put it to pratical use.

Dr. Watkins also stressed that there is need for advanced training of county extension agents. The county agent is the local extension worker. He is the front line worker in direct contact with the farmer. In Florida, the county agents are specialised and likewise assistant agents: they are specialists in citrus, vegetables, dairy, etc. The new assistant agent must hold the Masters degree or be registered in Graduate School before employment. This advanced training is necessary where farmers are specialised and have a high level of education themselves, though even in Florida there are many farmers who are not specialised or highly educated.

The guiding principle of Extension workers in the United States has been to help people to help themselves. It "operates informally, in line with the most important local needs and opportunities, and with respect to both short-term and long-term matters of concern. It joins with people in helping them to identify their needs, problems and opportunities; study their resources; become familiar with specific methods of overcoming problems; analyse alternative solutions to their problems where alternatives exist; and arrive at the most promising course of action in light of their own desires, resources and abilities. In so doing, extension workers bring to people the pertinent research information available; interpret and demonstrate its application to the immediate situations involved; and, through the most effective methods known, encourage the application of such research in solving problems. At all times, the widespread participation of the people is stressed in both planning and conducting these informal educational efforts".[8]

THE COMMONWEALTH CARIBBEAN

In common with most developing countries, the evolution of institutions and services in the Caribbean has been largely influenced by the pattern of developments in the metropolitan countries. In Puerto Rico, the Extension Service has followed the pattern of the Cooperative Extension Service of the United States while in the Commonwealth Caribbean the tendency has been to follow that of Britain, i.e. to separate extension from teaching and research and to place extension in the Ministries of Agriculture.

In order to understand this process, it is instructive to trace the evolution of government agricultural services in the Commonwealth Caribbean in response to the needs of the region. This account must of necessity be rather sketchy and of a general nature, but I think it will suffice for our purposes. The account that follows is largely based on Chapter 1, The Historical Background, and other Chapters of *Agriculture in the West Indies*[9] and various articles appearing in the *West Indian Bulletin* between 1900 and 1921, in particular the President's address given at the Agricultural Conference of 1899,[10] the first agricultural conference held in the West Indies; a review of the work of the Imperial Department of Agriculture up to 1911 by Sir Daniel Morris;[11] and an

8. Miller, P. A., *et al:* Op. cit. p. 4.

9. Colonial Office, Colonial Development & Welfare in the West Indies: *Agriculture in the West Indies,* Colonial 182, HMSO, London, 1942, pp. 1–10.

10. Agricultural Conference 1899: "The President's Address", *West Indian Bulletin,* Barbados, Volume 1, No. 1, 1900, pp. 11–25.

11. Morris, Sir Daniel: "The Imperial Department of Agriculture in the West Indies", Op. cit., Volume XI, No. 4, 1911, pp. 232–248.

article on tropical departments of agriculture by Sir Francis Watts which carried the account of the work of the Imperial Department to 1921.[12]

The original Carib and Arawak Indian inhabitants of the Caribbean region practised shifting cultivation of food crops, probably not greatly different from that still followed by latter day Mayas and Caribs of Belize (ex-British Honduras) and the Arawaks of Guyana (ex-British Guyana). These were quickly more or less exterminated by the European settlers and their farming practices have had little or no effect on the development of agriculture in the area.

West Indian colonisation, first by the Spaniards commencing in the early sixteenth century and by the British, French and Dutch about one hundred and fifty years later, was due, in part, to the demand for what were then rare and valuable commodities, particularly sugar, tobacco and spices. Sugar cane cultivation early became the main industry. To provide the labour required many thousands of Africans were imported as slaves. For obvious reasons, they also contributed little to farming practices and agriculture was based on the practices current in Spain, England, France and Holland at the time of colonisation modified to meet the requirements of sugar cane and other crops. West Indian agriculture consequently did not keep pace with developments in Europe and consequently did not benefit from the agricultural revolution in Europe with its development of rotational mixed farming and alternate husbandry which later occurred there

For about two hundred years the production of sugar and coffee brought great wealth to the Colonists and there was considerable exploitation of the land resources of the Colonies by the settlers and absentee proprietors. Food production was mainly for and by the slaves, most of the food requirements of the settlers being imported. Shifting cultivation was practised by the slaves on the lands allotted to them for food production in the mountains or "bush".

12. Watts, Sir Francis: "Tropical Departments of Agriculture With Special Reference to the West Indies", Op. cit., Volume XVIII, 1921, pp. 101–125.

The abolition of the slave trade in 1807 and the emancipation of the slaves in 1838 transformed the position and led to the abandonment of many of the less productive estates. On the better estates, cultivation was still profitable due to heavy fiscal protection in the United Kingdom and continued with paid labour, mainly immigrant labour including Portuguese, Chinese and East Indians, the latter continuing under a system of Government controlled indenture until as late as 1917. The East Indians brought with them many of the traditions and practices of Indian agriculture, including rice cultivation and Indian cattle. The Portuguese and Chinese immigrants appear to have had little or no impact on agriculture in the region; in fact, they showed considerable aptitude in moving out of agriculture as soon as they could into the more remunerative distributive and other service industries. This would seem to have been a bit of a waste as the Chinese in particular, with their tradition of four thousand years of farming behind them, could have made an important contribution to farming in the West Indies, especially to the agriculture of food production.

With the development of free trade and *laizez-faire* in Great Britain, the Colonies experienced fresh difficulties. The protective sugar duties were progressively reduced and finally abolished in 1856 and the Colonies were forced to compete on the open market with sugar grown with slave labour from Cuba, Puerto Rico and Brazil. The sugar industry consequently declined even further, going out completely in some islands. Elsewhere, more estates went out of cultivation and many small properties were amalgamated. More attention was paid to alternative industries: cocoa in Trinidad and Grenada, bananas in Jamaica and cotton in some islands during the American Civil War. During the ensuing thirty years, the sugar industry declined still further: European beet sugar fostered by bounties and cartels replaced cane sugar on the British market and prices fell to a very low level. For a time the United States had become the principal market for West Indian sugar due to the imposition of countervailing duties against the European countries but this market was lost with the McKinley tariff of 1898. To add to its difficulties, the sugar industry suffered from the breakdown between 1890 and 1895 with root disease of the Bourbon cane which had been grown for over a century in these islands. The end of the nineteenth century saw the West Indian colonies in acute distress.

During this period, there had been a slow development of government agricultural services. The first step appears to have been taken in 1764 with the establishment of the first Botanic Garden in the British West Indian Colonies in St. Vincent and in fact in the British Overseas Territories, with the object of facilitating the introduction and acclimatisation of useful plants. The Royal Society of Arts and the Royal Gardens at Kew which had been established in 1760 appear to have been largely instrumental and took a keen interest in further development along these lines in the area. In 1772, a Dr. Young who was then in charge of the St. Vincent Gardens was awarded a gold medal by the Royal Society in recognition of the flourishing state of the Garden.

This development in St. Vincent appears to have stimulated action in Jamaica. Dulcie Powel in *The Botanic Garden, Liguanea*[13], states that "when the English took Jamaica from the Spaniards in 1655, they inherited, along with its native products, such Spanish imports as sugarcane, bananas and plantains, European vegetables, oranges, limes and ginger. Coffee they introduced some seventy years later. In 1774, Long, in the *History of Jamaica,* bemoaned the fact that there was no botanic garden in Jamaica which could introduce new vegetable products into the island. He expressed surprise that the gentlemen of Jamaica should allow the small island of St. Vincent to be ahead of them in starting such an establishment. Long seemed to have stimulated the local gentlemen and, in 1777, Dr. Thomas Clarke was appointed the first Island Botanist. He brought with him a considerable number of plants well adapted to the two gardens proposed: one as a European and the other as a tropical garden". It was not, however, until 1779 that the first government botanic garden was started in Bath in the parish of St. Thomas. There was also at that time the Spring Gardens, privately

13. **Powell, Dulcie: *The Botanic Gardens, Liguanea.* Institute of Jamaica, Kingston, Jamaica. 1972.**

owned by Mr. Hinton East at Garden Town in the parish of St. Andrews. It was Mr. East who wrote to Sir Joseph Banks, then in charge of the Royal Gardens at Kew, in 1784 that "the acquisition of the best kind of Bread Fruit would be of infinite importance to the West Indies in affording exclusive of variety, a wholesome and pleasant food to our Negroes, which would have this great advantage over the Plantain Trees from whence our slaves derive a great part of their subsistence, that the former would be raised with infinitely less labour and not be subject to be destroyed by every smart Gale or Wind as the latter are". Arising from this correspondence and subsequent discussion in England with Sir Joseph Banks and the interest of Dr. Anderson at the Botanic Garden in St. Vincent, Captain William Bligh was sent out in the "Bounty" on his ill-fated first voyage to fetch these and other plants from the South Seas to St. Vincent and Jamaica. The second expedition of Captain Bligh to the South Seas was successful and the breadfruit, Bourbon cane and other plants introduced into St. Vincent and Jamaica in 1793. As a footnote to this event, Sturge and Harvey in *The West Indies in 1837* wrote "We breakfasted at the house of an old gentleman of the name of Wiles who was botanist on Capt. Bligh's expedition and came with him to Jamaica fortyfour years ago. He was induced by the assembly to remain and to undertake the superintendence of the Botanic Garden (at Bath), formed for the reception of the plants which they had brought.....He told us that the breadfruit tree has not succeeded so well as had been anticipated. It trives in moist situations, but never reaches the luxuriant growth of its native climate. The most valuable tree, he said which has been introduced in Jamaica in recent times, is the mango: a few plants of which were taken out of a French prize captured about half a century ago by Lord Rodney. It has spread with great rapidity, and is now found in every part of the island; the fruit, which it produces in very great abundance, forms a dessert for the whites and food for the negroes, as well as for cattle, horses, and hogs". The reference here is to the French ship captured by Rodney's squadron in 1782 while on its way from Mauritius to Hispaniola with a consignment of plants including spices and mango which were presented to the Botanic Gardens in Jamaica and St. Vincent by Rodney.

Under the influence of Kew, Botanic Gardens were also established in British Guiana and Trinidad between 1820 and 1860 and placed under the charge of officers trained in botany and horticulture at Kew. The gardens in St. Vincent, however, was closed down in 1830 and as many plants as possible transferred to Trinidad.

The serious decline of the sugar industry towards the end of the ninteenth century led to serious consideration of the economic prospects of the Colonies and to the possibility of introducing other industries which might assist in supporting some of the Colonies even if they did not entirely replace sugar. The gardens had already proved their value by the introduction of many useful plants, notably additional varieties of sugar-cane, including the White Transparent which later was to replace the Bourbon cane when it broke down with disease.

In 1884, Mr. Donald Morris, then Director of the Botanical Department of Jamaica, had submitted proposals to the Colonial Secretary of Jamaica for the formation in each of the smaller islands of small botanical establishments which should be placed under the direction of some local officer and that they should serve as centres from which could be distributed such plants as might be successfully introduced and could be considered as the basis of new industries.

In 1885 Sir Joseph Hooker of Kew expressed the opinion that there could be no doubt that the future prosperity of the West Indies would be largely affected by the extension to the other islands, unprovided with any kind of botanical establishment, of the operation, so successfully pursued in Jamaica. It was also proposed that in addition to distributing plants, these central institutions should organise a regular system of botanical bulletins containing practical hints on the treatment of economic plants and the conditions under which they might best be utilised.

As a result, in 1887 Botanic Stations were established in Grenada and St. Lucia and one at Dodd's in Barbados where experiments with sugarcane breeding and other experiments had already been started by

Professor Harrison and Mr. J. R. Bovell. This latter was the first experiment station as such in the West Indies. In 1890, one was established in St. Vincent on part of the site of the old Botanic Garden and Stations were also established in Antigua (1890), St. Kitts (1891), Dominica (1890), and Montserrat (1890), while a chemical laboratory largely devoted to agricultural problems was established in Antigua.

According to Sir Francis Watts, "this period marked a definite advance towards the development of scientific agriculture in the West Indies. The botanical establishments thus created were closely associated with Kew and marked the transition period from botanical establishments to experiment stations; they were useful in that they paved the way for later developments."

The Royal Commission 1897

The worsening of the general economic conditions led to the appointment of the first Royal Commission to enquire into the conditions and prospects of the sugar-growing West Indian colonies, at the end of 1896. The Commission visited the West Indies in 1897 and reported in the same year:

"Briefly the position then was that, in all colonies where sugar was the principal industry, conditions were extremely bad, standards of cultivation had been reduced and fertility exploited to the utmost; manufacturing methods were inefficient, and although in British Guiana Trinidad, and St. Lucia sugar factories had been established many of them were poorly equipped; elsewhere only muscovado sugar was made with its attendant great losses. Sugar properties without exception were heavily encumbered with debt and on the verge of bankruptcy. In Trinidad, Grenada, and Jamaica conditions were better, owing to the extension of cocoa cultivation in the two former and of banana growing in the latter. In Dominica prosperity was increasing owing to the extending cultivation of limes. Elsewhere the blackest depression was universal.

"Except in Jamaica and to a less extent in Trinidad and British Guiana peasant land ownership was negligible. It was fortunate that at that time there were considerable outlets for surplus population by emigration to the United States, the Panama Canal Zone and elsewhere in Central America which served to relieve to some extent the all pervading poverty and distress."

The Royal Commission concluded that (a) if these conditions persisted much longer the sugar industry of the West Indies would be destroyed and, since it appeared that no other agricultural industry could completely and satisfactorily replace it, this would have a profound effect on the Colonies; (b) the British Government should make all possible efforts to secure the abolition of the sugar bounties; (c) every effort should be made to secure greater diversity of production in West Indian agriculture; (d) provision should be made by the British Government to enable peasants to acquire land, particularly in St. Vincent; (e) a department of scientific agriculture for Barbados, the Windward and the Leeward Islands should be established which would have advisory functions in relation to the other larger colonies; the cost for the first ten years to be met from Imperial funds.

The Imperial Department of Agriculture

The Imperial Department of Agriculture for the West Indies was established in 1898 with Dr. (later Sir) Daniel Morris as Imperial Commissioner with headquarters in Barbados. Other staff included a mycologist and an entomologist, the first Colonial appointments of this kind ever made. The Department assumed charge of the existing agricultural services mainly the Botanic Stations previously mentioned in Barbados, the Windward Islands, and provided a series of grants from Imperial Funds for experimental and development work in the larger territories.

Botanic Gardens and Experiment Stations

The Royal Commission stated that botanical institutions in the West Indies had played an important part in improving agricultural industries and were capable of being made increasingly useful. Twenty years ago there were only three (British Guiana, Jamaica and Trinidad) such institutions in existence but now, owing to the organisation of the Botanic Stations there were thirteen of these institutions.

As the Colonies of Jamaica, Trinidad and British Guiana were in a position to maintain their own botanical establishments, no grants-in-aid were given them. The Botanic Stations of Tobago, Grenada, St. Vincent, Barbados, St. Lucia, Dominica, Montserrat, Antigua, St. Kitts-Nevis were placed under the direct charge of the Imperial Department and the cost of maintaining them paid from Imperial funds. They were to devote themselves in a systematic manner to the work of introducing, propagating and distributing all the promising economic plants of the tropics, including the improved varieties of sugar-cane. They were to act as centres for diffusing information and as training institutions and the headquarters from which agricultural instructors would be sent to give lectures and demonstrations on the selection of land for tropical economic plants, their suitable cultivation and the best methods for curing and packing the produce.

Agricultural Instructors

In regard to agricultural instructors, Dr. Morris said that considerable experience had shown that it was not sufficient to provide Botanic Gardens and Experimental Stations to influence the large body of cultivators in the West Indies. They must be reached in a more direct and effective manner. The first attempt to employ travelling instructors had been made on his recommendations in Jamaica in 1891 when two cocoa instructors were appointed: the results had fully justified the use of this method of assisting in the development of rural industries. He cautioned that great care was necessary in selecting men possessing the necessary qualifications and considered that in Dominica, St. Lucia and Grenada a knowledge of the local *patois* would be an advantage. He indicated guidelines for their *modus operandi:* it was important to arrange beforehand with the leading personages in each district, so that the people would be prepared to receive the instructor and made thoroughly acquainted with the objects of his visit. A public meeting was a useful first step to be followed by visits to gardens and cultivated areas when he would be able to give practical demonstrations in the right methods of preparing the soil, in draining and manuring and in putting out the plants in a neat and suitable manner, and so on. The directives could hardly be bettered today.

An agricultural instructor was attached to each Botanic Station and an officer with similar training attached to the Agricultural Schools and where it was not possible to attach an instructor, the Curator in charge of the Botanic Station was required to undertake the duties. In addition instructors or experts with special experience in various aspects of agriculture were required to spend a month or two in each island. Dr. Morris felt that for some years to come the peripatetic instructors had to be relied upon "to carry out the large share of training necessary amongst the adult population of the community. In spite of the disadvantages incidental to their isolated position, these people are not slow to follow the advice given them once they are convinced of its practical utility and of its direct bearing upon their future welfare". If only all agricultural extension officers could be made to believe this!

Dissemination of Information

In addition to the employment of travelling instructors, the problem of isolation of the agriculturists was tackled by preparing and distributing bulletins, handbooks and leaflets. The principal publications were the *West Indian Bulletin,* a quarterly scientific journal containing matters of general scientific interest; the *Agricultural News,* a fortnightly review of the Department, dealing generally with agricultural matters with special reference to the West Indies; the pamphlet series of small booklets dealing in a popular manner with subjects of interest to agriculturists in the West Indies, including the sugar-cane experiments, insect pests, fungus diseases, the cultivation of cotton, onions, tobacco, limes, etc; leaflets issued as required; and annual reports on the Botanic and Experiment Stations and Agricultural Schools.

These agricultural institutions and services were steadily developed and by 1911, at the end of the first ten years of the life of the Imperial

Department, the botanical establishments in Barbados, British Guiana, Jamaica and Trinidad had been consolidated and organised into Departments of Agriculture, modelled on the lines of the Imperial Department and paid for out of their own funds. In most of the smaller islands Botanic and Agricultural Stations and education centres had been established under the aegis of the Imperial Department. Thus developed the first official agricultural services in the West Indies with modest provision for agricultural education and agricultural extension. The foundation was laid for the future expansion of these services.

1911–1921

During this period the West Indies recovered rapidly from the depression prevailing at the end of the nineteenth century. A large grant was made to the sugar industry by the British Government and the abolition of bounties eventually occurred in 1903. Cane-breeding work in Barbados was extended and supplemented with large-scale experimental work to improve cultural conditions. Central sugar factories were established in Antigua and St. Kitts-Nevis and the gradual conversion to central factories in Barbados was initiated. Sea-island cotton growing was introduced and rapidly replaced sugar-cane as the principal industry in Montserrat, St. Vincent and Nevis, and became an important subsidiary in Barbados, St. Kitts and Antigua. Lime cultivation rapidly increased in Dominica and St. Lucia. Although much of the development was in respect of estates, increasing attention was paid to peasant agriculture and land settlement on a considerable scale was established in St. Vincent.

Similar developments occurred in the larger colonies: cultivation of sugar-cane improved and new varieties were introduced and sugar factories improved with new machinery. In Jamaica, banana cultivation expanded rapidly under the stimulus of food prices in the United States and began to assume a dominant position. In Trinidad, the cocoa industry similarly expanded, on both estates and small holdings. In British Guiana, rice cultivation on abandoned sugar lands by immigrant Indians expanded considerably and rice exports began.

So successful was the Imperial Department that the British Government in response to popular demand decided to continue its work in the smaller territories by a series of diminishing grants which terminated in 1921. By that time, the 1914-18 war had caused an unparalleled increase in prices and in the immediate post-war years the colonies reached "a zenith of prosperity which had not been equalled since the abolition of slavery". This period of prosperity was short-lived, however, and by 1921 decline in prices commenced and another period of depression was ushered in.

West Indian Agricultural College

During the post-war period, agricultural services expanded considerably. In Trinidad, Jamaica, Barbados and British Guiana, staff were increased and their activities and services greatly expanded and many new lines of work undertaken. Greatly increased attention began to be paid to the needs of peasant agriculture. In the Windward and Leeward Islands, the Imperial Department of Agriculture was closed in 1921 with the termination of the Imperial grant-in-aid and its staff merged in the West Indian College, a grant-in-aid for the foundation of which in 1921 was made from Imperial funds on the understanding that it would continue to discharge the functions of the Imperial Department without any further addition to staff. This proved impracticable and these colonies received little in the way of advice or assistance up until 1928 when a special advisory branch of the College, which had been renamed the Imperial College of Tropical Agriculture in 1923, was established.

The steady increase in population led to the extension of peasant agriculture and this became more pronounced as the depression decreased: estate lands were increasingly sold or rented to small holders and there was a revival of interest in land settlement. The majority of the peasant holdings were small in size, usually two to three acres or less and devoted mainly to the growing of cash crops. Food production was still undertaken mainly on subsistence holdings in the mountain or bush under shifting cultivation.

The Royal Commission: 1938-39

The continued depression in the 1930s led to the despatch of yet another Royal Commission to the West Indies in 1938-39. Depressed economic conditions, the growing volume of unemployment, and the low standard of living of the masses of the people which had led to disturbances in a number of the colonies forced the metropolitan government once more to intervene. Conditions were not as bad as they had been at the end of the nineteenth century but political activity was at a greatly increased level and the clamour for independence was beginning to make itself heard.

The Royal Commission enquired into all aspects of life in the West Indies and made a large number of recommendations[14] for improvement. Agriculture, of course, received special consideration and among those of particular interest for our present purposes were:

"Recommendation 20

"Agriculture is the principal source of sustenance and wealth in the West Indies and the standards of life must largely depend upon intensive use of the soil. The outstanding agricultural need in the West Indies is the more intensive use of land with increased production of food in order to support a rapidly growing population. The most urgent need is the development of peasant agriculture, but substantial progress among both peasants and estates is dependent upon far reaching reform of the basic methods now in vogue. The practice of shifting cultivation by peasant farmers must be abandoned and replaced by an organised system of permanent mixed farming; the present policy of those larger proprietors who grow a single crop continuously must be modified by the development of mixed farming in a measure which will vary from place to

14. West India Royal Commission, 1938–39: *Recommendations.* Cmd. 6174. H.M.S.O., London, 1940.

place with local circumstances. Neither of these reforms can be successfully carried through until new knowledge, which is obtainable only by scientific investigation, is obtained. War conditions will give an opportunity of which advantage should be taken for making an immediate start with both measures of reform."

"Recommendation 21(b): Regional Research Centre

"The centralisation of all major research and investigation at the Imperial College of Tropical Agriculture which would thus add to its present functions the duty of serving as a research station for the West Indies. The money required for this extension of the function of the ICTA should be provided by Parliament, which should be invited to ensure the continuance of the scheme for a number of years. The work of the Colonial Agricultural Departments should be concentrated on local replications of the central investigations and on advisory and educational work."

"Recommendation 21(c)

"The provision at the Hope Agricultural School, Jamaica, of facilities for all the West Indian Colonies for agricultural education at the stage immediately preceding that of the Diploma course at the ICTA which should continue to serve all its present purposes."

Recommendation 21(d)

Provided for a series of enquiries and investigations including a comprehensive soil survey of the West Indies; topographical survey; survey of peasant agriculture and investigations of better peasant farming systems; survey of soil erosion and investigations of methods of soil conservation and maintenance of soil fertility; investigation of marketing of estates and peasant produce and of the possibility of joint action by all the Colonies in both marketing and the allocation of production of certain products; investigation of possible systems of mixed farming in connection with sugar-cane and other crops; survey of agricultural indebtedness and credit.

"Recommendation 22

"The investigations mentioned above will doubtless show the need for a scale of expenditure far beyond the resources available to the Colonial Governments. We therefore recommend that a substantial sum should be allocated by the Imperial Exchequer for this strictly agricultural work. Expenditure could begin as soon as the first of the surveys recommended has been completed."

"Recommendation 24: Land Settlement

"(a) The order of priority should be, first, the improvement of the husbandry of existing small-holders in the light of some of the enquiries in 21(d) above; then, the improvement of existing land settlements and the establishment of new settlements;

(b) Governments should not regard themselves as committed to freehold tenure but should experiment with both leasehold and freehold tenure,....

(c) Government should take powers for the compulsory acquisition of agricultural land needed for land settlement and similar purposes;

(d) It should be firmly impressed on settlers and others that, while credit facilities will generally be required in the early stages of any scheme of land settlement, their success depends in the last resort on their own exertions and that Government cannot continue to provide financial support indefinitely."

The implementation of the recommendations was entrusted to a Comptroller for Development and Welfare, appointed under the provisions of the Development and Welfare Act, for action in consultation with the Colonial Governments. His headquarters were in Barbados and his advisory staff of specialist officers included an Inspector General of Agriculture for the West Indies.

Development and Welfare in the West Indies

The implementation of the recommendations of the Royal Commission were, of course, limited by the financial resources made available to the Comptroller and these do not appear to have been over-generous. It was reported for instance that considerable sums had been made available under the Colonial Development and Welfare Act: since this Act was passed assistance in respect of agriculture and veterinary schemes totalling £2,250,000 had been approved up to December 31, 1944, out of a total assistance of £7,700,000 approved for the whole of the West Indies during that period: not a princely rate of expenditure, but it must be remembered that in the early days at least, the rate was to quite an extent limited by the absorptive capacity of the Colony and this in turn depended on the availability of trained staff. The total expenditure increased with time, of course, and amounted to a very substantial sum by the time the Colonial Development and Welfare organisation was wound up in recent years. Even so, assistance has continued to be given to the Associated States and Colonies by the Ministry of Overseas Development through its Development Division which replaced the C.D.&W. organisation and like its predecessors is located in Barbados.

The Colonial Development and Welfare Act itself represented a new departure in Colonial administration which had previously been based on the policy that the Colonial Government was responsible mainly for the maintenance of law and order and the collection of taxes in order to provide the administrative framework needed for the functioning of primary industries and the export of their products to the metropolitan government. Any development needed must be paid for out of revenue and the colonies must be self-supporting. The Colonial Development and Welfare Act on the other hand was explicitly based on the policy that the Colonies were being held in trust by the metropolitan country for the benefit of the inhabitants of the Colonies and that these should therefore be developed in the best interests of the inhabitants with the cost being met by the British Government, if necessary, pending such time as they could be granted their independence. The smaller territories in the West Indies in particular benefitted from the C.D.&W. Act and the assistance channelled through the Comptroller. Relatively large grants have been made available for infrastructure and institutional development.

With the emphasis placed on agriculture, and land settlement by the Royal Commission, particular attention was paid to their needs and special efforts made to organise and staff the Agricultural Departments adequately for these purposes. It can be said, I think, that the Departments are now reasonably well staffed bearing in mind the recurrent cost of maintaining these Departments in relation to the financial resources of the territories.

The larger territories, Barbados, Jamaica and Trinidad and Tobago, have fully staffed Government Departments of Agriculture, complete with administrative, research and extension officers. The research officers undertake mainly applied research and, except in the case of Jamaica, double as subject-matter specialists available for consultation and advisory work in collaboration with the extension staff.

Agricultural Extension in Jamaica

In Jamaica, extension development took a rather different course from that in the other territories. There the Jamaica Agricultural Society established in 1895 was responsible for agricultural extension from there until 1951 when the extension staff was transferred to the Department of Agriculture. The Jamaica Agricultural Society is a farmers' organisation financed by an annual subvention from Government and subscription from members' revenue from the sale of farm supplies to its members. By the time the service was transferred to Government, the Society had built up its extension staff to some 65 agricultural instructors, and it was the most highly developed agricultural extension service in the region. The subsequent history of agricultural extension in Jamaica is rather chequered. In 1955, an attempt was made to coordinate the programmes by the various government and other agencies engaged in adult education to form an integrated rural development programme. Some measure of success was achieved but conflicts between agencies and field staff of agencies inevitably arose. Moreover, it was found that the agricultural extension staff were not engaged primarily in educational work but were heavily burdened with regulatory and statutory work. This led to the reorganisation of the Extension Service in 1964: it was divided into Development and Advisory branches and the island divided into 33 ecological areas and staff redeployed accordingly. A further change took place more recently when the Extension staff was transferred to the newly established Ministry of Rural Land Development, formed by splitting the Ministry of Agriculture and Lands into two Ministries.* Extension staff were then redeployed to the development areas into which the island had been subdivided, each under the control of a Land Development Authority.

While it may be true that re-organisation may be only a more rapid phase in the continuous evolution of any organisation, the somewhat frequent and rather drastic changes to which the Extension Service of Jamaica has been subjected in recent years must have had a prejudicial effect on the Service and on the morale of its officers. The original organisation of the Extension Service in Jamaica is unique in the West Indies and appears to have been based on the pattern found in some European countries, e.g. Denmark.

In the other Commonwealth Caribbean territories, the organisation has so far tended to follow somewhat the British type of organisation: that is, the extension or advisory services, with possibly one exception, form part of the Agricultural Departments within the Ministries of Agriculture. In a typically small island like St. Vincent, the territory is divided into two areas on a geographical basis, i.e. the Leeward and Grenadines and the Windward, each under an Agricultural Officer. The areas are sub-divided into districts, again on a geographical basis with some prominent topographic feature acting as boundary lines; each district is under the charge of a Senior Agricultural Instructor with one or more Assistant Agricultural Instructors under him depending on

* More recently the two Ministries have been merged into one Ministry of Agriculture and the various services, including extension, re-organised somewhat.

the geographical size of the district, its topography, road communications, and number of holdings, typically 600 to 1,000 small-holdings of less than five acres each and one or more estates of 100 acres or more. Supporting this organisation are a number of research officers with access to a government experiment station and other specialist officers as well as headquarters administrative staff. Normally, the Senior and the Assistant Agricultural Instructors are resident in their districts. These are the front-line extension workers in direct contact with the farmers.

The clientele of the district staff are the 600 or so small-holders with holdings ranging from a half acre to usually not more than five acres. They are typically past the middle age, since very few young people stay on these small-holdings, and mostly illiterate or functionally illiterate.

The Assistant Agricultural Instructor is usually a young man recruited in the rural areas with some knowledge of farming but little formal education, rarely up to "O" level secondary education, and no formal agricultural training. The Senior Agricultural Instructor has probably been promoted "from the ranks" because of long service or he may have received formal agricultural training at the Jamaica School of Agriculture or the Eastern Caribbean Farm Institute. The Agricultural Officer is usually a young university graduate: UWI B.Sc. Agriculture or similar qualification.

It is easy to understand that considerable difficulty of communication could arise between the front line local extension workers and the small-holders. Personal contact has been extensively relied upon for passing on information to the farmers but this has obvious limitations: the district is large, topography and road conditions difficult, the farmer old, conservative and suspicious of innovations, the local extension worker poorly trained in agriculture and in the art of personal communication. It is hardly surprising that many local extension workers visit as few farmers as possible.

To be successful under these conditions, the local extension worker must have some tried and successful innovation to demonstrate to the small-holder or is in a position to bring in a subject-matter specialist to deal with specific problems. His life is a difficult one and he is frequently accused of driving around in a motor-car and refusing to "dirty" his hands. I do not know that trying to cover a large district on a donkey would be any more successful. A technique that has proved successful when there is some innovation which has been proved by research to be valuable is to persuade one of the more influential and progressive small-holder to permit a demonstration of the innovation, perhaps a new fertiliser mixture or plant protection measure, on his holding, guaranteeing him against financial loss and meeting all the costs additional to his normal practice. A successful demonstration impresses not only the farmer concerned but his neighbours as well.

Better education and training of the Assistant Agricultural Instructors would certainly help and it is encouraging to note that more of them are receiving training at the Farm Institutes in Jamaica and Trinidad. Also, the Agricultural Extension Department of the Faculty of Agriculture is assisting by mounting annual in-service training courses in the Windward and Leeward Islands for the junior agricultural staff.

Clearly, however, mass communication methods must be used if diffusion of information is to be successful on a large scale. The problem here, however, is that we know little about the communication process under West Indian farming conditions. We know the methodology and techniques that have proved successful in North America and Europe, but here in the West Indies we are dealing with a different type of clientele and experience so far has shown that methods successful in other areas may not be so under ours. The Extension Department of the Faculty has also recognised this problem and with the generous assistance of the Research Division of the Ministry of Overseas Development a Windward Islands Extension Communications research project is shortly to be undertaken under the direction of Dr. Thomas Henderson, Head of the Department. It is a two-year project and we hope to know a good deal of the communication process under West Indian conditions when it is completed.

Another factor which tends to militate against the success of extension work is that the local extension worker is frequently asked to undertake regulatory and service duties in addition to or instead of the educational work he should be concentrating on. Regulatory work such as is involved in the administration of agricultural legislation, e.g. plant protection legislation and subsidy payments, tend to bring the extension worker into conflict with his clientele for obvious reasons. Performing "service" functions for the farmer, especially the large landowner and other influential persons, also tend to cause conflict within the extension worker since, though he would like to please these influential persons in the interests of his work, he realises that he is being exploited as a cheap source of labour. Dr. Henderson has written a most interesting paper on this topic [15] and I heartily recommend it to anyone who is interested. Unfortunately, because of shortage of staff, agricultural administrators frequently require their front-line extension workers to undertake regulatory and service functions. They should clearly understand, however, that this can only be at the expense of the education function and is harmful to the Extension Service as a whole. These practices must be eliminated if the Service is to achieve its basic purpose of educating people to help themselves.

A complicating factor in all this is that the administrator may feel that the extension worker does not have sufficient to do or the extension worker himself may think so. This usually arises from the

15. Henderson, T. H.: *Conflicts in the Role of the Agricultural Extension Officer in the Windward Islands.* Extension Bulletin No. 1. Department of Agricultural Extension, UWI, St. Augustine.

fact that few Extension Services in the West Indies undertake Programme Planning and Programme Evaluation. As Dr. M. O. Watkins[16] emphasised "there is no substitute for planning with the people on what they wish to accomplish. A programme is pretty sterile and there is not much interest or enthusiasm for carrying out a campaign to get something done which the people are not interested in. We therefore spend a great deal of time trying to find out from the people what they consider their problems to be, what their goals and objectives are in agriculture, and then attempt to structure a programme which will solve these problems and help the people to reach these goals". Unfortunately, Programme Planning and Evaluation has been neglected by the Extension Services of the Commonwealth Caribbean with the exception of Jamaica. It is no wonder that an Agricultural Instructor once told me that without subsidy payments there would be nothing for him to do. An Extension Service without Programme Planning is like a ship without a rudder, and little real accomplishment can be expected.

Although we now have a reasonable structure for agricultural extension in the West Indies, there are serious deficiencies. As was emphasised earlier, experience has shown that a close connection between Teaching, Research and Extension is necessary to secure the maximum benefits from each. We now have the Faculty of Agriculture offering agricultural extension as part of its B.Sc. Agriculture Programme, as well as post-graduate programmes in this field. We are now, therefore, in a position to produce qualified Agricultural Extension Officers. We also have, through the recommendation of the Royal Commission 1938-39 and the financial contributions of the Governments of Barbados, Jamaica, Trinidad and Tobago, and for the time being Britain, the Regional Research Centre attached to the

16. Watkins, M. O.: Op. cit.

Faculty of Agriculture serving "as a research station for the West Indies". Finally, we have the various Agricultural Extension Services of the Ministries of Agriculture, albeit not forming part of the University structure, but nevertheless working closely with the Extension Department of the Faculty of Agriculture. There is however, nobody of subject-matter specialists either at the University or in the Ministries of Agriculture to act as a link between the research workers of the University and the Regional Research Centre and the Extension staffs of the Ministries of Agriculture and to be available for consultation and advice when required by the local extension workers. No funds have ever been provided for the creation of such a body of specialists. The funds available to the Regional Research Centre will not permit this, nor could University staff or the research workers of the Centre be diverted from their research to undertake the duties of subject-matter specialists without seriously harming their research programmes, except perhaps for very short periods.

The Commonwealth CARIFTA Secretariat has been approaching this problem from a slightly different viewpoint and has been seeking financial assistance for the establishment of a "fire-brigade force" of specialists for work in the less developed countries of the Commonwealth Caribbean. Where this force would be stationed, if funds can be obtained for its establishment, has not been settled but there is a danger that we might have a disruption of the links of the Teaching/Research/Extension chain, so far established, if such a body of specialists does not work in close collaboration with the University and the Regional Research Centre.

Another defect in our extension work in the region is the fact that our Agricultural Extension Services deal only with the farmer and not with the farm family as a whole. We tend to ignore the fact that the family is an integral part of the farm business and must be given as much consideration by the Extension Service as the farmer himself. To enable this to be done would need staff trained in Home Economics and Nutrition but there are few such in the Agricultural Departments of the region and the Faculty of Agriculture has so far no facilities for teaching or research in these fields. Proposals for the establishment of a Department of Home Economics in the Faculty of Agriculture were submitted to the Heads of Governments meeting in Trinidad at the end of 1972 but consideration was deferred pending the results of manpower surveys to be undertaken by the Governments to determine their manpower requirements in this and other fields. These manpower surveys are now being organised and, hopefully, the results will convince the Governments of the need for Home Economics staff to complement Agricultural Extension staff in their work with farmers and their families.

Conclusion

In conclusion, I should like to say a few words on how I see developments in the Commonwealth Caribbean affecting the Agricultural Extension Services in the future. We are all, I am sure, acutely aware of the crisis through which agriculture is passing – it is clear that the masses of the people have rejected agriculture as a way of life and agricultural employment as a satisfactory means of earning a cash wage. There are many reasons for this attitude which is particularly marked among the young people. Farming involves hard work for low remuneration; the average size small-holding is too small to be economic or provide a satisfactory income except for certain very specialised types of farming, like vegetable production; agricultural labour is not acceptable because of its historical past; wages are too low, and so on. There is, in my opinion, a good deal of merit in the arguments of the young people against entering agriculture as at present organised, and what is needed to change this attitude is nothing short of an agricultural revolution based on land reform.

Under such a programme, there would be consolidation of the uneconomic mini-holdings and a break-up of the large units into family-sized holdings capable of providing a reasonable level of living for the family with suitable mechanisation of the farming operations. It is futile to keep on expecting agriculture to solve the unemployment problem, to increase food production and to attract young people back to the land all at the same time. Increasing agricultural efficiency and thus its attractiveness as a business opportunity for young people must inevitably mean few people engaged in farming. One way of achieving the objectives of a prosperous and therefore efficient agriculture would be by the establishment of family farms through a programme of land reform. There are, of course, other possible forms of organization, e.g. cooperative forms, group forms, etc.

If programmes of land reform are undertaken throughout the area, clearly there will be greatly increased need for larger numbers of better trained agricultural extension and home economics workers. I think these changes are inevitable and I suggest we should now start preparing for them in our Teaching, Research and Extension programmes.

St. Augustine
June 27, 1973

ELEVENTH MEETING OF THE CARIBBEAN FOOD CROPS SOCIETY
1st — 7th JULY, 1973 — BARBADOS

LIST OF DELEGATES

Country	*Name*
ANTIGUA	C. J. Walter
BARBADOS	W. deC. Jeffers
	M. M. Alam
	S. Blades
	E. Brathwaite
	A. Bryan
	M. T. Burke
	I. Chandler
	F. Chandler
	K. Chase
	V. M. Corbin
	E. Cumberbatch
	O. Davis–Isaacs
	C. Fraser
	J. Garvey
	J. Grace
	F. Greene
	O. Hamilton
	W. Harvey
	W. Headley
	R. M. Hoad
	J. P. W. Jeffers
	D. M. Knight
	R. D. Lucas
	D. Marsh
	G. Mason
	G. Morris
	O. O. Parris

Country	*Name*
	E. C. Patterson
	D. Payne
	E. Payne
	C. E. Pilgrim
	R. C. Quintyne
	D. Rawlins
	DeC. Sealy
	L. W. Small
	L. H. Smith
	G. McD. Taylor
	C. Trotman
	P. Webster
	J. A. L. Worme
DOMINICAN REPUBLIC	R. DeCock
DOMINICA	C. J. L. Dupigny
	C. Jno-Baptiste
FRENCH GUYANA	P. Blancaneaux
	J. Brochier
GRENADA	G. Barriteau
	A. Cape
GUADELOUPE	G. Anais

Country	*Name*	*Country*	*Name*
GUYANA	H. A. D. Chesney	U.S.A.	T. W. Scott
	R. O. Hart		
	Omawale		
		U. W. I.	G. Avril
JAMAICA	H. A. Beckford		R. A. Baynes
	A. U. Cameron		C. Brathwaite
	H. B. Crawford*		R. A. I. Brathwaite
	J. H. Donaldson		A. C. Brewer
	H. A. Fraser		T. Fergusson
	I. Goodison*		Dr. St. C. Forde
	H. Miller		J. Hammerton
	A. Naylor*		C. McIntosh
	D. C. Stanford		C. K. Robinson
			N. D. Singh
MARTINIQUE	G. Rimbaud		B. G. F. Springer
	J. Thonet		
MONTSERRAT	J. H. Green	PUERTO RICO	G. C. Jackson*
ST. CROIX	E. Hall		E. R. Kiel*
	D. S. Padda		M. A. Lugo-Lopez*
	H. Schuster		G. Samuels*
	F. B. Sands*		
ST. VINCENT	G. White	B.D.D.	E. Metcalf
			E. T. Wilmot
TRINIDAD	L. Cross*		
	F. B. Lauckner		
	D. D. Oudit	C.D.B.	E. G. B. Gooding
	C. K. Robinson		V. Sargeant
	G. M. Shekour		J. B. Yankey

* Accompanied by wife or husband.

AGRICULTURE AND THE GOVERNMENT AGRICULTURAL DEVELOPMENT PROGRAMME LECTURE — CAVE HILL CAMPUS

by

E. C. PILGRIM

The Role of Agriculture In Our Economy

Ever since the 17th century, agriculture has been of paramount importance to the economy of Barbados. The early Spanish explorers found no gold, silver or other precious metals or stones. Neither did the subsequent English explorers and settlers. From the early settlements, therefore, export agriculture in the form of cotton and tobacco became the mainstay of the economy; and, with the absence of bauxite or oil, remains the mainstay of our economy to this day. Tourism and light industry have grown considerably in importance over the past decade. However, the contribution of agriculture to the economy is still of paramount importance, expecially when the very substantial contribution of the agricultural sub-sector which produces food for local consumption is added to the sub-sector of export agriculture.

2. In 1971, agriculture provided 13% of the Gross Domestic Product of Barbados, utilized 78% of its land resources, employed between 17 and 20% of the working population and accounted for 80% of the total domestic export. Further, when one considers the much higher proportion of the agriculture dollar which remains in Barbados when compared with the dollar from tourism or industry, and the considerably higher income

generating power of the agricultural dollar when compared with the dollar from tourism or industry, one can realize that agriculture is still of pre-eminent importance in our economy.

The Role of Sugar

For over 200 years, sugar has been, and still remains the most important agricultural crop in Barbados. There are many good reasons why this has been so. Barbados although a tropical islands is very different in many respects from the mountainous island with deep soils and high rainfall which lie to the west in the main chain of Caribbean islands. Unlike those islands, Barbados is relatively flat, with thin soils of an average depth of about 2 over inert and agriculturally unproductive limestone. It has a relatively low annual rainfall, is subject to drying, salt-laden winds, especially in the dry season, and suffers from the occasional hurricane or near-hurricane.

For these reasons, Barbados is almost natural grass country. If I were to be brought into Barbados in the form of an overseas expert; given the facts concerning the topography, soils and climate of Barbados, and asked what type of crop I would recommend for this island without having to take into consideration anything other than the suitability of the island for the particular crop, I would unhesitatingly say: "A grass." Sugar cane is a grass. Furthermore it is a grass which has enabled each of our few and scarce acres to produce a relatively high *gross* income per acre (when the by-products of molasses and rum are included) which in 1972 amounted to approximately $750 per acre. It is true that very little of this gross income may find its way into the pocket of the cane plantation owner or small farmer. Nevertheless, it is value which is being produced for Barbados from each acre of the very small acreage of land which Barbados owns. It is our main earner of the foreign currency needed to buy those things which we cannot ourselves produce, and it generates more income earning capacity within Barbados than the revenue obtained from any other sector of the economy.

From the points of view of both our economy and its suitability for covering the 60,000 acres of our agricultural land under our climatic conditions, sugar cane is therefore still the most suitable general crop for Barbados, and recent increases in the world price for sugar, caused by the present world shortage of sugar, have further increased the value of this crop to Barbados and made it even more difficult to find satisfactory substitutes.

The Case For Agricultural Diversification

This rest on:

(1) The vulnerability of the sugar industry to excess world production in the future, with low-cost sugar possibly becoming in over-supply on the world market.

(2) The possibility of the loss of the protected British market consequent on Britain's entry into the European Economic Community.

(3) The need to reduce the cost of food imports into Barbados for feeding both our local population and our tourists.

(4) The need for finding crops which will employ more people per acre (although this last need may largely be mythical in view of the ever increasing difficulty in finding labour which is willing to work in agriculture).

It should have been pointed out that, although sugar is vulnerable on the world market, and poses problems for its long-term production, it is still less vulnerable than many of the tropical export crops associated with the Caribbean and grown by many of our sister territories – crops such as cocoa, coffee, citrus and bananas. Over the years, sugar has proven to be more stable as a money earner than any of these crops just named.

Nevertheless, Barbados would like to find agricultural enterprises which will provide higher returns per acre than sugar, on a continuing basis; which will reduce the volume and value of agricultural imports, and some of which would be capable of occupying the more than 50,000 acres of land now occupied by sugar cane if, for some reason, it became necessary to abandon sugar as our main crop at short notice.

Substitutes for Sugar Production

In the search for substitutes for sugar, the Barbados Ministry of Agriculture with very limited staff has examined, in the past 6 years, some 600 varieties of 40 different crops, as well as many breeds of livestock, with a view to finding adequate enterprises for our Agriculture. We have in this time found some crops which could be regarded as substitutes for sugar on limited areas of land and we have found certain other agricultural enterprises which give promise as replacements for some of our food imports. The main enterprises on which we are now concentrating are:

Substitutes for sugar:–	Grass (for livestock) Comfith
	Cane (for livestock feeding)
	Cotton (the drier and shallower sugar cane lands)
	Coconuts with grass (Scotland area only)
	Fruit Trees

Crops mainly for local consumption:–	Root Crops (with dehydration for storage)
	Vegetables
	Fruit
Livestock:–	Milk
	Beef (on a limited scale unless comfith and other such innovations prove successful)
	Pork
	Chicken and Eggs
	Mutton

In the light of our present knowledge – and let me say here that new ideas, new techniques and new kinds of production may yet revolutionize not only non-sugar agriculture but the use of the sugar cane crop as well – we would like to see, over the next 5 years, a gradual reduction in acreage under sugar cane, without necessarily a decrease in sugar production, and the use of some of the land for other purposes somewhat along the following lines:

Sugar Cane	50,000 acres (down from 64,000 acres)	
Grass	4,000 acres	
Cotton/Sorghum	4,500 "	
Coconuts and) Fruit Trees)	2,000 "	
Vegetables	2,000 "	(Continous cropping)
Root Crops	2,000 "	

Let us examine some of these crops in more detail.

Sugar

This crop still provides the most certain market, as I have already pointed out. It is still the only crop now available to Barbados which will return as much as $750.00 gross per acre over 50,000 acres. Further, recent research work on alternate uses for the sugar cane give fair promise that the production of sugar may eventually become the least important of the uses to which sugar cane will be put. The new diffusion process for extracting sugar from the cane gives promise for the production of hardboard from the sugar cane, in addition to the normal products of sugar, rum molasses for livestock feed. Further, it is now quite feasible to feed the raw sugar cane pith with the juice still in it – or Comfith as it is called – to beef and milch cattle as well as other ruminants and even, it seems, to pigs and poultry. The use of raw sugar cane for livestock feed may well become one of the more important uses of the sugar cane in the near future.

The production of sugar, of course, has its problems, the main ones being associated with the present need to burn most of the crop in order to harvest it mechanically, the problems associated with the introduction and large-scale use of mechanical harvesting, and the problems of soil erosion and loss of soil structure, which at the moment seem to accompany the burning and mechanical harvesting. However, Barbados still has its greatest agricultural expertise in the growing of sugar cane and the production of sugar, including its sugar cane breeding and variety testing stations of world wide fame.

We cannot therefore afford to allow the sugar industry to run down unless and until we have a satisfactory substitute or group of substitutes. To date we have no satisfactory substitutes. We would therefore like to intensify sugar production on the lands most suited to that crop. We would also like to see a trial made of developing the 70 to 80 acre family sugar cane farm of the type which has been so successfully developed in Australia, on which a man with his family and adequate machinery can make a satisfactory living from growing a relatively small acreage of sugar cane. We further hope to utilise some Government owned lands to embark, on a trial basis, on a system for spreading the benefits of large scale plantations operation more fully to the present plantation labour force through cooperative ownership of the plantation.

Starchy Rootcrops

These crops have been overproduced in Barbados in recent years.

Under the 1942 Food Production (Defence) Control Order, all plantations were required to plant 12% of their arable acreage in the starchy rootcrops such as yams, sweet potatoes, cassava and eddoes each year. Because of the over production of these crops permission has been granted in recent years for the growing of vegetable crops and corn in place of the starchy rootcrops on these lands. Further, the Minister of Agriculture has recently agreed to a reduction of the compulsory minimum acreage to be planted in such crops each year to be reduced from 12% to 5% of arable acreage.

Further, Government is developing systems for processing and storing these bulky and fairly perishable root crops. The dehydrated "Instant Yam" is now available in supermarkets and shops in both Britain and Barbados, and further work is being done on making similar products from sweet potatoes and some vegetables.

Cotton

The Sea Island Cotton, on which much research and development work has been done by the Ministry of Agriculture in Barbados recently, is one of the few crops which seems capable of replacing relatively large acreages of sugar cane in Barbados. Substantial promotion of Sea Island Cotton garments in Britain and Europe in the past three years has resulted in an immediate demand for over 3.3 million pounds of cotton lint, which would need at least 7,000 acres for its production, and a projected demand in the future for over 7.0 million pounds of cotton lint which would require from 15,000 to 20,000 acres for its production.

Quite apart from the production of cotton lint for garment manufacture, a large cotton crop would provide Barbados with valuable cotton seed oil, as well as cotton seed meal for use as a concentrate livestock feed. The crop is therefore of considerable potential value.

Large scale production of cotton is at the moment hindered by the need to develop a satisfactory system of harvesting and cleaning the cotton lint mechanically. If, as we expect, the problems of mechanical harvesting and cleaning are overcome in the 1972/73 cotton season, then it is expected that several of the sugar plantations in the drier and more margin sugar areas in the south and north of Barbados will switch to cotton production, enabling our acreage under this crop to climb from its present 200 acres, almost all of which is grown by the Agricultural Development Corporation, to 500 acres in the following year and to 4,000 acres or more within 5 years.

Sea Island Cotton poses much more serious problems of pests and disease control, and of soil erosion, than does sugar cane. In addition, the gross returns per acre are lower than with sugar cane. Nevertheless it is expected that growing this cotton in a rotation with crops such as sorghum will provide a satisfactory annual income per acre, and that measures now being tested for pest, disease and erosion control will enable the permanent cultivation of this crop as a foreign exchange earner and a local food producer for Barbados.

Coconuts and Fruit Trees

These crops are very well suited to the hilly areas of Barbados, and especially to the steep slopes of the Scotland Area. Returns per acre from Coconuts are low, and returns from fruit trees, although somewhat better, are very seasonal. For these reasons these crops are being developed in combination with a grass cover under the trees for a combined tree crop/livestock type of farming. We would wish to see at least 2,000 acres planted to these crops within the next 5 years, and, with processing facilities becoming available, and eventual expansion to not less than 7,000 acres.

Vegetables (Including Peanuts)

Because of the high level of returns per acre from these crops, and their value both as import substitutes and potential earners of foreign exchange, the Ministry of Agriculture has concentrated much of its recent research and development programme on the production of vegetables and peanuts; and our most notable recent successes have been with these crops.

Milk and Meat

The concentration here, under the agricultural development programme, is on Dairying, and on pig and poultry production.

Barbados at the moment consumes some 5.0 million gallons of milk per annum, and produces 1.5 million gallons of this milk. We are at the moment concentrating on the expansion of the fluid milk trade using locally produced fresh milk for this purpose, with imported milk ingredients being used for the manufacture of condensed and evaporated milk. The milk industry is still a low-return-per-acre industry, and with irrigable land for pasture in short supply and with the ever increasing cost of importing concentrated feeds, it is not envisaged that the fresh milk industry will expand rapidly unless and until new systems of feeding such as the COMFITH system improve the economics of local milk production.

Barbados at the moment also produces all of the fresh pork which it consumes, to an amount of some 1.3 million lbs. of pork per annum from a herd of about 21,000 animals. However, Barbados is also importing some 4.5 million lbs. of pork products per annum, including salted pork, trotters, ears, sausages, hams and bacon, to a total value of some $3.8 million, E.C.

We aim to step up our local production to 5.0 million lbs. in the next 5 years. However, the move out of the present production for the fresh pork market only will not take place until the proposed pork processing plant is in operation. We expect to begin construction on this plant during this year.

Barbados already has the capacity for self-sufficiency in the production of poultry meat and eggs, except for certain periodic shortages such as at Christmas time and for certain of the cheaper cuts such as chicken backs and necks which are unwanted in some of the more developed countries and are therefore available to Barbados from the very large poultry industries of those countries.

For our local chicken industry to reach its full potential, there is need for certain purchasing, processing, storage and distribution facilities, and the provision of these facilities is now being planned. There is also need for local poultry feeds of a consistent higher quality at reasonable prices. Government plans to overcome this latter problem with the erection of its livestock food plant this year. Permission has also been granted for the establishment of a Central poultry processing plant.

Beef production, because of its extremely low returns per acre per annum, has always been a relatively small sideline operation in Barbados. The use of new feeding systems such as Comfith feeding are expected, however, to cause a substantial increase in beef production in the near future by increasing the number of animals which can be reared off the produce of 1 acre of land and thus increasing the value per acre to be obtained from beef production. The industry will probably depend for some time on the use of culls from the dairy industry – bull calves and poor milking animals – with a gradual introduction of beef breeds of cattle and the use of the buffalo for meat production.

Land Tenure

In all of these new developments, the overall aim is to develop *family farms of medium size,* on which the farm family can, with adequate mechanisation, provide for itself an income which can compare favourably with the incomes being made in other sectors of the economy. The Sugar Cane farm will, for mechanical production and harvesting purposes, have to remain relatively large by our standards, although small by world standards. Here, it may well be possible for us to develop the medium-sized 60 to 80 acre fully mechanized family farm for sugar cane along the Australian pattern. Attempts must also be made to group many of our very small farms together for the application of modern agricultural techniques through cooperative effort. Government is also now busily engaged in preparing, for International funding in part, two projects for utilizing certain maginal sugar plantations for medium and small farmers settlement, involving the production of vegetables, milk, fruit, pork poultry products and Comfith beef.

MAJOR CONSTRAINTS TO THE DIVERSIFICATION PROGRAMME

1. Marketing Facilities

This is by far the greatest deterrent to the diversification of our agriculture. Sugar is still the only crop which has a reasonably long-term market guaranteed by contract, and it is the only crop on which the farmer knows the selling price of his product before the crop is planted. If Barbados is to move more swiftly into the production of crops such as vegetables and pulses for local consumption, import substitution and export, the situation *must* be created in which the farmer has a guaranteed minimum price for his crop prior to the planting of that crop.

Hand in hand with the guaranteed minimum price must go the facilities for selecting, grading, packaging, storage and utilization of the various commercial products based on these crops. The Agricultural Development Corporation, with its new facilities for producing dehydrated yam and for grading and drying onions, is embarking on providing some of the required facilities. The Barbados Marketing Corporation has for some years been trying, under very difficult circumstances, to assist in purchasing and selling local produce. To perform this task adequately, this organization needs more equipment, more trained staff, and a monetary arrangement whereby losses sustained in the initial years of developing the marketing system for a new crop or group of crops can be recovered through some type of Government subvention.

2. Research and Extension Staff

Given adequate marketing at guaranteed and remunerative prices, farmers would, I am sure, increase their production of non-sugar crops very substantially in a relatively short period of time. Much of the initial research work needed to provide farmers with the best varieties of these crops and the best techniques for growing them in Barbados has already been done. However, facilities for passing this information over to the large number of small and large farmers who would now become interested in growing these crops and passing this information on in such a way that all of these farmers would be fully conversant with all of the most modern practices, are at the moment very inadequate. The Ministry of Agriculture has no agricultural information service, and the number of field extension officers now in post would be far too few to provide the kind of almost personal service which each farmer would need.

Further, the sustained production of present crops, and the development of new crops and cropping systems, is highly dependent on having a strong research unit with adequate staff to do the experimental work which is necessary and which must continue as long as production of the crop continues. It does not matter whether the acreage involved is 500 or 5 million acres.

The amount of research work which must be done to develop the crop and keep its production competitive is approximately the same. The perennial lack of adequate numbers of trained technicians in research and extension is one of the major reasons why tropical agriculture in the lesser developed countries tends to compete so unfavourably with agriculture in the more developed countries.

Steps are however being taken in the Ministry of Agriculture in Barbados to provide at least the minimum number of posts needed to these fields at present. The filling of these posts with adequately trained and motivated personnel presents another problem, as agriculture still suffers from a stigma which, in the context of our development, is wholly unjustified.

3. Lack of Farmer Organizations

The teaching of new techniques to farmers, the providing of common services for agriculture and the establishment of close and meaningful liaison between farmers and Government, depend to a large extent on those farmers being grouped in organisations through which they can speak and be spoken to. The sugar industry in Barbados is the only agricultural enterprise which is fully organized in this manner.

In the planning and implementation of a diversification programme for agriculture, therefore, there is great need for one or more organisations which will embrace all farmers in the non-sugar agricultural enterprises such as vegetable production, pig production, poultry meat and egg production, and dairying, and which would be able to appoint farmer representatives to the National Boards and Committees which cater to their interests.

The Barbados Agricultural Society is aware of this need, and, I understand, is preparing itself to provide the type of service which is needed. It is to be hoped that the Agricultural Society will be able to perform these functions in the near future, with Government assistance if necessary. Time and money spent in assisting the Society, especially in the early stages of reorganization, to perform these functions fully and well would, in my opinion, be time and money well spent.

4. Indiscriminate Importation of Substitute Products

One of the lesser realized but nonetheless very important deterrents to increase local food production is the relatively free importation of food supplies of all kinds, many of which are direct or indirect substitutes for food items which are or could be locally produced. It may well be necessary to provide protection for locally produced foodstuffs against the open competition – including "dumping" – from similar or substitute foodstuffs produced in large quantity in the larger and more developed countries of the world. Certainly at least one of our sister territories has taken steps to stimulate local production by banning the importation of a large number of food items, and present indications are that this bold step is achieving its purpose. Steps have already been taken in Barbados to protent certain food items (e.g. poultry, eggs, onions, carrots) from direct competition from imports of those products during periods of high local production. It may be necessary, in the near future to considerably expand on this form of protection if our drive to grow our own foods is to be successful. Indeed it is the intention of Government to employ more effective control over the importation of food items into Barbados.

5. Credit

If the constraints to agricultural diversification already discussed are removed, then the demand for medium and long term credit for agriculture, which is even now substantial, is expected to increase considerably. Here local lending institutions such as the Sugar Industry Agricultural Bank, the Agricultural Credit Bank and the Barbados Development Bank, if given adequate funds and staff, should be able to provide all of the credit facilities needed for a rapidly developing agricultural sector.

6. The CARIFTA Export Market

One of the aims of the Caribbean Free Trade Association has been the development of trade in agricultural products within the area. This is achieved in theory by ensuring that any of the countries within the Association must purchase the surplus of any agricultural product which is available for export from any of the other countries within the Association before the importing countries go to markets outside of the Association for its supplies.

Barbados, like some of the other territories such as Jamaica and Trinidad which have comparatively better developed agricultural sectors, has benefited in the past from being able to export produce under the conditions of the agricultural protocol.

Barbados is however regarded as one of the M.D.C's or More Developed Countries, although in fact it has far more in common with the smaller, highly agricultural island of the L.D.C's (Less Developed Countries) than it has with the much larger territories of Jamaica, Trinidad and Guyana with their much larger land resources and their strong mining sectors based on bauxite, oil and other minerals.

The L.D.C's have managed, by dint of much forceful argument, to get the M.D.C's to accept the proposition that the latter must curb production of such crops as the L.D.C's can grow for export to the M.D.C's. This is to counterbalance the substantial inflow of manufactured articles and produce for their own development to the Lesser Developed Countries from the More Developed Countries. However, Barbados, in this thinking, is already being expected as an M.D.C. to curb its production of certain crops which it has spent much time, money and effort in developing, such as onions and carrots, in order to enable the L.D.C.'s to develop and export trade in these same products. This approach may well prove to be a considerable constraint to the development of non-sugar agriculture in Barbados; which should really be grouped with the L.D.C.'s with respect to its agriculture.

Finally, and in summary, Barbados in recent years has made substantial progress in pursuing its policy of diversifying its agriculture. However, if much additional progress is now to be made, Barbados will have to take some bold steps to remove or at least to greatly minimize the present constraints to such progress and will have to spend a much larger portion of its earnings on the development of its agriculture.

THE CONTRIBUTION OF AGRICULTURE TO THE ECONOMY OF BARBADOS

by

J. M. MAYERS

Research Fellow, Institute of Social and Economic Research (E.C.), University of the West Indies

INTRODUCTION

The overall economy of Barbados has been expanding rapidly within recent years. As can be seen from Table I, the Gross Domestic Product increased from $128.7 million in 1961, to $298.4 million in 1971 and much of this increase has been in the areas of transport, construction and public services, reflecting the rapid growth of the tourist industry over the period. The Government sector also increased substantially over the same period, but the agricultural sector did not keep pace with the other sectors and this was due to the slow growth of income generated from sugar, as well as the modest growth of the remainder of the agricultural sector. Unfavourable weather was the major factor causing low incomes in sugar, particularly in 1968 and 1969. Sugar production was also low in 1972. Per capita income has increased substantially and the tourist industry has been the major factor in this development. The result is, that the agricultural sector declined in relative importance, especially with regard to its contribution towards a favourable balance of payments which was essential for development of the other sectors. We shall consider the contribution of agriculture to the Barbados economy under the two broad headings of; Sugar and Non-Sugar Agriculture.

Sugar

Sugar-cane has been the mainstay of the Barbadian economy for the past 300 years. Its products constituted 16.6% of the Gross Domestic

TABLE I

GROSS DOMESTIC PRODUCT AT FACTOR COST BY INDUSTRIAL ORIGIN, 1960–1971

$M

Sector	Firm Estimates				Provisional Estimates							
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Sugar	25.5	25.9	25.3	37.0	29.7	31.5	32.0	35.1	28.6	24.0	27.1	24.0
Other Agriculture	8.1	8.1	8.4	9.0	9.4	9.9	11.4	12.7	13.1	13.3	13.2	14.0
Construction	11.8	13.6	14.0	14.4	14.6	14.9	15.3	16.4	20.0	22.3	27.5	28.0
Manufacturing and Mining	10.0	12.2	13.3	14.0	15.1	16.2	17.3	18.6	21.0	23.9	27.6	29.8
Transport and Public Utilities	6.8	7.9	8.3	8.5	8.7	9.0	10.3	14.6	18.2	18.4 R	20.9 R	24.4
Distribution	27.6	28.0	29.2	33.6	34.1	35.6	37.3	39.2	50.0	59.2	71.2	83.9
House Ownership	6.2	6.2	6.4	6.4	6.5	6.5	6.8	7.3	8.0	9.0	11.1	12.2
Services	12.1	14.5	14.6	15.0	15.4	17.0	17.9	19.5	27.8	29.9	32.2	34.8
Government	11.7	12.3	13.6	15.0	16.5	17.6	21.3	25.8	30.0	35.3	42.7 R	47.3
	119.8	128.7	133.1	152.9	150.0	158.2	169.6	189.2	216.7	235.3 R	273.5 R	298.4

R = Revised

Source: Economic Survey of Barbados, 1971

Product over the period, 1966–68, and the exports of these products were 16% of all exports for those years. At present, the value of sugar, rum and molasses per acre of sugar-cane crop land varies between $750 to $800 approximately and sugar is grown on almost 90% of all crop land. As can be seen from Table II, both the acreage planted in sugar-cane as well as the yield per acre have declined over the past ten years. Some 2,000 acres formerly under sugar-cane, are now planted into other crops, but some of the land has also been used for non-agricultural purposes. Most of the decline in acreage has taken place in the drier rainfall areas, where it is possible for short season crops to grow during the short rainy season.

Total sugar production has fallen as a result of a decline in yield of cane per acre as well as in yield of sugar per ton of cane; and these have been caused primarily from unplanned fires, unfavourable weather since 1967 and shortage of careful workers. The payment for sugar-cane is on the basis of weight rather than on sugar content and varieties are therefore selected on the basis of tonnage of production. It is not surprising therefore, that, as shown in Table II, the production of one ton of sugar in 1970 required 9.3 tons of cane, as compared with 8.8 tons in 1965.

In 1970, there were approximately 1,300 small holdings (i.e. less than 10 acres) producing about 20% of the cane with an average yield of about 21.5 tons. The estates, on the other hand, had an average yield of about 32 tons; but it must be remembered that much of the small holdings are in the low rainfall areas and are therefore less productive than most of the land in estates. Also, small producers are less efficient than the large estates in the use of modern technology and management practices.

The sugar industry has always been the largest employer of labour. Approximately 20,000 persons were employed in the industry in 1960, but by 1970, this number had been reduced to 14,000, or an average drop of about 3% per year. Indications are that this trend will continue, as young persons are not attracted to the industry. In 1969, about 40% of sugar-cane workers were over 55 years of age, whereas only 20% of the total labour force is in this age group. Since 1967, the seasonal labour

TABLE II

ACREAGE, YIELD AND PRODUCTION OF SUGAR CANE AND YIELD PRODUCTION OF SUGAR IN BARBADOS, 1961–1970

Year of Harvest	Total Acres ('000)		Tons of Cane		Sugar Production		Tons of Cane per Ton Sugar
	Planted	Reaped	Total ('000)	Per acre Reaped	Total ('000)	Per acre Reaped (T)	
1961	65.2	49.4	1,378	27.9	159.5	3.22	8.6
1962	64.4	49.0	1,435	29.3	158.5	3.23	9.0
1963	66.3	50.0	1,681	36.4	190.7	4.12	8.8
1964	65.3	50.8	1,476	29.0	161.5	3.17	9.1
1965	62.6	49.9	1,731	35.0	196.0	3.95	8.8
1966	65.4	51.5	1,559	30.3	171.9	3.34	9.0
1967	65.0	52.2	1,826	35.0	200.6	3.84	9.1
1968	61.7	50.6	1,369	27.0	159.1	3.51	8.6
1969	62.6	50.5	1,264	25.0	138.5	2.74	9.1
1970	62.0	49.8	1,433	28.8	153.9	3.09	9.3

Sources:

1. Ministry of Agriculture.
2. Barbados Sugar Production and Export Control Board.

force on the plantations has been supplemented by immigrant workers from St. Vincent and St. Lucia and the industry has become increasingly dependent on this labour, as numbers have risen from 282 in 1967 to 1,365 in 1970. As living standards and job opportunities increase in these islands, there is the possibility that this supplementary labour force may become more and more difficult to obtain and it may be necessary for the sugar industry to find means of attracting young local persons into the industry, perhaps by way of offering training courses and by increasing wages for certain types of jobs.

Over the last decade, there has been a considerable increase in the wage rate for agricultural workers; but despite this, as well as increases in other unit costs of production, the sugar industry has managed to survive by preventing any significant increase in the overall manufacturing costs of sugar. Despite this performance in largely offsetting cost increases by increasing production efficiency, the industry has been nevertheless subjected to an increasing cost-price squeeze.

From studies carried out in 1969 by the Ministry of Agriculture and the Barbados Sugar Producers Association, it was shown that the gross margins from producing sugar-cane were generally lower than for producing other crops, particularly in the low-rainfall areas. One advantage with sugar, however, was that the income derived from it was guaranteed, whereas there was general uncertainty about the income from other crops and this is particularly true if there were rapid increases in production from the other crops, with the possible exception of corn and sorghum. Furthermore, the net export value per acre of sugar-cane is substantially higher than for any other crop, except for some fruits and vegetables and it is important therefore for Barbados to maintain its production of sugar at or about the quota level, insofar as this is feasible. The conversion of cane land to corn production may not cause a great loss to foreign trade, especially if the corn can be utilized for human consumption and animal feeds.

The decline of domestic workers in the sugar industry has caused concern over canes remaining unharvested and steps have been taken within recent years to mechanize cane harvesting. There are two limitations to complete mechanization, the first being that the slopes on some of the cane lands are too steep and secondly that too much of "trash" adhere to the cane after cutting. It is believed that the existing machinery is feasible only on slopes of less than 10% and this means that approximately 28% of the land now under sugar is unsuitable for mechanical cultivation.

At present, the bulk of Barbados' sugar is sold in the U.K. market on preferential terms, under the Commonwealth Sugar Agreement. Barbados has a nominal quota, but the Agreement terminates at the end of December, 1974. As yet there are no arrangements for Commonwealth sugar to enter either the United Kingdom or the European Economic Community, except for a transitional period up to mid 1975, when the quotas are to be reviewed. It is vital for Barbados and the other members of the West Indies Sugar Agreement to obtain quotas after 1974 and any increase in sugar production will strengthen the bargaining position with Britain.

Non-sugar Agriculture

Although sugar-cane is well adapted to the natural environment of Barbados, and has been dominating the agricultural scene for the past 300 years, it became necessary over a decade ago for the Ministry of Agriculture to recommend crop diversification, not only to overcome the structural rigidity of the agricultural sector economy, but also in an attempt to reduce the growing deficit in the balance of payments on current account, resulting from the increased overall costs of food imports. While sugar is likely to remain the primary source of export revenue in the forseeable future, and while it still is necessary to continue to promote the efficiency of its production, some emphasis must be given to non-sugar agriculture to supplement agricultural income, as well as to safeguard against potential problems. In Barbados, there appears to be substantial need for import substitution, since the value for food imports rose from $23.2 million in 1961 to $57.8 million in 1971.

There is scope for import substitution with respect to fruits, vegetables, starcy roots, pulses and animal feeds, despite the many problems which will continue to interfere with diversification objectives. Such problems include limited rainfall, crop diseases and insect pests.

Fruits

The planting of fruit in Barbados is largely for home consumption and production per tree is only a fraction of yields of commercial orchards in other countries. Modern technology has not generally been applied to fruit production in Barbados, such that the yield of oranges, for example, is about 2,500 fruits per acre, as compared to 40,000 fruits per acre from commercial orchards in Miami. The 1961 agricultural census of Barbados showed that there were enough fruit trees in the island to plant 1,100 acres approximately. Indications are, however, that with proper management and agronomic practices, yields can be considerably increased and be comparable with those from other tropical areas where good practices are applied.

There is a strong need and apparently a favourable situation for citrus production in Barbados, as the rainfall pattern is similar to other citrus producing areas. However, the soils must be reasonably deep and well drained and winds and salt spray could cause problems. The annual imports of fresh oranges, tangerines and mandarins into Barbados is approximately 2,000 tons per year, and this could be produced from 200 acres, if a reasonable average yield of 10 tons/acre is assumed. It is possible that with well managed small farms and family labour, much of these crops could be produced locally and sold as no change in the present marketing system would be required. The importation of other citrus fruits and juices probably could be replaced largely by other orchard crops. The planting of another 400 lime trees would be about enough to cease the imports of limes and lime juice. It will be necessary, of course, for marketing to be distributed over most of the year in order to avoid seasonal gluts.

Barbados imports about half a million pounds of oranges per year, which could be produced on about 60 acres of well managed groves. Less acreage of avocados would be required to remove imports, but the problem in the case of both crops would be the seasonal distribution of production. Guavas could be considered for the Scotland District, where they are reported to produce well, however, there is no immediate prospect of this crop becoming commercial in Barbados. Any consideration of guava as a commercial crop will have to be based on improved varieties and processing into nectar, juice and jellies. Next to pasture, coconuts as an import substitution crop have the greatest land area requirements, as some 5,000 acres would be required to produce sufficient coconuts to replace current imports of coconuts and coconut products. About half of the island's production grows in the Scotland District area and the trees are free from lethal and red ring diseases, and the rhinoceros beetle, commonly found in other areas throughout the Caribbean.

Other minor fruits that are found in Barbados appear to be adapted to the conditions on the island. For example, the soursop tree (Anona maricata) is reported to be doing well in the Scotland District. Sugar-apple (Anona squmora) and pomegranate (Punica granatum) may be of some demand by the tourist industry. The cashew nut (Amacardium occidentale) often succeeds where nothing else will grow profitably and does well on the ridges and slopes in the Scotland District. The Barbados cherry (Malphigia glabra) bears a fruit which has one of the richest natural sources of Vitamin C. Many of these fruit trees have some desirable characteristics for erosion control as well and indeed the Soil Conservation Section of the Ministry of Agriculture has placed considerable emphasis on agronomic measures and within recent years has greatly expanded its plant propogation work and research on fruit production. More than 40,000 fruit seedlings were propogated at Haggatts Agricultural Station during 1972, including 15,000 citrus, 6,000 Barbados cherry, 10,000 mangoes, 10,000 avocados and 3,000 pawpaws. More than 4,000 Barbados cherries have been planted in the Scotland District by the Soil Conservation Section of the Ministry. A number of orchard trials have also been planted at Haggatts, which, it is expected, will provide long term information on management and cultural practices.

Many years of research will be required in order to select desirable varieties of these fruits and to determine more accurately their economic feasibility in Barbados. In some cases, varieties already proven in other Caribbean territories may be used. Within recent years, the Government has made tremendous efforts in growing fruit trees and making them available to growers at reasonable prices. Oranges, mangoes and guavas are all estimated to have the possibility of producing average gross margins per acre, substantially in excess of the gross margin from sugar-cane.

With the exception of citrus, it is possible that present numbers of fruit trees in Barbados would be sufficient to meet domestic demand, if they were productive trees of good varieties and well managed. In addition, adequate technical assistance and credit will have to be provided and it may be also necessary for Government to provide subsidies to encourage the establishment of orchards. Prior to this, however, careful studies will have to be made of the feasibility of obtaining satisfactory economic results from planting various kinds of fruits. These studies should include estimates of probable yields, expected costs and prices and prospects for exports.

Vegetables, Root-crops and Pulses

At present about one third by weight of the supply of vegetables is imported, whereas more than 80% of the pulses are imported and only 18% of the root-crops are imported, the latter being in the form of white potatoes. These crops offer the greatest potential profits from minimum investments that are available in agriculture in the country. They also involve, perhaps, the greatest risks in production as well as of failure in marketing. In spite of this, there is enough evidence to show that handsome profits can be realized on small acreages, so long as recommended practices are applied. Vegetable crops and root crops, except white potatoes, yield high incomes per year under good management. In fact, the incomes are higher than incomes from sugar-cane, especially in the low rainfall areas. The pulses are important in the local diets, but yields are still low and profits not as attractive as in the case of vegetables. Root-crops are profitable, but the risks are lower and profits per acre are somewhat less than the more perishable vegetables.

It was estimated that the production of all of these crops totalled about 70,000,000 pounds in 1968, compared with an importation of about 23,000,000 pounds and the wholesale value of production was estimated at $4.9 million, compared to the c.i.f. value of $2.9 million for the imported items. The data indicated that Barbados was largely self sufficient in the production of these crops, except pulses, white potatoes, onions and processed vegetables. Import substitution was shown to be feasible for peanuts, onions and other fresh and frozen vegetables and it was estimated that about 720 acres would be all the land that was necessary to produce the amounts of these items that were imported in 1968.

It is of interest to note that the acreage planted under onions increased from an approximate acreage of 30 acres in 1969, to 153 in 1971 and to approximately 250 acres in 1972, while production increased from 400,000 as in 1969, to 1.9 million pounds in 1970 and 2.0 million pounds in 1971 and reached a peak of 2.5 million pounds in 1972, representing a 625% increase in production since 1969. The export trade in onions also had a dynamic rise, increasing from 58,950 pounds in 1969; 179,910 pounds in 1970; 850,000 pounds in 1971 and 2,000,000 pounds in 1972. Chances are, that due to certain marketing and agronomic difficulties, the production and export values for 1973 are not expected to exceed those for 1972.

There have also been achievements in the production of peanuts, though not as dramatic as in the case of onions. The acreage under peanuts was 250 in 1972, as compared to 100 acres in 1963, but whereas in 1969 the yield was approximately 1,500 pounds per acre, this had risen to 2,000 pounds per acre by 1972. As to be expected, peanuts imports dropped from 626,365 pounds in 1969, to 461,997 pounds in 1971. In 1972 Barbados was self sufficient in peanuts for 10 months of the year. It is hoped that peanuts would be exported in 1973 and investigations are now underway for the establishment of a peanut processing plant, so as to meet some of the regional demand for the product.

In 1970, the imports of carrots amounted to 205,275 pounds and this was reduced to 117,413 pounds in 1971. Imports dropped further in 1972 and the performance was so satisfactory, that Barbados was allocated an export quota of 563,200 pounds to CARIFTA territories for the first four months of 1973. It was unfortunate that, due to improper marketing arrangements, farmers had to plough back into the land 62 acres of their carrots and the export quotas could not be met.

The prices of vegetables in Barbados are relatively high and the imported items tend to influence strongly the prices of local products at the farm. Seasonal variation in prices are caused by weather conditions that result in reduced yields in some months of the year. In general, prices of vegetables tend to be higher during the latter part (wet months) of the year, than in the early months.

A survey of vegetable production was completed by the Ministry of Agriculture in 1969 and data was obtained from 42 estates and 82 small farms on which vegetables were produced for sale. This study showed that more than half of the small holders had experienced crop failures at least once for each of the five major crops (beans, cabbage, carrots, cucumbers, and tomatoes). Estates (as shown by Gooding) also experienced crop failures, though not to the same extent. The hawker was the main marketing outlet, with the Barbados Marketing Corporation ranking second. The lack of irrigation was another problem confronting vegetable producers, as only one-third of all the small holders could irrigate more than 1/8 of an acre, although 90% had more than ½ acre in production. Only six of the 42 estates used irrigation. Vegetable crops are mostly harvested in the period, December to March (tourist season), which is also the dry period when irrigation is needed.

Studies of several vegetable crops on estates as well as small holdings have shown that with good management in 1967 and 1968, the gross margins for carrots and beets exceeded $2,000 per acre on small holdings and exceeded $800 per acre for cabbage and carrots on estates. Gross margins on estates were generally less than half as much as those on small holdings, which probably explained by small holders, produced 83% of the vegetable crops. Not only is production higher on small holdings, but the prices received are also higher, largely due to greater fertilizer use and closer plantings. As regards the estates, vegetable crops are generally planted on preparation land as a cash crop and lower production costs are due to greater mechanization, less fertilizer use and the more frequent sale of crops direct from the field.

Yams are commonly planted on preparation land, where the furrows for sugar-cane are already prepared with spacing of about 5 feet 6 inches between the furrows. There are about 5,300 plants to the acre and the gross margin may be as high as $400, though it is still less, than for most vegetable crops. A recent and important development is the establishment of a pilot Yam Processing Plant, which flakes the yam and prepares it as an instant product. This Plant has been so successful, that currently there are proposals for the establishment of a commercial Plant, thus providing farmers with a guaranteed market for their yam production. It is to be hoped, however, that production costs do not rise to such a level that the final product is priced out of the local as well as the export markets. It is hoped also, that sweet potatoes will soon be processed with equal success as in the case of yams. It must be remembered as well, that the Control Order of 1942 has recently been relaxed and this could lead to a situation where the plant has no yams to process, especially if prices and labour costs for harvesting are unrealistic.

Barbados has made substantial progress in the field of vegetable production and its diversification can be generally regarded as being a success, largely due to research. In the field of vegetable production, intensive research has been carried out in the cultivation of string beans, cabbages, cauliflower, beet, lettuce, cucumbers, onions, sweet and English-potatoes, carrots, tomatoes, melons and cotton. Specialist research has also been undertaken in the fields of pests and disease control, weed control, successional planting and seasonal trials, varietal selection, crop rotation, crop management, irrigation and water management, soil nutrition studies, mechanical harvesting, land preparation methodology, erosion control and the washing, sorting, grading and storage of produce. Research and feasibility studies are also being carried out on various types of food processing (especially for peanuts and pork), corn drying and curing, onion drying and processing, animal feed processing and yam processing as previously mentioned. Some estates are doing research on mechanization for the harvesting of yams and potatoes.

Recent increase in the total production of food crops in Barbados is significant, as the area devoted to vegetable crops increased from 700 acres in 1959, to 1,850 acres by 1971. From the 1968 survey, it was shown that the small farms utilized 10.4% of their crop land for vegetables, while the estates only utilized 0.7%. The estates, on the other hand, planted root crops on 10.6% of their crop land, whereas small farms had only 7.9% on their land in these crops. The Ministry of Agriculture, through an agreement for technical assistance from the Organisation of American States, has placed emphasis on vegetable production for a three-year programme (1970–73) which explains the substantial increases in plantings of the major crops over the past three years.

The production of pulses will probably continue to increase gradually and not fast enough. This is important, especially as Barbadians eat about 80% less protein than they need for good health. It may be necessary to consider mechanization of harvest, if production is to increase substantially.

The successful implementation of any food crop production system depends to a considerable extent, on the marketing systems and techniques. This has presented many problems, despite the lack of sophistication among the local buying product. In many cases, the problems have arisen between the producer and the marketing agency, as there is yet little or no coordination between the quality of production and the systems of collection and distribution. Consequently, producers have at times found that their produce could not be accepted, whereas at other times the marketing agency (B.M.C.) had to dump produce it was unable to distribute. The fact that the producer is encouraged by the Ministry of Agriculture and the B.M.C. functions through the Ministry of Trade, possibly aggravates the situation further.

The production and marketing of increased volumes of food crops over the past four years, came about because of certain adjustments in the existing structure and cultural practices, since that time. For example, there has been technical assistance through the Extension Sciences; some new lands became irrigated; some of the crops were sold under contract before they were even planted; market information is being developed and research in the Ministry of Agriculture has been useful and applied. There is still the need for improvement in many other areas, e.g. improvement in storage and distribution. Further success will depend on the co-operation between the producer, the private suppliers and the Government, in particular the B.M.C. Marketing arrangements agreed on through the Agricultural Marketing Protocol will also have an effect.

Livestock

Barbados has never been a livestock country, despite the relative ease with which grasses (including sugar-cane) grow throughout the country. The small numbers of livestock have been kept mainly for family consumption and within more recent times, to comply with the Livestock Defence Control Order, 1942. Animals are now kept on a more commercial basis than ten years ago, within which time a milk plant was established. Local dairy herds have been developing and beef is a by-product of these animals. About one-third of milk consumption is the local fresh milk, the remainder being imported evaporated, condensed, dried milk and fresh cream. Realising the need for increased local milk production and the need to increase the number of cows, Government has, over the past years, imported purebred holstein heifers from Canada. In spite of good management, however, the production of milk from these animals has been far below expectations.

As regards feed, corn is the only grain produced for animal feed in Barbados. It has been estimated that 4½ million pounds were produced in 1968–69 from 1,500 acres. The acreage planted in corn in 1972 was also 2,000 acres. If we assume a yield of 4,000 pounds of corn per acre and a total requirement of 16 million pounds, then this corn could be produced on 4,000 acres, which is less than half of the available "preparation land" on sugar-cane each year. In fact, it could be possible to produce this corn without reducing the production of food crops or cane.

The main factors limiting increasing corn production are the low yields per acre and the high labour cost. Until recently, the availability of cheap imported corn was a constraint, but within the past six months the world grain shortage has caused prices to rise considerably and all of the livestock economies dependent on foreign grain have felt the impact of this shortage. It has been suggested that major increases would be greatly facilitated by mechanization of the harvest and proper artificial drying of the grain.

Besides corn, the by-products of the sugar industry is one of the main sources of animal feed. These products were generally molasses, sugar-cane tops, filter press mud, rum vat yeast and bagasse, of which only small proportions are used in feed. One new product which has developed within recent months is Comfith. This is the white pith, crushed after the peel has been removed from the cane and may also be mixed with chipped cane tops. There is now enough nutritional evidence through research in Barbados, to support the fact that one acre of sugar-cane can support five head of cattle per year, as against one head (approximately) per year from pangola grass.

Over the past decade, the demand for livestock products has been rising and projections show that this demand will continue to rise over the next decade, at a faster rate of growth than the population. This means that until a feed mixing plant is installed, Barbados will be continuing to import livestock products and the imported products would be ever increasing as a proportion of total consumption. Even if we agree that feed must be imported, it is still possible that this could be done under more favourable price arrangements. More attention needs to be given to the improvement of milk production per cow. Cows in the U.S.A., New Zealand and Japan produce milk about 3 to 4 times of cows in the Caribbean and there seems to be no reason why with proper management, milk production per cow could not be doubled. Until this situation can be rectified, Barbados will continue to keep most of its cows in New Zealand. Much research will be needed in all areas of production and management and these seem to be the areas on which to focus attention. The demand for poultry, meat and eggs is expected to increase over the next decade and greater emphasis should be placed on the expansion of that industry. Already the success in the poultry/meat producing industry has been spectacular. In 1971, Barbados produced 1,625,000 lbs. of whole chicken and 375,000 lbs of whole chicken were imported. In addition, 1,950,000 lbs. of special parts and 4,250,000 lbs. of other parts were also imported. The total consumption was estimated at 8,200,000 lbs. In 1972, it is estimated that approximately 5,000,000 lbs. of whole chicken was produced (170% increase). Total consumption was 9,200,000 lbs. It is interesting to note that Barbados produced ½ of its requirements in 1972, compared with only one-fifth approximately, in 1971.

Sea Island Cotton

Sea island cotton was grown as a commercial crop in Barbados over three hundred years ago. In recent decades, it was grown mainly on low rainfall areas, on both plantations and small holdings, and after the second world war the acreage dwindled, due to pest and disease problems and by 1960 cotton was discontinued in Barbados. However, an investigation into the feasibility of reviving the West Indies Sea Island Cotton Industry was carried out in 1968–69 and the results showed that there was a substantial potential market throughout Europe and North America, and also because of its length, the fibre fetches a premium price in some major markets.

Gross margins per acre are similar to those for sugar and corn at present prices and yields, and it is expected that the demand for land for other crops will restrict the acreage available to cotton to less than 2,000 acres. Increased yields and successful mechanical picking are essential to the success of the Sea Island Cotton Industry.

CONCLUSION

Despite the very shallow, heavy, clay soils and despite often inadequate marketing facilities, the diversification programme and hence the production of food crops in Barbados, can be considered to have been successful. Exports of non-sugar agricultural produce is progressing slowly, but needs to be more organized. One major problem is the decline of ground provision harvesting on many estates and this may eventually lead to a reduction in the acreages of yam and sweet potatoes. There is a need for training in agriculture at all levels, as well as the need for a system of supervised credit.

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SOILS OF BARBADOS

by

N. AHMAD

GEOLOGY

The Caribbean island of Barbados is a coral island of about 430 sq. km. rising gently to a maximum height of just over 305m. The geology of the island has been studied in great detail by a number of workers and their findings have been summarized by WRIGHT (1959). The oldest rocks, Eocene sediments of great thickness, were laid down in a region of rapid and continuous subsidence. Subsequently, they were uplifted, strongly folded, thrust faulted, partially eroded and covered by a thick series of mud flows, the product of mud volcanoes. Further depression in the late Eocene was followed by deposition of radiolarian chalk and tuff of considerable thickness. Deformation certainly continued during the deposition of these materials because the lower members are somewhat folded and faulted. During the final phase of the building of the island, corralline limestone to a maximum thickness of about 120m accumulated, the lowest layer of which consists of coral reef debris and algal and foraminiferal limestone. Higher strata are made up of massive coral with interstitial reef debris and coral sand.

There appears to be some difference of opinion about the eventual emergence of the island. At first, geologists were of the opinion that uplift was gradual as this explained the terrance edges which are a conspicuous feature of the Barbados landscape. Later TRECHMANN (1940) concluded from fossil evidence that the entire coral cover was of uniform age and that the whole of the submarine platform was elevated by an oblique thrust from the west and south, thus producing an east and northeast rise to the land and cracking of the coral cap along the present escarpment of the currently eroded Scotland District. In contrast, recent radiochemical dating of coral in the lower terraces by BROECKER et al. (1968) indicates that the island has emerged at a constant rate over at least the past 125000 years. The surface of the seamount had one major irregularity in the form of a raised ridge (Christ Church Ridge) towards the southern end, and at one stage in the emergence this ridge would have formed a separate island. The valley (St. George's Valley) separating the two high areas was occupied by a shallow arm of the sea or inland lagoon on the floor of which detritus was deposited (VERNON and CARROLL, 1965).

The oldest rocks of Barbados, the Scotland formations, are very thick sediments deposited into a rapidly and continuously subsiding geosynclinal foredeep. They show the sedimentary structures characteristics of such turbidite deposits and large scale slumping and sliding features are common. The origin of these sediments appears to have been an emerging geanticlinal ridge of metamorphic and igneous rocks somewhere to the south of the present position of Barbados. The Scotland formations are strongly folded and the limbs of the folds are often overturned and thrusted.

In the Middle Eocene, when the volcanic eruptions began in the Lesser Antilles, these clastic sediments were covered by a thick, structureless deposit, the Joes River Formation. The chaotic texture and pebbly nature of this formation supports Senn's (1947) view that it formed from a thick series of flows from mud volcanoes, although it is also possible that this formation may represent large scale shear zones mobilized by the break-up of oil, gas and water reservoirs.

CLIMATE

The annual rainfall and land humidity of Barbados are shown in Fig. 2.

SOILS

The soils of Barbados can be conveniently divided into the limestone derived soils and soils of the Scotland District. A soil association map of Barbados is shown in Fig. 1.

LIMESTONE – DERIVED SOILS

Black Soil Association:

Site and soil characteristics. The soil pit is located at Friendship and the soil generally occurs from sea level to 60m and where the rainfall is less than 152cm. The soil is a black clay to the parent rock with a transition zone of only about 2.5 cm. Clay content increases with depth ranging from 66 to 82 percent and the profile has CEC values between 40 and 45 m. e./100gm of soil; $CaCO_3$ is present in small quantities throughout.

The clay consists of inter-layered montmorillonite, kaolinite and small quantities of amorphous minerals. (Table 2). The particle size distribution and chemical properties are shown in Table 1.

Soil Profile Description:-

Depth cm	*Description (moist)*
0-15	Black (N2/0) clay; strong changing to moderate subangular blocky structure with depth; friable to firm with depth; sticky when wet; roots plentiful; fragments of marl up to 1.5 cm diameter common; gradual smooth boundary.
15-30	Black (N 2/0) compact clay; moderate medium subangular blocky structure; firm; sticky and plastic when wet; roots common; gradual smooth boundary.

Depth cm	*Description (moist)*
30-60	Black (N2/0) compact clay; structureless; firm, very sticky and plastic when wet; clear smooth boundary.
60-75	Gritty coral intermixed with grey (2.5YR 5/1) clay; structureless; transition to hard grey coral mass with wavy surface.

St. George's Valley Association:

Site and soil characteristics. The Bulkeley pit is located at Bulkeley. The soil occurs from sea level to 30m in St. George's Valley where the rainfall is 140-152 cm. The Valley was once occupied by a shallow arm of the sea where the sediments were deposited on preformed coral. The soil is a uniform dark grey clay on the surface changing to mottled lighter grey at depth. The clay content increases with depth ranging from 71 to 93 percent and the CEC 35 to 37m. e./100gm soil. The clay consists of kaolinite and montmorillonite in about equal amounts with small quantities of sesquioxides; $CaCO_3$ occurs only in the surface layers. (Table 2). The particle size distribution and chemical properties are shown in Table 1.

Soil Profile Descriptions:-

Depth cm	*Description (moist)*
0-15	Dark brown (7.5YR 3/2) clay; strong to moderate medium subangular blocky structure; common gravel to pebble-size pieces of limestone; very common roots; moderate cracking on exposure; gradual smooth boundary.
15-30	Dark brown (7.5YR 3/2) compact clay; weak medium subangular blocky structure; sticky when wet; few roots; gradual smooth boundary.

Depth cm	*Description (moist)*
30-61	Brown (7.5YR 4/4) compact clay; very weak massive blocky structure; few diffuse brownish yellow (10YR 6/8) mottles; gradual smooth boundary.
61-122	Brown (7.5YR 5/2) very compact structureless clay with few fine brownish yellow (10YR 6/8) mottles; cracks intensely on exposure and desiccation; sticky and plastic when wet; gradual smooth boundary.
122+	Profile continues as brown (7.5YR 4/4) compact clay.

Grey Brown Association:

Site and soil characteristics. Soil pit is located at Edgecombe and the soil generally occurs at an elevation of between 60 and 120m with rainfall of 152 to 165cm/annum. It is a dark grey clay and generally shallow with CaC03 distributed throughout. The clay content ranges from 47 tò 59%, the soil having a CEC of 35 to 45 m.e./100gm. The clay minerology consists of a mixed assemblage of kaolinite, montmorillonite and small quantities of amorphous oxides (Table 2).

The particle size distribution and chemical properties are shown in Table 1.

St. Philip Plain Association:

Site and soil characteristics. The soil pit is located at River in the St. Philip's Plain and the soil occurs from sea level to 90m in rainfall less than 140cm/annum. The soil is derived from lagoonal deposits. It is a uniformly dark grey to black clay, the profile being a few meters deep. The clay content ranges from 74 to 89 percent and the CEC from 61 to 69m. e/100gm soil. The predominant clay mineral is montmorillonite with lesser amounts of kaolinite and amorphous oxides. (Table 2). Calcium carbonate is found throughout the profile.

The particle size distribution and chemical properties are shown in Table 1.

Yellow Brown Association:

Site and soil characteristics. The profile is located at Pool and the soil occurs at an elevation of between 120 to 210m with rainfall of 165 to 178cm/annum. The surface soil is uniform yellowish brown in colour and the sub-soil is mottled reddish yellow and grey. Aggregate stability is good in the top soil. Clay content ranges from 80 to 99 percent and there are small amounts of CaC03 throughout the profile. The CEC decreases with depth from 25 to 18m. e./100gm soil. The clay fraction consists mainly of kaolinite and small amounts of montmorillonite and amorphous minerals. (Table 2). Iron oxide is present as goethite.

The particle size distribution and chemical properties are shown in Table 1.

Soil Profile Description:-

Depth cm	*Description (moist)*
0-15	Dark reddish brown (5YR 3/4) clay; strong medium crumb structure on surface changing to weak to moderate fine subangular blocky structure; friable; slightly sticky when wet; sparse cobble to gravel-size marl; roots common; gradual smooth boundary.
15-30	Dark reddish brown (5YR 3/4) clay; weak medium subangular blocky structure; friable to firm; slightly sticky when wet; pieces of marl rare; roots common; gradual smooth boundary.
30-46	Same, gradual change to
46-107	Yellowish red (5YR 5/8) clay; weak coarse blocky structure; friable; sticky and plastic when wet. At

Depth	*Description (moist)*
	105cm profile ends abruptly with wavy surface hard blocky coral limestone.

St. John Valley Association:

Site and Soil characteristics. The soil pit is located at Redland and the soil occurs at an elevation of between 210 and 330m with greater than 178cm of rainfall/annum. The surface soil is uniform brick red to chocolate brown friable clay, having stable crumb structure. The subsoil is mottled red and grey to white with weak structure development The clay content increases with depth ranging between 80-90 percent in the profile The CEC decreases with depth from 24 to 15m. e./100gm soil. Small amounts of $CaCO_3$ occur in the surface. The clay fraction consists mainly of kaolinite with small quantities of montmorillonite and amorphous minerals. (Table 2). Fe_2O_3 is present as goethite.

The particle size distribution and chemical properties are shown in Table 1.

Soil Profile Description:-

Depth cm	*Description (moist)*
0-15	Dark reddish-brown (5YR 3/4) clay; fine to medium moderate subangular blocky structure; friable common gravel-size pieces of marl; sugar cane roots common; gradual smooth boundary.
15-30	Same, gradual smooth boundary.
30-46	Light grey (5YR 7/1) compact clay with diffuse faint reddish yellow (5YR 5/8) mottles; firm; weak to moderate fine subangular blocky structure; very few roots; gradual smooth boundary.

Depth cm	*Description (moist)*
46-61	Light grey (5YR 7/1) compact clay with common distinct red (10YR 4/8) and few faint reddish yellow (YR 6/8) mottles; weak thin to medium platy structure; firm; slightly sticky when wet; no roots seen; discontinuous clay coatings present.
61-122	Same, with common faint reddish-yellow (5YR 6/8) mottles ending abruptly on hard limestone with wavy surface.

Red Sand Association:

Site and soil characteristics. The soil pit is located at Lancester. The distribution of these soils is confined to a narrow strip, along the Leeward coast on parent material, consisting of beach sand of calcareous and silicious origins. The derived soils are clearly delimited from soils over coral by their very sandy texture. The red sands may overlie coral at a depth of a few meters but polysols are common. The texture becomes lighter with depth and the tilth is usually very fine after recent cultivation. Angular blocky structure is common; the soil cakes on the surface and is very hard when dry.

Free CaCO3 is generally absent; CEC varies between 10 to 15m. e./100 gm soil; exchangeable K is low but available and may be high. The clay mineralogy consists of kaolinite and montmorillonite with some mica. (Table 2).

The particle size distribution and chemical properties are shown in Table 1.

TABLE 1

PARTICLE – SIZE AND CHEMICAL ANALYSES

Depth	CsSand 2-0.2 mm	F.Sand 0.2-0.05mm	Silt 0.05 0.002mm	Clay 0.002mm	pH	$CaCO_3$	CEC	TEB	Ca	Mg	K	Na	C	N	C/N
	Particle-size analyses				Chemical analyses										
cm	%	%	%	%		%	me/100g						%	%	
							St. John's Ass'n								
0-15	3	7	10	79	7.3	1.3	23.8	29.7	30.5	3.3	0.28	1.24	2.1	0.21	10.0
15-30	3	7	8	83	7.9	1.6	20.8	26.0	23.7	3.7	0.15	1.08	1.7	0.16	10.6
30-60	1	10	8	83	7.7	0.3	14.5	13.3	16.5	0.7	0.15	0.57	–	–	–
60-90	1	4	8	90	7.7	Tr	16.7	18.0	19.3	3.0	0.09	0.35	–	–	–
90-150	1	4	6	91	7.1	Tr	17.3	18.4	19.5	2.9	0.09	0.46	–	–	–
							Yellow Brown Ass'n								
0-15	3	10	12	79	7.6	0.9	24.9	26.8	27.6	3.7	0.15	0.81	2.5	0.23	10.9
15-30	2	7	12	81	8.0	2.8	22.9	24.9	23.5	5.3	0.17	1.49	1.9	0.18	10.6
30-60	0	2	6	96	8.0	0.5	19.1	18.5	20.0	2.5	0.16	0.76	–	–	–
60-90	0	1	2	99	7.5	0.3	20.0	18.1	19.1	2.0	0.12	0.84	–	–	–
							Grey Brown Ass'n								
0-15	10	4	31	55	8.0	20.5	34.9	nd	nd	6.9	0.11	0.78	1.6	0.17	9.1
15-30	13	2	26	59	8.1	22.4	36.0	nd	nd	6.9	0.10	0.86	1.2	0.15	7.9
30-45	10	4	39	47	8.0	18.6	45.0	nd	nd	6.0	0.12	0.95	1.1	0.14	7.8
							Black Soil								
0-15	12	18	5	66	7.0	0	44.2	47.5	45.0	2.3	0.17	1.22	1.5	0.10	15.0
15-30	10	18	7	71	7.1	0.3	41.2	40.8	38.3	1.2	0.11	1.40	1.2	0.08	15.0
30-60	10	15	7	74	7.0	0.4	39.4	41.0	37.4	2.1	0.11	1.70	–	–	–
60-75	7	10	5	82	7.4	0.8	43.3	45.6	40.1	2.8	0.12	2.01	–	–	–
							St. George's Valley								
0-15	5	10	12	73	7.7	7.5	36.2	39.3	42.8	4.7	0.14	3.86	1.3	0.12	10.8
15-30	6	10	12	75	8.1	8.8	34.6	39.5	46.3	5.2	0.12	3.62	1.3	0.11	11.8
30-60	6	12	12	71	7.9	8.0	35.6	36.6	45.7	4.9	0.12	3.69	–	–	–
60-90	1	3	8	93	7.8	0.9	36.9	38.1	38.4	4.3	0.12	3.34	–	–	–
90-120	0	4	7	90	7.5	0	36.8	38.5	38.3	4.5	0.13	3.43	–	–	–
							St. Philip Plain								
0-15	6	9	8	80	7.6	9.5	69.0	69.8	70.6	9.5	0.60	4.10	1.3	0.11	11.8
15-30	8	9	11	74	7.7	12.3	67.1	68.4	69.1	10.8	0.65	4.00	1.5	0.13	11.5
30-75	3	6	9	84	7.7	4.4	66.8	70.2	67.7	11.3	0.66	4.39	–	–	–
75-90	10	4	9	79	8.0	4.2	68.2	69.4	69.4	13.3	0.72	6.24	–	–	–
90-120	2	5	6	89	7.8	1.4	61.2	71.5	70.3	10.9	0.60	5.77	–	–	–

TABLE 2

CLAY MINERALOGY OF SURFACE HORISONS (0-15 cm)
(VALUES EXPRESSION ON OVEN-DRY BASIS)

Soil Association	Amorphous SiO_2 %	Amorphous Al_2O_3 %	Kaolinite %	Montmorillonite %	Fe_2O_3* %
St. John's Valley	9.8	4.1	58	20	7.51
Yellow Brown	9.9	5.8	43	30	11.09
Yellow Brown – R+	6.8	5.5	45	34	7.88
Grey Brown	12	4.8	37	42	4.01
Black Soil	15	5.8	29	48	2.26
Black Soil – R+	13	3.6	26	51	6.44
St. George's Valley	4.2	2.8	42	48	3.25
St. Philip Plain	18	3.0	25	52	1.55

*Extractable by citrate-dithionite.

Soil Profile Description:

Depth cm	*Description*
0-12	Dark brown (10YR 3/3, moist); fine sandy loam; weak fine to medium subangular blocky structure, breaking to granular; loose to friable, very slightly plastic, almost non-sticky consistence; gradual, slightly wavy boundary to:
12-67	Dark brown (7.5YR 4/4, moist), passing to red-brown (5YR 4/4, moist); fine sandy loam passing to loamy fine sand; virtually structureless at 15 inches; firm non-sticky, almost non-plastic consistence; diffuse, smooth boundary to:
17-87	Red (2.5YR 4/8, moist); fine sand; structureless; firm non-sticky, non-plastic consistence; abrupt, wavy boundary to:
At 87	Hard, blocky coral.

SCOTLAND DISTRICT

The soils of the Scotland District are quite unlike those of the coral regions of Barbados. Most of the soils are immature because of rejuvenation by accelerated erosion. Landslips result from spring water which lubricates slip planes between pervious and underlying impervious strata. The slip planes are often deep, and trees, crops, houses, bridges and roads are frequently destroyed. Landslips have been prevented by using subterranean pipes to drain spring water away from unstable areas (MARTIN–KAYE and BADCOCK, 1962; and CUMBERBATCH, 1966a). Further erosion is prevented by land moving (reshaping) operations to reduce slope gradients, fill ravines and prepare rough terrain for mechanical cultivation.

Slumping results from the toe erosion of swift flowing streams which undercut steep V-shaped slopes. Small earth dams have been used successfully to prevent slumping.

The areas with high concentrations of oil and sodium salts have remained uncultivated and even bare of natural vegetation for years. In addition, the bulldozers spread contaminated soil during land reshaping, and some potentially good agricultural land has been ruined. The oil and salt are widely distributed in the clay and sand strata.

Overstocking has denuded slopes, leading to sheet erosion and gullying, and exposure of infertile subsoil.

The problems have resulted in the loss of valuable land and this must be stopped. KON (1964) calculated that 70 percent of the Scotland District was threatened by erosion, and that 11 percent of the area had already reached a very severe stage of degradation. The present writer estimates that only 60 percent of the 15000 acres comprising the Scotland District is effectively cultivated today. The population density in Barbados is among the highest in the world (ANON., 1965), and reclamation even though expensive, is essential.

The Soil Conservation Board is reforming and draining steep, eroded land in the Scotland District. Ripping by heavy tractors, however, brings oil-impregnated and salt-rich subsoil to the surface and it is difficult to retain any topsoil on these strongly eroded slopes. The raw subsoils exposed by the reforming operations may be almost sterile because of low nutrient levels, poor structure or high levels of free lime. Considerable efforts and special techniques are required for restoring fertility. These reformed soils are not further described, but, with the limitations already mentioned, may be regarded as generally similar to normal soils from the same parent material developing on a stable site.

The following are the main mapping units:

(1) Soils from the Joes River Muds. Soils developing from Joes River Muds are uniformly dark coloured sandy clays of mixed mineralogy. Their drainage is imperfect and they typically cover steep eroded slopes.

The Joes River muds range from dark grey sandy and argillaceous silts, to silty and sandy clays including angular and subangular pebbles, fragments and boulders of dark brown to black tar sand and other sandstones. There are also smaller, rounded clay pebbles, fragments of clay, ironstone and fibrous calcite. The formation is impregnated with oil.

The soil has pH values of slightly over 7 with CEC of 20 to 30 m. r. e./100 gm, Ca being the major exchangeable cation. The clay mineralogy consists of montmorillonite, illite and kaolinite in 2: 2; 1 ratio.

Soil Profile Description:

Depth cm	*Description*
0-15	Very dark grey-brown (2.5Y 3/2, moist); sandy clay loam; weak to moderate fine to medium subangular blocky structure; friable, slightly plastic, slightly sticky consistence; gradual, slightly wavy boundary to:
15-45	Dark grey-brown (2.5Y 4/2 moist), mottled with olive brown; sandy clay; moderate medium subangular blocky structure; firm, slightly plastic, slightly sticky consistence; diffuse, slightly wavy boundary to:
45-102	Dark grey brown (2.5Y 4/2, moist), with varying colours due to weathering rock fragments, stony sandy clay; structureless; very firm, slightly sticky, slightly plastic consistence.

(2) Scotland Sandstones

Upper Scotland Formation.

The Scotland Sands are very soft, friable sandstones. They consist of a vari-coloured banded and laminated sandstone and siltstone sequence with a grey silty claystone. There are occasional beds and lenses of calcareous sandstone and sandy limestone. One member is largely composed of poorly sorted grits and conglomerates.

Soils developed from the base deficient weakly coherent sandstone are acid and light textured. The profile is shallow and poorly structured. Texture is very variable due to the graded nature of the beds and the very rapid alteration of strata with very different grain sizes. There is probably as much variation within beds as between them.

Where contaminated with coral calluvium the pH values are above 7.0, otherwise the soils are slightly acid; CEC is of the order of 10 to 15m. e./100 gm soil with Ca being the dominant exchangeable cation. The clay mineralogy consists of 50 percent montmorillonite, 30 percent illite and 20 percent kaolinite.

Soil Profile Description:

Depth cm	*Description*
0-10	Brown (10YR 5/3, moist); fine sandy loam, weak to moderate fine angular blocky structure; friable, very slightly sticky, non-plastic consistence; gradual, smooth boundary to:
10-45	Brown (10YR 5/3, moist); fine sandy loam; moderate to strong medium and coarse angular blocky structure: firm non-plastic, non-sticky consistence; clear. slightly wavy boundary to:
At 45	An intimate mixture of horizon II material with powdery fragments of weathering white sandstone.

(3) Scotland Clays

Lower Scotland Beds.

The Scotland Clays consist mostly of evenly bedded and regularly laminated silty and shaley claystones ranging in colour from dark grey to olive brown. Nodules and thin beds of clay ironstone are relatively common. There are streaks and thin beds of fine sandstone and siltstone and a few thicker and coarser sandstones. Ferruginous limestone occur in lenses.

Soils formed from Scotland Clays are greyish silty clays of mixed mineralogy. They are poorly drained and easily eroded. Colours tend to vary widely in the sub-soil wherever weathering parent material begins to appear. The subsoil may contain many black and reddish-brown concretions. Textures may occasionally be fine sandy instead of silty. The structural grade is usually weaker and finer after recent cultivation. pH values are slightly above 7 with small quantities of $CaCO_3$ being present in some profiles. CEC is around 40 m.e./100gm; exchangeable Ca and K are usually high. The mineralogy consists of montmorillonite, illite and kaolinite in about equal amounts.

Soil Profile Description:

Depth cm	*Description*
0-10	Brown (10YR 5/3, moist); silty clay; moderate medium angular blocky structure; friable, slightly sticky, slightly plastic consistence; gradual, slightly wavy boundary to:
10-32	Almost concolorous grey-brown (2.5Y 5/2, moist); silty clay, moderate to strong medium and coarse angular blocky structure; firm to friable, slightly sticky, plastic consistence; gradual, slightly wavy boundary to:
32-55	Grey brown (2.5Y 5/3, moist), mottled with light olive brown; silty clay loam; poor prismatic structure – almost structureless; firm, sticky, plastic consistence; gradual, slightly wavy boundary to:
55-120	Olive grey (5Y 5/2, moist), intermottled with light olive brown and brown in a mosaic pattern; silty clay

Depth	*Description*
	loam; structureless; very firm plastic, slightly sticky consistence.

(4) Soils from the Oceanic Formation

The Oceanic Formation includes a great diversity of geological materials. A distinction could be made, however, between soils developed over calcareous globerigina marls and siliceous radiolarian earth. Four sub-groups can be recognised as follows:—

(a) The grey-brown sub-group: grey, medium textured soils with a high CaCO3 content derived from the oceanic marls; soil neutral to weakly alkaline in reaction.

(b) The brown sub-group: moderately weathered and leached slightly calcareous silty clay soils over-lying Oceanic marl.

(c) The red-brown sub-group: More strongly leached clay soils resembling the Red-Brown Association of the coral derived soils. Their parent materials are clay beds within the Oceanic Formation, presumably of volcanic formation. The sub-group is confined to relatively flat areas immediately above or below the Scotland District escarpment.

(d) The Bissex Hill sub-group: Light textured yellowish soils from the sandy Bissex Hill marl. The soils of the Oceanic Formation have very variable clay mineralogy.

(5) Alluvial Soils

The alluvial soils of the Scotland District can be classified on the basis of the materials from which they are derived as follows:—

Mapping Unit	171	From Joes River Mud
Mapping Unit	172	From Scotland Sandstones

Mapping Unit	173	Finer-grained variant of Unit 172
,, ,,	174	From Lower Scotland Formation
,, ,,	175	Gleyed variant of Unit 174.

Unit 171 derived from Joes River Muds is variable in texture and uniformly dark in colour. It has better structure and moisture retention than the other sandy alluvial soils. The soil is deep and virtually stone-free.

Unit 172 is a relatively coarse – textured sandy alluvial soil. A profile description of this Unit is as follows:–

Depth cm	*Description*
0-12	Brown(10YR 4/3); loamy fine sand; weak to moderate fine medium angular blocky structure; friable, non-plastic, non-sticky consistence; gradual, smooth boundary to:
12-55	Yellowish-brown (10YR 5/4, moist); predominantly fine sand; single grain structure; compact, non-plastic, non-sticky consistence; clear, slightly wavy boundary to:
55-110	Brown (10YR 5/3, moist): medium and coarse sand; single grain structure; loose, non-plastic, non-sticky consistence.

Unit 173 is derived from Lower Scotland Formation. Drainage is free but not excessive and it has better surface structure and moisture supplying capacity than Unit 172.

Unit 174 is sandy although predominantly derived from the fine textured Lower Scotland Formation. The top-soil is commonly a fine sandy loam or silty loam with weak blocky structure. The sub-surface horizons are poor or loose and subsoil packing may occur. Traces of gleying may appear at about 60 cm depth.

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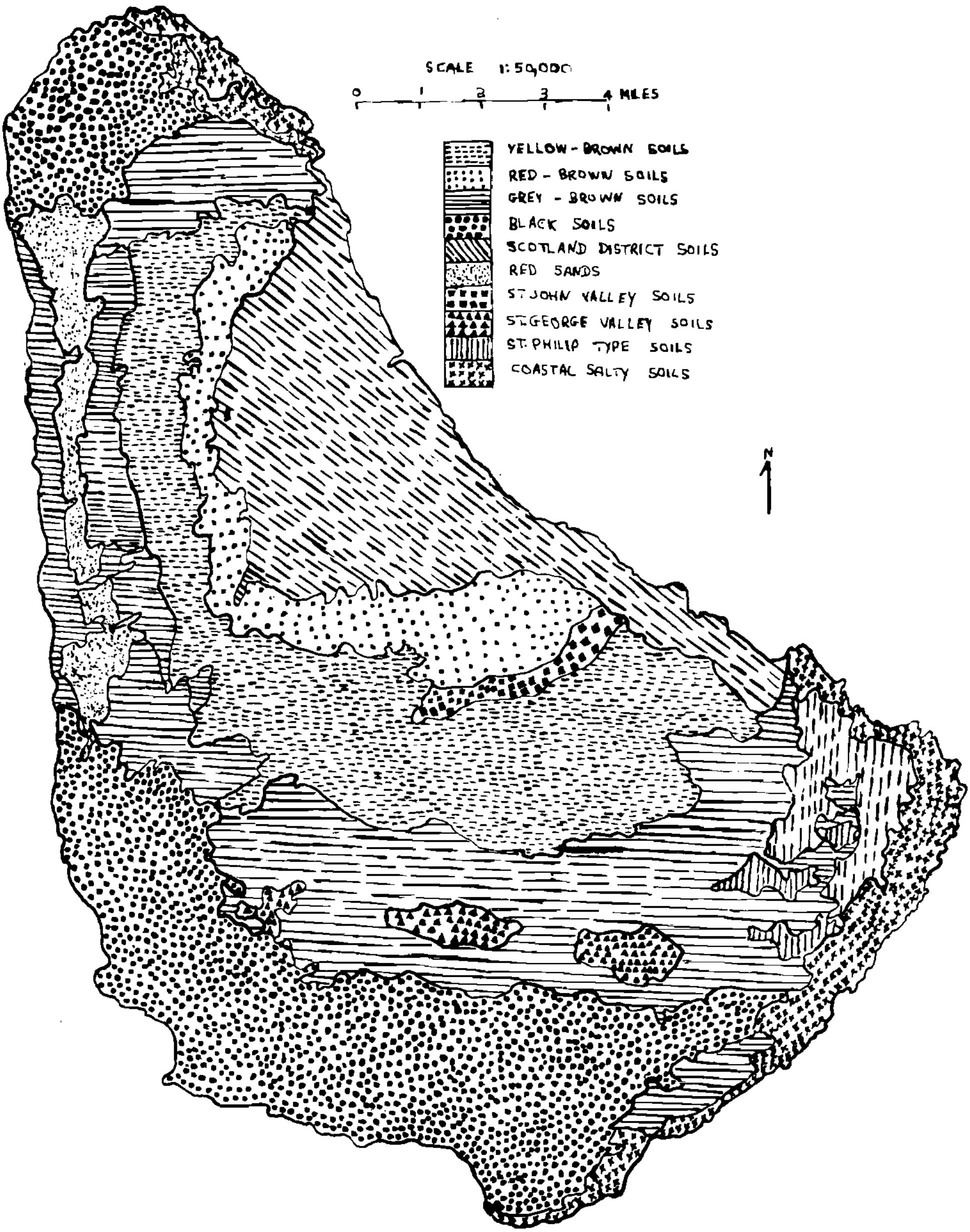
SCALE 1:50,000
0
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YELLOW-BROWN SOILS
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RED SANDS
ST JOHN VALLEY SOILS
ST GEORGE VALLEY SOILS
ST. PHILIP TYPE SOILS
COASTAL SALTY SOILS
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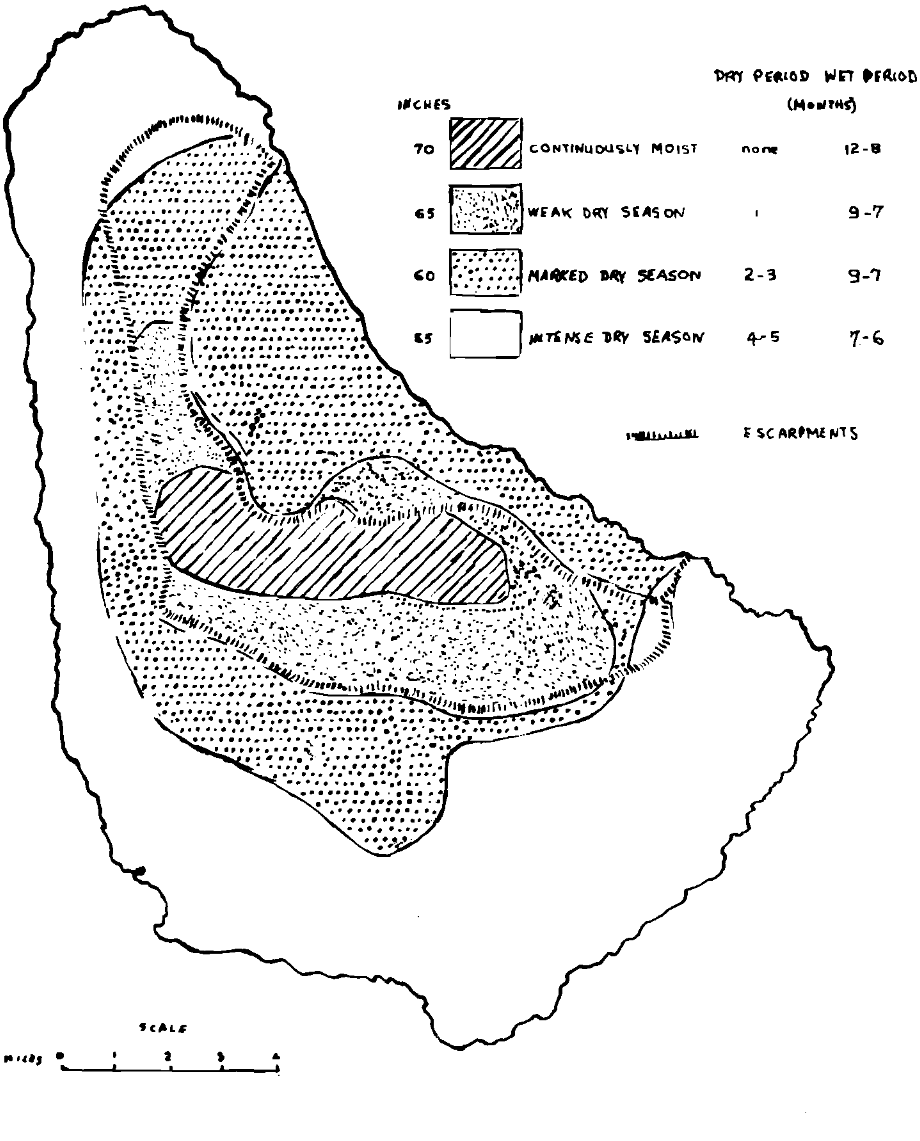
DRY PERIOD WET PERIOD
(MONTHS)
INCHES
70 CONTINUOUSLY MOIST none 12-8
65 WEAK DRY SEASON 1 9-7
60 MARKED DRY SEASON 2-3 9-7
55 INTENSE DRY SEASON 4-5 7-6
ESCARPMENTS
SCALE
MILES 0 1 2 3 4

THE CLIMATE OF BARBADOS

by

B. A. ROCHEFORD

INTRODUCTION

The island of Barbados has an area of 166 sq. miles, is lowlying with a fairly smooth surface rising at its highest point to just over 335 metres (1,100 feet) and is located in latitude between 13° 02'N and 13° 20'N and in longitude 59° 25'W and 59° 39'W. It lies therefore about 100 miles to the east of the Windward island chain and about 3,000 miles west of the coast of West Africa.

The surface layer of rocks over about 86% of the island consists of coral limestones. Over the other 14% of the island the coral limestones have been removed by erosion and tectonic movements, and the older rocks, mostly shales and sandstones, are exposed at the surface. This region is situated in the north-eastern part of the island and is subject to much soil erosion and land slippage, especially during and after periods of heavy rainfall.

Topographically, the island is relatively smooth except for the Scotland District of the north-east. The land rises generally from the western, north-western and south-western coastlines towards the centre of the island in a series of terraces to a maximum height of just over 335 metres (1,100 feet) at Mount Hillaby, (See Fig. 1). From the south-western coastline, the land rises to a little over 91 metres (300 feet) in what is known as the Christ Church Ridge, then descends to the St.

George Valley before rising again, in terraces, northwards towards the Central Uplands. From the eastern and north-eastern coastlines, the land rises quite abruptly in the Scotland District and is characterised by ridges and valleys giving a much rougher aspect.

FACTORS DETERMINING THE CLIMATE

The main factors are radiation, sea surface temperature and air flow characteristics.

Barbados lies within the belt of the Easterlies or Trade Winds associated with the southern region of the semi-permanent high pressure area located south of the Azores. It is, therefore, almost constantly under an easterly flow of warm moist air. Secondly, it is located in a tropical ocean whose surface temperature varies little from 26.7°C (80° F) at any time. Thirdly, it receives an almost constant amount of solar radiation at its surface from month to month. These three factors combine to give a climate with a fairly constant, high air temperature rarely rising about 33° C (92°F) or falling below 15.6°C (60° F). Broadly, the year may be divided into a dry season and a wet season. The wet season falls roughly from the beginning of June through to the middle of December, when most of the rainfall is received during the passage of tropical disturbances through the region. The dry season starts in mid-December and ends around the end of May. However, these are generalizations since it is quite possible to experience 'dry' spells in the 'wet' season and 'wet' spells in the 'dry' season. These latter are caused by the effect of the intrusion of mid-latitude systems into the region.

CLIMATIC ELEMENTS

Temperature

As the island is quite small, the air temperature is determined to a great extent by the temperature of the winds blowing off the surrounding oceans, which, as mentioned earlier on, have a surface temperature varying little from around 26.7°C (80° F) all the year round. Therefore, there is little variation either annually or diurnally in air temperatures over the island. Temperatures are lowest in the months of December through to March, an effect due to the sun's low angle in the southern sky and the slight reduction in sea surface temperature. Temperatures are highest in May and early June, the last part of the dry season when radiation is highest and vapour pressure is low. With the advent of the wet season in the latter half of June there is a fall in air temperatures from those of the previous months. This is due to the combined influence of the increase in cloud cover at this time, reducing radiation received at the surface, and of the loss of heat from the land surface used up in evaporating some of the rainfall. It has, therefore, been observed that if there is a prolonged dry spell in the wet season there is an immediate increase in air temperatures. The constancy of temperature is well illustrated by data from the former station at Codrington where in the period 1903 – 1964, the mean monthly temperature ranged from a high of 26.8°C (80.3° F) in June to a low of 24.6°C (76.3° F) in February, a range of only 4° F. The extreme maximum temperature in the same period was 35°C (95° F) in August 1943 and extreme minimum 16° C (61° F) in January 1949 and February 1944. (See Figure 2).

These temperatures and their ranges are not as uninteresting as they might appear since they are in the critical region for important physiological processes from many crop plants, e.g. night time temperature must be less than 72° F (22° C) for fruit set for tomatoes. When it is realised that the optimum growing temperature for some crops may be sensitive to within a few degrees, it can be appreciated that the seasonal temperature variation is important in the seasonal performance of some crops, (Thompson 1942). Corn seedlings have an optimum growing temperature of about 32° C whereas for cucumber seedlings the optimum growing temperature is about 35°C. It is therefore important to have a knowledge of the range and frequency of temperatures which can be expected at particular times of the year.

With regard to the distribution of temperatures over the island, it appears that there is a difference of about 2°C – 3° C (4° F – 6° F) between the mean temperatures occurring in the highest areas and the low lying areas, (Skeete 1963).

Grass minimum temperatures between 15.6° C (60° F) and 18.3° C (65°F) from May to November and between 12.8°C (55°F) and 15.6°C (60° F) from December to March were recorded at Waterford in St. Michael. The extreme minimum recorded there was 11.6° C (52.8° F) in December 1964.

Soil Temperatures

Reliable soil temperature data are sparse. Data taken over five years at Waterford Climatological Station show mean that monthly 2–inch soil temperatures at 9 a.m. are lowest in the months December, January, February and March with a mean for the period of 24.2° C (75.6° F) and highest in the months April to November with a mean of 26.9° C(80.4° F). Mean monthly 2–inch soil temperatures at 4 p.m. are lowest in the months October to February with a mean of 30.7° C (87.2° F).

Some attempts have been made to grow potatoes in Barbados. Unfortunately, it was not realised that potato tubers do not grow in soils when the temperature exceeds 29.2° C, and the optimum soil temperature for tuber growth is about 17°C. The temperature of the soil can greatly influence the growth of roots and in this way affect the growth of the plant.

Wind Speed and Direction

As the island lies in the belt of the north-east Trade Winds, the most frequently recorded wind directions were from the east through to the north-east. At Seawell Airport, over the period 1942 – 1951, the wind blew from either the east, east-north-east or north-east 85% of the time with a maximum percentage frequency of 95% occurring in December, and a minimum percentage of 70% in October. The corresponding figures for Codrington for the period 1933 –1952 showed a percentage frequency of 87% with a maximum percentage frequency in January of 94% and a minimum occurring in September of 75%. Tables 1 and 2 show wind direction data for these two stations.

During the months of December through to March, the wind blew almost exclusively from directions east through north-east. In the months of April to July there is a slight shift with south-easterly winds blowing occasionally. From August to November there is a more pronounced shift to south-easterly and south winds with the occasional wind from the south-west, these latter associated with tropical disturbances passing over or near the island.

Wind speed is highest on average during the months of January through to July, corresponding roughly with the dry season. At Seawell Airport over the period 1942 – 1970 wind speed averaged 6.6 metres per second (12.9 knots) during January to July and 5.2 metres per second (10.2 knots) during August to December, (See Table 3). Gusts of 15.6 to 22.4 metres per second (35 to 50 m.p.h.) are occasionally experienced with the passage of tropical disturbances. A speed of about 45 metres per second (100 m.p.h.) was estimated to have occurred during Hurricane Janet in 1955 in the southern coastal districts, with sustained maximum winds of 35.8 – 38.0 metres per second (80 – 85 m.p.h.)

Unfortunately, the Caribbean Agriculturalist seems to recognize the damage that is done to his crop by gale force winds only. Equally important, however, is the loss which can accrue from removal of blossoms and the deformation of tree crowns by winds far below gale force. Over the whole of Barbados, this deformation of plant tops can be seen on permanent tree crops and other trees. It seems likely that in the near future wind breaks and shelter belts will become a feature of Barbadian agriculture.

With the increase in the number of cane fires and the increased frequency of crop damage due to wind borne agricultural chemicals it is hoped that the local agriculturalists will begin to pay more attention to wind speeds and directions.

Cloud Cover

Convectional clouds are the predominant type seen over Barbados, ranging in size from the small cumulus humilis to the giant towering cumulo-nimbus seen during the months of August, September and October. Data from Seawell Airport give a mean annual cloud cover of 3.6 expressed in oktas or eights, i.e. lying between 3/8ths and 4/8ths of sky covered by cloud, (See Figure 3). Cloud cover is highest during the daytime hours. The months of greatest cloud-cover during the daytime are June through to December with a mean of 3.91, but April also shows a high figure of 3.81. Mean daytime cloud cover for the months January through to May was 3.66.

Day to day variation can be quite large, cloud amounts ranging from 2/8 to 6/8 of sky covered, with days of completely overcast or completely cloud-free sky being very rare. There is a tendency for clouds to form over the more elevated parts of the island and also to line themselves up in 'streets' parallel to the prevailing wind. These factors contribute greatly to the observed variations in the amounts of solar radiation received by different surfaces across the island. Diurnally, cloud amounts are highest in the day and lowest between 8 p.m. and 2 a.m. (See Figure 4).

Cloud cover influences the temperature of plant leaves. Leaf temperature is extremely important in the germination of some fungal spores. Thus the occurrence of certain crop diseases at some times of the year, or at certain locations may, in some cases, be attributed to the difference in cloud cover.

Solar Radiation

The quantity of daily solar radiation received at the top of the atmosphere for latitude 13° 21'N varies from a maximum of 932 langleys in mid-May and around the end of July, when the sun is overhead on its path northwards and returning southwards, respectively, to a minimum of 719 langleys around the middle of December when the sun is at its farthest point south of the island. (See Figure 5). However, average cloud cover over the island is higher over most of the months of high radiation than over the months of low radiation, and this tends to give a more even distribution of the radiation received at the surface over the period of a year. The exceptions to this are March, April and May when low cloud cover coincides with high radiation values to give high surface values of radiation.

Measurements of solar radiation are available for a comparatively short period of time, but sunshine duration has been recorded for longer periods.

Data obtained from a study made in 1964 at the Brace Experiment Station, St. James showed that total radiation received at the surface is greatest in the months of March, April and May and least in the months of September to December. (See Figure 5).

The range of monthly values of mean radiation is not large, the largest value occurring in March with 513 langleys out of a possible 888 langleys, and the smallest in September with 411 langleys out of a possible 896 langleys, a difference of about 180 langleys. Cloud cover is the factor responsible for the smoothing out of these values since cloud amounts increase during June at the beginning of the wet season and remain high until December. (See Figures 3 and 5).

Cloud cover is also the most important factor in determining the proportion of diffuse radiation in the total radiation. As cloud cover increases, the percentage of diffuse radiation in total radiation increases also.

Table 5 shows the distribution of the daily total radiation. The number of days in a month in which total radiation was greater than or less than certain amounts are shown as well as the highest and lowest daily amounts for each month. On some days in March, April and May the total radiation was greater than 600 langleys. These months also have the highest number of days with more than 500 langleys. The months of July, September, October, November and December have the highest number of days with less than 400 langleys per day and September is the only month with more than 10 days recording less than 400 langleys.

Table 6 shows the distribution of radiation by hours of the day. The greatest hourly value of total radiation usually occurs between 11 a.m. and noon and for diffuse radiation one hour later.

Radiation values vary widely over the island, (Tout 1968) and this is mostly due to the distribution of cloud cover. Clouds tend to form more frequently over the elevated regions in the centre of the island, while the coastal areas in the south-west, east and south-east remain comparatively free of cloud. The high regions thus benefit from the effects of reduced radiation and higher rainfall, combining to produce a much more favourable water balance in the soil.

The amount of solar radiation received by a crop influences the amount of dry matter produced. It seems likely that the mineral consumption of the crop can in this way be influenced by the radiation climate. Thus the use of fertilizer may not only be dependent on the soil conditions but on the climate as well.

Annual totals of sunshine duration from Codrington and Seawell Airport are both just over 3,000 hours, with little variation from year to year. Mean daily sunshine at both stations is highest during the months of March and April, the figure at Codrington being 8.9 hours and at Seawell Airport 9.0 hours. This pattern agrees with that obtained from the measurements of solar radiation quoted from the Brace Experimental Station.

Rainfall

Rainfall is lowest in the period from mid-December to the end of May, with March as the driest month. (See Table 4). The wet season runs from early June to mid-December with September and October as the wettest months. Monthly totals of rainfall vary quite considerably from year to year, especially in the drier areas, for example 330 mm (12.98 ins) were recorded at Waterford in St. Michael in July 1963 and 69 mm (2.71

ins) in July 1959. Annual rainfall is also quite variable, (See Figure 6). Eighty years of data for the period 1843 – 1922 from Oughterson Plantation, St. Philip give a maximum of 1905 mm (75 ins) in 1853 and a minimum of 787 mm (31 ins) in 1885 with a mean of 1369 mm (53.9 ins).

As mentioned earlier, the volume of rainfall in the wet season is determined mostly by the frequency of tropical disturbances which account for most of the rain in this period. Local convectional showers account for most of the remainder.

In the dry season, most rainfall originates from the effects of mid-latitude systems intruding into the region. Since the intrusions of these systems tend to be somewhat randomly distributed in time, i.e. they do not intrude predictably either in number or in time of occurrence, the rainfall they produce in the area is very variable over time. This is in contrast to the passages of tropical disturbances in the wet season, which, over a long period of years, tend to occur with a statistically predictable frequency roughly one every four days. (Riehl 1954). Thus the variability of rainfall in the wet season is lower than in the dry season. This is confirmed by the statistical study by Lirios and Farnum 1972, who report that there is a large coefficient of variation of rainfall in the months of low rainfall, while the coefficient of variation is small in months of high rainfall. There is a small contribution to the rainfall of the dry season by showers of local convectional origin, but the conditions for formation of these clouds are less favourable in the dry season than in the wet season.

Rainfall amounts vary from place to place across the island. (See Figure 7). The low lying areas of the south-east, south-west and the north are the driest with a mean annual rainfall in the period 1908 – 1970 of less than 1,270 mm (50 ins). The wettest areas are the central and north-central elevated regions which had mean annual rainfall amounts for 1908 – 1970 greater than 1,651 mm (65 ins.) with as high as 2,057 mm (81 ins) in places. According to Lirios and Farnum 1972, areas which receive high rainfall amounts have a low variability of rainfall from year to year, while areas of low rainfall amount have a high variability from year to year.

Evaporation

From the very limited data on evaporation available, the data from four complete years of Class 'A' pan evaporation measurements taken at Waterford Climatological Station show that monthly evaporation is least in the months September to February, the mean for the period being 147 mm (5.8 ins) of water with a minimum in November of 132 mm (5.2 ins), and is greatest in the months March to August with a mean of 203 mm (8.0 ins) and a maximum in May of 226 mm (8.9 ins). (See Figure 7A for a plot of some evaporation data.)

Moisture Balance

Rouse and Watts (1966), made a study of the moisture balance of the island in which a slightly modified version of Thornthwaite's system was used to estimate the moisture balance in the soil.

They estimated potential evapotranspiration and actual evapotranspiration. The first of these, the P.E., is the amount of water which will be evaporated and transpired from vegetation provided that this water is available in the soil. The A.E. is the amount of water which will actually be evaporated and transpired, this amount being controlled or limited by the amount of rainfall received by the soil and its moisture retention capacity.

They found that the potential evapotranspiration is closely related to the elevation. The areas with high potential evapotranspiration 1676 – 1778 mm (66 – 70 ins) lie exclusively where elevations are less than 61 meters (200 feet); those with moderate P.E., 1295 – 1651 mm (51 – 65 ins) in regions with elevation between 61 – 244 meters (200 –800 feet); those with low P.E., 1168 –1260 mm (46 –50 ins) usually above 244 meters (800 feet).

Actual evapotranspiration showed a different areal distribution. A.E. is lowest where the P.E. is highest. Thus, the areas of greatest moisture requirement do not receive or retain sufficient moisture and there is a large moisture deficit. Along a narrow zone of the southern coast, this deficit exceeds 508 mm (20 ins) per year. An exception to the above is the coastal areas of St. James and St. Peter and North-western St. Lucy where higher rainfall and soils of greater moisture retention capacity combine to give the highest A.E. for the whole island. A.E. is low to moderate in the areas of higher elevation where P.E. is low to moderate and there is little or no moisture deficit.

Vapour Pressure and Relative Humidity

Vapour pressure of the air is lowest in the dry season months of January to April with a mean value of 24.5 mb at Seawell Airport and 22.9mb at Codrington Agricultural Station. It is highest in the wet season months of July to November, with a mean of 28.7 mb at Seawell and 27.4 mb at Codrington. The values at Codrington are lower in all months than those at Seawell, reflecting the reduction of moisture in the air in a low lying area away from the sea coast. (See Figure 8.)

The figures for relative humidity at the two stations show a similar pattern to that for vapour pressure. Relative humidity is lowest in the months January to April with mean at Seawell of 72.5% and at Codrington of 67.6%, and highest in months July to November with mean at Seawell of 78.8% and at Codrington of 74.8%. (See Figures 9 and 10.)

SUMMARY

Barbados has an even climate, with a broad division of the climatic year into a wet and dry season. Topography and elevation determine the variations experienced in the climate at different locations on the island especially with regard to radiation received, cloudiness and rainfall, the areas of higher elevation receiving generally less radiation, but having more cloudiness and rainfall. The temperature variation is small, both from month to month and from place to place, but diurnally can reach up to 10°C (18°F). Winds are predominantly from the East, and are strongest in the dry season, except during passage of the occasional hurricane. There is a moisture deficit over most of the low lying areas in the southern regions of the island, with little or no deficit in other regions.

ACKNOWLEDGEMENT

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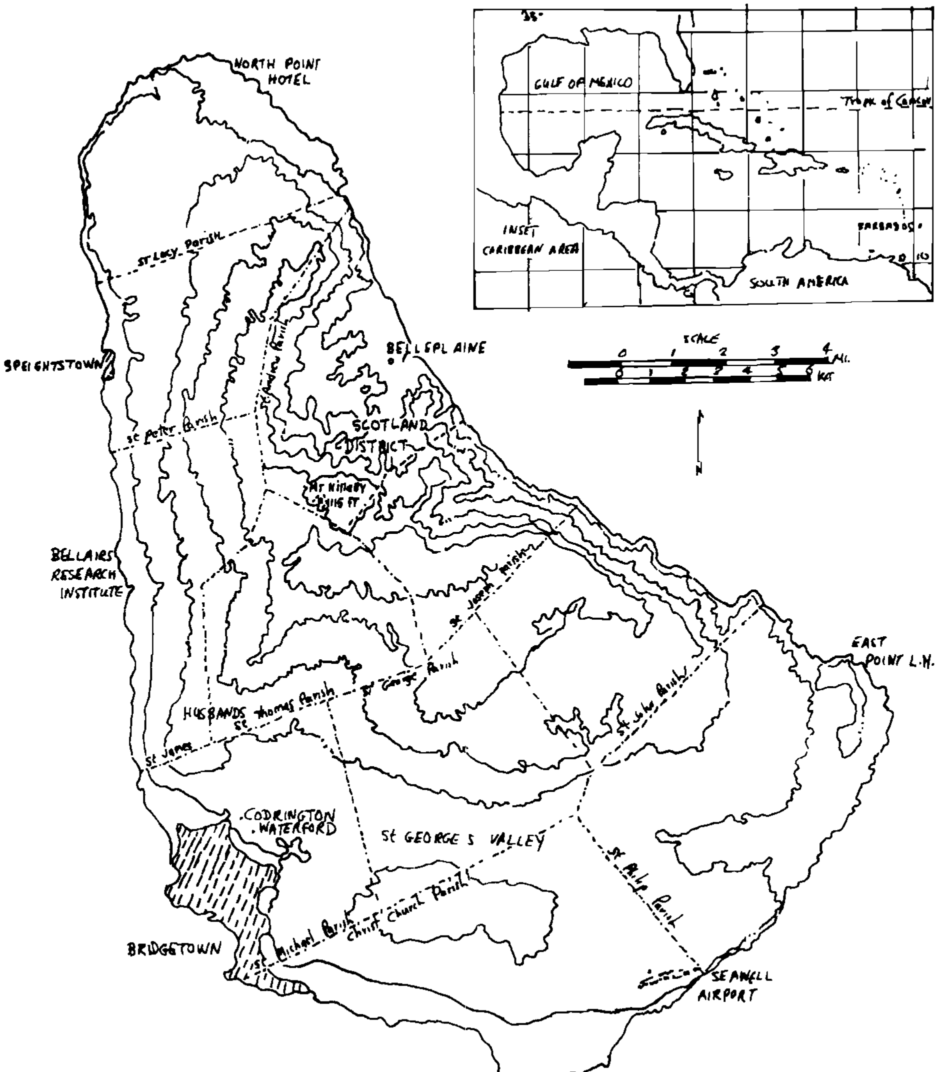
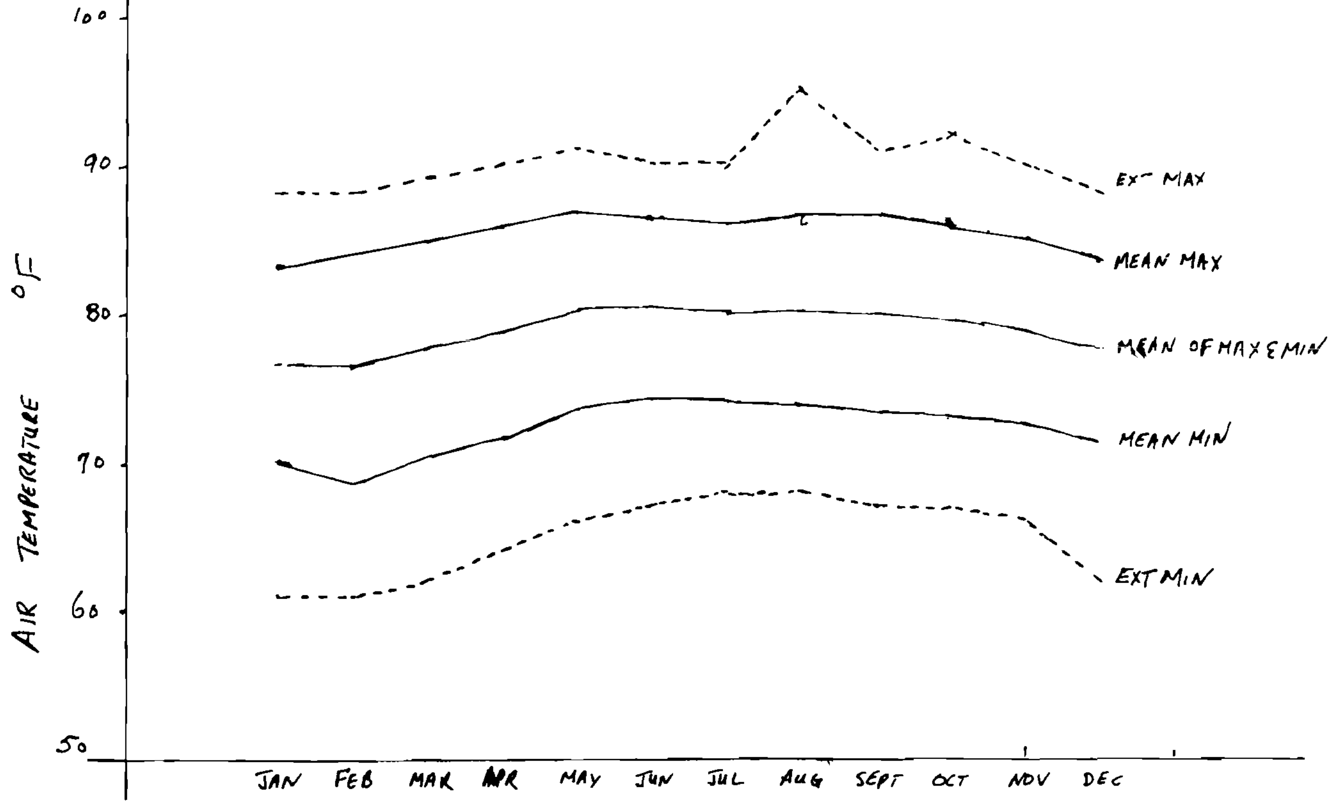


BARBADOS
LOCATION MAP
FIG. 1

Fig. 2

MEAN OF EXTREME VALUES OF MAXIMUM & MINIMUM AIR TEMPERATURE CODRINGTON (1903 - 1964)



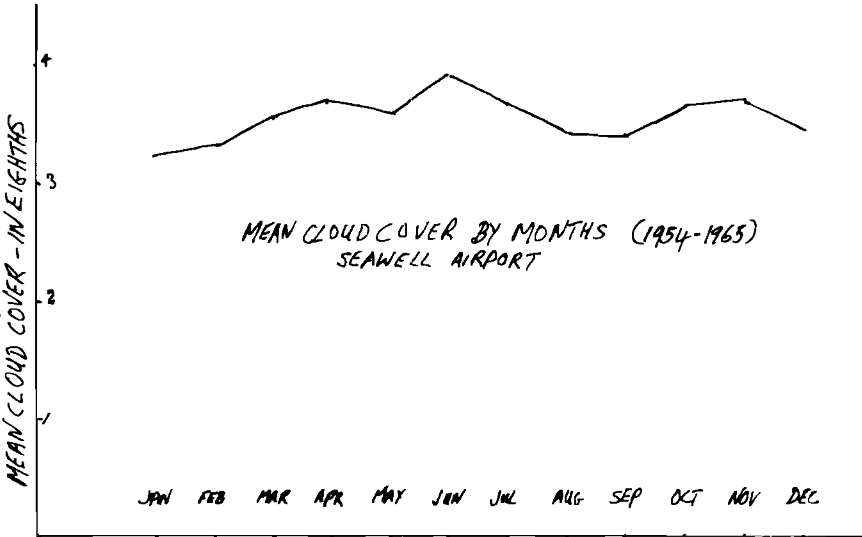

MEAN CLOUD COVER - IN EIGHTHS
4
3
2
1
MEAN CLOUD COVER BY MONTHS (1954-1965)
SEAWELL AIRPORT
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

FIG 3

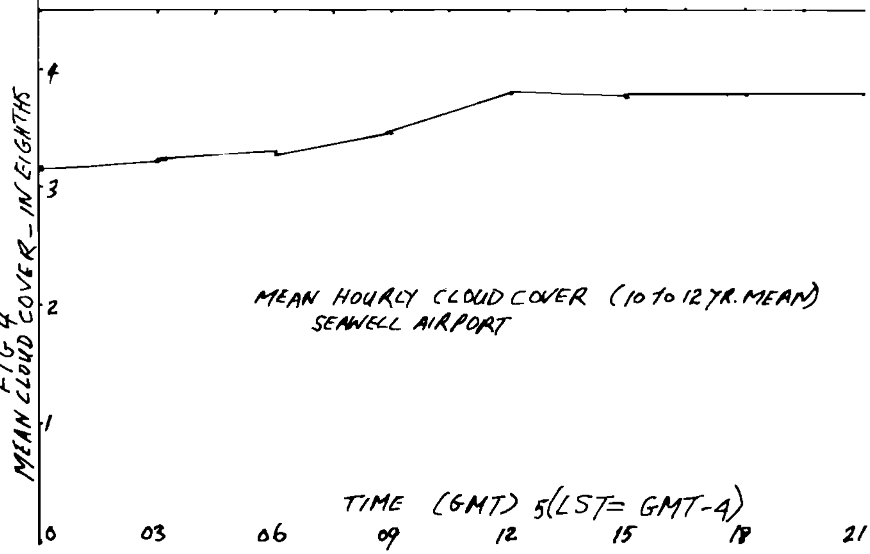

MEAN CLOUD COVER - IN EIGHTHS
4
3
2
1
MEAN HOURLY CLOUD COVER (10 to 12 YR. MEAN)
SEAWELL AIRPORT
TIME (GMT) 5(LST= GMT-4)
0 03 06 09 12 15 18 21

FIG 4

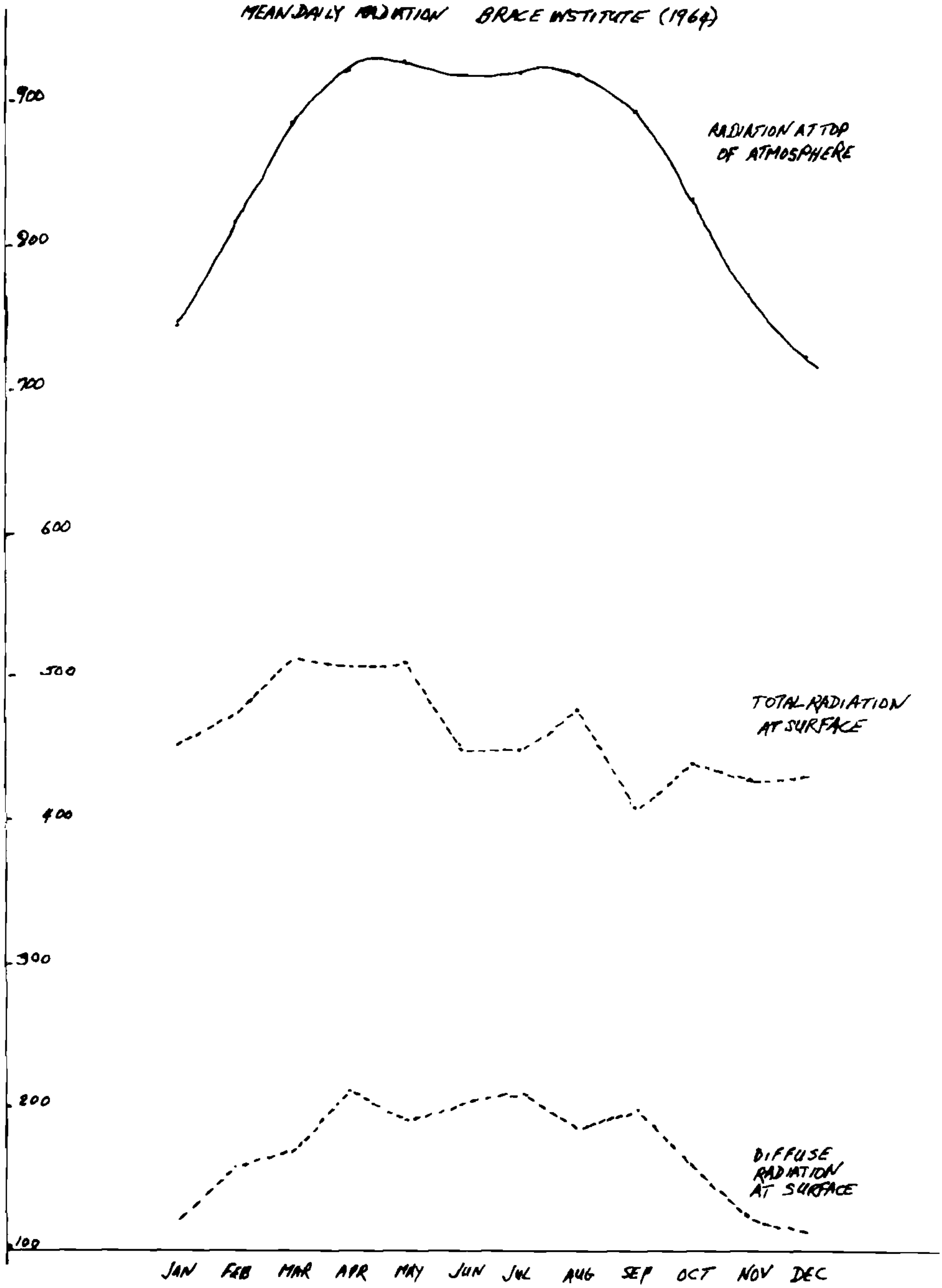
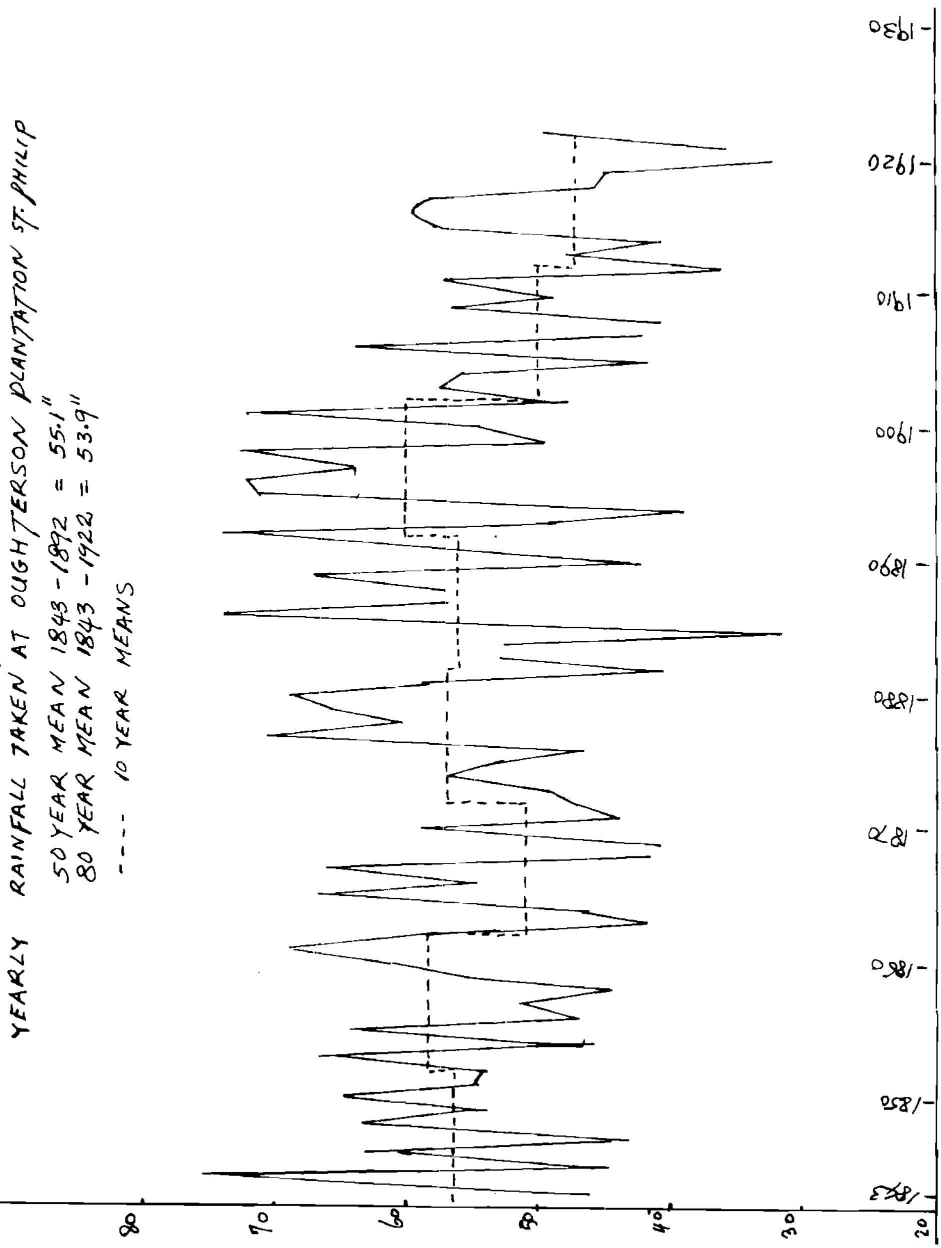
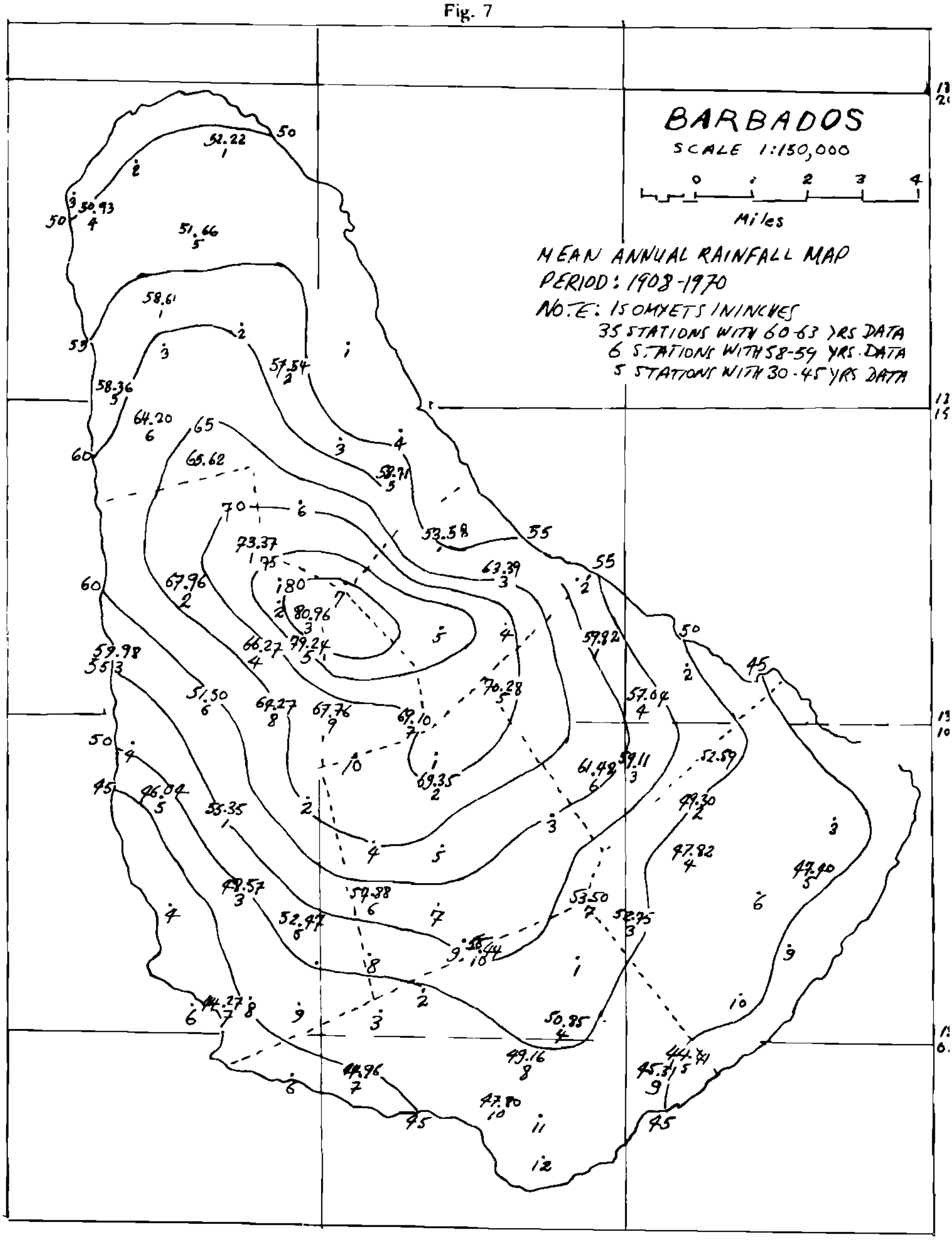

MEAN DAILY RADIATION BRACE INSTITUTE (1964)
900
800
700
600
500
400
300
200
100
RADIATION AT TOP OF ATMOSPHERE
TOTAL RADIATION AT SURFACE
DIFFUSE RADIATION AT SURFACE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

Fig. 6



YEARLY RAINFALL TAKEN AT OUGHTERSON PLANTATION ST. PHILIP
50 YEAR MEAN 1843 - 1892 = 55.1"
80 YEAR MEAN 1843 - 1922 = 53.9"
---- 10 YEAR MEANS
80
70
60
50
40
30
20
1843
1850
1860
1870
1880
1890
1900
1910
1920
1930

Fig. 7


BARBADOS
SCALE 1:150,000
0 1 2 3 4
Miles
MEAN ANNUAL RAINFALL MAP
PERIOD: 1908-1970
NOTE: ISOHYETS IN INCHES
35 STATIONS WITH 60-63 YRS DATA
6 STATIONS WITH 58-59 YRS DATA
5 STATIONS WITH 30-45 YRS DATA

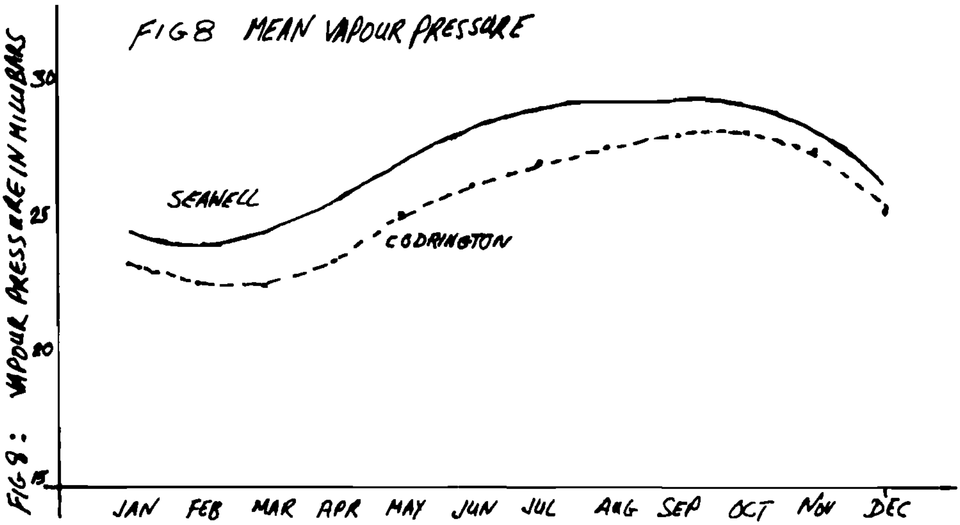
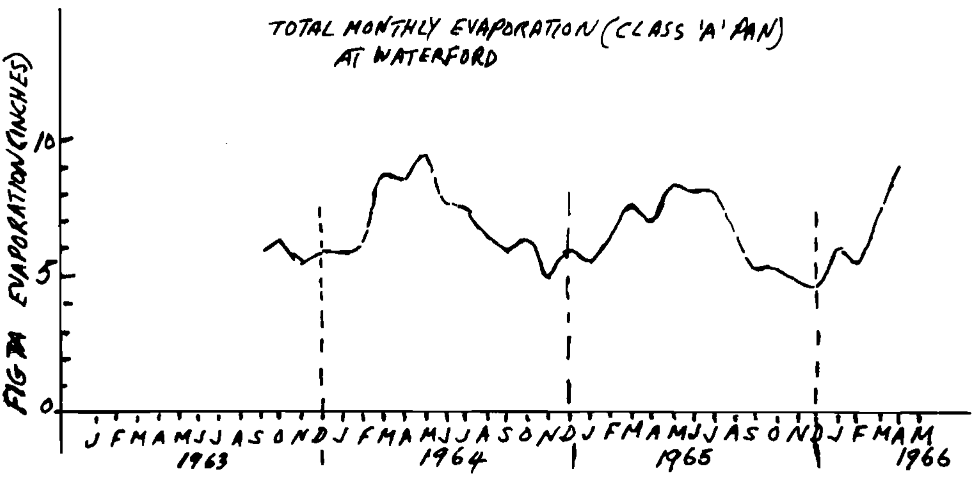
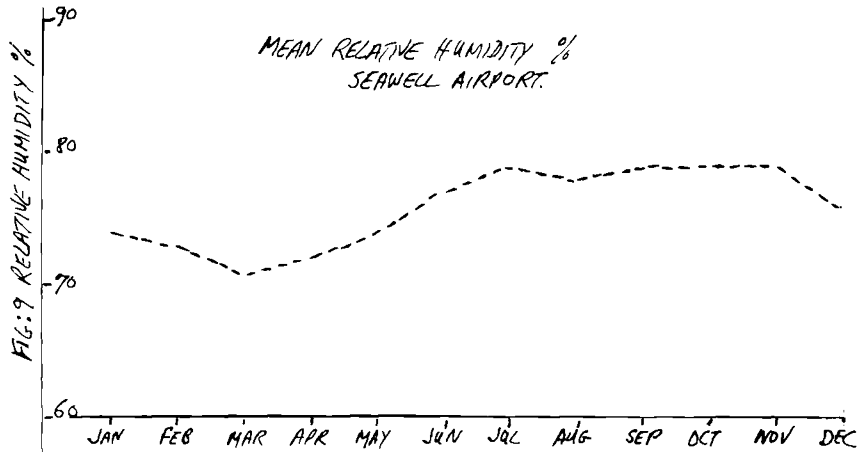


FIG 8 MEAN VAPOUR PRESSURE
FIG 9: VAPOUR PRESSURE IN MILLIBARS
30
25
20
15
SEAWELL
CODRINGTON
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC


TOTAL MONTHLY EVAPORATION (CLASS 'A' PAN)
AT WATERFORD
EVAPORATION (INCHES)
10
5
0
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M
1963
1964
1965
1966


MEAN RELATIVE HUMIDITY %
SEAWELL AIRPORT.
FIG: 9 RELATIVE HUMIDITY %
90
80
70
60
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

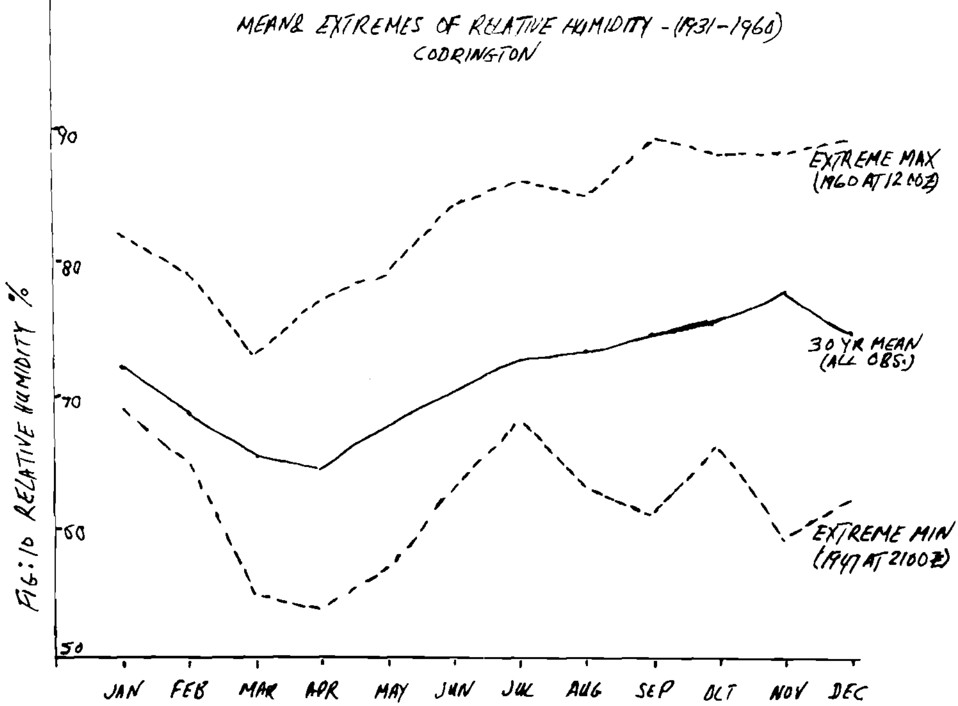

MEAN & EXTREMES OF RELATIVE HUMIDITY - (1931-1960)
CODRINGTON
FIG: 10 RELATIVE HUMIDITY %
90
80
70
60
50
EXTREME MAX
(1960 AT 1200Z)
30 YR MEAN
(ALL OBS.)
EXTREME MIN
(1947 AT 2100Z)
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

TABLE 1

WIND DIRECTIONS BY FREQUENCY (%) – AVERAGE OF OBSERVATIONS AT 0800 AND 1400 FOR THE PERIOD 1942 – 1951 – SEAWELL AIRPORT.

	N	NE	E	SE	S	SW	W	NW	CALM
JAN.	5	45	46	2	0	0	0	1	1
FEB.	2	48	42	6	0	1	0	1	0
MARCH	3	40	51	5	0	0	0	0	1
APRIL	1	31	57	11	0	0	0	0	0
MAY	1	21	67	11	0	0	0	0	0
JUNE	0	29	64	7	0	0	0	0	0
JULY	1	32	57	8	1	0	0	0	1
AUG.	2	28	53	12	4	0	0	0	1
SEPT.	2	23	51	18	3	1	1	0	1
OCT.	1	16	54	24	3	1	0	0	1
NOV.	3	30	48	10	5	1	0	1	2
DEC.	2	49	46	3	0	0	0	0	0

TABLE 2

WIND DIRECTIONS BY FREQUENCY (%) – AVERAGE OF OBSERVATIONS AT 0900 AND 1500 LST FOR THE PERIOD 1933 – 1952 – CODRINGTON STATION.

	N	NE	E	SE	S	SW	W	NW	CALM
JAN.	2	34	60	2	0	0	0	1	0
FEB.	1	29	64	5	1	0	0	1	0
MARCH	1	30	63	5	0	0	1	0	0
APRIL	1	22	67	9	1	0	0	0	0
MAY	0	15	70	12	2	0	0	0	0
JUNE	0	19	71	9	1	0	0	0	0
JULY	0	22	68	7	1	1	0	0	0
AUG.	1	20	60	11	4	2	1	1	0
SEPT.	2	17	58	13	6	2	1	1	1
OCT.	2	17	60	13	5	2	0	1	1
NOV.	2	21	62	11	2	2	0	1	0
DEC.	2	27	65	4	1	0	0	1	0

TABLE 3

VALUES OF MEAN WIND SPEED IN KNOTS TAKEN AT SEAWELL AIRPORT FOR THE PERIOD – 1942 – 1970.

MONTH	WIND SPEED	EXTREME
January	12.1	15.5
February	12.5	17.4
March	12.6	15.8
April	12.9	15.9
May	13.3	17.8
June	14.0	18.2
July	12.6	16.5
August	10.5	13.1
September	9.7	13.4
October	9.9	12.6
November	9.6	13.0
December	11.2	14.0

TABLE 4

VALUES OF MEAN MONTHLY RAINFALL IN INCHES FOR THE PERIOD SPECIFIED AT THE FOLLOWING STATIONS:–

(a) Seawell Airport (1942 – 1970)
(b) Codrington (1903 – 1957)
(c) Island (1847 – 1960)

MONTH	SEAWELL	CODRINGTON	ISLAND*
January	2.65	2.43	3.37
February	1.78	1.52	2.20
March	1.36	1.36	1.93
April	1.79	1.57	2.34
May	2.65	2.03	3.21
June	4.22	4.46	5.41
July	5.75	5.30	6.26
August	5.79	6.48	7.31
September	6.34	6.83	7.65
October	6.65	6.94	7.89
November	5.59	6.65	7.74
December	3.87	3.57	4.77
TOTAL			60.08

FIG. 1 FIG. 2

*Calculated from returns of about 80 stations in various parts of the island.

TABLE 5

DAILY TOTAL RADIATION (LANGLEYS)
AT BRACE EXPERIMENTAL STATION, 1964

	Number of days H > 600	Number of days H >500	Number of days H < 400	Highest	Lowest
January	0	6	3	542	314
February	0	10	3	581	362
March	4	18	2	614	318
April	5	20	4	628	298
May	2	20	3	623	254
June	0	9	5	591	41
July	0	11	9	592	231
August	0	15	4	587	232
September	0	7	13	555	175
October	0	12	9	559	271
November	0	4	8	526	213
December	0	2	8	510	270
Year	11	134	71	628	41

TABLE 6

MEAN HOURLY VALUES OF RADIATION (IN LYS)

	A.M.						P.M.					
Hours:	6–7	7–8	8–9	9–10	10–11	11–12	12–1	1–2	2–3	3–4	4–5	5–6
January	1.6	11.1	34.9	49.8	62.2	69.0	67.2	60.0	49.1	30.7	15.5	1.6
February	2.8	17.3	36.3	53.5	65.0	70.5	67.4	62.4	49.0	32.8	15.3	2.1
March	4.6	23.3	41.7	58.7	67.6	70.5	72.3	62.3	52.9	38.4	17.4	3.6
April	6.6	21.4	39.9	56.5	66.1	71.4	70.5	61.1	51.3	38.3	20.5	5.7
May	7.6	24.0	40.6	56.7	65.8	70.2	68.6	59.4	51.8	37.1	22.6	6.2
June	6.0	19.9	34.2	45.1	58.3	62.7	62.9	55.1	44.6	33.4	19.9	6.9
July	5.3	18.0	35.6	46.8	56.5	61.1	60.2	55.8	49.1	34.3	20.9	6.7
August	5.7	21.9	37.7	54.1	59.7	64.3	65.0	58.8	49.8	37.0	19.8	4.9
September	4.2	18.0	33.2	46.6	54.3	56.7	55.0	52.5	41.4	30.7	15.3	3.6
October	2.6	16.7	37.3	51.4	60.3	64.0	62.0	54.8	43.9	32.9	13.1	2.6
November	1.6	12.1	37.1	50.5	60.1	66.9	58.4	53.9	42.9	29.2	14.1	2.3
December	1.1	7.5	33.8	49.6	63.0	64.8	59.7	55.2	47.6	32.3	16.1	1.9

BACKGROUND PAPER

on

WATER SITUATION IN BARBADOS

Presented by

WILLIAM A. JOHNSON, C.Eng. M.I.Mech.E., M.I.W.E.
Engineer, Waterworks Department, Barbados

1. INTRODUCTION

(1.1) Generally speaking, water is available in Barbados as ground water only. There are one or two small streams but these are seasonal and are of little consequence in this consideration. The absence of surface water in the island can be attributed to three main factors:-

(a) The Geology of the island.

(b) Comparatively low rainfall.

(c) Lack of forests or heavily wooded areas.

2. GEOLOGY

(2.1) The Island is substantially of coral formation, 85% of its total area being capped with coral limestone. The remaining 15% includes the heavily folded clay outcrop of the "Scotland Area." The theory is that this is geologically the oldest section of the Island from which the coral cap has been eroded. These two features are illustrated in Fig. 1.

(2.2) Other topographical features of interest are:-

1. A central dome with Mount Hillaby as its highest point.

2. A terraced formation surrounding this central dome.

3. The Christ Church dome in the south of the island running in an East-West direction.

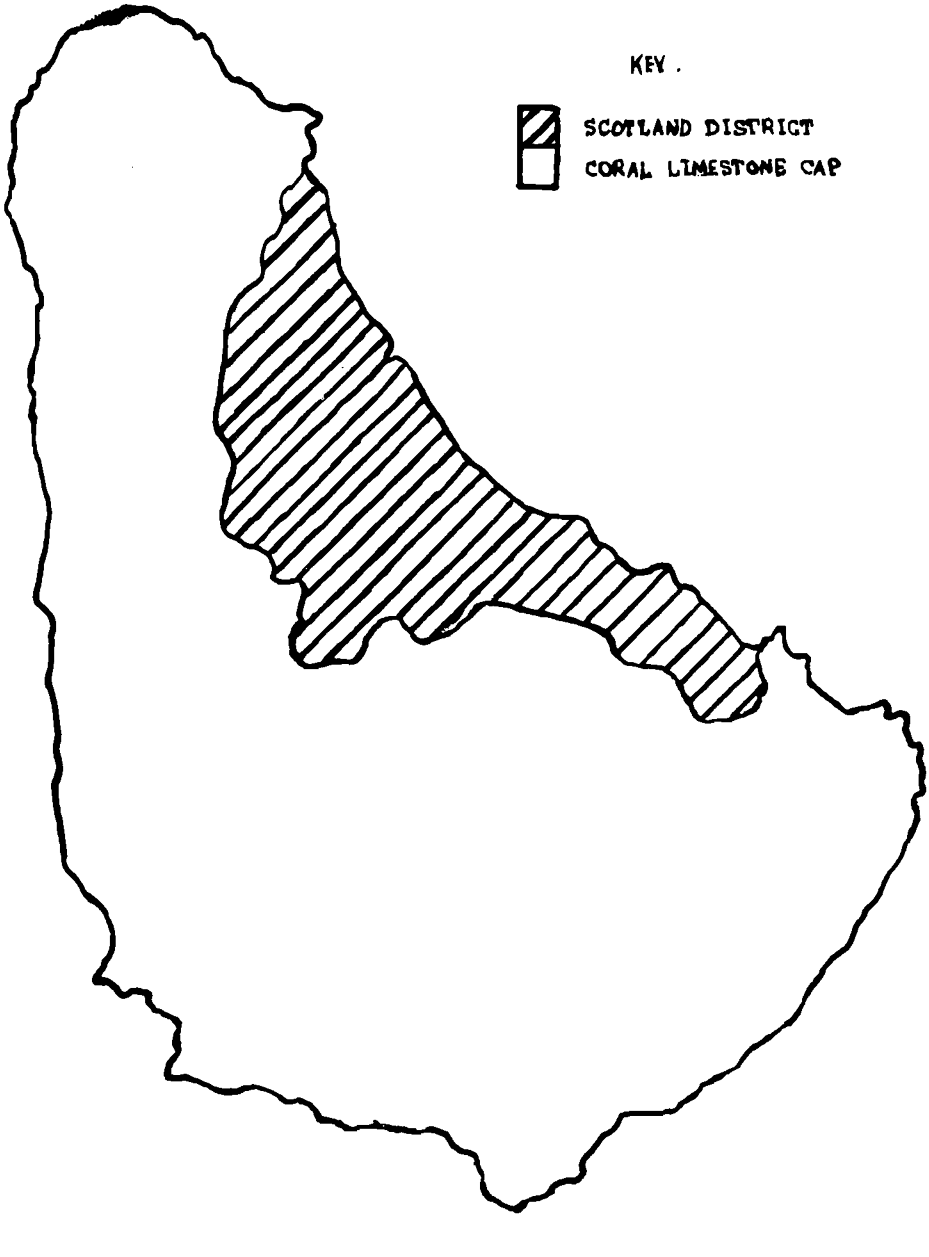
4. The St. George's Valley which also runs in an East-West direction between the southern slopes of the central dome and the northern slopes of the Christ Church ridge.

5. A system of large deep gullies radiating from the central dome on the western side of the island.

(2.3) The geological formation of the island is in many respects suited for the provision of the good ground-water supply on which the island entirely depends. Fig 3 shows a simplified typical cross section of the island. The depth of top soil varies from nothing where the coral limestone outcrops to ten or more metres in sections of the St. George's valley. Underlying this is the coral cap of the island which varies in depth up to about 90 m. and then underneath this, the impervious oceanics.

(2.4) The occurrence of Ground water in Barbados has been superbly described by H. A. Sealy in his report on the "Development and Distribution of water supplies in Barbados"[1] from which I quote:

> "Rainfall which occurs predominantly in the central higher regions of the island averages sixty inches per year. It is estimated that one fifth of this volume of rain percolates through the pervious coral which has an infiltration rate of half a foot per day. As the water moves downwards under the action of gravity it eventually reaches the impervious clay, where its downward movement is arrested, and the


KEY.
SCOTLAND DISTRICT
CORAL LIMESTONE CAP

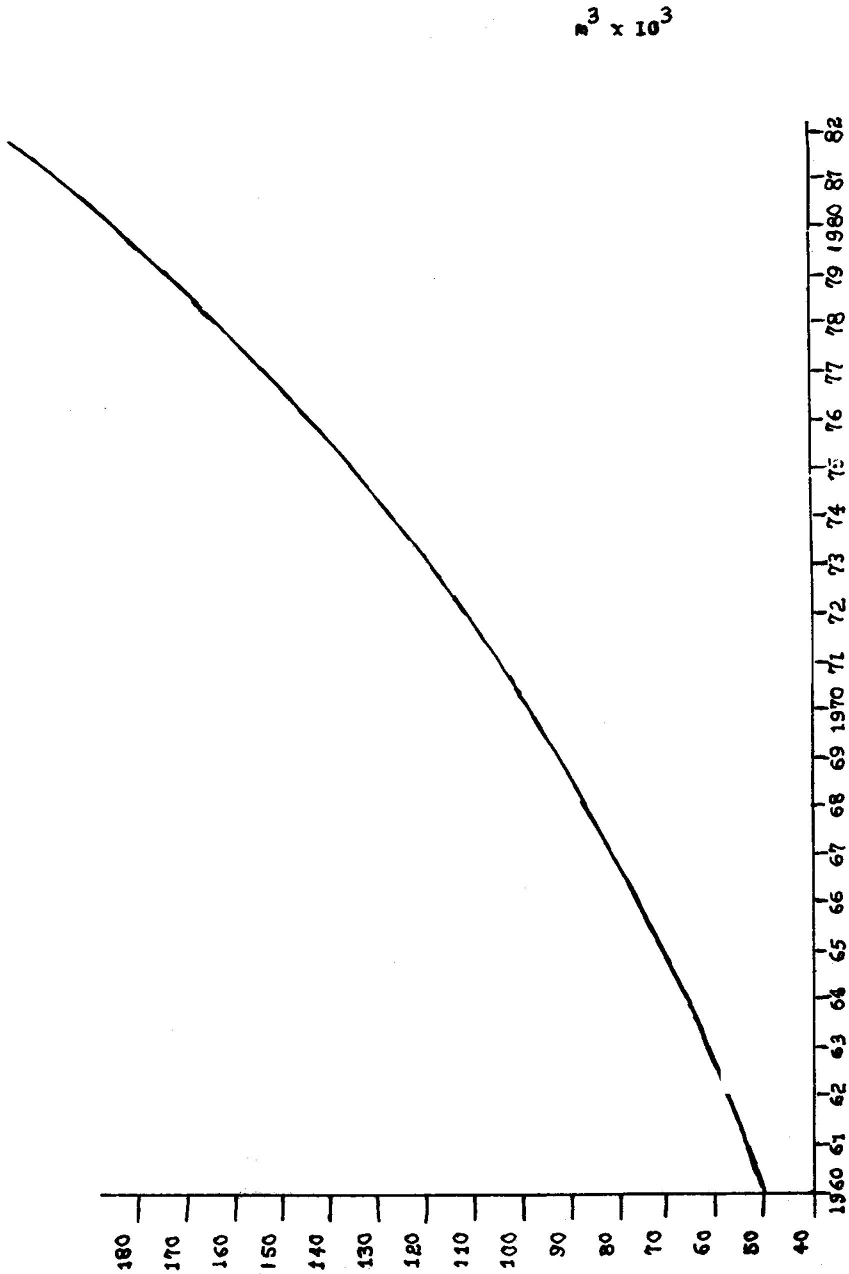
water then travels along the dip of the impervious stratum towards the sea. Near the sea shore, the heavier sea water forms a fairly effective barrier to the movement of the fresh water which eventually fills all the pore space of the coral to a height somewhat above sea level.

The height above sea level to which fresh water rises is controlled partly by the permeability of the surrounding coral, and partly by the rate of inflow of fresh water into the reservoir.

Finally, after a period of time, the Fresh Water-Salt Water system reaches the hydrostatic balance of the Ghyben-Herzberg relation. This coastal reservoir of fresh water has been given the name "sheet water." The sheet water exists in a strip along the entire South and West Coasts of the Island, and extends landwards to the point where the clay stratum rises above mean sea level. The sheet water basin varies in width from a few hundred feet to about four miles in places. At the beginning of the sheet water system, the fresh water rises to a height of one to four feet above mean sea level.

The fresh water as it moves down the dip of the clay stratum before reaching the sheet water system described above, has formed for itself, over a period of years, rather discrete channels by solution of the coral along the coral/clay interface. The water which flows in these discrete channels is called 'stream water'."

(2.5) Apart from a quantity of water from three springs in the island varying between 5,000 & 15,000m^3/day depending on recent rainfall, all water used in Barbados is obtained by pumping from the sheet water area, directly from the stream water area, or from elevated basins which have been formed by faulting of the subterranean strata.


m3 x 10^3
1960 61 62 63 64 65 66 67 68 69 1970 71 72 73 74 75 76 77 78 79 1980 81 82
40 50 60 70 80 90 100 110 120 130 140 150 160 170 180

(2.6) Considerable research work has been done by A. Senn, [2] H. Tullstrom,[3] H. A. Sealy[4] and others into the water resources of the island. Tullstrom in his specifically applied research estimated that with an average rainfall of 1020 m.m. per annum, the ground water resources of the island would be of the order of 145,000 m^3/day, and for a rainfall average of 1530 m.m. per annum this figure would be increased to 200,000 m^3/day. These quantities are for potable water conforming to WHO standards and do not include a quantity of about 15,000 m^3/day of brackish water chiefly near the coast line which though unsuitable in its natural state for potable use is perfectly satisfactory for agricultural purposes, its total chlorides content being of the order of 700 milligrams per litre.

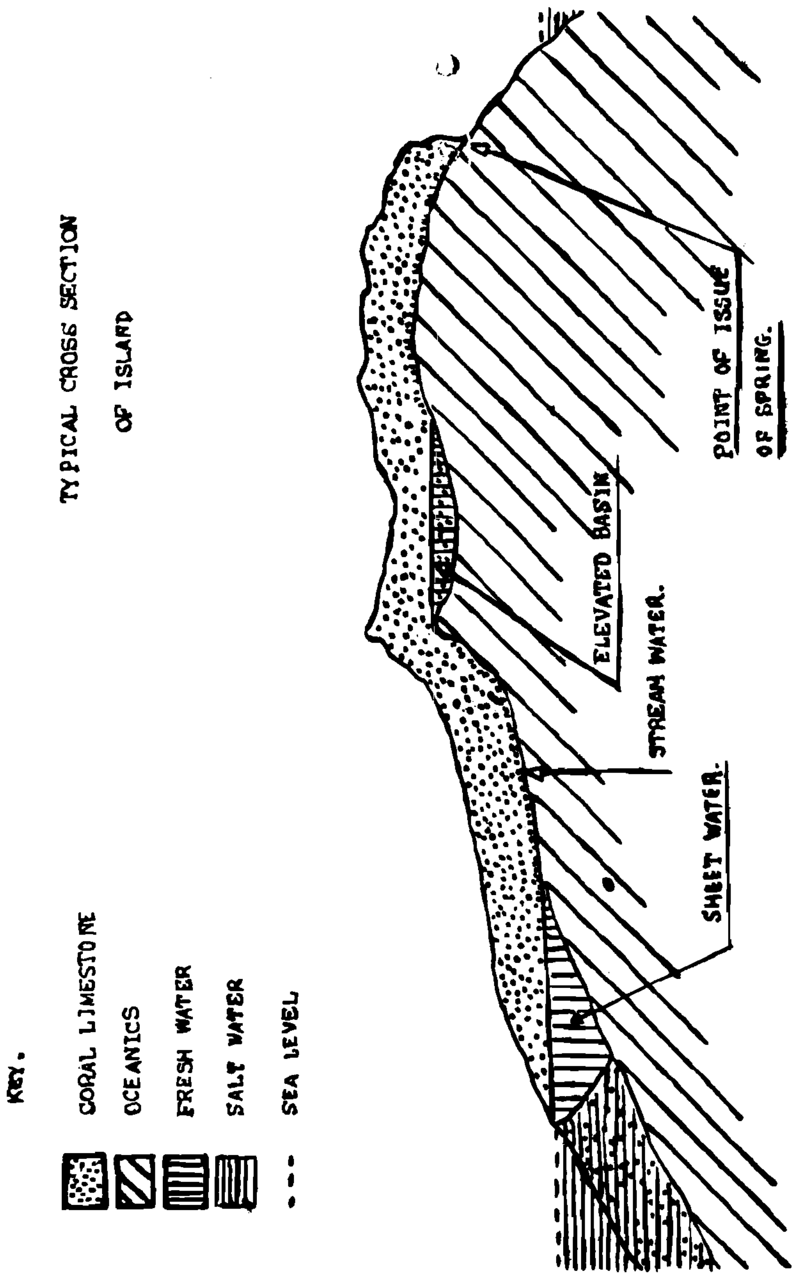
(2.7) Tullstrom also estimated that a further 45,000 m^3/day would be available in the Scotland District about two-thirds of which would be suitable for potable water supply but requiring the usual treatment of surface water supplies. The remaining 15,000 m^3/day because of high sulphate content would be suitable for agricultural purposes only.

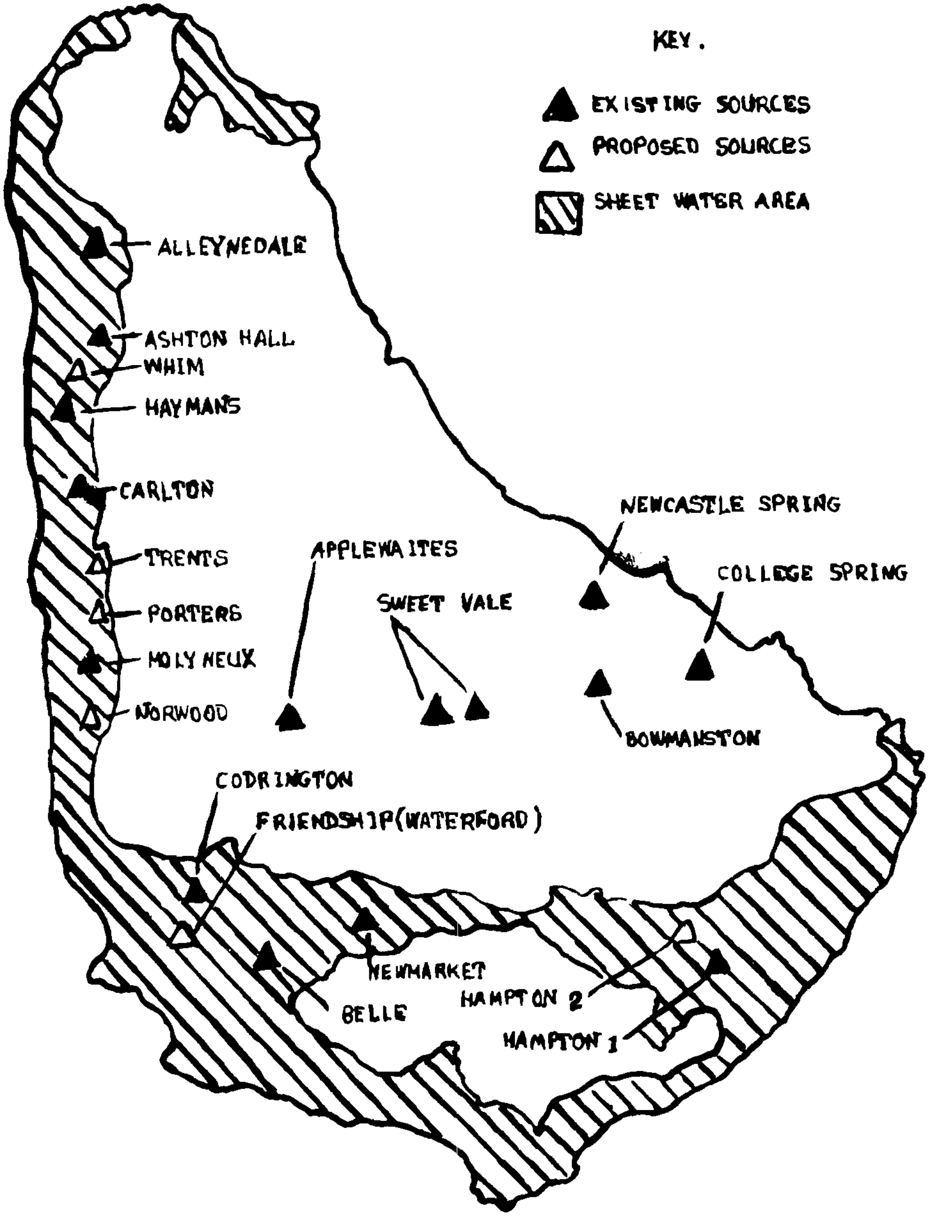
(2.8) Because of the inherent topographical instability of the Scotland District the construction of the required impounding reservoirs to conserve the available water in this area could prove to be prohibitively expensive. A possible solution to the problem could be to construct comparatively small collecting chambers from which the water could be pumped over the central dome and discharged into recharge wells in the limstone cap on the western slopes of the island. However, because of the greater engineering problems involved in utilising this source and the higher costs of production, this will probably be the last natural source of water to be developed.

3. GROUND WATER EXTRACTION

(3.1) The public water supply for the island is derived from a total of fifteen (15) sources which includes two (2) spring supplies.

(3.2) The spring supplies, though small, are of historical interest in that they provided for the first public water supply system in the island. The springs issue on the eastern side of the island at elevations


TYPICAL CROSS SECTION
OF ISLAND
KEY.
CORAL LIMESTONE
OCEANICS
FRESH WATER
SALT WATER
SEA LEVEL
ELEVATED BASIN
STREAM WATER.
SHEET WATER.
POINT OF ISSUE
OF SPRING.


KEY.
EXISTING SOURCES
PROPOSED SOURCES
SHEET WATER AREA
ALLEYNEDALE
ASHTON HALL
WHIM
HAYMANS
CARLTON
TRENTS
PORTERS
MOLYNEUX
NORWOOD
APPLEWAITES
SWEET VALE
NEWCASTLE SPRING
COLLEGE SPRING
BOWMANSTON
CODRINGTON
FRIENDSHIP(WATERFORD)
NEWMARKET
BELLE
HAMPTON 2
HAMPTON 1

of 102 m. and 109 m. above mean sea level. The water was then piped under gravity flow through 26 km. of cast iron water main to a reservoir on the west of the island strategically located to supply almost the entire Bridgetown area. This sytem is now some 140 years old and is still in use though in a considerable modified form.

TABLE I

Source	Present Rate of Extraction m^3/day	Estimated safe yield m^3/day
Alleynedale	3,750	6,250
Applewhaites	2,500	15,000
Ashton Hall	2,000	5,000
Belle	40,000	40,000
Bowmanston	9,500	10,000
Carlton	2,250	5,000
Codrington	14,650	–
Hampton–1	20,500	20,000
Haymans	7,000	4,250
Molyneux	5,000	4,000
Newmarket	10,700	1[illegible],[illegible]00
Sweet Vale	4,150	6,250
Springs	4,000	3,750
Total	126,000	132,000

TABLE 2

Proposed Source	Estimated safe yield m^3/day	Estimated by
Friendship	7,750	Sealy
Hampton–2	21,500	Sealy
Norwood	1,250	Tullstrom
Porters	3,500	Tullstrom
Trents	5,000	Tullstrom
Whim	4,000	Tullstrom
Total	43,000	

(3.3) The thirteen well extraction points are scattered throughout the island, nine (9) of them located in the sheet water area and the remaining four (4) located either directly on the streams or on the elevated basins referred to in (2.5). The locations of all sources presently in production are shown in Fig. (4), daily average output from each source together with the estimated safe yields as determined by Tullstrom are shown in Table (1).

(3.4) The Waterworks Department in conjunction with the Ministry of Agriculture carries out a continuous programme of research to up date and clarify existing data and also to determine the best sites for proposed future wells. The Department proposes to sink a total of six new wells within the present decade, the first of which is in process of construction. This is the well at Waterford which is intended to replace the old source at Codrington, considered by some to be geologically unsuitably located and presenting too high a risk of faecal pollution. The Waterford well being in the same sheet water area cannot therefore be considered as an addition to the total number of sources. The six proposed wells are shown in Fig. (4) together with the existing sources. Their anticipated safe yields as determined by Tullstrom and Sealy are given in Table (2).

(3.5) As stated earlier, it is expected that all the proposed new wells will be in production by 1980 and if the growth in demand continues at its present rate, (see Fig. 2) by then too, the island will have reached the limit of its safe yield under the present rate of natural aquifer replenishment.

4. POSSIBILITIES FOR FUTURE AUGMENTATION OF GROUND WATER SUPPLIES

Artificial Aquifer Recharge

(4.1) Reference has already been made to one possible method of artificial recharge entailing the pumping of some 30,000 m^3/day from the Scotland District into recharge wells on the western slopes of the island.

(4.2) Considering that only an estimated 20% of rainfall percolates the coral to replenish the ground water aquifers, some improvement could be effected by the construction of more recharge wells at strategic points to take advantage of the run-off water which follows every heavy rainfall. This would have the additional advantage of minimising the dangers and damage due to flooding.

(4.3) With active consideration now being given to a central sewage treatment facility, suitably treated effluent could be recharged into the aquifer or utilised as a hydraulic dam between fresh and salt water, thus effectively increasing the sheet-water basin capacity. The decision as to which method would be used would have to be based on biological, engineering and economic considerations. However, let us not lose sight of the fact that because of the present methods of waste water disposal practised in the island, a certain amount of effluent recharge is already taking place.

Use of Brackish Water

(4.4) Reference has already been made to the availability of some 15,000 m^3/day of brackish water. As the chlorides content of the majority of the island's ground-water is low by WHO drinking-water standards, it would be feasible to effect a dilution system where this brackish water could be mixed with other water of low chlorides content to give a resultant water well within the acceptable standards.

Desalination of Sea Water

(4.5) This once-considered uneconomic method of potable water supply is getting more-and-more into common use. The technology of the methods used varies, and with it the cost of production. Claims for plant operating costs vary between U.S. 13 cents per m^3 and U.S. 80 cents per m^3 of potable water produced.

These figures do not take plant maintenance and amortisation costs into consideration, but the true cost is likely to be in the vicinity of twice the quoted figures as plant maintenance replacements are very costly. Compared then with a current total average cost of production in Barbados of U.S. 8 cents per m^3 desalinated water is extremely expensive and unless there is some significant technological break through in this field Barbados would not consider this method except as a final resort.

(4.6) It should be pointed out that where desalination can be combined with other processes such as power generation, then the overall economy of the operation assumes more attractive significance.

5. PRESENT WATER USAGE IN BARBADOS

(5.1) Total water use in the island can be accounted for under three main heads.

(a) Public Water Supply by the Waterworks Department.

(b) Private extraction for irrigation both for private and commercial purposes.

(c) Extraction by sugar factories during sugar cane reaping season for boiler feed and processing water.

(5.2) The Waterworks Department at present puts into supply an average of just under 130,000 m^3/day. Due to the prolonged drought conditions this represents a deficit of demand over supply of about 5,000 m^3/day. This deficit is experienced in the highest levels only which obtain their supplies from the stream water and elevated basin sources, these being directly dependent on a fairly constant replenishment rate if they are to maintain a constant yield. Work at present in hand will provide for transfer of water from the sheet water sources into the higher level reservoirs and these measures should be operative before the next dry season. There is a seasonal variation in demand of about 10%, with the lowest demand days occurring between June and November, and the highest demand days usually between March and May. This variation is somewhat masked by the annual growth in demand attributable to increasing numbers of individual service connections and increasing per capita demands consequent on improved standards of living. With a population of just under a quarter of a million, the present average per capita consumption is 0.52 m^3/day. A large proportion of the population, however, have a per capita consumption very much in excess of this figure. When one considers that 35% of the population receives its potable water supplies from stand-pipes and the average stand-pipe user consumes about 0.05 m^3/day, the average for the remainder of the population stands at over 0.77 m^3/day.

(5.3) Private extraction for irrigation purposes both non-commercial and commercial, swimming pools, golf courses etc. is increasing in the island. With Government encouragement and aided schemes for the purchase and installation of irrigation equipment there has been considerable stimulation of interest in this field. The total amount used for these purposes (excluding that taken from the public water supply) is still comparatively low, being estimated to be between 12,000 and 15,000 m^3/day.

(5.4) This section of water extraction from the aquifer is, of course, seasonal and is mostly confined to the months of February to

June. The quantity extracted varies to some extent with availability, many of the factory wells being so located as to be seriously affected by drought conditions. Such has been the case this year where many factories have had to take all or a large portion of their water requirements from the public water supply system. The estimated average factory extraction for the whole island is about 7,000m^3/day during the sugar-cane reaping season.

(5.5) Present maximum extraction rates from the island's resources are therefore made up of the quantities arrived at in (5.2), (5.3) and (5.4) giving a total of about 150,000 m^3/day. The sum of the estimated safe yields as indicated in Tables 1 & 2 is 175,000 m^3/day indicating that there could be yet 25,000 m^3/day available immediately if wells already existed in the appropriate locations.

6. CONCLUSIONS

(6.1) Undoubtedly this conference is primarily concerned with the production of food and consequently its greatest interest in the present water situation in Barbados is what proportion of the total available water in the island can be utilised for food-crop production. The statistics already produced speak for themselves but must be considered in conjunction with the water demand graph depicted in Fig. 3. The effect of more universal metering if and when introduced is sure to reduce the present rate of increase in water demand, but experience in other countries has shown that such reduction is only temporary and can be considered only as a period of respite during which further development of resources can take place.

(6.2) In summarising I present the following statistics as those most important to your deliberations over the next few days as far as water available for agriculture is concerned.

(a) Present potable water demand 135,000 m^3/day.

(b) Present potable water available from coral sources 175,000 m^3/day.

(c) Possible potable water available from Scotland District 30,000 m^3/day.

(d) Brackish water at present available 15,000 m^3/day.

(e) Non-potable water possibly available from Scotland District 15,000 m^3/day.

(6.3) The Water situation in Barbados is at present serious but not yet critical. By total and careful resource control including large-scale if not universal metering, the safe yield of our resources under present demand and population trends could satisfy our potable water requirements for the next two decades. The world is now verging on a new technological field called "Water Quality Engineering" which aims at maximum utilisation of water by establishing a long-cycle use. Such a process would achieve greatest usefulness in an industrial society but there may be benefits in this approach for our own mixed agricultural/industrial society. And finally, we may have but one option – desalination, which, when we need it, will have to be paid for.

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AN INVESTIGATION ON THE YIELD RESPONSE OF TWO TOMATO VARIETIES TO DIFFERENT LEVELS OF NITROGEN AND POTASH FERTILIZER AND TO A DRY GRASS MULCH COVER

by

LIONEL H. SMITH
Agrometeorologist, Caribbean Meteorological Institute.

INTRODUCTION

In Barbados tomatoes are grown on small areas by many farmers. Unfortunately, there has been no research on the fertilizer requirements of tomatoes on the various soils of the Island. There is a need for information on the response of tomato varieties to fertilizers on all the major soil types of the Island. This experiment attempts to determine the response of tomatoes to nitrogen and potassium fertilizers on the Vertisol (30 series Vernon & Carrol 1961) at the Central Agronomic Research Station, Graeme Hall, Christ Church.

In the drier areas of the Island tomatoes are planted at the end of the wet season. Farmers in these areas may often cover the soil with a dry grass mulch during the growing period of the tomato crop. Many farmers are unable to give an explanation of the value of this traditional practice. This experiment thus also attempts to determine whether a dry grass mulch could appreciably increase the yield of the crop.

The fertilizers and mulch were tested in a trial in which two varieties of tomatoes were used. The varieties were planted at the same time in adjacent areas of the station. The variety 'Indian River' was selected because of its reported heavy vegetative growth characteristic and longer vine (plant) persistence.

The 'Bounty' variety was selected because of its reported hardiness under local growing conditions. This variety also shows less vine growth and is reported to be higher yielding. The 'Bounty' variety is more commonly grown by farmers than the 'Indian River'. During the trial, observations were also made of the growth habit of these two varieties.

METHOD

The experiment consisted of a 2^3 factorial design with each of the two varieties. The three primary treatments were as follows:–

(1) Dry grass mulch cover VS No mulch cover.

(2) Zero Potash fertilizer VS 200lbs Sulphate of Potash per Acre.

(3) Zero Nitrogen fertilizer VS 200lbs Ammonium Sulphate per Acre.

The area was marked out into 32 plots each 600 sq. ft (30 x 20 ft), with 6 ft guard areas between adjacent plots. Sixteen (16) plots were planted (15.4.71) with the 'Indian River' variety and sixteen (16) with the 'Bounty' variety. Four (4) seeds were planted at sites spaced approximately 18" x 18" apart in each plot. Three weeks after planting the seedlings were sprayed with 'Gustathion" to avoid damage by insects.

It was necessary to thin out and transplant the plots to achieve the desired plant density. This was first done 30 days after planting. The final thinning out and transplanting were done 7 days later. At this stage the final plant population averaged 220 plants per plot.

The crop was periodically sprayed with 'Lannate' to protect it against severe 'leaf-miner insect' attack. The plants were also sprayed with 'Antracol' to protect them against damage due to leaf-fungal disease.

The plots were irrigated at intervals of about once per week during the first 6 weeks of crop growth, the last irrigation being on the 11th May.

The appropriate fertilizer treatments were applied to the plots 40 days after planting. After the plots were fertilized the dry sour grass mulch cover was applied to the appropriate plot areas. The whole area of the plot was covered with the mulching material.

The crop was harvested on 10 occasions between 15th June and the 3rd August, 1971. At the final harvest the vines were removed. All the fruits were removed from the vines and the number of immature fruits still on the plant were counted and weighed.

RESULTS AND DISCUSSION

The fruits were harvested and separated into marketable and unmarketable groups; each group was weighed separately. The major cause of unmarketable fruits was bird damage. Seventy-one (71) percent of the total number of fruits harvested from the 'Bounty' variety were marketable. This quantity of fruits constituted a similar seventy-one (71) percent of the total fruit-weight. Two percent of the fruits were unmarketable because of immaturity at the time of the final harvest. Twenty six percent were unmarketable due to bird damage and one percent had damage or blemishes which made them unmarketable.

The 'Indian River' variety had fifteen percent of its fruits damaged by birds and six percent immature fruits at the time of the final harvest. It would seem that the fruit of the vigorously vegetative 'Indian River' variety is not as easily accessible to birds. This results in less bird damage to these fruits.

The harvest dates for both varieties started about 75 days after planting, but the 'Bounty' variety showed greater signs of senescence after 130 days of growth. During the 10 harvest days (between the 75th and 130th day after planting) the fruit yield obtained from the 'Bounty' variety was 53% of that obtained from the 'Indian River' variety.

TABLE I(a)

The effect of a grass mulch cover and varying levels of Ammonium Sulphate on the yield of the Indian River variety of tomatoes (lbs/Acre) harvested

AMMONIUM SULPHATE LBS/ACRE

		Cover	0	0	2002	200	Average
K_20 lbs/	0 0	None Mulch	24,825 13,000	11,475 31,375	33,650 28,500	18,925 11,575	21,665
Acre	120 120	None Mulch	42,000 23,325	16,575 17,200	28,300 17,150	36,525 32,400	26,684
	Average		22,471		25,878		

(Average None = 26,534)
(Average Mulch = 21,815)

TABLE 1(b)

The effect of a grass mulch cover and varying levels of Ammonium Sulphate on the yield of the Bounty variety of tomatoes (lbs/Acre) harvested

AMMONIUM SULPHATE LBS/ACRE

		Cover	0	0	200	200	Average
K_20 lbs/	0 120	None Mulch	6,475 11,275	5,725 22,950	2,000 7,925	14,675 2,925	9,243
Acre	120 120	None Mulch	9,225 20,325	20,025 15,725	9,825 20,050	21,075 16,350	16,575
	Average		13,965		11,853		

(Average None = 11,128)
(Average Mulch = 14,690)

TABLE 2(a)

The effect of a grass mulch cover and varying levels of Nitrogen and Potassium fertilizers on the number of fruits produced by 200 Indian River variety tomato plants

AMMONIUM SULPHATE LBS/ACRE

		Cover	0	0	200	200	Average
K_2O	0	None	1,538	588	1,746	1,132	1,158
lbs/	0	Mulch	664	1,610	1,308	680	
Acre	120	None	2,198	1,148	1,720	2,194	1,606
	120	Mulch	1,242	1,174	1,286	1,888	
	Average		1,270		1,494		

(Average None = 1,533) (Average Mulch = 1,231)

TABLE 2(b)

The effect of a grass mulch cover and varying levels of Nitrogen and Potassium fertilizers on the number of fruits produced by 200 Bounty variety tomato plants

AMMONIUM SULPHATE LBS/ACRE

		Cover	0	0	200	200	Average
K_2O	0	None	376	464	230	858	556
lbs/	0	Mulch	1,028	1,032	288	172	
Acre	120	None	1,890	1,142	580	1,254	1,141
	120	Mulch	1,066	1,162	1,056	980	
	Average		1,020		677		

(Average None = 849) (Average Mulch = 848)

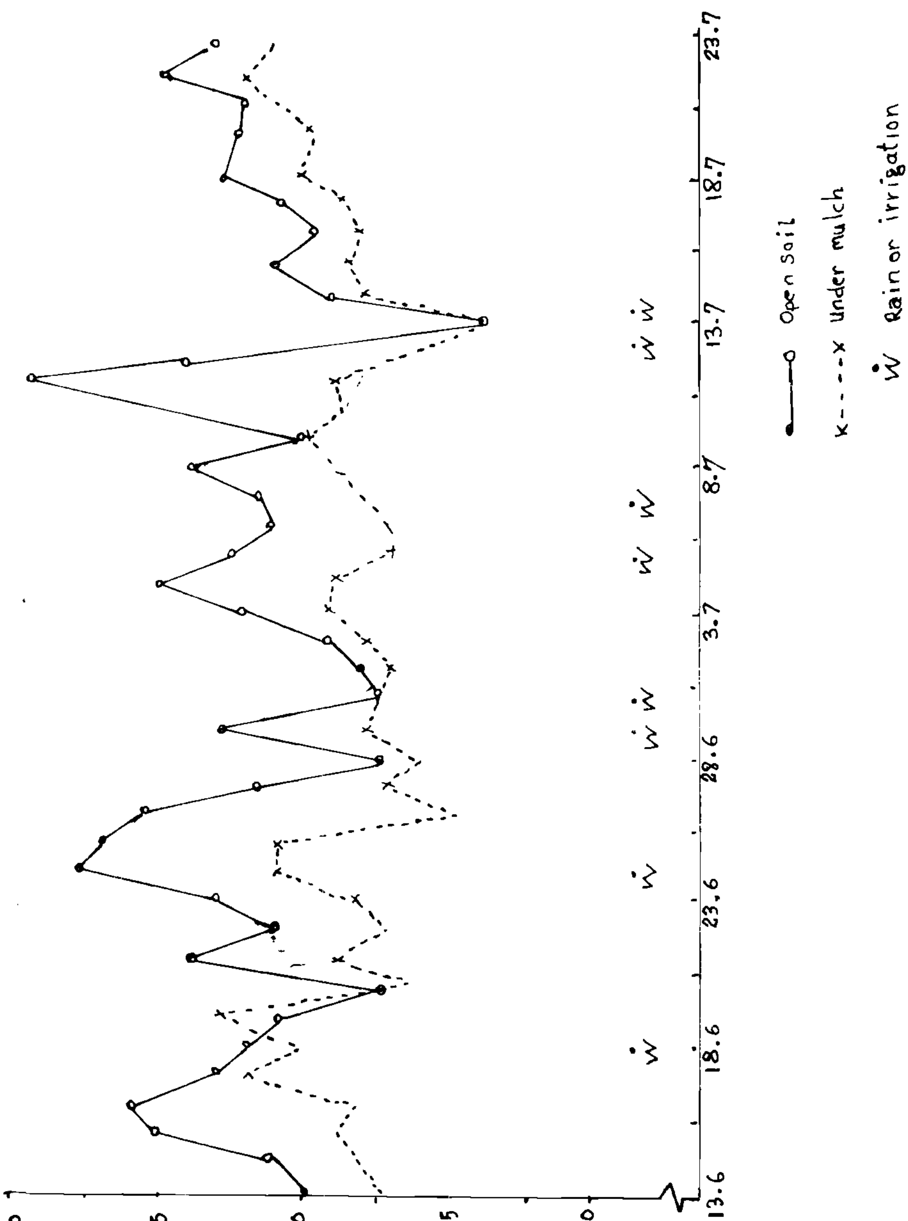
Note: 1 ounce = 28.35 gms; 1 pound = 0.45 kg; 1 acre = 4046.8 m^2; 1 hectare = 2.47 acres.

After 130 days the vines were harvested and all the immature green fruits were removed, counted and weighed. There was 320 immature fruits for 200 plants of the 'Bounty' variety and 506 immature fruits for 200 plants of the 'Indian River' variety. It could be inferred that the potential difference in yield between the two varieties was greater than actually measured during the normal harvest period.

Both varieties responded to the application of Potassium Sulphate, a yield increase of about 5,000 lbs per acre was achieved in the 'Indian River' variety (23% increase) while in the 'Bounty' variety the increase was about 7,000 lbs per acre of 79% increase (see Table I). The data in Table 2 shows that this increase was a result of increased fruit production rather than fruit size; since the percentage increase in number of fruits harvested by the Potash application was greater than that of the weight increase.

The mulch increased the yield of the 'Bounty' variety but not of the 'Indian River' variety. Table 2 shows that there was no difference in the number of fruits produced. It could be inferred that the mulch increased the yield of 'Bounty' by increasing the size and weight of the fruits. It should also be noted that the highly vegetative 'Indian River' variety covers the ground surface and is somewhat self mulching so that the difference in mulched and unmulched surfaces under this variety might not be as great as in the 'Bounty' variety. The temperature in the open soil was generally about $4^{0}F$ higher than in the soil under a dry grass mulch (Fig.I). During periods when the soil was wet either through rain or irrigation, the temperature of the soil was reduced; the reduction was greater in the uncovered soil. On some days wetting the soil surface reduced the maximum soil temperature in the open soil below that recorded in the mulched areas. It could be expected that the faster evaporation loss from the exposed soil surface when wet will cause a greater evaporative cooling of the exposed soil and as a result a lower temperature.

The 'Indian River' variety responded to the application of 200 lbs of Ammonium Sulphate per acre, producing an increased fruit weight yield of more than 3,000 lbs/acre. This weight increase was brought about by


100
95
90
85
80
13.6
18.6
23.6
28.6
3.7
8.7
13.7
18.7
23.7
Open Soil
Under mulch
Rain or irrigation

an increase in the number of fruits produced (Table 2) rather than an increased fruit size.

The 'Bounty' variety gave no positive response to the nitrogen application but rather both fruit numbers and yield were depressed as a result of the nitrogen application. Under the present farming practice in tomatoes, it is likely that low nitrogen levels prevail in the mulch fields during growth. It is therefore interesting to note that in this experiment the increase in the 'Bounty' fruit size occurred mainly in the Zero Nitrogen fertilizer plots. It could be speculated that vegetative growth could have been enhanced in the high nitrogen plots and that as a result the increased ground cover diminished the mulching effect. However, the vegetative growth change was not ascertained in this experiment.

CONCLUSION

The 'Indian River' variety produced a much higher fruit yield than the 'Bounty' variety. Both varieties responded strongly to the application of potash, both in terms of the weight and number of fruits produced.

The 'Indian River' variety which has much more vegetative growth than the 'Bounty' variety responded both in fruit numbers and yield to the application of Sulphate of Ammonia.

The 'Bounty' variety which does not shade the ground surface as readily as the 'Indian River' variety, responded to the use of a soil mulch cover. This response was exhibited in greater fruit yield weight but not fruit numbers. Thus the mulch brought about the formation of bigger and heavier tomatoes.

The farmers in the nothern districts who mulch their fields when growing the 'Bounty' variety, are likely to obtain heavier and bigger tomatoes.

LHS/jh

21st November, 1973.

TOMATO VARIETY SELECTIONS AND CULTURAL PRACTICES FOR THE CARIBBEAN

by

G. ANAIS[1] AND P. DALY[2]

INTRODUCTION

The choice of tomato variety is an important decision for the grower. The selection of a suitable variety can lead to rapid progress without much additional investments. However, the yields of potentially good varieties can be reduced if the right cultural practices are not employed. For this reason varietal selection and cultural practices are closely related.

This paper is the product of several years of research conducted by IRAT since 1963 and INRA since 1964. The trials were conducted at various locations in the islands of Guadeloupe and Martinique. The paper deals only with the large fruited tomato varieties tried at the various locations. The locations were selected to be representative of a wide range of ecological conditions and the results are applicable to areas in other Caribbean Islands.

Selecting a suitable variety

In general varieties which originate in the southern USA (Florida, Texas and Louisiana) are better adapted to the Caribbean ecological

[1] Station d'Amelioration des plantes
Centre de Recherches Agronomiques des Antilles et de la Guyane Institut National de la Recherche Agronomique (France) Domaine Duclos – *Petit-Bourg* (Guadeloupe)

[2] Institut de Recherches Agronomiques Tropicales (IRAT) Lareinty – *Lamentin* (Martinique)

conditions than varieties originating in temperate areas. Some of the varieties tested were tolerant to physiological disturbances such as fruit cracking and blossom end rot which affected production.

None of the varieties so far tested were very well adapted to the rainy season. Varieties which yielded well in the dry season of the year were also the best at other times during the year.

In our trials the varieties could be grouped as follows:– (a) indeterminate for staking; (b) determinate for bush culture. The suitability of a variety depended on the micro-climate of area and the parasites encountered in the area.

I (A) AREAS WITH PSEUDOMONAS SOLANACEARUM (SOUTHERN BACTERIAL WILT)

In volcanic areas where Pseudomonas is present only varieties resistant to this disease can be successfully cultivated. For many years there were no bacterial wilt resistant large fruited varieties available in the region. This disease problem could only be counteracted by grafting the large fruited varieties on to the pseudomonas resistant rootstock.

Recently, the University of North Carolina released two resistant varieties, Venus and Saturn. In our trails Venus appeared to be the better of the two varieties. Both varieties were resistant to the bacterial wilt but were not very high yielding. At the plant breeding station of INRA (Guadeloupe) we carried on a breeding programme which has so far led to some useful selections. The breeding lines are higher yielding than either Venus or Saturn and are also resistant to bacterial wilt. In addition some of the large fruited lines are also resistant to other diseases and pests such as *Stemphylium Fusarium, Spider mites* and *Rootknot nematodes.* These selections are all indeterminate and are more suitable for staking.

I (B) AREAS FREE OF PSEUDOMONAS SOLANACEARUM

The trials were conducted in two different micro-climate areas which were disease free:– (a) humid areas;(b) dry areas.

(a) Humid areas:–

This condition exists at Matouba in Guadeloupe; this location being at a high altitude. Under these conditions Floradel was the best variety. This variety is resistant to leaf mould *(Cladosporium)* which is prevalent under humid conditions. Floradel was also resistant to Fusarium and Stemphylium diseases. Another, but older variety Manalucie, is suitable for these conditions and its fruits are more resistant to cracking, however, the fruit appearance is less attractive than Floradel. These varieties are both indeterminate and are suitable for staking.

(b) Dry areas:–

These areas have the typical black vertisols soils which contain the montmorillonite clay minerals. Under these conditions Floradel also gave good results in all the trials. However, Louisiana out-yielded Floradel in all the trials. The Louisiana 161.2 has larger fruits than Floradel. In addition, it is resistant to *Fusarium, Stemphylium, Root-knot nematodes* and *fruit cracking.*

A sister line released by the University of Louisiana which was also tested is Pelican (L 210). Pelican is superior to Floradel in both yield and fruit quality. On this basis Pelican is preferred to Floradel, and this variety should be suitable to areas where root-knot disease is a problem.

Tropic is another large fruited variety which was tested but is less productive than either Pelican or Floradel.

The varieties Floradel, Pelican, Louisiana 161.2 and Tropic are all indeterminates and are best for staking and pruning. The determinate bush culture types can be cultivated unstaked and unpruned during the dry season. These types can be staked or grown on wire tunnels during the wet season. Best varieties of the bush type are Tropi-Red-resistant to Fusarium and Stemphylium, Walter resistant to Fusarium (1 and 2), and Stemphylium.

II TECHNICAL PRACTICES

1. Soil pH:–

Tomatoes require a soil pH between 5.0 and 6.8. Under pH 5 liming is advisable with Calcaro – Magnesium 2 or 3 months before planting.

2. Manuring:–

On Vertisols (Beauport: Guadeloupe – Ste-Ane: Martinique with the variety Floralou) the following formula is advisable:–

$$N\ 200 - P_2O_5\ \ 150 - K_2O\ 250$$

3. Spacing:–

During the wet season the indeterminate varieties which were staked gave similar yields for plant densities of 24,000 to 34,000 per hectare. The Indian River variety gave a yield of about 17 tons/hectare. At the end of the wet season the yield of the Indian River variety increased significantly. The yields were significantly lower at plant densities of 18,000 plants per hectare and below. The variety ES24 gave yields which increased with density from 18,000 to 34,000 plant/hectare. At the end of the wet season the yield of Marglobe was significantly higher at densities of 24,000 and 34,000 plants/hectare than at 18,000 plants/hectare.

4. Pruning:–

The pruning methods tested on indeterminate varieties were as follows:–

(a) Pruning to one stem, topping to the 5th cluster – 30,000 plants/hectare.

(b) Pruning to two stems over the 3rd leaf topping to the 5th cluster – 20,000 plants/hectare.

(c) Pruning to two stems but each stem topped over each cluster, then vegetation on the lateral bud – 20,000 plants/hectare.

(d) Topping over the 3rd leaf then plants unpruned – 20,000 plants/hectare.

RESULTS

The observations are given in the following table.

TABLE I

The effect of pruning indeterminate varieties of tomato plants on the fruit yield. Vigour and subsequent growth of the plants in Martinique and Guadeloupe

Treatment	Yield Ton/Hectare	Vigour	Foliage	Covering of Fruits by Leaves	Healthy Fruit %	Fruits Over 100 g
1	30	Good	Wide Leaves	Bad	92.6	76
2	33		Medium	Good	86.6	68
3	38		Medium	Good	80.6	70
4	43	Very Good	Smaller leaves	Very Good	72.0	65

When cultivating indeterminate varieties it is desirable to use the first method of pruning (pruning on one stem at a density of 25,000 plants/hectare). This method produces large fruits but requires a great deal of labour.

In all our experiments it appears that one is not obliged to prune the plants. However, if the plants are not pruned special attention must be given to the phytosonitary protection of the crop.

Pests and diseases can develop rapidly among crops with heavy foliage. During the dry season ground culture can be practised with unpruned tomatoes. Under rainy conditions it is preferable to support the plants even when unpruned.

Tomatoes can be grown on flat land in dry conditions, however, it is better to grow the plants on raised beds during humid conditions. Black plastic mulch can be used to control weeds in tomatoes. The cost of this method of control is equivalent to the cost of four hand weedings. Sprinkler irrigation must be used after planting to prevent the plants from burning against the black plastic.

CONCLUSION

The choice of disease resistant and well adapted varieties will facilitate the production of a tomato crop. Similarly, the correct choice of variety can minimise the labour normally required to produce the crop.

The plant breeding station at INRA in Guadeloupe is directing its future effort in this programme towards developing suitable large fruited varieties for rainy season production.

INVESTIGATION ON THE EFFECT OF DIFFERENT FREQUENCIES OF HARVEST ON THE YIELD OF STRING BEANS

by

LIONEL H. SMITH

Agrometeorologist, Caribbean Meteorological Institute.

INTRODUCTION

The String Bean (Snap Bean Cultivar Bountiful, Herbs Brothers Seed Company, U.S.A.) is a commonly used fresh vegetable in Barbados. There is a constant demand for this vegetable throughout the year. The Vegetable Research Unit of the Ministry of Agriculture has tested machinery for harvesting this crop. The harvester used was a 'once over harvester' which destroys the vines as it harvests the fruits. Bean harvesting by hand is probably the highest single cost factor of bean production in Barbados.

This experiment was carried out to determine the influence of various frequencies of harvest on the yield of the crop. It was hoped that the experiment would provide information as to whether there was any stage at which beans could be harvested once, and which would not result in considerable loss in the potential yield.

METHOD

The experiment was carried out at the Central Agronomic Research Station. The soil at the station is a vertisol (Vernon & Carrol 30 series). The area was one in which other vegetables were grown and on which 200 lbs/acre of mixed fertilizer was applied before the field was rotavated.

The seeds were planted with a 'Stanhay Vegetable Planter'. The planting consisted of six rows 8 inches apart. in a bed 55 inches wide as is common for this crop under commercial production in Barbados. A pre-emergence weedicide was used and no further weed control was necessary during the period of the experiment.

The field was divided into 48 plots. Each plot consisted of one (1) bed 30 ft. long. There were two (2) ft. spaces between the plots, the beds were separated by a space of approximately the same two (2) ft width. The 8 Treatments were randomly allocated among the plots. All 6 replicates were irrigated soon after planting, and irrigation water was supplied as necessary during growth. The plants were harvested at intervals of between 1 - 3 days depending on the appearance of the crop and convenience for marketing. After the 8th picking, the plants were all harvested and counted so that the yield on a plant basis could be determined.

RESULTS

The plots all started to flower uniformly and the first harvest was started about 14 days after flowering had begun. Table I shows the influence of the number of harvest on the fruit yield per plant. The yield decreased from 1.54 ounces per plant when the crop was picked 8 times between the 7th and 29th April, to a value of 0.44 ounces per plant when the crop was harvested once, at the end of the harvest period.

Fruits which were left for 21 days (harvested 16.4.71) were more than 50% hard and unmarketable. After the 25th day after flowering more than 95% of the fruits were hard and unsuitable for marketing.

The data in Table I shows that the full yield potential of the plant was realized by increasing the frequency of harvest.

The data in Table 2 shows the average quantity of beans harvested and the percentage of the final total at various stages of development.

The first harvest of beans occurred fourteen days after flowering; at that time only 10% of the total crop was harvested. Delaying the harvest three days resulted in a crop which was 39% of the total crop. The longest possible date for which the first harvest could be delayed was 21 days after flowering; at that time 59% of the crop was harvested.

It should be noted that frequent harvest between the second and third week after flowering yielded about the same percentage of the total crop.

Delaying the harvest longer than 21 days after flowering resulted in a decrease in the marketable weight and total yield of the bean crop. If the harvest was delayed between the 21st and 27th day, 50 to 80% of the crop was "seedy" and unsuitable for market; delay into the 4th week resulted in the yellowing of the pods. At that time also, the plants began to show severe signs of senescence.

TABLE I

THE INFLUENCE OF THE NUMBER OF HARVEST ON THE BEAN PLANT (SNAP BEAN YIELD)

Period	7.4.71 29.4.71	10.4.71 29.4.71	14.4.71 29.4.71	16.4.71 29.4.71	20.4.71 29.4.71	22.4.71 29.4.71	26.4.71 29.4.71	29.4.71 29.4.71
No Harvest	8	7	6	5	4	3	2	1
Yield Ounces/plant	1.54	1.52	1.20	1.12	0.89	0.65	0.70	0.41

NOTE: 1 ounce = 28.35 gms; 1 pound = 0.45 Kg; 1 Acre = 4046.8 m^2; 1 hectare = 2.47 acres.

TABLE 2

THE INFLUENCE OF THE NUMBER OF HARVEST ON THE YIELD OF BEANS HARVESTED AT VARIOUS PERIODS BETWEEN THE SECOND AND FOURTH WEEK AFTER FLOWERING.

Date	7.4.71	10.4.71	14.4.71	16.4.71	20.4.71	22.4.71	26.4.71	29.4.71	Total Weight
Average yield lb/Acre	284.0	380.8	361.6	274.8	495.2	292.4	98.0	106.0	2292.8
Accumulated %	10.5	24.9	53.1	633	81.6	92.4	960	100	
Average yield lb/Acre		1098.0	862.0	296.0	468.0	116.0	116.0	106.0	3058.0
Accumulated %		39.0	60.5	711	87.9	92.4	96.5	100	
Average yield lb/Acre			1246.0	206.0	301.0	144.0	96.8	114.0	2107.8
Accumulated %			59.1	68.7	83.1	89.9	94.5	100	
Average yield lb/Acre				*1230.0	284.0	118.0	42.0	116.8	1790.8
Accumulated %				68.6	84.5	91.1	93.4	100	
Average yield lb/Acre					**1096.0	254.8	160.0	111.2	1622.0
Accumulated %					67.5	83.2	93.1	100	

* Beans unpicked after one week were 30% hard and unmarketable; ** Beans unpicked after two weeks were 50% hard.

TABLE 2 *Cont'd.*

THE INFLUENCE OF THE NUMBER OF HARVEST ON THE YIELD OF BEANS HARVESTED AT VARIOUS PERIODS BETWEEN THE SECOND AND FOURTH WEEK AFTER FLOWERING.

Date	7.4.71	10.4.71	14.4.71	16.4.71	20.4.71	22.4.71	26.4.71	29.4.71	Total Weight
Average yield lb/Acre						**880.0	118.8	73.2	1072.0
Accumulated %						82.0	93.1	100	
Average yield lb/Acre							***955.0	103.2	1058.2
Accumulated %							90.2	100	
Average yield lb/Acre								***816.0	816
Accumulated %								100	

***After 4th week beans were 100% hard.

DISCUSSION

The bean plants showed an increase in the yield per plant and total yield, if the crop was harvested frequently. This was in keeping with the observations of several crop physiologists who have noted that removal of early flowers and fruits will induce further flowering and fruiting of plants. This inducement of the crop to further flower and fruit formation results in higher yields of the plant and as a result a greater crop harvest.

It would seem possible to delay for a few days (5) the first harvest of the bean crop without affecting the total yield of the crop. Longer delays in harvesting would likely result in reduced crop yields.

CONCLUSION

The bean crop can be harvested between two to three weeks after the flowers are opened, delaying the crop harvest results in reduced crop yields.

The more frequent harvest, allows the plant to realize its optimum yields. There is no period at which the use of the bean harvester in the crop is likely to recover more than 60% of the potential marketable crop.

The bean harvester would have to reduce the cost of harvesting by more than 60% of the hand labour method before its use could be justified.

EFFECTS OF FERTILIZER ON GROWTH, YIELD AND LEAF MINERAL CONTENTS OF PIGEON PEAS (*CAJANUS CAJAN* (L.) MILLSP.)

by

JOHN L. HAMMERTON
Agronomist, Faculty of Agriculture, University of the West Indies, Mona, Kingston 7, Jamaica

SUMMARY

Application of a compound fertilizer to supply 224 kg/ha each of N, P_2O_5 and K_2O in 5 equal doses during flowering, increased the yield of June-sown dwarf pigeon peas by 25% over the untreated control. The same total quantity during vegetative growth or over the entire growth period gave much lower yields. The N and P contents of a standard leaf were increased by fertilizer application, but neither leaf-N nor-P appeared related to yield. Fertilizer application to a November-sown high density crop increased the yield of only one of three cultivars, in an experiment in which yields were very poor. Nitrogen alone decreased yields in a September-sown trial as did $MNSO_4$ as spray or soil drench and complete fertilizer as drench. The effects of fertilizers on branch number and plant height were generally small and variable.

INTRODUCTION

Pigeon peas *(Cajanus cajan* (L.) Millsp.), in common with many tropical subsistence crops, traditionally receive no fertilizer application (Gooding, 1962; Henderson, 1965) in spite of normally being grown on impoverished soils. This implies an efficient root system able to absorb nutrients of low availability. A limited number of experiments on fertilization have shown a general lack of response (Gooding, 1962), but some positive responses have been reported. Sallette & Courbois (1969) in Marie Galante obtained yield responses of 35–45% to phosphate and potassium application, but not all cultivars showed a response. In India, Bhatawadekar, Chiney & Deshmukh (1966) found that phosphate application increased, but nitrogen decreased, pigeon pea yields. On a leached sandy soil in Tanganyika, applications of as little as 5 tons/ac. farm-yard manure (f.y.m.) increased yields of pigeon peas while in the absence of f.y.m. both potassium and calcium gave substantial yield increases (Evans & Mitchell, 1962). Oke (1969) in Nigeria reported that sulphur alone, or with phosphate, increased nodule dry weight and nitrogen content in pot experiments, and Nichols (1965), using sand culture, found that absence of calcium, phosphorus or magnesium severely reduced nodulation. Nodule dry weight was highly correlated with stem, root and leaf dry weights.

Data on mineral contents of pigeon pea leaves are scanty. Nichols' (1965) data for 13-week old nodulated plants grown in sand culture, show ranges of 2.9–3.2%N, 0.18–1.18%P_2O_5 and 0.98–4.34%K_2O in leaf dry matter.

The experiments herein reported were undertaken to examine the response of some of the semi-determinate dwarf pigeon pea cultivars, developed by the Regional Research Centre of the University of the West Indies, to fertilizer application, and to obtain some indication of the factors modifying this response, if any.

EXPERIMENTAL METHODS

All experiments were carried out on Caymanas clay loam in St. Catherine, Jamaica. A typical chemical analysis gives 0.15%N, 7400 ppm available P_2O_5 and 360 ppm available K_2O, with a pH of approximately 7.4. The cultivars grown were developed at the Regional Research Centre of the University of the West Indies; they are drawf and semi-determinate in bearing. Weeds were controlled by pre-emergence prometryne (1.1

kg/ha) and one or more shielded or directed paraquat sprays. Malathion or DDT were sprayed or mist-blown for leaf-hopper and pod-borer control. Three or four seeds were sown per hold and later thinned to one plant.

Experiment 1

Treatments were all combinations of (i) 3 rates of fertilizer – 0, 56 or 224 kg/ha each of N, P_2O_5 and K_2O; (ii) 3 times of application – every 15 days from 15–90 days inclusive (during vegetative growth), every 15 days from 75–135 days inclusive (during flowering) or every 15 days from 15 to 135 days inclusive; and (iii) 2 cultivars– CH 11/33/34 and GI 27/4a. The six nil treatments of the 18 treatment combinations were retained in the field layout. There were six replicates and plot size was 2.73 x 1.82 m with 6 plants at 91 x 91 cm. Plots were sown June, 16, 1970. Fertilizer was applied by hand in a ring around each plant, using a commercial 10–10–10 compound. The experiment was normally irrigated within 3 days of fertilizer application, unless rain fell. The height of every plant was recorded 62, 92 and 122 days from sowing, and branch number (primaries) was recorded at 64 days. Leaf samples, taking the 5th expanded leaf, were collected at 67 and 107 days for chemical analysis: replicates were bulked to give duplicate samples which were washed and oven-dried. At 180 days dry pods were harvested, weighed and sampled to obtain yield components. At this time there were few green pods on the plants, but a few flowers were present.

Experiment 2

Treatments were all combinations of (i) 2 sowing dates – November 3 and December 3, 1970; (ii) 3 cultivars – CH 11/33/34, GI 26/2 and GI 27/4a; (iii) 2 plant populations (or spacings), normally 47,500 per ha (46 x 46 cm) or 95,000 per ha (23 x 46cm); and (iv) 2 fertilizer levels – nil or 100 kg/ha N, 100 kg/ha P_2O_5 and 125 kg/ha K_2O at sowing, plus a further 100 kg/ha N (as urea) at 40 days from sowing. The design was a split–split–split plot design with sowing dates to main plots, cvs to sub-plots, densities to sub-sub-plots and fertilizer to sub-sub-sub-plots. There were 4 replicates and sub-sub-sub (unit) plot size was 2.3 x 4.6 m. The heights of 8 random plants per unit plot were measured at flowering. Leaf samples (5th expanded leaf) were taken at 63 days (early flowering): these were bulked to give duplicate samples, washed and oven-dried for N P K analysis. The bulking permitted significance tests of sowing date, cultivar and fertilizer effects. Yields of dry seed were taken from an area 1.36 x 4.0 m in each unit plot, at 125 days (CH 11/33/34) and 140 days (GI 26/2 and GI 27/4a) from the November sowing only, as praedia larceny destroyed most of the December sown plots. Pod and seed numbers were determined on 10 randomly selected plants per unit plot. Seed samples were oven-dried to give 100 seed weights and to adjust yields to 88% dry-matter.

Experiment 3

This has also been described elsewhere in these proceedings (Hammerton, 1973). Treatments were (i) $MnSO_4$ $4H_2O$ as a foliar spray (0.5% wt/vol plus "Citowett") or at 2.2 kg/ha per application as a soil drench; (ii) a soluble complete fertilizer (20%N, 20%P_2O_5, 20%K_2O, 420 ppm MgO, 780 ppm Mn, 290 ppm B, 255 ppm Mo, 64 ppm Cu, 51 ppm Fe, 46 ppm Zn) as a foliar spray (6.25% wt/vol plus "Citowett") or at 55 kg/ha per application as a soil drench; (iii) N at 22.5 kg/ha per application either as urea or sulphate of ammonia, as soil drenches; (iv) an untreated control and a treatment receiving $MnSO_4$ as a foliar spray "post-bearing". This latter treatment need not concern us here. The 8 treatments were replicated 3 times; plot size was 2.3 x 2.3 m containing 25 plants at 46 x 46 cm. The experiment was planted September 7, 1972 with cv CH 11/33/34. Treatments (except the "post-bearing") were applied 5 times at weekly intervals from 47 days (October 24). Mature green pods were harvested once, at 140 days; plants were still flowering, but the onset of the yellowing and die back syndrome (Hammerton, 1973) effectively prevented any further bearing. Heights and (primary) branch numbers (>2.5 cm) were recorded at 60, 75 and 120 days.

RESULTS

Experiment 1

Both cultivars began flowering at about 105 days and were in full flower by 120 days. The U.W.I. semi-determinate dwarf cultivars behave differently in Jamaica compared with Trinidad: growth form is laxer and less dwarf, and flowering persists longer with a greater range of pod maturities than is obtained in Trinidad. Neither fertilizer treatment nor cultivar affected height at 62 or 92 days, but at 122 days GI 27/4a (190 cm) was significantly taller than CH 11/33/34 (186 cm) (S.E. ± 0.83 with 85 d.f. for error). Application of fertilizer from 73–135 days (during flowering) increased plant height significantly over that of plants fertilized over 15–90 days or throughout the 15–135 day period. Means were, respectively, 193, 188 and 187 cm (± 0.24). Branch number at 64 days averaged 13 and was unaffected by any treatment.

Yields are summarised in Table 1. Cultivars did not differ in yield and, overall, fertilizer rate had no significant effect on yield. Averaged over rates, fertilizer application from 75–135 days increased yields significantly. The highest yield was obtained by the higher rate over 75–135 days: the same rate earlier, or over the entire period, gave a yield similar to that of the nil control. The lower rate over 75–135 days was also significantly better than the nil control. Surprisingly, the lower rate applied over 15–90 days was better than the higher rate over the same period. Mean number of peas per pod and mean dry weight per pea were not significantly affected by any fertilizer treatment. The cultivars did differ however; mean numbers of peas per pod were 4.10 and 4.43 (± 0.098) and mean dry weights per pea were 106 and 114 mg (±2.8) for CH 11/33/34 and GI 27/4a respectively.

Leaf contents of N, P and K are shown in Tables 2 and 3. At 67 days, GI 27/4a had a greater leaf-N content than CH 11/33/34, but at 107 days it had greater leaf-N, P and K contents. Phosphorus and K, but not N, decreased considerably between 67 and 107 days. Leaf-K was unaffected by fertilizer treatment at both 67 and 107 days. The high fertilizer rate from 15–90 days increased both N and P at 67 days; note that only 4 of the 6 applications had been given at the time of sampling and hence only two-thirds of the quantities had been applied. At 107 days, the high rate increased leaf-N compared with the low rate or nil control. Leaf-P was increased by both rates and equally, the 75–135 day treatment in both cases giving higher values than the 15–90 day treatment.

Experiment 2

Fertilizer application increased plant height at flowering (Table 4) in all three cultivars: the increase was greatest in the shortest cultivar, CH 11/33/34. Overall, sowing date had no effect on height when fertilizer was given: in its absence December-sown plants were slightly, but significantly, taller (Table 5). Yields of dry seed were extremely poor, due partly to grossly sub-optimal plant populations, and also due to severe loss of leaf as a result of rust (caused by *Uredo cajani).* Yield data refer only to the November sowing. Fertilizer increased yields, but only with CH 11/33/34, which was the highest yielding of the three cultivars (Table 4). Table 6 shows that, averaged over cultivars, the response to fertilizer occurred only at the higher population, which gave a significantly greater yield than the lower population. Pod number per plant showed the same trends (Table 4) as yield. Seed dry weight was unaffected by fertilizer, but differed among cultivars. Means were 72, 79 and 91 (±0.09 with 6 d.f. for error) for CH 11/33/34, GI 26/2 and GI 27/4a respectively (weights in mg.)

Only leaf-N showed a significant effect of fertilizer (Table 5). Fertilizer increased leaf-N, but only in the November sowing. Overall, November-sown plants had significantly higher leaf-N contents than December-sown (4.75 and 4.31%, respectively, ±0.012 with 1 d.f. for error). Leaf-P was also lower in December-sown plants but the difference was not significant (0.42 and 0.34% ±0.005 with 1 d.f.). Fertilizer slightly but significantly increased leaf-P (0.37 and 0.39% ± 0.004 with 6 d.f.). Leaf-K averaged 0.90% but was not significantly affected by any treatment. Cultivars showed no difference in either N, P or K contents of the leaves.

Experiment 3

Data on branch numbers, plant heights and yield are summarised in Table 7. By 60 days all except the control and "Mn-post-bearing" treatment had received two applications as spray or drench, and by 75 days four applications (the fifth was given on the 75th day). The Mn-foliar, Mn-soil, Fert.-foliar and $(NH_4)_2SO_4$ treatments all reduced branch number, relative to the control, at 60 days. Urea increased height and Fert-foliar decreased it however. By 75 days $(NH_4)_2\ SO_4$ increased branch number, but not height, whereas urea increased height. Branch number apparently decreased in some treatments between 75 and 120 days. At 120 days, Mn-foliar and Fert-soil both decreased branch number, compared with the control, but increased plant height. Yields were low, due probably to severe rust: all treatments except Fert-foliar reduced yields significantly below that of the control, the reduction being greatest with the nitrogen treatments.

DISCUSSION

Although the general levels of yield were low, particularly in Experiments 2 and 3, and the soil type is described as of "high to very high" natural fertility (Vernon, 1958), some increases in yield due to fertilizer application were obtained. The low yield level was at least partly due to severe rust infection resulting in heavy leaf fall. The semi-determinate nature of these cultivars exacerbates this loss of leaf. In Experiments 1 and 2, but not in 3, an NPK or complete fertilizer increased yields. The evidence of Experiment 3 suggests, in agreement with data of Nichols (1965) and Bhatawadekar et al (1966), that N alone depresses yield, presumably by depressing nodulation. The results of Experiment 1 suggest that timing of fertilizer supply may be important. The small return for very heavy applications should be noted.

N and P, but not K, appeared to be readily absorbed from soil applications and to give leaf contents higher than those of Nichols (1965); his data refer to "whole-plant" leaf samples however. Neither N nor P contents appeared in anyway associated with yield in Experiment 1. A similar comparison for Experiment 2 is prevented by loss of the December yield data. Data presented elsewhere in these proceedings (Hammerton, 1973) cast doubt on the efficacy of foliar applications of nutrients, and the yield data of Experiment 3 tend to confirm this, insofar as foliar fertilizer neither increased nor decreased yield compared with the control, although it did affect branch number and height.

Only one of the three cultivars showed a yield response in Experiment 2. This may imply a genetic capacity to respond , though no cultivar x treatment interaction was recorded in Experiment 1, nor did this cultivar (CH 11/33/34) show a positive response in Experiment 3. One might predict that plants under population stress would be more likely to respond positively to increased nutrient supply than those at lower populations. The marked fertilizer x population interaction of Experiment 3 (Table 6) supports this, although more recent work (unpublished) shows these populations to be well below the optima.

Branch number was not affected by the treatments of Experiment 1, and in Experiment 3 the effects were not consistent though the data suggest that branches produced in response to fertilizer were short-lived, so that the increase in branch number, over the control, at 75 days was only temporary. Height increases were generally small, and not consistent, in Experiment 3. Indeed the latter experiment suggests some antagonism between branch production and increase in height.

The Mn treatments of Experiment 3 were included as part of the investigation of the yellowing and dieback syndrome reported elsewhere in this volume (Hammerton, 1973). Mn had inconsistent effects on branch number and no significant effects on height: both foliar and soil applications reduced yields however, implying some phytotoxicity.

These data do little more than suggest that the response, in yield or growth, of pigeon peas to fertilizer, may vary with the cultivar, with planting date and with plant population. The yield responses obtained were small and clearly uneconomic in view of the large quantities applied and the uncertainty of the response. On every impoverished soils a response to P and K might be obtained and possibly to other nutrients. The data do suggest that much more work could usefully be undertaken on nutrient uptake, on the efficacy with which mineral nutrients are used within the plant, and on the whole question of nodulation and the nitrogen economy of pigeon peas.

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Table 1

Effect of rate and time of fertilizer application on the yield of dry seed (kg/ha at 88% dry matter) of pigeon peas. Plots were harvested once. Means of two cultivars (CH 11/33/34 and GI 27/4a). (Experiment 1).

Time of Fertilizer application	Rate of fertilizer application (kg/ha of each of N, P_2O_5 and K_2O)			Mean (of 56 and 224 Kg/ha)
	Nil	56 kg/ha	224 kg/ha	
		± 28.5[2]		±21.5
15–90 days	± 17.6[1]	1099 bc	924 d	1012 b
75–135 days	1013 cd	1107 b	1262 a	1184 a
15–135 days		958 d	931 d	944 b
Mean ± 21.5	1013 a	1055 a	1039 a	

1 S. E. of nil fertilizer mean

2 S. E. of rate x time interaction means. Error d.f. 85. Means within the body of the table (i.e. nil *and* rate x time interaction means) and marginal means over rates or times of application, followed by the same letter, do *not* differ significantly by Tukey's test.

Table 2

Nitrogen, phosphorus and potassium contents of the 5th leaf (% in dry-matter) of two pigeon pea cultivars at 67 and 107 days after sowing. Means over rates of application. (Experiment 1.)

	67 days		107 days	
	CH 11/33/34	GI 27/4a	CH 11/33/34	GI 27/4a
	± 0.018[1]		± 0.040[2]	
Nitrogen (N)	4.35 a	4.68 b	4.41 a	4.69 b
	± 0.006[1]		± 0.001[2]	
Phosphorus (P)	0.21 a	0.22 a	0.10 a	0.12 b
	± 0.012[1]		± 0.011[2]	
Potassium (K)	1.09 a	1.09 a	0.86 a	0.92 b

1 Error d.f.5

2 Error d.f. 9. If the two means of a pair are followed by the same letter they do *not* differ significantly by Tukey's test.

Table 3

Effect of rate (as kg/ha or each of N, P_2O_5 and K_2O) and time of fertilizer application on the nitrogen and phosphorus contents of the 5th leaf (% in dry matter) of pigeon peas. Means of two cultivars (CH 11/33/34 and GI 27/4a). (Experiment 1.)

Time of sampling	Nil	Rate and time of fertilizer application: 56 kg/ha, 15–90 days	56 kg/ha, 75–135 days	224 kg/ha, 15–90 days	224 kg/ha, 75–135 days
		Nitrogen (% in leaf dry matter)			
			± 0.023[1]		
67 days	4.45 a	4.45 a	–	4.65 b	–
			± 0.062[2]		
107 days	4.53 a	4.45 a	4.50 a	4.65 a	4.63 b
		Phosphorus (% in leaf dry matter)			
			± 0.0076[1]		
67 days	0.20 a	0.20 a	–	0.24 b	–
			± 0.0017[2]		
107 days	0.10 a	0.11 b	0.12 c	0.11 b	0.12 c

1 **Error d.f. 5.**

2 **Error d.f. 9. Means on the same line followed by the same letter do *not* differ significantly by Tukey's test.**

Table 4

Effect of fertilizer application and cultivar on plant height at flowering, yield of dry seed (88% dry matter), and mean number of pods per plant. Heights are averaged over two planting dates, but yields and pod numbers are for one planting date (November) only. (Experiment 2)

		Cultivar			
		CH 11/33/34	GI 26/2	GI 27/4a	Mean
		± 0.008[1]			± 0.006[1]
Height (m)	No fertilizer	0.94 e	1.08 c	1.13 b	1.05 b
	Fertilizer	1.03 d	1.12 b	1.19 a	1.11 a
	Mean ± 0.017[2]	0.98 b	1.10 a	1.16 a	
		± 8.3[3]			± 4.8[3]
Yield (kg/ha)	No fertilizer	176 b	85 c	173 b	145 b
	Fertilizer	248 a	86 c	172 b	169 a
	Mean ± 11.1[4]	212 a	86 b	173 a	
		± 0.37[3]			± 0.21[3]
Pods per plant	No fertilizer	13.3 b	5.0 d	5.9 cd	8.1 b
	Fertilizer	15.4 a	3.9 e	7.2 c	8.8 a
	Mean ± 0.59[4]	14.4 a	4.5 b	6.5 b	

[1] Error d.f. 36. [2] Error d.f. 12. [3] Error d.f. 18. [4] Error d.f. 6.

Means for fertilizer x cultivar interactions, marginal means over fertilizer on cultivars, followed by the same letter do *not* differ significantly by Tukey's test.

Table 5

Effect of fertilizer application and planting date on the nitrogen content of the 5th leaf (% in dry matter) at 63 days (early flowering) and on plant height at flowering. Means of three cultivars (CH 11/33/34, GI 26/2 and GI 27/4a). (Experiment 2.)

	Fertilizer and planting date			
	No fertilizer		Fertilizer	
	November	December	November	December
		±0.027[1]		
Nitrogen (%)	4.62 b	4.32 c	4.87 a	4.30 c
Mean ±0.012[1]	4.46 b		4.59 a	
		±0.007[2]		
Height (m)	1.04 c	1.07 b	1.11 a	1.10 a
Mean ±0.020[2]	1.05 b		1.11 a	

[1] Error d.f. 6 [2] Error d.f. 36

Means on the same line followed by the same letter do not differ significantly by Tukey's test.

Table 6

Effect of plant population and fertilizer application on yield of dry seed (kg/ha at 88% dry matter). November planting only, means over three cvs. (Experiment 2)

	Nominal plant population (000's/ha)		Mean
	47.5	95.0	
	±6.8[1]		± 4.8[1]
No fertilizer	135 b	155 b	145 b
Fertilizer	141 b	197 a	169 a
Mean ± 5.6[2]	138 b	176 a	

[1] Error d.f. 18. [2] Error d.f.

Means in the body of the table (fertilizer x population interaction), and marginal means over fertilizer or populations, followed by the same letter do *not* differ significantly.

Table 7

Effect of nutrient application on mean branch (>2.5 cm) number per plant and mean plant height (cm) at 60, 75 and 120 days from planting, and yield as pods per plant at 140 days. (Experiment 3)

	Mean branch number per plant			Mean plant height (cm)			Pods per plant
	60 days	75 days	120 days	60 days	75 days	120 days	140 days
Mn-foliar	8.1 b	15.5 ab	11.7 b	87 ab	109 ab	123 a	8.3 b
Mn—soil	7.0 c	15.9 ab	13.3 ab	85 bc	104 b	118 ab	8.3 b
Fert..foliar	8.4 b	14.7 ab	13.5 ab	81 c	108 ab	116 b	9.8 a
Fert.-soil	9.1 ab	14.5 ab	11.9 b	88 ab	107 ab	122 a	7.8 bc
Untreated control	9.4 a	14.0 b	18.2 a	86 b	105 b	118 ab	9.9 a
Mn-post-bearing*	9.4 a	14.1 b	16.6 a	87 ab	106 ab	119 ab	10.2 a
$(NH_4)_2\ SO_4$-soil	8.4 b	16.2 a	15.0 ab	86 b	109 ab	114 b	7.2 c
Urea-soil	8.8 ab	14.5 ab	16.7 a	91 a	111 a	116 b	7.3 c
S. E. (14 d. f.)	± 0. 19	± 0.41	± 1.14	± 0.89	± 1.10	± 1.17	± 0.21

*Treatment not applied until 137 days onwards.

EFFECT OF PLANTING DATE ON SOYABEAN OIL AND PROTEIN IN TRINIDAD[1]

by

R. A. I. BRATHWAITE
Department of Crop Science, The University of the West Indies, St. Augustine, Trinidad.

INTRODUCTION

The soyabean (*Glycine max* (L.) Merrill) is grown mainly for its seeds which contain oil and protein of high biological value. These seed chemical constituents are known to vary with changing planting dates, but in Trinidad, where the crop is currently the subject of much research, there is little information in the literature on these effects. Inconclusive data for oil content for two planting dates in Trinidad were reported by RADLEY (1968). This paper presents more extensive data concerning oil and protein contents and yields of two soyabean varieties as influenced by different planting dates during a year.

MATERIALS AND METHODS

The experiment was conducted on cambered beds on River Estate Loam (pH 5.7 and low in major nutrients) at the University Field Station, Champ-Fleurs, Trinidad. Inoculated seeds of soyabean varieties ACADIAN and F62/3977 were sown by hand at exactly four-week intervals throughout a twelve-month period commencing 23rd October, 1968. Plots were thinned, within two weeks of planting, to 7 cm. between plants in a row giving a plant population of approximately 235,000 plants per ha.

[1]A paper prepared for the Eleventh Annual Meeting of the Caribbean Food Crops Society held in Barbados from 1st to 7th July, 1973. This paper is a portion of a Ph.D thesis submitted to the University of the West Indies in February, 1972.

Table 1.

Effect of planting date on seed oil and protein contents (percentage on a moisture free basis) of two soyabean varieties

	OIL		PROTEIN	
	Acadian	F62/3977	Acadian	F62/3977
	±1.01		±1.00	
October	19.5 c*	22.5 b	43.0 b	42.0 ab
November	21.0 bc	25.0 a	44.1 a	43.0 a
December	22.0 b	24.3 ab	44.0 a	44.0 a
January	23.0 b	21.1 bc	45.4 a	44.1 a
February	22.0 b	26.9 a	44.2 a	42.7 a
March	27.1 a	21.4 b	47.3 a	39.0 b
April	17.0 d	19.7 c	44.0 a	43.0 a
May	17.6 d	20.4 c	43.6 b	40.6 b
June	18.1 c	19.7 c	38.8 c	42.5 a
Early July	18.3 c	20.5 c	44.0 ab	40.4 b
Late July	18.8 c	21.9 b	46.1 a	44.7 a
August	17.9 cd	22.8 b	42.4 b	39.9 b
September	19.4 c	20.1 c	45.7 a	45.3 a
Varietal Means	(± 0.28) 20.1	22.0	(± 0.28) 44.0	42.4
Coefficient of Variation	9.6%		4.6%	

*Means in the same column with the same letter do not differ significantly at the 5% probability level based on Duncan's Multiple Range Test.

Table 2.

Effect of planting date on seed oil and protein yields (kg./ha.) of two soyabean varieties.

	OIL			PROTEIN	
	Acadian	F62/3977		Acadian	F62/3977
	± 37.0			± 55.7	
October	348 b*	487 a		768 ab	913 a
November	422 ab	501 a		866 a	847 a
December	329 bc	416 ab		656 b	758 b
January	202 c	309 bc		400 d	643 bc
February	272 c	239 c		548 c	378 d
March	543 a	538 a		843 a	987 a
April	331 b	228 c		859 a	496 cd
May	219 c	255 c		540 c	506 c
June	246 c	385 b		525 cd	835 a
Early July	259 c	338 b		622 bc	677 b
Late July	256 c	392 b		629 b	799 ab
August	80 d	243 c		189 e	422 d
September	174 cd	337 b		410 d	763 b
Varietal Means (± 10.3)	283	359	(± 15.4)	604	693
Coefficient of Variation	23.1%			17.2%	

* Means in the same column with the same letter do not differ significantly at the 5% probability level based on Duncan's Multiple Range Test.

The experimental design was a randomised block with four replications. Each plot consisted of seven rows 9 metres long spaced 53 cm. apart. A 13:13:20 commercial compound fertilizer at the rate of 376 kg./ha. was broadcast and lightly raked into the soil before the plantings. Irrigation was used during dry periods, and three hand weedings and weekly sprayings with Dipterex SP 80 (Dimethyl 1-hydroxy 2 trichloro ethyl phosphonate) at a concentration of 3g per l and a rate of 300 litres per ha, were carried out during the growth of each crop.

Plants from an area 11.9 m^2 of each plot were harvested and threshed by hand. The winnowed seeds at 13% moisture were used for estimating plot yields. Duplicate samples of these seeds from each plot were analysed for oil content, gravimetrically using a standard Soxhlet unit with petroleum ether as solvent, and total Nitrogen content, using a micro-Kjeldahl procedure – Protein was estimated as total nitrogen X6.25. Oil and protein yields were computed by multiplying the seed yields by the oil and protein contents.

RESULTS

The effects of planting date on seed oil and protein contents in the two soyabean varieties are shown in Table 1. For both constituents, analysis of variance showed highly significant differences between varieties, planting dates and the variety X planting date interaction.

Seed oil and protein yield data are summarised in Table 2. There were highly significant differences between varieties and dates of planting in both attributes. The variety X dates interaction was significant at 5% and 0.1% probability levels for oil and protein yields respectively.

Correlation coefficients between seed oil and protein contents were non-significant for both varieties.

Correlation coefficients were computed for some meteorological factors (daylength, total sunshine hours and mean, minimum and maximum temperatures) and agronomic characters (growing period, period of full bloom to harvest, seed size and seed yield) with seed oil and protein contents. None were significant for ACADIAN. For F62/3977, associations significant at the 5% probability level, were shown by seed oil content with daylength (r = - 0.596) and growing period (r = - 0.554), and seed protein content with seed size (r = +0.679).

DISCUSSION AND CONCLUSION

The seed oil and protein contents and yields varied considerably with both planting date and variety, a finding in agreement with the many reports (BYTH and WAITE, 1962; CARTTER and HARTWIG, 1963; TANG, 1965; RADLEY, 1968) from different countries where planting date studies in the soyabean have been conducted. The highest oil and protein contents were not necessarily produced at planting dates which gave the highest oil and protein yields in either variety. Only in ACADIAN was the highest seed oil content and the highest oil yield produced at the same planting date.

Daylength varies by only ninety minutes over the year in Trinidad but showed a negative correlation with seed oil content in F62/3977. HOWELL (1963) in the United States of America reported that temperature variations affected the composition more than the yield of seed, but the present results show no such association. Temperature variations in Trinidad may not be large enough to influence oil and protein synthesis in the seed.

Consistent with JOHNSON, et al (1955) a negative association between growing period and seed oil content, typical for most American varieties, was recorded for F62/3977, and in contrast with many workers (JOHNSON and BERNARD, 1963) there was no association between oil content and period of full bloom to harvest. For the various planting dates, large seed size was associated with high seed protein content in F62/3977 and it is probable that both seed protein content and seed size responded similarly to an external factor.

Numerous investigators have reported a negative correlation between seed oil and protein contents (JOHNSON and BERNARD, 1963) but this relationship does not always occur (HOWELL, 1963), as shown by the present study. F62/3977 of Florida, U.S.A. appeared the better adapted variety and produced consistently more oil but apparently less protein than ACADIAN which was bred in Louisiana, U.S.A.

The data show that varying planting dates produced different effects on the seed oil and protein contents and yields of the two varieties, and the highest values of these attributes were obtained from the October, November and March plantings.

SUMMARY

A planting date study was conducted on soyabeans *(Glycine max* (L.) Merrill) at the University Field Station, Trinidad to provide data on the variation of seed oil and protein contents and yields. Seeds of varieties ACADIAN and F62/3977 were planted at four-week intervals on 13 successive dates commencing 23rd October, 1968.

Significant differences were observed between the varieties, planting dates and the variety x dates interaction for oil and protein contents and yields. Oil contents ranged from 17.0 to 27.1% (ACADIAN) and from 19.7 to 26.9% (F62/3977) and protein contents from 38.8 to 47.3% (ACADIAN) and from 39.0 to 45.3% (F62/3977). Oil yields ranged from 80 to 543 kg./ha. (ACADIAN) and from 228 to 538 kg./ha (F62/3977) and protein yields from 189 to 866 kg./ha. (ACADIAN) and from 378 to 987 Kg./ha (F62/3977). In F62/3977 only, oil and protein contents showed associations with some meteorological factors and agronomic characters. In general this variety produced consistently more oil but apparently less protein than ACADIAN. Plantings in October, November, March and April in ACADIAN and October, November and March in F62/3977 gave the highest oil and protein yields.

ACKNOWLEDGEMENTS

The research work formed part of the Grain Legume Programme of the Faculty of Agriculture, the University of the West Indies, financed by the Rockefeller Foundation. The author wishes to thank Professor E. A. Tai and Dr. J. L. Hammerton under whose supervision the work was carried out, and the Central Analytical Laboratory, the University of the West Indies, for seed protein analyses.

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A YELLOWING AND DIE-BACK SYNDROME OF PIGEON PEA (*CAJANUS CAJAN* (L.) MILLSP.)

by

JOHN L. HAMMERTON

Agronomist, Faculty of Agriculture, University of the West Indies, Mona, Kingston 7, Jamaica

SUMMARY

Certain cultivars of pigeon pea *(Cajanus cajan (L.)* Millsp.) when grown at one site in Jamaica, display a yellowing of new leaves and progressive dieback, leading to premature death and loss of later bearings. The symptoms do not correspond with any reported disease of pigeon peas. Leaf analysis suggests that Mn deficiency may be a primary cause of the syndrome. Foliar sprays and soil drenches of MnS04 and complete fertilizer do not prevent or reverse the symptoms. The possible relationship of nematodes to incidence of the syndrome has been investigated; nematicides increased yields but did not prevent yellowing and dieback.

INTRODUCTION

Early in 1970, many pigeon pea *(Cajanus cajan* (L.) Millsp.) plants of U.W.I. semi-determinate dwarf cvs. growing at Lawrence Field, St. Catherine, Jamaica, were observed to be suffering from a chlorosis and dieback. These plants had been reaped in late 1969, had been severely defoliated by rust (caused by *Uredo cajani),* but were at the time of the initial observations, producing new leafy shoots. It was these young leaves that were chlorotic. Old bearing shoots were dying at the tips and this dieback apparently progressed down the plant, until the entire plant died. Yellowed and apparently healthy green plants occurred within 0.5 to 1 m of each other. Some dwarf cultivars appeared more susceptible than others. The syndrome was again observed in 1971–72 and 1972–73, and several imported cvs., including some tall indeterminate types, were found to be seriously affected. Many indeterminate types are apparently less susceptible however.

This syndrome has not been seen elsewhere in Jamaica on the same or other cvs, nor has it been reported from those Commonwealth Caribbean territories to which the susceptible U.W.I. dwarf cvs have been sent for trial. The soil at Lawrence Field is a Caymanas Clay Loam derived from recent alluvium. It is well drained with good moisture supplying capacity, highly fertile and alkaline in reaction (Vernon, 1958). Lawrence Field is situated in a low rainfall (750–1000 mm per annum) zone

DEVELOPMENT OF SYMPTOMS

Only new leaves, produced after the plant has borne its first flush of pods, are affected. These are usually much reduced in size, cupped and twisted, but may be more-or-less normal in size and show no distortions. Leaves may be pale green at first becoming uniformly yellow later or may be yellow from the outset. Branches with yellow leaves and branches with apparently normal (green) leaves are occasionally found on the same plant. These green leaves ultimately become yellow and the plant eventually dies. Dieback begins at the tips of the old bearing shoots and progresses downwards until only the basal portion of the main stem is alive, typically bearing a few clumps of small yellow leaves. These leaves shrivel and fall as the dieback progresses. The time from bearing and reaping to death may be 5 to 12 weeks, depending partly on the size of the plant. Recently dead plants are usually easily pulled from the soil, the main structural roots apparently breaking quite easily.

OBSERVATIONS

Symptoms have invariably been seen on rust-infected plants that have suffered severe defoliation. Three cvs showing some rust-resistance have not succumbed to the syndrome, but many rust-susceptible cvs also show resistance to the syndrome. Symptoms do not resemble those of any reported disease, nor has examination of whole still-living plants revealed any "novel" lesions that might indicate a living causal agent. Examination of root (and soil) samples has shown the presence of nematodes on both affected and unaffected plants.

Plotting the incidence of the syndrome within experimental plantings or over larger areas has shown no pattern that could be considered non-random. Within a plot of uniformly spaced plants some may appear healthy while others are severely yellowed. This is partly due to differences in the time and rate of development of symptoms. Water stress appears to hasten the development of symptoms and increase the proportion of affected plants.

EXPERIMENTS AND RESULTS

Soil Analysis.

Soil samples taken in 1971 from below affected plants had a mean pH (1 : 5 soil : water suspension) of 7.4 compared with 7.6 from below unaffected plants or adjacent fallow land. This difference was statistically significant (S.E. = ± 0.025 with 12 d.f.). There were no significant differences in available P_2O_5 or K_2O or in total N.

Soil Bioassay.

Large samples from below affected and unaffected plants and from adjacent fallow land were sieved, and half of each sample autoclaved. No effects of either origin or autoclaving on emergence, appearance or fresh weight at 35 days of either pigeon peas or beans *(Phaseolus vulgaris)* were found. Plants were grown in 6 cm pots with ten replicates. Self-sown pigeon pea plants below severely yellowed or dead plants showed no abnormalities.

Leaf Analysis.

A total of 37 leaf samples have been analysed for Mn and Fe : 23 of these have also been analysed for Zn and 13 for Cu. Leaves were classified as "yellow", "young green" (i.e. new green leaves camparable in age with the yellow leaves), or "old green". They were mainly from U.W.I. dwarf cvs grown at various sites in 1971 and 1972. Leaf lamina only were analysed after careful washing and oven drying. The data are summarised in Table I. Mean Mn, Fe and Zn contents of yellow leaves are respectively about half, seven-eighths and two-thirds those of young green leaves. The mean Cu content is higher in yellow leaves however. Old green leaves, which were badly rust-infected, were similar in mean Mn and Fe contents to young green leaves. Ratios of Mn to Fe+Zn show a marked difference between yellow and green leaves. Taken overall, Mn appears most clearly linked with yellowing, although Fe cannot be entirely ruled out. A Mn content of 65 ppm, and a Mn/Fe+Zn ratio of 0.17, appear to discriminate between yellow and green leaves.

Attempted Induction of Symptoms.

Plants were established in one (U.S.) quart cans containing soil collected from Lawrence Field. Lime or acid was added to batches of soil to give pH's of 8.1 and 4.5 respectively: unamended soil had a pH of 7.4. Plants were induced to flower by artificially shortening the photoperiod. A range of micronutrient, soil drench treatments, with untreated controls, were superimposed. Not one plant showed any yellowing or dieback symptoms.

Correction of Symptoms.

Foliar sprays of soluble or chelated forms of Fe, Zn, Mn, Cu, Co, B and Mg plus various wetting agents, have consistently failed to delay or reverse symptoms. Soil drenches have also failed. Some data from two recent experiments with sprays and drenches are summarised in Tables 2 and 3. In the first, treatments were made to June-sown plants. Five applications were made, weekly, from December 8, 1971. Plants were classified on January 25, 1972, as yellow, pale green or green and leaf samples taken. There were 4-6 plants per plot and two replicates.

A chi-square test showed no significant effect of treatment on the number of yellow, pale green or green plants. Soil drenches did not increase leaf Mn contents (Table 2) relative to the controls, but soil drenches (and foliar fertilizer) did increase leaf Fe. Foliar sprays of Mn and fertilizer increased leaf Mn to very high levels, presumably due to surface adsorption resistant to washing. Differences between yellow and pale or green leaves in Mn and Fe contents were not consistent, and values for yellow leaves were very high, particularly for Mn, compared with those of Table 1.

In the second trial, planted September 7, 1972, a number of pre-bearing treatments were compared with a control and a "post-bearing" foliar spray. Treatments are shown in Table 3: they included urea and $(NH_4)_2SO_4$ as drenches to examine, *inter alia*, the effect of sulphur. There were 25 plants per plot, spaced 46 x 46 cm and three replicates. At 150 days after planting, when plants had borne one crop of pods and were flowering again, over 40% of plants of the control and urea treatments were severely affected, significantly more than with Mn, complete fertilizer or $(NH_4)_2SO_4$ as soil drenches. "Post-bearing"Mn was only slightly better than the control in % severely affected plants. By 190 days all plants receiving the latter treatment were dead or severely affected. The lowest value was with complete fertilizer to the soil. By 205 days, no treatment had less than 75% of plants severely affected, and it is clear that no treatment did more than delay the development of severe symptoms.

Nematicides.

Mr. D. Hutton, Nematologist, Ministry of Agriculture, Jamaica, examined soil samples from beneath pigeon pea plants at Lawrence Field. *Rotylenchulus reniformis* was the major species found: others included *Tylenchorhynchus* sp., *Helicotylenchus* sp. *Scutellonema* sp., *Pratylenchus* sp., *Longidorus* sp., and *Hoplolaimus* sp. Root damage by nematodes is a possible cause of lowered nutrient uptake, so a simple nematicide trial was laid down. Plot size was 1.22 x 6.1 m with 20 plants 30.5 m apart in a single row. There were 4 replicates and treatments are given in Table 4. All nematicide-treated plots received D-D on October 5, 1972. The experiment was planted October 20, and treatments applied January 19, 1973. Pods were harvested from February 12. Two of the treatments significantly increased yields, as number of pods per plant, over the untreated control (Table 4). The distribution of yellowed plants was erratic and unrelated to treatment up to May 16, 1973, when a final assessment was made.

DISCUSSION

Much of the data support the hypothesis that Mn deficiency is at least associated with the syndrome. "Lime induced" chloroses, due to non-availability to the plant of soil Mn and Fe are well known and the Ph of the Lawrence Field soil is sufficiently alkaline to reduce Fe and Mn availability. Foliar sprays are a recognised means of correcting Mn deficiencies so that the failure of spraying to reliably correct symptoms in pigeon pea does not support the hypothesis that Mn deficiency is a primary cause. It is unlikely that the large amounts of leaf Mn recorded in the first spraying trial (from *yellow* leaves) were entirely surface-adsorbed and physiologically non-functional. In the second spraying trial Mn sprays reduced yields without affecting the subsequent development of the syndrome. Soil drenches were scarcely more effective, nor did the "complete" fertilizer materially improve survival and/or recovery, either as foliar spray or drench. This suggests that deficiencies of mineral nutrients were not primary causes of the syndrome. The possibility remains that "low" leaf Mn (i.e. below c 65 ppm) is merely associated with, and not a primary cause of, the yellowing syndrome.

Little is known of the mineral nutrition of *Cajanus cajan.* Nichols (1965) studied the effects of major element deficiencies on growth, nodulation and mineral content, and also described and illustrated the major deficiency symptoms (Nichols 1964). His experiments did not examine the effect of Mn, nor did his analytical data include this element. His data for leaf-Fe in 13-week old nodulated plants, give 126 ppm with complete nutrients (in sand culture) – a value below the presently reported median ranges – and 61 ppm when Fe was absent. This latter is similar to the minimum value found in the present work.

It would be premature to comment on the role of nematodes in the syndrome. Ayala (1962) and Ayala & Ramirez (1964) have reported on the nematode species found on pigeon pea roots in Puerto Rico. In view of the wide host range of *Rotylenchulus reniformis* and its importance, further studies on this and the other species recorded by Mr. Hutton, appear necessary. Work is already in progress and planned for the future. Two nematicide treatments increased yields, which were in any case very low, but none prevented yellowing and dieback symptoms developing. Association of nematodes with this syndrome is therefore unproven. More work with nematicides is planned, to ascertain further their effects on yield and the role of nematodes in yellowing.

There are many odd features to the occurrence of the syndrome that cannot be readily explained: the spatial distribution and the absence of any symptoms, apparently regardless of planting date, prior to bearing. Pre-bearing crops are normally well watered whereas post-bearing plants tend to receive less regular watering. There are also several possible causes that remain unexplored or incompletely tested. Soil borne diseases (and diseases in general), changes in the root system and nodules coincident with the end of the initial bearing, changes in mineral nutrient availability with change in wetting-drying cycles in the soil, are all topics that merit investigation in addition to the topics already under study.

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Table 1

Mn, Fe, Zn and Cu contents (ppm in lamina dry-matter) and the Mn/Fe+Zn ratio of pigeon pea leaves. Leaves were classified as yellow, young green or old green. Means, ranges and median 50% ranges are given.

Leaf type	No. of samples	Mean	Range	Median 50% range
		Manganese (Mn)		
Yellow	15	48	12–76	40–63
Young green	15	93	50–165	80–111
Old green	7	92	55–165	65–109
		Iron (Fe)		
Yellow	15	210	82–325	185–225
Young green	15	246	59–375	200–289
Old green	7	246	140–350	193–300
		Zinc (Zn)		
Yellow	8	40	5–95	19–50
Young green	10	60	21–146	45–58
Old green	5	37	9–50	35–40
		Copper (Cu)		
Yellow	7	23	13–68	13–17
Young green	6	13	5–17	10–15
		Ratio Mn/Fe+Zn		
Yellow	8	0.15	0.10–0.26	0.13–0.16
Young green	10	0.26	0.14–0.49	0.21–0.26
Old green	5	0.28	0.18–0.41	0.20–0.31

Table 2

Mn and Fe contents (ppm in lamina dry-matter) and the Mn/Fe+Zn ratio of pigeon pea leaves as affected by various foliar and soil treatments. Plants (and leaves) were classified as yellow (Y), pale green (P) or green (G). Values in parentheses are weighted) means for treatments. (Cv. CH 11/33/34).

Treatment	Mn (ppm)			Fe (ppm)			Mn/Fe+Zn		
	Y	P	G	Y	P	G	Y	P	G
Mn[1] – foliar	1216	1300 (1263)		180	197 (189)		*	4.32 (4.32)*	
Mn[1] – soil	82	(109)	144	254	(254)	255	0.19	(0.19)*	0.19*
Fert.[2] – foliar	395	(362)	317	217	(228)	199	*	(0.97)*	0.97*
Fert.[2] – soil	95	83 (106)	253	170	262 (231)	259	0.33	0.20 (0.29)	0.64
Water – foliar		309 (267)	161		168 (171)	180		0.96 (0.83)	0.50
Water – soil	110	(133)	149	304	(282)	266	0.24	(0.34)	0.42

*value missing or based on imcomplete data

[1] $MnSO_4$ $4H_2O$ at 0.33% wt/vol. plus Citowett as foliar spray to run-off, or 6.6g in 2 litres per plant as a soil drench.

[2] Soluble fertilizer (32%N, 12%P_2O_5, 12%K_2O, 6%S, 1%CaO, 3%MgO, 1500 ppm Mn, 850 ppm Fe, 600 ppm Cu, 525 ppm Zn, 120 ppm B and 15 ppm Mo) at 0.66% wt/vol. plus Citowett as foliar spray to run off, or 13.3 g in 2 litres per plant as a soil drench.

Table 3

Effect of treatments on percentage of severely affected plants at 150, 190 and 205 days from sowing. Figures in parentheses are angular transformed values, to which S.E.'s apply. (Cv. CH 11/33/34)

	Percent severely affected plants at		
	150 days	190 days	205 days
Mn[1] – foliar*	21 (27.4 a[4])	60 (50.9 ab[4])	87 (69.1 ab[4])
Mn[1] – soil*	23 (28.5 a)	43 (41.2 ab)	82 (65.0 ab)
Fert.[2] – foliar*	32 (34.5 ab)	72 (58.4 c)	97 (80.8 bc)
Fert.[2] – soil*	24 (29.5 a)	38 (38.0 a)	75 (60.2 a)
Untreated control	44 (41.4 b)	67 (55.0 bc)	95 (78.1 bc)
Mn[1] –– Post–bearing**	37 (37.7 ab)	100 (90.0 d)	100 (90.0 c)
$(NH_4)_2SO_4$[3] – soil*	26 (30.8 a)	45 (42.1 ab)	80 (63.3 ab)
Urea[3] – soil*	48 (43.9 b)	54 (47.5 ab)	93 (74.9 abc)
S.E. (14 d.f.)	(2.14)	(3.35)	(3.40)

[1] $MnSO_4\ 4H_2O$ at 0.5% wt/vol plus "Citowett" as foliar spray to run-off, or 2.2 Kg/ha per application as soil drench.

[2] Soluble fertilizer (20%N, 20%P_2O_5, 20% K_2O, 420 ppm MgO, 780 ppm Mn, 290 ppm B, 255 ppm Mo, 64 ppm Cu, 51 ppm Fe, 46 ppm Zn) at 6.25% wt/vol plus Citowett as foliar spray to run-off, or 55 kg/ha per application as soil drench.

[3] To give 22.5 kg/ha N per application as a soil drench.

[4] Means with the same letter do not differ significantly by Tukey's test.

*Treatments applied "pre-bearing"; 5 applications, weekly, from October 24, 1972 (47 days after planting.)

**Foliar spray; 5 applications between January 22 and February 14, 1973 (137 to 160 days from planting).

Table 4

Effect of nematicide treatments on yield of pigeon peas, as pods per plant from 4 pickings over 35 days beginning February 12, 1973. (Cv. CH 11/33/34).

	Untreated control	Nematicide treatment[1, 2]			
		Nemagon	Nemacur	Vydate	Furadan
Yield: pods per plant (± 0.43)	7.2 a[3]	9.1 ab	7.9 a	10.3 b	10.6 b

[1] All nematicide-treated plots received preplant 'D–D' (dichloropropane – dichloropropene mixture) at 445 l/ha on October 5, 1972.

[2] 'Nemagon' (dibromochloropropane) at 16 kg/ha a.i.

'Nemacur 'P' (O–ethyl O–(3–methyl–4–methylthiophenyl) isopropylamidophosphate) at 18.0 kg/ha a.i.

'Vydate L' (methl N', N–dimethyl–N– [(methylcarbamoyl) oxy]–1–thiooxamimidate) at 2500 ppm as foliar spray.

'Furadan' (2, 3–dihydro–2, 2–dimethyl–7–benzofuranyl methylcarbamate) at 13.4 kg/ha a.i. All applied January 19, 1973.

[3] Means with the same letter do not differ significantly by Tukey's test.

RED PEA VARIETY TESTING IN GUADELOUPE

by

F. KAAN & C. SUARD+

Large tonnages of dry red kidney beans are imported in the French West Indies. Retail prices are very high.

Local production is practically non existent and we do not know if commercial production would be economically feasible. However, production in family gardens should be recommended from the nutritional viewpoint.

About 200 introductions of kidney beans with red, rose or predominantly red seeds were examined in four trials, grown without poles. Conditions were:

Soil: ferralitic.
Climate: very variable in the different trials.
Spacing between rows: 0.76 m.
Spacing between plants: about 0.07 m.
Phytosanitary treatments: seed dressing with DEMOSAN.
(CHLORONEB) fungicide against damping off.
Number of harvests: 2–3.

RESULTS

All varieties of European origin, or those used for pod production, or extremely indeterminate (pole) types, performed very poorly in these conditions.

+ Station d'Amelioration des Plantes
Centre de Recherches Agronomiques des Antilles–Guyane – I.N.R.A. 97170:
PETIT BOURG

We made an estimate of yield performance in our 2 last trials:

Trial A was carried out in very humid and relatively cool Autumn conditions. Rhizoctonia solani disease was heavy on all varieties and in many completely destructive. Yield data are somewhat inconsistent for this reason.

Trial B was performed during the dry season with some irrigation. Soil fertility was very low in this trial and yields consequently were poor. Powdery mildew (Erysiphe polygoni) developed on many varieties.

In both trials yields were very low, varying from 300 kg to 1,500 kg/ha.

The results of 8 of the best introductions are compared to those of 2 standard red kidney varieties in the table: the standard varieties are Red cote and California kidney.

We are now experimenting with more recent introductions from Brazil, Columbia, Costa Rica and Haita, which could be of interest.

Table

EXPERIMENTAL RESULTS IN RED PEA VARIETIES IN GUADELOUPE (1973)

Varieties	Growth	Seed size	Seed Colour	Trial A			Trial B	
				Rhizoctonia				
				leaf	pod	Yield	Powdery mildrew	Yield
(104) Calima	D	L	White, red stripes	3	0	100	3	220
(121) Carabobo	D	S	Red	3	0	206	0	154
(132) Honduras 18	I	S	Red	2	0	215	0	172
(94) Maluquinho 12449	I	I	Red	3	0	117	0	224
(92) Manteigac 977	D	L	Rose, red stripes	4	0	25	0	193
(112) Mil por um	I	I	Salmon	1	0	308	0	213
(53) Pompadour	D	L	White, red stripes	2.5	0	150	2	194
(164) 27 R	D	L	Rose	3	0	112	3	184
(150) Red Kote *(standard)*	D	L	Rose	3	0	123	3	144
(91) California kidney *(standard)*	D	L	Rose	3	0	116	1	88

D = Determinate I = Indeterminate L = Large
S = Small Yield = % of mean
Disease intensity: from 0 to 5

THE RESPONSE OF PLANTAINS TO MAGNESIUM FERTILIZERS IN PUERTO RICO

By

GEORGE SAMUELS; ERNESTO HERNÁNDEZ
and

SANTIAGO TORRES

Agronomist, director of department, and technical aid respectively, Agricultural Experiment Station, Univ. Puerto Rico, Rio Piedras.

INTRODUCTION

Plantains *(Musa paradisiaca)* are one of the principal starchy crops consumed in Puerto Rico. In 1961-62, the production was 191 million Plantains, and this increased to 240 millions in 1970-71 (2). The value of the crop has increased rapidly from $27.35 per thousand in 1961-62 to $65.00 per thousand in 1971-72. The increase in both production and farm price has placed the value of the plantain crop at $14 million for 1971-72 which represents 4.7% of the gross agricultural income.

A majority of the plantains are planted in the humid mountain regions in highly leached, acid, clay soils with low to moderate cation exchange capacities. Farmers have fertilized these soils heavily. A recent survey (2) indicates that farmers are using an average of 19 quintals/ha (21 cwt/A) of mixed NPK fertilizer for this crop usually at the rate of 340 gm (12 oz.) per plant with 2130 plants/ha (850/A). However, such high fertilizer rates do not always include magnesium. Previous work has shown that these humid mountain soils respond to magnesium for other crops

(4). Recent research findings have shown that plantains also respond to magnesium applications (1, 3,5). It is the purpose of this paper to report on an experiment on the response of plantains to various levels of magnesium fertilizer in the humid mountain soils of Puerto Rico.

MATERIALS AND METHODS

The magnesium fertilizer experiment was done at the Corozal Substation of University of Puerto Rico, Agricultural Experiment Station. The soil used was a Humatas clay (Ultisol), a red acid clay (pH5.1) with a cation exchange capacity of 10.5 m.e./100g. The plots consisted of 4 rows of plants 1.83 m. (6 ft.) apart in the row and also between rows giving 16 plants per plot of which 9 were harvested leaving 6 plants as buffer rows between plots for the various fertilizer treatments. The field was not ploughed prior to planting according to soil conservation practices in this region. Instead planting holes were made 31 x 31 x 31 cm (18 in.). Lime was not applied as pH values above 5 were not considered sufficiently acid to warrant liming for plantains.

There were 3MgO levels: O, 55, and 165 Kg/ha (O, 60 and 120 lbs/A) with 6 replications in a randomized block design. All treatments received 360 N, 180 P_2O_5, and 360 K_2O in Kg/ha (400-200-400 lbs/A) divided into 3 applications including MgO at planting, 4 mo., and at flowering. Growth measurements were taken at 7.5 months measuring from the soil level to the point on the trunk where the first fully expanded leaf emerged. Leaf samples were taken at 4, 8, and 11 months of age of the crop using the center 1/3 portion, without midrib, of the third expanded leaf.

The experiment was planted on March 30, 1971 and harvested from Feb. 22 to September 9, 1972. The experiment suffered from the very start from a lack of water due to an unseasonal drought. A few applications of water were applied by portable overhead irrigation to keep the crop growing.

RESULTS AND DISCUSSION

The results of the various magnesium treatments on plantain yields are given in table 1. The 165 kg/ha MgO treatment gave highly significant yields over the O and 55 kg/ha MgO treatments in number and total weight of plantains per hectare. The 55 kg/ha MgO level did not appear to supply sufficient magnesium. The deficiency of water due to the drought was reflected in the poor production obtained in the O and 55 kg/ha MgO treatments despite the high fertilizer level used. It appears that magnesium deficiency on the Humatas clay is increased by a water deficit.

Growth measurements reflected the responses to the magnesium applications (table 2). The 165 Kg/ha MgO treatment had a growth increase by 37 percent as compared to the O and 55 kg/ga treatments.

Leaf-Mg values reflected responses to magnesium application at 8 and 11 months of age samplings, but not at 4 months. The similar values at 4 months may have been due to the drought. Caro-Costas *et al* (1) reported leaf-Mg values of 0.38 percent at 7 months after planting for applications of 160 kg/ha (165 lbs/A) MgO on a Cialitos clay in an area similar and nearby this experiment.

Unfortunately, available soil-Mg values showed no differences for Mg-treatment levels with the O and 165 Kg/ha MgO treatments both having 100 ppm. Mg. The Ca: Mg ratio for the same treatments averaged 16:1 indicating low soil-Mg levels in relation to soil-Ca levels.

At present some growers in the humid mountain region are just beginning to use magnesium in their fertilizer mixtures usually at the rate of 3% MgO per ton. Even with the reported use (2) of 19 quintals/ha (21 cwt/A), the use of a 3% MgO mixture per ton of fertilizer would only supply 48 kg/ha (53 lbs/A) MgO. This amount does not appear to be sufficient to supply the magnesium needs of plantains on these soils. A recommendation of 165 kg/ha (180 lbs/A) MgO would require a plantain fertilizer formula to have a 10% MgO content. This could be done by using sulfate of potash-magnesia instead of muriate of potash as the potash source in mixing the fertilizer formulas such as 10-5-20 or 12-6-16 used for plantains. Of course the use of dolomitic limestone would be a very good source of magnesium, and it could be supplied in the liming program. Unfortunately dolomitic limestone is found in very limited quantities in Puerto Rico, and the small deposits have never been commercially exploited.

CONCLUSION

For the humid mountain soils of Puerto Rico, the use of 165 kg/ha (180lbs/A) MgO is recommended for correcting magnesium deficiencies in plantains. Leaf-Mg values of 0.35% Mg at 11 months are associated with high yields of plantains.

SUMMARY

An experiment of levels of magnesium fertilizer on plantains was conducted on a Humatas clay at the Corozal Substation in the humid mountain region of Puerto Rico. Yields of plantains were sharply increased by the application of 165 kg/ha (180 lbs/A) MgO as compared to O and 55 kg/ha (60 lbs/A) MgO. Leaf-Mg value of 0.35% at 11 months was associated with the highest yields of plantains. Soil-Mg values did not show any relationship to MgO applications. It was suggested that a 10% MgO per ton of mix fertilizer be used for fertilizing plantains inasmuch as no local commercial source of dolomitic lime is available.

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Table 1

THE INFLUENCE OF MAGNESIUM APPLICATION ON PLANTAIN PRODUCTION, COROZAL SUBSTATION 1971-72

MgO applied Kg/ha (lbs/A)1/	Number of plantains per ha. (acre)2/	Quintals of plantains per ha. (cwt/A)2/	Weight per plantain grams (lbs)
0	6,325 (2,530)	13.5 (15.4)	254 (0.56)
55 (60)	13,455 (5,382)	26.8 (30.4)	277 (0.61)
165 (120)	56,925 (22,770)**3/	123.9 (140.8)**	281 (0.62)

1/ Numbers in parenthesis refer to units indicated in parenthesis in the column heading.

2/ Based on 3025 trees per hectare or 1210 trees per acre.

3/ ** Significantly different than other treatments at the 1% level.

Table 2

LEVELS OF SOIL AND LEAF MAGNESIUM ASSOCIATE WITH VARIOUS MAGNESIUM FERTILIZER APPLICATIONS

MgO Kg/ha (lbs/A)	Plant height, Cm	Leaf-Mg values, % dry weight for months after planting of:			Soil-Mg ppm
		4	8	11	
0	67.5	0.29	0.12	0.24	100
55 (60)	68.6	.28	.12	.24	75
165 (180)	94.0	.29	.21	.35	100

YAM PLANTING DENSITY TRIALS IN GUADELOUPE

by

R. ARNOLIN, R. POITOUT and L. DEGRAS
Station d'Amelioration des Plantes
Centre de Recherches Agronomiques des Antilles-Guyane – I.N.R.A.

97170 = PETIT BOURG

SUMMARY

Planting density experiments with *Dioscorea trifida, Dioscorea alata* and *Dioscorea nummularia* cultivation raised yield by a 50% when going from 14,000 plants to three times more per hectare.

Significant gain in yield was not obtained when planting density was raised by 30 to 50% only. High density planting seems to be economical only with Cush-cush Yam.

INTRODUCTION

In the process of modernisation of West Indian cultivation practices, Yam planting is showing an important shift from "hole", "mound", or "hill" planting to ridge planting, occasionally set with mechanical aid. While for hill planting a number or seed pieces were gathered around a point, for ridge planting seed pieces are set down at regular intervals all along the ridge. Therefore, new trials are needed to ensure that plant distribution makes the best utilisation of the surface.

Moreover, as staking is now common in modern cultivation of great Yams *(Dioscorea alata)* and Cush-cush Yams *(D. trifida)*, and as weeding should be more difficult if continued during all the plant's growth, a rapid close up of the canopy is required.

So attention is now paid to planting density. Expecting higher yields with higher density, care must be taken also concerning the amount of tuber harvest used up by the level of planting material required. The problem arises in the case of *Dioscorea alata,* some *D. cayenensis* and D. *esculenta* where the planting material is a part of the commercial production. In most *D. cayenensis* and in *D. trifida,* seed pieces are either the special regrowth of the second harvest, the small tubers or even the undertuberized stoloniferous material which have no other uses.

MATERIALS AND METHODS

I. D. trifida

Two hybrids (see DEGRAS, 1969, DEGRAS et al. 1971), cultivars INRA 25 and INRA 31 were used in 1972 trials. These cultivars are now released in Guadeloupe and Martinique where extensive diffusion is developed.

Both trials were in latin square with the same four planting densities.

	D	C	B	A
Seed pieces/ha	14,000	21,000	28,000	42,000
Spacing (cm)	20 x 142	30 x 142	40 x 142	60 x 142

II. D. alata

The following cultivars were used for short trials (two replicates):
- cv PACALA from our Station, in Guadeloupe
- BARBADOS and ORIENTAL from Trinidad
- BELEP and LUPIAS from Lifu (Pacific Island)

Planting densities were the A, C and D level indicated above.

III. D. nummularia

A little trial with two replicates was done with the recently introduced pacific cultivar WAEL belonging to *D. nummularia* with A, C and D density levels.

RESULTS

Mean results can be seen in Table I

I. Due to soil heterogeneity and poor plot dimensions significant differences occur only between A and D densities for *D. trifida.*

For cv. INRA 25, the relationship between total weight and net (commercial) weight is shown in Figure I. The general relationships expressed through individual plots yield are the same as for the regression slope. But though not tested statistically, a higher production of commercial tubers could apparently be gained with lower densities.

II. The general trends are the same in spite of some fluctuation, due to the same soil and plot characteristics as above, enhanced by the limitation of few replicates.

III. Yield obtained may be seen in Table I.
(About *D. nummularia* see DEGRAS et al., 1971, 1972)

DISCUSSION AND CONCLUSION

In all cases, higher planting densities, in our trials, do not give a yield return in accordance with the increased amount of seed pieces. There is only a 50% more yield for a 300% increase in planting material.

But two specifications must be made.

Table 1

Yam Planting Density Trials In Guadeloupe

(a) Yield in Ton/ha

(b) Yield in % of D

CULTIVAR		A	B	C	D
INRA 25	a	23,2	18,4	19,3	16,2
	b	143	113	119	100
INRA 31	a	20,8	16,7	12,2	12,2
	b	170	137	100	100
BELEP	a	42,7	–	25,0	25,8
	b	165	–	97	100
PACALA	a	25,8	–	21,5	20,2
	b	128	–	106	100
BARBADOS	a	10,2	–	5,8	5,7
	b	179	–	102	100
LUPIAS	a	55,6	–	41,6	37,9
	b	147	–	110	100
ORIENTAL	a	16,3	–	18,7	10,0
	b	163	–	187	100
WAEL	a	23,9	–	21,0	18,0
	b	145	–	127	100
Means					
	a	27,3	–	20,6	18,0
b/a means		151,6	–	114,4	100
b/b means		155,0	–	119,2	100

First, the poor level of precision of our trials does not permit detailed affirmation on the absolute yield levels. We think however, that the general trends could be valuable for deeper investigation.

Secondly, as indicated above, the nature of the seed pieces must be considered.

In *D. alata* (and possibly *D. nummularia)* seed pieces represented a part of the commercial tubers. When considering the yield of BARBADOS for example it could not be admitted that heavy densities cut on its poor yield (under our normal conditions.) But even with LUPIAS, while the A density represents 6.4% of the expected yield, D. density is equal to 13% of the commercial harvest.

In *D. trifida* the case is different. Yields indicated in Table 1 are commercial harvest weight. For each cultivar, total harvest is higher by an amount equal or superior to the needed planting material. The data for cv INRA 25 (tons) is given in Table 2.

From this, it seems feasible to utilize higher levels of seed material in Cush-cush Yams without damage to the commercial harvest. It remains only tô estimate the higher cost of planting due to labour charges.

Table 2

Relationship between seed and harvest for *D. trifida*

	Tons/ha			
	D	C	B	A
Seed pieces (1)	4.2	2.8	2.1	1.4
Total harvest (2)	27.2	21.8	21.6	17.7
Commercial harvest (3)	23.2	18.4	18.1	16.2
(2) – (3)	4.0	3.4	3.5	1.5

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A SUMMARY OF PEANUT RESEARCH IN BARBADOS

by

L. H. SMITH
Agrometeorologist, Caribbean Meteorological Institute

and

H. WILLIAMS
Agricultural Research Officer, Ministry of Agriculture, Barbados

INTRODUCTION

The plant *Arachis hypogaea* is of great commercial importance in several tropical and subtropical areas of the world. It is the world's third most important oil seed after Soya beans and Cotton seed.

The fruit before it is processed is commonly referred to as ground nuts or peanuts. The processed product is almost exclusively referred to as peanuts. The peanut is marketed in both the natural (shelled and unshelled) form or in processed products such as peanut oil and peanut butter. The peanut and its products are of high nutritional value and are grown mainly for human consumption. The crop can be used for feeding livestock, and the highly flavoured 'Smithfield' hams were originally produced from pigs fattened on peanut cake.

In Barbados there were several attempts to introduce peanuts as a peasant crop. Unfortunately, the crops were never extensively or intensively cultivated in Barbados. This was a result of the local dominance of sugar production, and also of the minor role to which peasant crop cultivation had been relegated. The reports of the

Agricultural Department suggest that peanuts were being cultivated in Barbados before the 1940's.

Attempts at improvement of this in the early 1940's was limited solely to the importation of varieties from the Unites States, South Africa and West Africa. The main characteristics for which the nuts were to be selected were yields and earliness of fruiting (Short season crop). The Agricultural reports of the Department of Agriculture in Barbados do not indicate which varieties were the most successful and important.

Further, it is not possible to determine how extensively the peanut trials were carried out, or what was the final disposition of the seed.

In spite of this apparent early neglect, peanuts were continually grown on a small scale by some peasants, particularly in areas of St. Lucy, St. Peter and St. Philip.

The seed used for planting was kept from year to year and was of a variety which exhibited seed dormancy. Recently in Barbados this local variety has been the subject of controversy among agronomists and growers. Some agronomists claim that the local variety now being grown is a recently introduced Spanish variety of Mexican origin. Most growers however, claim that this local variety is a variety that has been cultivated by them for more than 20 years. It is not particularly easy to determine the origin of this local Barbados variety.

ECONOMIC IMPORTANCE

Peanuts are produced in many areas of the tropics and sub-tropics. India is by far the largest world producer, with a production of about 5.4 million tonnes (6 million tons) in 1965. The Americas, Brazil and the United States of America were the largest producers in 1965, producing more than 880,000 tonnes (980,000 tons) of peanuts. In the Caribbean the only significant producer is the Dominican Republic which had a 1965 production of about 45,000 tonnes (50,000 tons).

Barbados has been an importer of peanuts and peanut products. In 1966 Barbados was importing 1.8 Kg (4 lbs) of peanuts per person; this figure dropped to approximately 0.9 kg (2 lbs.) per person in 1967. The value of the crops imported in 1966 was $373,871 EC, while in 1968 the value of the imported crop was $197,018. Table 1 shows the quantities of nuts imported in 1966, 1967 and 1968, the value of the crops and the countries of origin.

* * *

Table I

Ground nut imports into Barbados 1966–68

Country of Origin	Kg Imported 1966	Kg Imported 1967	Kg Imported 1968	Value C.I.F. 1967	Value C.I.F. 1967	Value C.I.F. 1968
U.K.	32,806	5,073	–	51,595	7,830	–
Canada	5,804	8,618	21,682	20,339	17,679	19,152
St. Vincent	18,681	9,885	16,652	10,120	6,641	4 032
Trinidad	107	100	–	100	118	–
U.S.A.	465	73	600	1,397	76	448
Mexico	201,847	145,867	369,999	143,708	98,558	136,478
Turkey	87,547	56,602	–	65,879	21,381	–
Syria	6,045	3,904	25,319	4,737	2,727	8,681
Formosa	–	25,873	–	–	18,929	–
Egypt	10,971	–	–	75,024	–	–
Brazil	163	–	–	230	–	–
Israel	–	–	79,362	–	–	28,230
Totals	364,436	255,996	513,614	373,129	173,939	197,021

MARKET POTENTIAL

There is a good market for peanuts in Barbados and throughout the Carifta territories.

The average market requirements for unprocessed peanuts in Barbados during the period 1969–1972 was 104,420 kg (230,000 lbs) of nuts. The average Carifta requirements during the same period (1969–1972) were 1.04 million kg (2.3 million pounds) of nuts. In Barbados the import market for processed nuts was 50% of the fresh market imports.

We can therefore make the following projections for Carifta requirements for unprepared nuts.

1974 = 1.10 million kg (2.43 million pounds) of unprocessed nuts
1976 = 1.20 million kg (2.46 million pounds) of unprocessed nuts
1978 = 1.32 million kg (2.91 million pounds) of unprocessed nuts

The target demand in 1978 being 1.4 million kg (3 million pounds) of nuts. If we assume that the potential market for processed nuts is 50% of the fresh market we can assume a potential of about 0.7 million kg (1.4 million pounds) of processed peanuts products – mainly salted nuts and peanut butter.

It ought to be noted that should the demand for the processed nuts be under-estimated it will be possible to shift the fresh market quantities into the processed market. It is also safer to assume that a large quantity of the unprocessed nuts sold are roasted by the individual retailer.

A GENERAL CLASSIFICATION

The peanut *(Arachis hypogea)* belongs to a small genus of leguminous oil seeds. The plant is native of South America and was probably brought into the Caribbean by the South American Indians.

The crop is grown mainly in the tropics and subtropics. The plant is deep rooting and can be grown in the dry tropical areas with short wet seasons (3–4 months).

Professor S. W. Purseglove in "Tropical Crops", Volume I, gives a full botanical description of the Genus. This bulletin attempts only to assist farmers in being able to recognize some of the characteristics among the varieties now being grown by them.

There are several classifications of peanut varieties, the more detailed classifications of varieties are based on the growth habit, the pod size and shape, the kernel and colour characteristics. The commercial grower usually needs to identify two groups of peanut varieties; plants in each group may show some variations or modifications which identify the groups.

In the first varietal group of peanut plants, the inflorescences are observed to develop at the second and at most of the successive nodes of the first and subsequent branches. The flowering in this group of plants occurs at an early stage of development. As a result of the growth and flowering habits, these plants appear bunchy and fruits are produced near to the base of the main stem. There is no seed dormancy in this group of plants and the mature seeds are seen to develop shoots while immature seeds and flowers are still developing on the plant. The varieties which belong to this group usually mature in 3 – 4 months under local growing conditions. It is desirable to harvest these plants early and avoid excessive loss due to 'sprouting.'

It is reported that plants among these varieties are most susceptible to *Cercospora* leaf spot damage. Under local soil conditions the varieties in this group all tend to show yellowing. In general chlorosis and necrosis due to some plant nutritional imbalance are most pronounced among these varieties in Barbados.

In the second distinguishable group of peanut varieties, the flower inflorescences do not appear at as early a stage of plant growth as in the

Bunching type. The first main stem and first side branch do not bear flowers. There is a tendency for the development of alternate vegetative and reproductive branches. At the first two nodes vegetative growth occurs while at the following two nodes reproductive growth occurs. This pattern of two vegetative and two reproductive branches is repeated during the whole period of growth and development of the branch.

This development pattern results in a production of fruits over a widely dispersed area under the plant. The maturity of fruits is less uniform and the length of the growing season in Barbados is between 4 to 5½ months. The seeds in this group of varieties show dormancy and cannot be used as planting material immediately after the crop is harvested. A good timing of the harvest date is essential since the stages of seed maturity are more varied. The plants when growing in the field have a flat 'running' appearance and cover the ground surface more completely than the Bunch type varieties.

* * *

PEANUT VARIETIES AND SPACING TRAILS IN BARBADOS

PLANT SPACING

In these Variety Trials, plants were spaced in rows of 30 cm (1 foot) apart in beds 150 cm (5ft) wide, and with 45 cm (1½ ft) between each 150 cm (5 ft) bed. In the Runner type varieties there were 4 rows per bed while in the Bunchy type varieties there were 5 rows per bed. For the various varieties an analysis of plant yields as a function of the number of plants in a 0.9 sq. metre (10 sq. ft) plot, showed there was no difference in the yield of nuts per plant in the various replicates, at several locations around the Island. We can therefore assume that the yields obtained in the variety trials were a good indication of how the plants might be expected to perform under commercial cultivation. (Ref. Page 9). We could also conclude that rows 30 cm (1 foot) apart would not be too close for planting the crop.

Virginia Florigiant

This variety is a Virginia Runner type peanut in which some of the side branches are erect. This growth habit gives the plants in the field a somewhat bunched appearance. The pods and kernels are large, there are usually 2 kernels per pod. The size and yield of nuts have made this the most preferred of the newly imported varieties grown by local farmers. In experiments on various soil types an average yield of 4256 kg/ha (3800 lbs per acre) of incompletely dried nuts (2 days sun-drying 28 – 31°C (82 – 88°F) were obtained. The seeds of this variety exhibit dormancy after harvest. When the dormancy period is broken germination rates of about 80% can be obtained. This high rate of germination under local climatic conditions decreases to a very low value in about 3 – 4 months. The seeds on drying tend to lose their testa quite easily, as a result there is a high frequency of split kernels. This crop matures in about 4 to 4½ months. The seeds of this variety were obtained from Atlanta, Georgia.

Early Runner

This is another variety produced by the Goldkist Seed Company. The plants of the variety tend to cover the ground more closely than the Virginia Florigiant. There are a large number of pods per plant and the yields obtained under local conditions were as good as with the Florigiant. The Early Runner seemed easier to harvest on the black soils than most of the other Runner type which were tried. Yields of 3500 kg/ha (35000 lbs per acre) of incompletely dried nuts (2 days sun-drying) were obtained under local soil conditions. The pods and kernels are smaller than the Florigiant. This variety does not lose its seed coat as readily as the Florigiant and matures 2 to 3 weeks earlier (i.e. 4 months).

Virginia Bunch 67

This variety was tried in Barbados only on the black soil types (verti-sols). The plant is a Bunch type which gave yields as good as the Early Runner. The pods and kernels are similar in size to the Early Runner and the crop is equally as easy to harvest under similar field conditions. This variety is more susceptible to diseases than the Florigiant and Early Runner in the United States and these two varieties are apparently now perferred in Georgia. During the period of trial there were no serious disease problems in any of the varieties.

The NC-2 and NC-5

These two varieties have been tried in large plots (1/5 ha (½ acre)) mainly on the black soil types (vertisols) of Barbados. The growth habit of these two varieties is somewhat like the Florigiant, and the pods and seeds are similar in size. The yields on most soils were about 3900 kg/ha (3,500 lbs per acre) of imcompletely dried nuts. These seed varieties do not lose their testa as easily as the Florigiant. These varieties have been grown only on one particular farm in the vertisol area.

Starr

The Starr variety is reportedly a high yielding oil nut. In small experimental plots (27 sq metre (300 sq. ft.)) on the verti-sol these plants showed marked lime induced chlorosis and about 5% of the plants died before harvest. The yields seldom exceeded 1700 kg/ha (1500 lbs per acre) of dried nuts. The pods and kernels are small and the variety was not tried in larger commercial plots.

Argentine and Surinam

Bunch type peanuts were tried under similar conditions as the Starr variety. Both of these varieties showed chlorotic yellowing and in the Surinam variety 20 – 30% of the plants died before maturity. In the Surinam variety mature plants seldom had more than 4 or 6 mature nuts per plant.

Tennesse Red

This Spanish type peanut grows in a bunch. The variety was tried under all the various soil conditions along with the Florigiant. This variety when properly spaced (close) yielded 4300 kg/ha (3,800 lbs per acre) (2 days sun-drying). The pods are as long as the Florigiant but usually not as large. The pod average 3 kernels per pod as compared with 2 kernels in the pods of the other small seeded varieties. Among the Bunch type peanuts this variety showed a lesser tendency to suffer chlorosis. The nut has a dark red seed coat which does not break easily. The variety is probably the best peanut for eating as it has a very good flavour. The seeds do not exhibit dormancy and the mature seeds tend to germinate if the crop is not harvested at an early period 3½ to 4 months.

'Local Peanut'

A local variety obtained from the parishes of St. Lucy and St. Philip (where it is reported that the variety has been grown for several years) was planted in large plot trials. The plants of this variety cover the ground rapidly and there is no tendency to be chlorotic. At locations where all varieties showed some chlorosis this variety remained dark green. The plants matured at about 4½ – 5 months and bore several (13) large mature pods per plant. The yields averaged 2,000 kg/ha (1,800 lbs/acre) dried nuts. In this variety the pods had a high frequency, of 3 kernels per pod.

The long growing season which this variety requires if high yields are to be obtained, has made it less suitable for most of the large growers.

Florirunner

This variety has been recently introduced into Barbados. Yield potential and growth characteristics will be examined before this peanut is released for local commercial production.

VARIETY CHARACTERISTICS

The seed size is an important characteristic for the local retail market. It is also important for farmers to have some idea of seed size so that good planting rates can be achieved, and adequate orders for seeds placed. The varieties are placed in an order which indicates an increasing seed size.

Table 2

Peanut varieties ranked by seed size

Argentine	–	Small 2750 seed per Kg (1250/lb)
Starr	–	↓
Tennesse Red		↓
Early Runner		↓
Virginia Bunch	–	Medium 1750 seed per Kg (800 /lb)
NC–2		↓
NC–5		↓
Florigiant	–	Large 1200 seed per Kg (550 /lb)
'Local Barbados'	–	Large 1200 seed per Kg (550 /lb)

SOIL (PHYSICAL ASPECTS)

A good soil on which to produce peanuts should be a soil with good and stable physical structure. These types of soils will facilitate cultivation and allow good seed bed preparation. In peanut production it is desirable to have a good and uniformly prepared seed bed to ensure maximum and uniform seed germination.

In preparing a field for peanut growing, it is usual to rotivate the field after ploughing. The field should also be raked and rolled. Often it is not possible to have the field rolled after raking. When rolling is not possible the field may be allowed to stand and 'dry out' so that the larger soil clods will crack and break into smaller aggregates.

For peanut production one should avoid soils that are too heavy (high in montmorillontic clay). One should also try to avoid any soil compaction during preparation. The penetration of the flowers 'pegs' into the soil is reduced on heavy or compacted soils. This reduced 'pegging' results in the reduced yields of nuts. Since 'pegs' penetration is important, it is usual to recommend peanut production on soils with a sandy texture or good stable structure as is found in soils with high kaolinitic clay content.

In Barbados experiments have shown that the structure of the Red and Red-yellow soils in St. John (60 series) gave the best yields of peanuts, and were better suited to peanut harvesting than the Red sandy clays of St. James (48, 49 series). The Alluvial sandy soils of St. Andrew were also found to be well suited to peanut production.

The darker soils (30 and 40 series) of St. Philip, St. Lucy and Christ Church were much more variable in structure. On some of these soils the penetration of the flower pedicel was not affected and yields were high at several experimental plots on these soil types. Unfortunately, these soils tend to retain moisture for long periods of time after precipitation, as a result harvesting either by forking or using the mechanical digger shaker equipment is extremely difficult. The major difficulty being the stickiness of the soil, which allows the formation of large 'clumps' which do not easily shatter and which tend to strip the nuts from the plants and bury them under the clumps. The large clumps of soil often cause some damage to the mechanical 'digger shaker' equipment.

On these soils harvesting would have .o be carefully planned and timed to the suitable soil moisture conditions if a high loss of nuts and damage to the equipment are to be avoided. It has been observed during experiments that by harvesting the crop at the right stage of maturity, some of the loss of nuts due to poor soil conditions can be avoided.

SOIL (CHEMICAL ASPECTS)

On some of the soils of the 40 series (St. Lucy, St. Philip, Christ Church) symptoms of yellowing have been observed in some fields. This yellowing and necrosis occur in small patches in the field and is more conspicuous in some varieties than in others. The Bunching types of peanuts seem to be more affected by yellowing than the Runner type varieties. It was first believed that this problem was due to Iron or Boron deficiency in the plant. Research on this micro-nutrient deficiency problem failed to identify any particular nutrient. It should be realized that it could alternatively be a toxicity problem in the crop. Beans and Alfalfa growing on some of these soils have also shown somewhat similar symptoms of yellowing and necrosis.

FERTILIZERS AND PEANUTS

Fertilizer experiments were conducted on all the major soil groups. The data showed that there was a varietal difference in crop response to the fertilizers.

At all the locations the Tennesse Red peanut variety responded to potash applications of up to 67 kg K_2O per hectare (60 lb/acre) and phosphate of 90 kg P_2O per hectare (80 lb/acre). The only other variety responding to fertilizer was the Florigiant which gave a response to potash on the 'Red Sands' and Sandy Alluvial soils. These soils are inherently low in potash.

The general conclusion from the experiments was that the Tennesse Red was likely to respond to either potash or phosphate and that the quantities required for this crop were not high (112 kg of sulphate, or muriate or potash per hectare (100 lb/acre)).

The ground nut because of its deep rooting habit is able to exploit the deeper horizons of the soil for available nutrients and water. It is likely that a low 'booster' quantity of fertilizer before seeding may encourage early rapid root development.

The common practice in Barbados is to grow peanuts in fields which have previously grown cane. The sugar cane crop is regularly fertilized with potash and ammonium sulphate; as a result it would not be normally necessary to fertilize peanuts being grown in a succession to cane. However, if the peanuts are being grown in a field which has not been recently cultivated, then about 250–380 kg/ha (2–3 cwt/acre) of a complete fertilizer mixture should be useful. Peanuts grown on the black (verti-sols) soils of the island show varying degrees of chlorosis depending on the variety and apparently fine moisture conditions. Experiments which involved the application of complete micro-nutrient sprays were inconclusive as to the cause of this chlorosis. There is futher need for this minor element problem in crops to be resolved since some of the other vegetable crops and Alfalfa showed similar symptoms. In experiments seeds were coated with micro-nutrients before planting, however, no significant yield differences were observed between the various treatments. There was evidence that plant chlorosis was not prevented by the micro-nutrient treatments. It is believed that the peanut chlorosis observed is closely related to the presence of soluble carbonates and soil moisture stress.

Peanut seeds were treated with *Rhizobium spp.* culture. The culture for this crop was obtained from the Nitrogen Company in the U.S.A. Nodules were observed on all the plants examined. However, there was no difference between the yields of inoculated and non-inoculated plots.

IRRIGATION

Peanuts have been grown at the Central Agronomic Research Station during the dry season by employing irrigation. The crop was irrigated about once in every eight to ten days. The amount of water applied was enough to completely wet the soil to a depth of about 22 cm (9 inches). So far no research has been carried out on the water requirements of this crop under local climatic conditions.

The crop under irrigation did not appear to be seriously affected by leaf spot diseases *(Cercospora)*. However, the rust *(Puccinia)*appeared to be a little more frequent although not a serious problem.

SEED TREATMENT

At present nearly all the seeds used for planting are imported from commercial seed suppliers in the United States. The majority of these suppliers treat their seeds with fungicides and insecticides as a standard practice.

The Tennesse Red and 'local' variety are not usually treated when they are made available to the growers. The growers should in all cases treat these seeds with both a fungicide and insecticide before planting. Under local conditions untreated seeds are usually attacked by soil borne insects and fungi. Experiments carried out have shown that the untreated seeds may only give 30 to 40 percent of the germination of treated seeds. The major cause of this reduced germination was fungal attacks *(Aspergillus)* on the seeds before the embryo fully develops. There was also some damage due to ants and other insects.

Seed treatments with Ceresan, Captan and Sevin at recommended rates 3.75 g/kg (6 oz/100 lb) should therefore be carried out. Seeds must be treated with a fungicide and an insectide especially if the conditions are fairly dry and germination is expected to be delayed for any length of time.

SPACING

There is no standard field spacing for the crop in Barbados. The average spacing being used by farmers consists of 4 rows in a 1.8 metre (72 inch) wide bed with the seeds dropped at 10–15 cm (4 or 6 inches) in the row. The experiments in the Ministry have shown that having 5 rows in this bed gave higher yields per hectare. The yield per plant at the higher density per bed was the same as at the wider row spacing.

Apparently, the main limitation of altering the crop spacing is the type of planting equipment available. The farmer must however select the row spacing which is convenient for his inter-row cultivation and harvesting. Fields which will be cultivated by hand labour can easily adopt the closer seed spacing. It usually requires between 70 and 130 kg of shelled seeds per hectare (60–120 lb/acre); the seed size and row spacing being the two factors which account for this great difference in the required quantities. The manual which comes with the planting equipment will usually give information on the seeds required for various plant spacings and seed drop rates. The planting of unshelled seeds have never been widely practised in Barbados.

LAND PREPARATION

The field before planting should be ploughed, rotavated and raked. The old cane stumps if present, should be removed from the field, as these will interfere with the seeding equipment. Farmers on the verti-sols (dark colour soils) may find it useful to roll the field before planting. If fertilizers are to be applied these may be applied before rotavating or rolling. A good seed bed should be prepared before planting. After seeding and before emergence a pre-emergence weedicide should be applied over the whole area.

WEED CONTROL

The yields of peanuts are greatly reduced if adequate weed control is not achieved. Weeding the field when the crop is already well established may cause damage to the developing 'pegs', this practice should be avoided as far as possible. It is essential to use a good pre-emergence weedicide just after planting if this after cultivation is to be reduced to a minimum. Some pre-emergence weedicides can be applied as late as the soil 'cracking' stage, which usually occurs about 5–7 days after planting.

Several weedicides have been tested for peanuts under local growing conditions. The effectiveness of all the weedicides was greatly influenced by the soil moisture conditions. All weedicides were more effective if the soil was moist at the time of spraying or if the soil was wetted within the few hours after spraying.

During 1969 to 1971 'Amiben' gave the best control of a wide range of weeds. Other commercial products such as 'Alanap' and 'Dynap' gave fairly good control at some locations.

In the St. Philip area where nut grass *(Cyperus rotundus)* is a serious major weed problem, all the chemicals tried were ineffective. Under these weed conditions 'Balan' (Benefin) (Vernam) (Vernolate) and mixtures of these chemicals with 'Dinitro' were tried in some fields. These mixtures were sprayed on the fields after ploughing and about one hour before the fields were rotavated. The sprays all failed to give good control of the nut grass at the different locations. The severe dry period which followed spraying may have been an important contributing factor to their ineffectiveness. There is a need locally for equipment which can do a more effective soil injection treatment with these various chemicals.

The product 'Premerge' (Dinitron) as a post emergence directed spray between the rows, gave some control of the weeds late in the growing season. The use of a 4 row inter-row cultivator between the nuts caused damage to the plants. The modification of the 4 row inter-row cultivator on to a two row bar was carried out by Mr. Henderson Williams of the Ministry of Agriculture. Trials with this "two row weeder" have been very successful in the young peanut crop at Graeme Hall. If weed competition late in the growing season is high, then it is usually more advantageous to hand weed the nuts, than to allow the weed growth to persist.

Research work on weedicides for peanuts is being carried out both in Barbados and in Jamaica. It is expected shortly that a wider range of chemicals will be recommended to our farmers.

DISEASES

The varieties now being grown in Barbados have not been selected for resistance to any particular disease or pest. It is likely that in future varietal selection programmes, consideration will have to be given to pests and diseases. These two factors do not at present limit yields of this crop in Barbados.

Seeds and pods which are improperly dried and kept in storage, or planted without a fungicide treatment, are likely to be attacked by soil borne molds *(Asperguillus spp).* These molds grow on the pods and testa giving the seeds a blueish grey appearance. These molds *(Asperguillus niger)* can also attack the germinating seedlings causing the wilting and death of the seedlings (Crown rot). Damage to seeds and seedlings have so far not been a serious production problem. Seeds for planting should be treated with a fungicide. It is possible to treat the seeds with a systemic fungicide (Benlate) to reduce mold attacks on the young seedlings.

The growing plants are likely to be attacked by one of the *Cercospora* leaf spot diseases. The disease is likely to occur if there are successive rainy or very humid days, and usually when the foliage is fairly dense. The spots may appear first as pale linear streaks, which become more yellow as they develop. The spots finally become dark brown and rounded when fully developed. Spraying should begin when the first streak appears on the leaves. Further research on the control of *Cercospora* leaf spot is presently being undertaken by the Pathology Unit of the Ministry of Agriculture.

The Pathology Unit of the Ministry of Agriculture has been conducting trials on the control of peanut rust *(Puccinia arachidis).* This disease is not locally a major problem of production, however, it seems to occur to some extent in all the growing areas of the Island. The rust appears on the leaf as a brown raised spot which when severe can cause leaf fall. Previously there were no standard recommended chemical control methods for this disease; it is likely that the new systematic and organic fungicides may provide some good control.

PESTS

The corn Earworm has so far caused the most damage to the peanut crop. This light green colour caterpillar (moth larval stage) feeds on the leaves, causing considerable leaf loss. These larvae may spend 14–21 days of their 30-day life cycle in this stage. This offers not only a good opportunity for considerable crop damage but also facilitates chemical control of the pest.

In addition, there are several other caterpillars which attack the peanut foliage. Frequent field inspection and prompt spraying can reduce the problems caused by these leaf eating pests.

The sucking insects Aphids and Thrips have not been, so far, significant pests of this crop. It seems likely that as the acreage increases, there will be a greater frequency and incidence of attacks by these and other pests.

TIME OF PLANTING

Rainfall is the factor which determines the time of planting of the crop. The crop has to be planted at such a time that rain and high soil moisture conditions late in the growing season do not hinder the timely harvest of the crop. Also the seeds must be planted when there is sufficient moisture available to allow the rapid germination of the seeds.

Seeds which were planted during a dry spell survived for six weeks, after which they germinated when the soil moisture conditions were adequate. Seeds which remain in the soil for long periods before germinating are likely to suffer temperature and insect damage in the soil. Under dry conditions seeds may survive better if planted at 5 cms (2 inches) depth in the soil, where the temperature is not as high as within the top 2.5 cms (inch) of the soil. However, if seeds are planted at this depth and heavy rainfall should follow planting, the seeds may be further covered over and as a result could suffer from inadequate aeration for germination.

Timing of planting should also allow for a fairly high soil moisture level during the first month of the growing cycle when the root system is not yet extensive.

PLANTING

The two Row American type 'Row Crop' planted has been used in most cases to plant the peanut crop. The 'Stanhay' precision planter was slightly modified and used to plant the smaller size seeds (Tennesse Red). These modifications were insufficient for this planter to plant the larger size seeds (Florigiant and Local variety).

The difficulty of using the planters presently available is that it is difficult to obtain a row spacing less than 30 cms (1 foot) between rows. However, if the closer 5 row per bed spacing is desired it would be necessary to plant part of the crop by hand.

The other major pests of peanuts in Barbados are Rodents. These cause considerable damage to peanuts in storage, eating both treated and untreated nuts.

SPRAYING

Many of the local farmers are aware of the effectiveness of insecticides and fungicides in controlling the various pests and diseases. Few farmers, however, seem to realize that the timeliness of applying a spray treatment will most often reduce the frequency or number of times this spray will have to be applied. Spraying a crop at the right time can help to reduce the cost of crop protection. Peanut growers should make frequent inspections of all their fields. They should pay particular attention to the new leaves for the appearance of disease spots or insect eggs. At the first sign of pest or disease the required spray treatment should be ascertained from the Agricultural Extension Service of the Ministry of Agriculture. Spraying should begin within 24 hours after the first sign of attack. Farmers should not wait until the Extension Officer comes to inspect the crop.

Farmers should not continue the spraying on a routine cycle basis, but should rather continue the field inspection cycle and spray only when a new attack seems likely. Although spraying on a routine cycle gives good assurance of freedom from attack, it can most often be unnecessary, costly and wasteful.

SPRAY CHEMICALS

The most common products used for the control of fungal diseases are the Copper and Zinc base fungicides. Common among these products are Ceresan, Captan, Cupravit and Zineb. Lately the organic non-copper product 'Antracol' is being used with a wide range of crops. 'Benlate' which is a systematic fungicide is probably the most widely used of all the locally available products. Although expensive, this product seems to give very good control for most fungal diseases of the vegetable crops being grown.

The large farms with tractor mounted equipment generally use DDT (Toxophene Metacystox) and Malathion to control the insects in their peanut crops. However, products such as Perfecthion and Foliothion have been used in the *Ultra Low* Volume (ULV) sprayers for the smaller and more widely separated plots. The ULV sprayers seem to be more effective than the other spraying equipment.

Fields have also been periodically sprayed with 'Lannate' or 'Rogor 90'. These chemicals are effective in the control of Thrips and Aphids. It is also likely that pods and seeds attacks by soil borne insects could be reduced by these systematic sprays.

HARVESTING

In the areas of the Red-yellow soils near Victoria, St. John, the Alluvial sandy soils in the flat areas of St. Andrew and the Red sandy clays of St. James and St. Peter, peanuts can be easily and completely harvested by the 'digger shaker' and peanut combine equipment.

In areas of the heavier verti-sols (Black soils), the stickiness and high water holding capacity of the soils do not allow the blocks to shatter or easily fall away from the pods. In order to overcome this difficulty, some farmers have partially lifted the vines from the ground using the blade of the 'digger shaker' equipment to undercut the plants. The plants are then finally pulled out of the soil by hand. Fewer nuts are lost in the soil if the hand lifting is completed as soon as possible after under-cutting the plants. The plants after being pulled out of the ground are wind-rowed and dried. There can be a high loss of nuts at this stage resulting from praedial larceny. After drying, the nuts can be picked by the combine as it moves along the 'Wind-row'.

Instead of wind-rowing, the plants could be placed to dry in 120 or 150 cm (4 or 5 ft) high stacks, so that the pods are exposed to the outside of the stacks. If this method of drying is used, it is better to have the nuts stacked on a frame which is raised about 30 cm (1 foot) above the surface of the ground. If such a frame is not provided, it is noticeable that plants in contact with, and near the soil surface, remain moist and encourage pests.

Precipitation which occurs during the wind-rowing or stacking phase, helps to clean the pods; seldom at this time of the year are showers persistent enough to interfere with drying. Stacked plants can be hand fed into the combine when dry. In this way the amount of extraneous matter from the field which gets into the combine is reduced.

In spite of the method used to dry the plants, it is essential that there is as little soil as possible adhering to the pods. Soil which collects in the conveyor system of the combine will eventually choke the system. This choking results in a great wastage of time during harvesting to clear and clean the equipment.

DRYING

The harvested peanuts can be further dried after removal from the vines. It is convenient and cheap to sun-dry the nuts in trays with wire mesh bottoms. These trays can be easily built by most farmers. Some farmers may prefer to dry their nuts on bags or tarpaulins placed on the ground in the open.

Raking the nuts during sun-drying helps to remove most of the adhering soil particles from the pods. If the nuts are on trays these particles easily fall through the mesh leaving the nuts comparatively free of foreign matter. Raking once a day is usually sufficient for cleaning the nuts. Proper drying of the nuts allows the seeds to develop a better flavour and eating quality. Peanuts will lose about 40% of their wet weight after the nuts have been properly dried.

Facilities are available which could be adapted for artificially drying peanuts. This method of drying needs carefully controlled conditions of temperature and humidity. Farmers should not attempt this method without some further technical help from the Ministry of Agriculture.

STORAGE

The major part of the crop is sold soon after harvest and few farmers have been faced with the problems of having to store their crop for any length of time. Peanuts are one of the few crops which can be stored under local climatic conditions. There is no necessity to create an artificial environment for storing the nuts. Farmers who find it necessary to store part of their harvest, must provide space that is well protected against Rodents. The unshelled peanuts can be stored on concrete floors or in bags in rooms which can be maintained rodent free. Few insects will attack well dried unshelled nuts, and seldom is an insecticide (usually Lindane) treatment necessary. The use of systematic insecticides (Lannate Rogor 90) during the growing cycle will reduce the number of nut pods which are insect attacked before harvest. Nuts which are to be kept in storage should have less than 11% moisture in the pods, if the keeping quality is to be maintained.

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STUDIES OF PANGOLA GRASS *(DIGITARIA DECUMBENS* STENT.) IN BARBADOS

EFFECT OF LEVEL OF NITROGEN FERTILIZATION AND FREQUENCY OF CUTTING ON THE YIELD, CHEMICAL COMPOSITION AND *IN VITRO* CELLULOSE DIGESTIBILITY

by

R. C. QUINTYNE
Animal Nutrition Unit, Ministry of Agriculture, Barbados West Indies

and

E. DONEFER
Animal Science Department, Macdonald College of McGill University P.Q. Canada

SUMMARY

The effect of 0,224, 448 and 896 KgN/ha and 4,6, and 8-week cutting frequencies on yield, chemical composition and *in vitro* cellulose digestibility of Pangola grass was studied in a 32-week experiment. Increasing cutting frequency and N level resulted in decrease in DM and increase in CP contents. Cellulose tended to increase, and ADL to decrease as cutting decreased. Increasing N had little effect on cellulose, ADF, ADL or NDF. Decreasing cutting and increasing N increased DM yield. Yield of DM/unit N and of CP increased while 24-hour IVCD decreased as cutting decreased. Yield of CP and 24-hour IVCD increased with increasing levels of N.

INTRODUCTION

Since its introduction in 1955, Pangola grass *(Digitaria decumbens,* Stent.) has become the major forage crop grown in Barbados. Because of the relative ease with which it is established, its adaptability to a wide range of soils, its vigorous growth and drought tolerance, Pangola has become very popular. It is, however, tolerant of low soil fertility, and a number of workers have reported excellent responses to nitrogen fertilization. (Hosaka and Godell 1954; Engibous *et al.* 1958; Little *et al.* 1959; Adeniyi and Wilson, 1960; Vincente-Chandler *et al.* 1961; Rivera-Brenes *et al.* Crowder *et al.* 1964; Bryan and Sharp, 1965; Kretschmer, 1965; Richards, 1965.) In general results suggest that response to nitrogen fertilization is linear up to 336 kg N/ha. (Oakes *et al.* 1959; Vincente-Chandler *et al.* 1961). Rivera-Brenes *et al.* (1954) reported a linear response up to 896 kg N/ha, and Pangola has been found to continue responding to increasing levels of nitrogen even up to 1,944 kg N/ha. (Rivera-Brenes, 1961; Salette, 1965.) However, as a rule, the efficiency of nitrogen utilization was reported to decrease with increasing rates of this element.

Although Pangola grass has been grown in Barbados for more than 15 years, no work has been done on its nutrient requirements. This paper reports the results of an experiment with this grass lasting 32 weeks at the Pine Animal Nutrition and Grassland Research Station. The experiment was designed to measure the effects of different cutting treatments and levels of nitrogen on the production, chemical composition and *in vitro* cellulose digestibility of Pangola grass.

MATERIALS AND METHODS

The Pine Animal Nutrition and Grassland Research Station which is in the South-Western part of the island, is about 45 metres above sea level, and enjoys "intermediate rainfall", an average annually of 1,186 m.m., with most of the rain falling from June to mid-January. The soil on the station is a Black Association Soil, (Vernon and Caroll, 1966) pH 7.3, with a high cation exchange capacity, although exchangeable potassium is low.

The experiment was laid down on a four-month old sward of grass which had already been cut back twice. It involved a 3x4 factorial design with each treatment replicated 4 times. The treatments studied were nitrogen in the form of Sulphate of Ammonia, at 0,224,448 and 896 kg. per hectare and cutting frequencies of 4,6 and 8 weeks. The gross plot size was 5.1 x 1.8 metres. Fertilizer was applied in water at the start of the experiment and after every cutting.

At harvest guard rows 0.46 metre were cut from the end of plots and a strip 0.92 metre wide between two guard-rows 0.46 metre wide was cut by motor scythe. The grass was collected and fresh weight was recorded. A sample of approximately 500 gm. was taken and dried in a Unitherm oven 95^{o} C for 24 hours for calculation of dry matter yield on a per hectare basis. Dried samples were milled and kept until completion of the experiment in the field, and then samples from each cutting at each N level were combined. Sub-samples were analysed for crude protein and ash (A.O.A.C., 1965), Neutraldetergent fibre (Van Soest and Wine, 1967), Acid-detergent fibre and Acid-detergent lignin (Van Soest, 1963) and cellulose (Crampton and Maynard 1938 as modified by Donefer *et al.* 1960). The *in vitro* cellulose digestibility of forage samples was determined after 24 hours using the method of Donefer *et al.* (1960).

The experiment was run for a 32-week period covering both a wet and a dry season. Between harvests, the experiment was irrigated, when necessary, to ensure that it had received 76.2 mm of water every 11 days.

RESULTS AND DISCUSSION

1. Effects of Treatments on Chemical Composition

(a) Frequency of Cutting

As the frequency of cutting increased, the mean Dry Matter (DM) content decreased (range 28.2% - 21.8%) and the mean crude protein (CP) content increased (range 7.4% - 12.3%) linearly. (Table 1) These trends are in agreement with those reported for Pangolagrass (Chicco, 1962. Butterworth, 1963- Grieve and Osborne, 1965, Vincente-Chandler *et al.* 1961). There was a tendency for the cellulose content to increase as cutting frequency decreased (31.2% to 33.1%). This agreed with the results reported by Gomide *et al.* (1969). Acid-detergent fibre, ADF showed a slight increase (36.9% to 38.0%) as cutting frequency decreased. This represents the ligno-cellulose content and therefore showed trends similar to cellulose. Acid-detergent lignin (ADL) on the other hand decreased (6.1% to 4.8%) as the interval between cuts increased. This decrease in ADL with age is contrary to all other reported work and is not understood. However, Neutral-detergent (NDF), representing the cell constituent was unaffected. Ash content decreased slightly as the cutting interval increased, in agreement with the results obtained by Gomide *et al.* (1966).

(b) Nitrogen Level

As would be expected, mean DM content decreased (25.4% to 23.3%) and mean CP content increased (8.7% to 11.9%) as nitrogen level increased. There was an exception however, at the 6-and-8-week frequencies when CP decreased as nitrogen was increased from 0 to 224 kg/ha. This decrease was probably due to a reduction in the leaf/stem ratio. The grass in the plots receiving 0 kg N was observed to have grown slower and to have less stem than grass in the 224 kg N plots.

Neither cellulose, ADF, ADL nor NDF was affected by increasing nitrogen levels. This result was in agreement with that reported by Gomide *et al.* (1969) and agrees with the report of Blaser (1964) that nitrogen fertilization does not generally alter the structural carbohydrates of forages. Similarly, the effect on ash content was slight and not consistent. (Table 1)

2. **Effect of treatments on Yield**

(a) Yield of Dry Matter

Both decreasing cutting frequency and increasing level of nitrogen fertilization had a highly significant ($P < .01$) positive effect on DM yield. (Table 2) This effect was also reported for Pangolagrass by Adeniyi and Wilson (1960) and Caro-Costa *et al.* (1965). Highest yield of 20, 190 kg/ha over the 32 week experimental period was obtained from the 8-week cutting frequency receiving 896 kg N/ha. per year. This is equivalent to 32,812 kg/ha in a 52-week period. The response to nitrogen was almost linear up to 896 kg N/ha when cut at the 4-and 6-week frequencies, while at the 8-week frequency it was linear up to 448 kg N/ha at which point the yield per additional unit of nitrogen decreased.

The yield of DM per unit of applied N increased as the cutting frequency decreased but tended to be highest at the 448 kg N level and lowest at the 896 kg N level. Although the effect of maturity reported here agreed with the results obtained by Vincente Chandler *et al.* (1961) the effect of increasing N differed in that these workers in Puerto Rico found a rapid decline in yield of DM per unit of applied N as the level of N fertilization increased. The mean for all treatments reported here was 150.0 kg/ha of applied N, which was less than that of 23.9 kg (range 1.3 to 69.6) reported by Vincente-Chandler *et al* (1961) and 21.8 kg (range 20-119) reported by Bryan and Sharpe (1965).

(b) Yield of Crude Protein

The mean yield of CP (Table 2) increased as the cutting frequency decreased. The highest yield of 1,828 kg CP was obtained in the 4-week frequency at 896 kg N per ha. On the other hand, the mean increase of protein yield as a function of increasing N fertilization was much more pronounced being 350.7, 597.0, 997.1 and 1,748 kg/ha at the 0,224, 448 and 896 kg N/ha levels respectively (i.e. 596.9, 970.0, 1745.3 and 2841.8 kg/ha per year)· Vincente-Chandler *et al* (1961) reported a similar trend, however, the yields obtained in this study are lower than those (865.8, 1878.2, 2688, 3173.0 kg/ha per year) reported by these workers.

The proportion of applied nitrogen recovered in the forage (Table 3) was found to increase with increasing rates of fertilizer nitrogen. These results do not agree with those published by Vincente-Chandler *et al* (1961) or by Bryan and Sharpe (1965), who both reported a decrease in nitrogen recovered as the fertilizer nitrogen increased, but they are in agreement with those reported by Whitney and Green (1969).

The effect of cutting frequency on the proportion of applied nitrogen recovered in the forage was inconsistent. The proportion recovered from the 8-week cutting treatment was highest while that from the 6-week frequency was lowest. Reports by other workers on this effect are conflicting. Bryan and Sharpe (1965) reported that the proportion of applied nitrogen recovered declined as the cutting frequency increased. Vincente-Chandler *et al* (1961) on the other hand found that the nitrogen recovered in the forage was not appreciably affected by the cutting interval.

3. Effect of treatments on *in vitro* cellulose digestibility.

The *in vitro* cellulose digestibility carried out in the Animal Science Department of Macdonald College was found to decrease as the frequency of cutting decreased. (Table 3). The results obtained here are in agreement with results published for temperate forages by Lloyd *et al* (1961) and Donefer and Mosi (1970) and for tropical forages, including Pangola, by Gomide *et al* (1969). These latter workers suggested that this decrease was probably due to the early lignification of tropical grasses as reported by French (1956). However, the effect of age on lignin content reported here does not agree with this suggestion: but it was noticeable that, as was the case with work done elsewhere, the early decline in IVCD occurred simultaneously with early increase in cellulose content of the grass. Increasing levels of nitrogen fertilization tended to increase the IVCD of the forage. However, when the grass was cut on an 8-week frequency there was a tendency for the IVCD to decrease with increments in N fertilization over 224 kg/ha. This trend agreed with the report, by Gomide *et al* (1969), that with more matured Pangolagrass, the IVCD decreased with increasing nitrogen fertilization. These workers did not study growth stages between 4 to 12 weeks, so the point at which fertilizer nitrogen began to have a depressing effect on IVCD was not known.

Table 1

The effect of nitrogen fertilization and frequency of cutting on the chemical composition (dry matter basis) of Pangola grass

Cutting Frequency	Level of N kgN/ha/yr.	DM	CP	Cellulose	ADF	ADL	NDF	ASH
		%	%	%	%	%	%	%
4 weeks	0	21.8	10.1	31.7	38.8	6.4	69.4	10.5
	224	23.1	10.8	30.6	37.1	5.5	67.7	10.7
	448	22.7	12.2	30.9	35.7	6.3	68.7	10.4
	896	19.6	16.1	31.4	35.8	6.0	69.9	10.5
	Mean	21.8	12.3	31.2	36.9	6.1	68.9	10.5
6 weeks	0	24.5	9.2	32.6	37.7	5.9	69.6	10.10
	224	25.5	8.5	32.3	36.0	5.4	68.1	9.4
	448	26.4	8.9	33.5	37.2	5.6	68.9	9.7
	896	23.3	11.5	33.6	37.5	5.1	68.3	9.5
	Mean	24.9	9.5	33.0	37.1	5.5	68.7	9.7
8 weeks	0	30.7	7.4	32.4	37.4	4.7	67.2	10.6
	224	30.7	6.9	32.8	37.6	4.9	68.4	9.9
	448	27.5	7.0	33.2	38.4	4.7	67.9	9.1
	896	24.0	8.1	33.9	38.7	4.8	69.0	9.1
	Mean	28.2	7.4	33.1	38.0	4.8	68.1	9.7

Table 2

The effect of nitrogen fertilization and frequency of cutting on the yield of dry matter and crude protein and efficiency of utilization of applied nitrogen over a 32-week period

Cutting Frequency	Level of N kgN/ha/hr	Yield of dry matter per hectare	Yield of crude protein per hectare	Recovery of N in forage	Dry matter produced per kg of each increment of N.
		kg	kg	%	kg
4 weeks	0	2,813 e	282.7	–	–
	224	5,098 de	551.0	31.1	10.2
	448	7,640 cd	935.1	37.9	10.8
	896	11,370 c	1,828.2	44.9	9.6
6 weeks	9	4,483 de	414.2	–	–
	224	6,799 d	508.6	11.0	10.3
	448	10,252 c	915.5	29.1	12.9
	896	15,526 ab	1,780.8	40.0	12.3
8 weeks	0	4,815 de	355.3	–	
	224	10,616 c	731.4	43.7	25.9
	448	16,367 ab	1,140.7	45.6	25.8
	896	20,190 a	1,637.4	37.2	17.2

a,b,c,.. Figures bearing the same superscript are not significantly different (P = 0.05) (Duncan's Multiple Range Test.)

Table 3

24–hr *in vitro* cellulose digestibility of Pangolagrass cut at three frequencies at different levels of nitrogen fertilization

Fertilizer level kg N/ha	24-hr. IVCD 4 weeks	6 weeks	8 weeks	Mean
0	49.1	47.0	48.9	48.3
224	53.1	52.0	51.2	52.1
448	56.3	52.8	51.0	53.4
896	60.4	55.6	50.4	55.5
Means	54.7	51.9	50.4	

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ATTEMPTS AT MECHANICAL HARVESTING OF ROOT CROPS IN BARBADOS

by

W. O'N. HARVEY

and

J. P. W. JEFFERS

SUMMARY

A locally constructed harvesting aid and an imported digger-elevator were used for harvesting Sweet Potatoes. The harvesting aid was also used in yams and work so far indicates a saving in harvesting costs of up to $48.00 per acre. So far, the mechanical diggers have not damaged more tubers than hand digging methods. Further work is planned.

ATTEMPTS AT MECHANICAL HARVESTING OF ROOT CROPS IN BARBADOS

Traditionally, harvesting of root crops in Barbados has been carried out by hand labour. In the case of potatoes one individual has been able to unearth the tuber using a normal garden fork. However, in the case of yams which go somewhat deeper, two individuals are often required. One of these digs and undermines the yam with the fork, while the other pulls on the vines and helps to lift the yam free from the soil. In either case the job is cumbersome, it requires tremendous physical effort, is very time consuming and is also labour intensive. Superimposed on these short comings is the rapidly increasing labour shortage with which agriculture is faced.

In an effort to offset some of the above difficulties investigations into partial mechanical harvesting methods have been made. To date a locally constructed harvesting aid and a power-operated elevator digger which was imported from England have been tried.

THE LOCALLY CONSTRUCTED HARVESTING AID

Background Information

The first harvesting aid was built in Bridgetown in October 1970 by Jim Suttie, Technical Engineer attached to the British Development Division, and shipped to St. Vincent for use in arrowroot. It consisted of a trailing V–blade (with separating rods at the rear.) which was welded to the points of two subsoiler units mounted on an MF 100 tool carrier. In St. Vincent it was used as a first stage implement for under-cutting and loosening the arrowroot. Here it did a satisfactory job until its use was superceded by the Johnson elevator digger which is currently being used. In St. Vincent, the subsoiler blade was also used with some measure of success for lifting bunch-type peanuts.

Following the work in St. Vincent, the Ministry of Agriculture in Barbados in November 1971, procured a Ramsomes C83 tool carrier, with two sub-soiler units, which was modified with the aim of assisting the land harvesting of yams.

The modifications consisted of placing the units 102 cm (40") apart, and joining them by a straight blade, 102 cm (40") x 20.3 cm (8") made of 1 cm (3/8") thick steel. On the trailing edge of blade five (5) 2.5 cm (1") diameter rods were welded 16.5 cm (6½") apart and protruding 38.1 (15") to assist in separation of soil from the tubers.

The blade was subsequently used in carrots, yams and sweet potatoes.

Harvesting of Carrots

With carrots the blade has worked well. The carrots were topped using a rotary slasher before using the blade for under cutting and loosening the tubers. It was later found however, that the carrots could be better handled and bundled with the tops intact. Topping prior to loosening was therefore abandoned.

Harvesting of Yams

The blade was first tried (in January 1972) in yams which had all the vines intact. Though some measure of success in undercutting and loosening was achieved, the whole operation was marred by constant fouling of the implement and tractor by the vines. This led to the decision to do a harvesting trial in yams which had the vines removed prior to digging. The vines were cut off manually leaving about 20.3 cm (8") to serve as a marker. In these vine-free yams lifting and loosening were satisfactory. However, separation of the soil and tubers on the separating rods at the back of the blade left much to be desired. The yams therefore tended to be reburied in soil after dropping on to the ground.

This year, in an effort to improve separation of the soil from the tubers, the five rigid 2.54 cm (1") diameter separating rods on the trailing edge of the blade were replaced by five lengths of old, flat car springs. The idea here was to introduce some degree of vibration as the yams and soil travelled over the springs and so achieve more efficient separation.

Where lifting was done in very dry, light soil, separation was definitely improved. However, where the soil was heavy and contained moisture, it tended to adhere to the flat surface of the springs. This resulted in a build up of soil on the front of the springs producing a bulldozing effect.

An interesting observation was that when used in yams, the originally straight blade gradually developed a gentle curve in its centre. When this first happened it was thought necessary to have a stronger blade, so the bent blade was replaced by another straight blade made of 1.27 cm (1") rather than 0.95 cm (3/8") thick steel. Like the first blade this second blade also bent in its centre. It was later found however that in yams the bent blade worked better than the straight blade.

Harvesting of Sweet Potatoes

As far as sweet potatoes are concerned, the story was much the same as that for yams. One noticeable difference however was the relative ease with which the blade undermined and lifted the potatoes. This could probably be attributed to the shallower depth of rooting of the crop. With potatoes separation of the soil from the tubers remained a major problem.

The Johnson Elevator Digger

In October of last year, in an effort to get around the soil separation problem, it was decided to purchase a Johnson elevator digger for use in yams in January of this year. The implement however did not arrive in the island until late March, by which time no yams were available for harvesting trials. So far therefore it has only been used in sweet potatoes.

The implement is a power-operated digger similar to that used in arrowroot in St. Vincent. It carries an undercutting blade and shaker chains that elevate the tubers and sift out most of the soil, dropping the tubers and remaining debris (i.e. vines, clods, occasional stones etc.) from the rear of the conveyor on to the ground. The tubers are then picked up by hand and bagged. The cutting blade is operated just below the tuber zone and delivers the tubers on to the rod-chain type conveyor. The elevator chain is agitated by oval-shaped idler sprockets.

The machine was originally tried in potatoes which had all the top growth intact. The longer vines however tended to choke the elevator, so that manual slashing of the vines prior to digging and lifting the tubers had to be done. Some 450 kilos (1000 lbs.) of potatoes were dug with the machine in less than half an hour. Separation of soil from the tubers was very good as the soil moisture content was minimal at the time. The undermining and lifting of the tubers by the machine was also very good. A check behind the machine revealed that less than five per cent of the tubers were left in the ground.

Mechanical damage of the tubers has been estimated to be in the region of four to six per cent. Most of this damage has been due to cutting of some of the tubers by the pair of coulton disks at the front of the implement. However complete removal of the disks, along with the use of narrower ridges for planting, should lead to less incidence of tuber damage.

CONCLUSION

So far no statistically tested trials have been carried out using either the subsoiler blade or the Johnson elevator digger. However, preliminary work in yams with the blade indicates a saving of three cents/hole, in comparison to hand digger and loosening. With yams planted on ridges 168 cm (5ft. 6") wide, and spaced at 152 cms (5ft.) within the row, this represents a saving of approximately $48.00 per acre.

Effective mechanical digging and lifting of yams and sweet potatoes can only be achieved if the vegetative growth of the crops is removed prior to digging.

Mechanical harvesting of yams and sweet potatoes could be better handled with the existing machinery, if pure stands of the crops were planted on considerably smaller ridges than the 168 cm (5ft. 6") ridges presently in use.

Pure stands of the crops are also essential as neither the subsoiler blade nor the Johnson elevator digger works well in a mixed stand.

FURTHER WORK

Further work with both the blade and the Johnson digger has been planned for next year's crop.

A SOLAR CROP AND SEED DRIER

by

OLIVER St.C. HEADLEY

and

BASIL G. F. SPRINGER
The University of the West Indies
St. Augustine, Trinidad.

SUMMARY

A new type of solar crop and seed drier is described. The design is derived from an integrated solar crop drier and features temperature control over the range 35 – 80°C. Bodi beans (*Vigna* sp.) dried in this unit have shown excellent germination rates.

INTRODUCTION

The authors described, in (1), an integrated solar crop drier with the following advantages:

(i) ease of construction;

(ii) ease of transport;

(iii) no maintenance;

(iv) no moving parts (e.g. pumps etc.);

(v) protection of the crop from weather;

(vi) increased drying rates.

This type of drier is therefore very suitable for use by farmers especially in remote parts of tropical and semi-tropical areas, as there are no power requirements and skilled maintenance is unnecessary. Cost will depend on the materials and method of construction.

The design of the integrated crop drier positions the three main components, collector, drying cabinet and dehumidifier, so as to permit a natural convection flow within a closed system. The unit is a parallelepiped which is sloped during operation. The whole upper surface is a double glazed collector which feeds hot air into the drying cabinet through vanes in its roof. An air tunnel separates the lower half of the collector from the dehumidifier whose upper surface is of glass.

Under high intensity conditions, operating temperatures were in the vicinity of 80°C – 100°C. Although these temperatures are desirable for crop drying they are above the critical 40° – 50°C range required for seed drying.

When the authors were approached to design a seed drier, the integrated crop drier was studied in an attempt to modify it and to control the maximum temperatures within the range required for seed drying.

A new design

Since high temperatures are not required, double glazing was dispensed with, the ratio of drying cabinet volume to collector area was increased and the total volume below the vanes of the parallelepiped is therefore used for drying material, which is contained in perforated trays.

The collector is a series of overlapping vanes (see Figure 1) arranged such that hot air is induced to flow from the heated space between the glass cover and the vanes to the drying cabinet. In operation the unit is tilted to an angle of $10^0 - 15^0$ and its lower and upper walls are variable aperture doors. Ambient air enters the unit through the bottom door and is heated by passage over and through the vanes. It then enters the drying cabinet where it removes moisture from the crop and is finally exhausted through the upper door. Dehumidification is therefore by natural convection, but since the system is open a separate dehumidifier is unnecessary.

The maximum temperature obtained in the air stream depends on the apertures of the doors. At maximum apertures internal temperatures are between 35°C and 40°C with ambient temperatures of about 30°C. As the apertures are decreased the *(internal)* temperatures increase to a maximum of 85°C with the doors completely closed. The unit then behaves as a simple solar drier and the glass cover acts as a dehumidifier as in solar still (2). A distillate drain is therefore provided at the lower edge of the glass cover for use during this mode of operation.

In a closed system with a double glazed cover a separate dehumidifier must be provided. If the above unit is to be operated as a dual purpose crop and seed drier the cover must be singly glazed.

Performance

This dual purpose drier has so far been used mainly as a seed drier. The seed pods of many legumes are left on the plant after the seeds have matured to be dried by the sun for use as planting material. This however, is undesirable during the rainy season since the seeds tend to germinate in the pods. Under these conditions fully matured pods can be harvested and dried in the seed drier. Bodi bean (*Vigna* sp.) pods were harvested and treated as described above. The apertures of the doors were set so that the internal temperature did not exceed 45°C under bright sunlight conditions (5000 Kcals $m^{-2} d^{-1}$). The seeds dried over a period of two days and excellent germination rates were obtained.

CONCLUSION

The integrated solar crop drier is more efficient than the dual purpose drier for crop drying. However, it is more expensive to build than the dual purpose drier and it cannot be used for drying seed for planting material.

The dual purpose crop and seed drier, while not having the ultimate crop drying performance of the integrated solar crop drier, is cheaper and more versatile.

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THE ANALYSIS OF AN ARRANGEMENT DESIGNED FOR LIMITED RESOURCES

by

F. B. LAUCKNER+

and

B. G. F. SPRINGER

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

SUMMARY

A modified composite design is described. This design has been specially developed for experimentation under conditions found in the Caribbean. An example of the analysis of such a design is shown.

INTRODUCTION

In many experiments in the Commonwealth Caribbean, the experimenter operates under limited resources with regard to land and finance available. Yet the nature of the problems to be solved require consideration of a number of factors over a wide range of levels for these factors. One type of design suited to this sort of problem is a composite design which is a full or fractional replicate of a factorial system with additional treatment combinations within and outside the treatment range chosen for the factorial system. A discussion on composite designs can be found in Cochran & Cox (1966). These designs suffer from the drawback that the treatment combinations outside the factorial system are fixed by

+Seconded on technical assistance by the United Kingdom Overseas Development Administration.

the choice of combinations within the system. Also some of these outer treatment combinations may not be of immediate interest to the experimenter. As an illustration figure 1 represents one replicate of a central composite design in three factors.

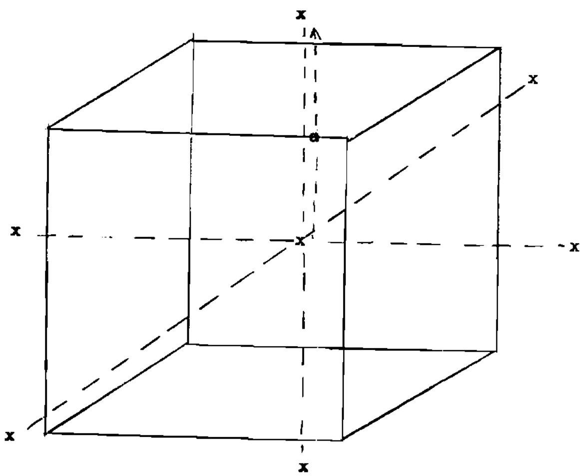

Figure 1

The design consists of eight points at the corners of the cube (as in a 2^3 factorial) plus an additional point at the centre of the cube and six further points each distant a from the centre at the end of lines drawn perpendicular to the six faces. This distance a is determined by the size of the cube. Now the experimenter may well wish to consider points further away than a from the centre of the cube; further he is likely to have chosen his lower levels of the three factors in the 2^3 such that he is not interested in experimenting at levels still lower. Thus three of the points outside the face of the cube in Figure 1 are not likely to produce results of interest.

MODIFIED COMPOSITE DESIGN

To overcome these difficulties Springer (1972) suggested a modified version of the above design. The modified composite design is shown in Figure 2.

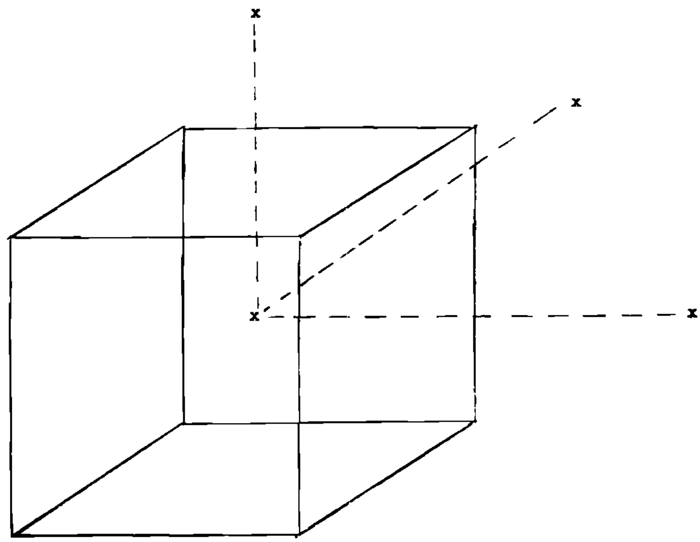

Figure 2

Here we have eight points of the 2^3 factorial as before, but in addition, this time we have four observations at the centre and two observations at three points on the outside of the cube. These three points are at a distance from the centre determined by the experimenter and are chosen, at points along the perpendicular to the faces, which are likely to be of interest. The three points outside the other faces are discarded as being of little or no interest. We regard the treatment levels at the corners of the cube as levels 0 and 2, the level at the centre level 1, and the peripheral treatment levels as level 3. Springer (1972) suggested that in an experiment to investigate the response of a crop to three nutrient levels, level 0 should be such as to permit some growth of the crop under investigation, level 2 should be the experimenters guess at the optimum level of the factors, level 1 is the mean of levels 0 and 2 and level 3 should be chosen not too close to level 2, but not so far away as to induce a toxic effect.

ANALYSIS OF A MODIFIED COMPOSITE DESIGN

The data in Table 1 refer to a modified composite design analysed at U.W.I. St. Augustine. The experiment was to investigate the effect of

Nitrogen (N), Phosphorous (P) and Potassium (K) on the yield of corn. The treatment code levels are as described above. The eighteen points of the modified composite design were split into two sets or fractions and there were two replicates of each making four blocks in all.

The analysis of this experiment is shown in Table 3. The blocks sum of squares is found from the four block totals and the grand total.

These are shown in table 1.

$$\text{Blocks sum of squares} = \frac{9328^2 + 10128^2 + 9897^2 + 10903^2}{9} - \frac{40256^2}{36}$$

We next consider the main effects and interactions of N, P and K over levels 0 and 2. Over these levels, the NPK interaction is completely confounded with blocks so this does not appear in the table. These main effects and interactions are calculated in the usual way for a 2^3 factorial, but we consider only the four treatments at levels 0 and 2 in each block. To calculate the relevant sums of squares we refer to table 2 and the treatment totals in Table 1. We find the factorial effect totals by adding or subtracting the successive treatment totals according to table 2. Then we square the factorial effect total and divide by 16 to find the sum of squares. For example the sum of squares for N is given by

$$1/_{16}[-1029 + 205 - 863 + 2552 - 749 + 576 - 1037 + 3233]^2$$

We can define four orthogonal contrasts associated with the treatments at the centre and outside the cube. We attempt to define contrasts which are likely to be most useful for the analysis. These contrasts must be orthogonal to each other as well as to the main effects and interactions already computed. In this example only three contrasts were calculated, the remaining contrast was not of interest.

Table 1

Results of modified composite design to investigate effects of nutrients on yield of corn

Treatment Code			Yield (Kilos/Acre)		
N	P	K	Rep 1	Rep 2	Total (Rep 1 + Rep 2)
0	0	0	843	186	1029
0	2	2	635	402	1037
2	0	2	217	359	576
2	2	0	1302	1250	2552
3	1	1	1839	2286	4125
1	3	1	1508	1089	2597
1	1	3	1315	1836	3151
1	1	1	403	1425	1828
1	1	1	1266	1295	2561
Block totals			9328	10128	
2	0	0	106	99	205
0	2	0	681	182	863
0	0	2	134	615	749
2	2	2	1677	1556	3233
3	1	1	2044	1894	3938
1	3	1	912	1833	2745
1	1	3	1834	1519	3353
1	1	1	1696	1801	3497
1	1	1	813	1404	2217
Block totals			9897	10903	

Grand total = 40256

The curvature effect compares the centre cube treatment (1, 1, 1) with the treatments in the 2^3 factorial to see whether the N, P, K relationship is linear with the cube. It is calculated from the 2^3 factorial treatment totals and the total of all replicates at the cube which is 10103 kilos per acre. The computation is:

$$\text{Curvature sum of squares} = \frac{(1029 + 205 + 863 + 2552 + 749 + 576 + 1037 + 3233 - 2 \times 10103)^2}{48}$$

Table 2

Main effect and interactions of N, P and K expressed in terms of individual treatment totals over levels 0 and 2

Factorial Effect	Treatment Combination							
	(0,0,0)	(2,0,0)	(0,2,0)	(2,2,0)	(0,0,2)	(2,0,2)	(0,2,2)	(2,2,2)
N	–	+	–	+	–	+	–	+
P	–	–	+	+	–	–	+	+
K	–	–	–	–	+	+	+	+
NP	+	–	–	+	+	–	–	+
NK	+	–	+	–	–	+	–	+
PK	+	+	–	–	–	–	+	+

The other two orthogonal contrasts investigate whether there is a linear or quadratic relationship between the outer points. Here we need to calculate the treatment totals for the outer three points which are 8063, 5342 and 6504. The computations are:

$$\text{Linear level 3 sum of squares} = \frac{(8063 - 6504)^2}{8}$$

$$\text{Quadratic level 3 sum of squares} = \frac{(8063 + 6504 - 2 \times 5342)^2}{24}$$

Table 3

Analysis of Variance of data in Table 1

	Source	D.F.	Sum of Squares	Mean Square	F-ratio
	Blocks	3	141956	47318.6	0.14
These main effects and interactions are over levels 0 and 2.	N	1	521284	521284	1.51
	P	1	1642240	1642240	4.77
	K	1	55932.3	55932.3	0.16
	NP	1	1489620	1489620	4.32
	NK	1	83810.3	83810.3	0.24
	PK	1	36481.0	36481.0	0.11
Orthogonal contrasts associated with the peripheral and centre treatments.	Curvature	1	2067530	2067530	6.00
	Linear Level 3	1	303810	303810	0.88
	Quad. level 3	1	628237	628237	1.82
	Residual	23	7925900	344604	
	Total	35	14896700		

Estimate of Error Standard Deviation on 23 d.f. = 587 . 03

Coefficient of Variation (Percentage) = 52 . 5

5% significance level of F with 1 and 23 d.f. = 4 . 28

Table 4

Table of Means (Kilos per acre) for data in Table 1

Level	Factor		
	N	P	K
0	460	320	581
1	1263	1263	1263
2	821	961	699
3	2016	1335	1626

LSD (5%) for differences between levels 0 and 1, and 1 and 2 = 527.2

LSD (5%) for differences between levels 2 and 3 = 745.6

If a different order of treatment combinations were decided upon, say N, K, P instead of N, P, K, the above computations would be different but the interpretation would be the same.

If desired, the curvature contrast can be replaced with a contrast which measures the mean of the treatments (1, 1, 1) against the mean of the treatments (3, 1, 1), (1, 3, 1) and (1, 1, 3). This is given by:

Average treatments 1
Average treatments
3 sum of squares

$$= \frac{2 \times (8063 + 5342 + 6504) - 3 \times 10103}{136}$$

However, this contrast cannot be included in the same analysis as the curvature contrast as these two contrasts are not orthogonal to each other.

The total sum of squares is found in the usual way by subtracting the correction for the mean $\frac{40256^2}{36}$ from the sum of squares of all the observations; then the residual sum of squares is found by subtraction.

The error standard deviation is the square root of the residuals mean square and this is divided by the overall mean of all the treatments to give the coefficient of variation. In this example, the coefficient of variation is very high; this suggests that our analysis is unlikely to be very useful. However, for illustration, we will demonstrate how to compare the factor levels for individual treatments. The table of means of N, P and K at each of the four levels is then drawn up in the usual way (Table 4). The least significant difference between two entries in the table is given by

$$587.03 \times t_{22} \frac{1}{\sqrt{(1/r_1 + 1/r_2)}}$$

where t_{22} is the students t distribution with 22 degrees of freedom chosen at the appropriate confidence level. r_1 and r_2 are the number of replications for the entries in the table which are being compared.

Extension of modified composite design

If it is desired to test over a wider range of treatment levels than is afforded even by a modified composite design, then two or more such designs can be laid out to test different factor levels. The analysis of variance would then contain a term for difference between the different designs.

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THE CONTRIBUTION OF PLOT CHARACTERISTICS TO THE DESIGN OF AN EXPERIMENT

by

A. C. BREWER

Seconded on technical assistance by the United Kingdom Overseas Development Administration

and

B. G. F. SPRINGER

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

SUMMARY

The need for information concerning the optimal plot size and shape for experiments performed in the Caribbean region is discussed, methods of determining optimal plot size and shape from suitable data are described, and the outlines of a research programme on these problems being conducted by the Biometrics Unit under sponsorship of the British Overseas Development Administration are given. Special mention is made of the need for suitable data from as many sources as possible in the Caribbean region.

INTRODUCTION

A question asked of a biometrician by an agricultural research worker when planning an experiment is: "how large a plot should I use?" If plots are made very large, little information is gained relative to the increase in size of the experiment and this represents a wastage of resources. If plots are made too small they will be highly variable, possibly unrepresentative, and therefore will not give results to the required precision and may also lose validity. In this instance, precision may only be acquired with excessive replication and this will represent a large increase in the work involved in management and recording, thus making the experiment economically unviable. What is needed is an optimum plot size between these two extremes.

To answer the question satisfactorily, the biometrician must have information of how the crop behaves and how the soil behaves on the plot of land upon which the experiment will be performed, as well as some details on the economic costs of maintaining plots. In the Caribbean such information is almost non-existent and therefore no concrete recommendations can possibly be given at the present time. A research programme is being sponsored by the Overseas Development Administration and is being carried out at the Biometrics Unit, U.W.I., in which one of the projects is to investigate the problem of finding optimal plot sizes and shapes for experiments in the Caribbean region. Towards this end, some further research will be performed in the theory of determination of optimum plot size and shape and data will be collected and processed for a number of crops and a number of regions in the Caribbean. The ultimate objective is to provide a service whereby, given the crop to be used and the conditions of the experimental site, together with some information on costs, the biometrician will be able at least to give reliable recommendations of the plot shape, and a range of plot sizes from which to choose. Further, if detailed information has previously been collected on the soil conditions at the site, perhaps in the form of a soil fertility map, then very accurate recommendations can be made on position, size, shape and orientation of plots and blocks in the proposed experiment. This paper describes the directions in which the research programme will be developed, and areas in which close cooperation is essential between members of the programme and agricultural research personnel throughout the Caribbean.

FACTORS THAT INFLUENCE CHOICE OF PLOT SIZE

Practical management techniques as well as statistical questions are involved in the choice of plot size and shape. Le Clerg et al (4) and Villas mil (6) list more important factors. They are as follows:

(a) Cultural practices may, to some extent, dictate the size or shape of a plot. For example, if machinery is to be used in the cultivation and harvest of the crop, the nature of the machine may require that plots must be of a certain width. If however, manual labour is extensively used, then smaller plots must be more economical.

(b) Limitations due to practical realities such as a fixed area of land, or a fixed amount of experimental material. In this case, when the number of plots is given, their size is automatically determined, and vice versa. This situation stands apart from that which is usually discussed. The question now is, how small a plot is needed to give the required precision in the results; is this size practically feasible and would it be worth the cost involved?

(c) Nature of experimental material. Different crops will have differing optimal plot sizes due perhaps both to cultural practices and to their inherent characteristics of variability.

(d) The theory of optimal plot size is closely associated with block size and experiments which differ in terms of number of plots per block may also differ in terms of optimal plot size. Larger numbers of plots per block may require smaller plots.

(e) Local variability, i.e., variability between plots which are close to each other, compare with overall variability across the entire experimental area. This basically determines the statistical properties of plots of different sizes.

(f) Cost per individual or unit relative to the cost of the experimental unit. This brings in the involvement of economic considerations.

The usual objective is to ensure a certain precision in the experimental results at a minimum cost. To this end, information on factors (d), (e) and (f) will be needed to give a recommendation on plot size, shape, and number of replications.

CURRENT METHODS OF DETERMINATION OF OPTIMAL PLOT SIZE

The definitive paper on the subject is that by H. Fairfield Smith (5) in which he devised an empirical law relating the size of the plot to its variability. The equation is:

$$V_x = \frac{V_1}{x^{b^1}}$$

Where V_1 = the variability of plots of unit area;

V_x = the variability of mean yield per unit area of plots of size x units;

b^1 = the coefficient of soil heterogeneity which must have a value between 0 and 1.

If b^1 = 1, the plot yields are independent and the soil must be extremely heterogeneous.

If b^1 = 0, the yields are perfectly correlated, the soil will be entirely homogeneous and small plots will give as much information as large plots.

In fact, this equation refers to variation over an infinite population of units whereas the actual application must refer to an experimental area or blocks of an experiment. The equation is more conveniently expressed in the form.

$$\log (V_x) = \log (V_1) - b^1 \log x$$

This is now a linear equation but the effect of the above discrepancy is to make it slightly curved (downwards).

Assuming that this law holds good, the immediate problem is to estimate the coefficient b^1. Smith (5) described the method of doing this when one has data from a uniformity trial. Having harvested the trial in small units, one then combines the units into plots of a certain size x and calculates V_x as the mean square of their mean yields per unit area. This is then repeated for various values of x and a regression is performed of log x on log (V_x), the regression, coefficient being the estimated value of b^1. Since the variances of larger plots are calculated from a smaller number of observations, these will be relatively less accurate than those computed from smaller plots and the regression should be weighted as the inverse of the variance of the variance estimates. Since the deviation from a straight line due to a finite population only becomes serious when the plot size becomes large, and this is where V_x is least accurately estimated, this effect can safely be ignored.

To find the optimum plot size, we need to consider the information gained from using plots of size x units in blocks of m plots, the information being the reciprocal of the variance. We do this by expressing the variance of this finite population of units in terms of the variance of an infinite population by relating the "finite relationship" to the "infinite relationship", the two being different as discussed above. It is found that:

$$\frac{1}{(Vx)m} = \frac{(m-1)}{m(1-m^{-b})} \quad \frac{x^b}{(V_1)_\infty}$$

Where $(V_x)m$ = the variance in yield per unit area of plots of size x units in blocks of m plots;

$(V_1)_\infty$ = the variance of single unit plots in an infinite population;

b = coefficient of soil heterogeneity in the infinite population.

b^1 has been found for the finite population and needs to be adjusted to give the value of b for the infinite population.

We also need to consider economics in terms of the "cost" per plot of x units. In many cases we may assume a simple model for this and state the cost for a plot of x units to be of the form:

$$K_1 + K_2 x$$

K_1 would be the constant cost of the plot regardless of size and K_2 would indicate the extra cost for each unit of land used. The experimenter must find estimates of these costs or at least their ratio.

From here we see the cost per unit of information in using plots of size x units to be:

$$\frac{m(1 - m^{-b})\ (K_1 + K_2 x)\ (V_1)_\infty}{(m - 1)\, x^b}$$

This is a minimum with respect to x when;

$$x = \frac{b K_1}{(1 - b) K_2}$$

thus giving the optimum plot size.

Smith's (5) theory may also be used to determine the amount of efficiency gained from using blocks with small numbers of plots compared to using blocks with a larger number of plots, thus indicating the desirability of using incomplete block designs such as confounded factorials as against complete block designs.

Koch and Rigney (3) extended the application of this theory to results from actual trials which involve hierarchial experimental design. For example, for a split plot design the mean squares in the analysis of variance corresponding to replication, main plot error, split-plot error and sampling error (when split-plots have been harvested in smaller sub-plots) can be combined in a certain way to give the variance estimates of the four corresponding plot sizes and these can be used as the values of V_x in Smith's regression technique. This is obviously extremely useful in that results from many designed experiments can be used to determine optimal plot size for future experimentation.

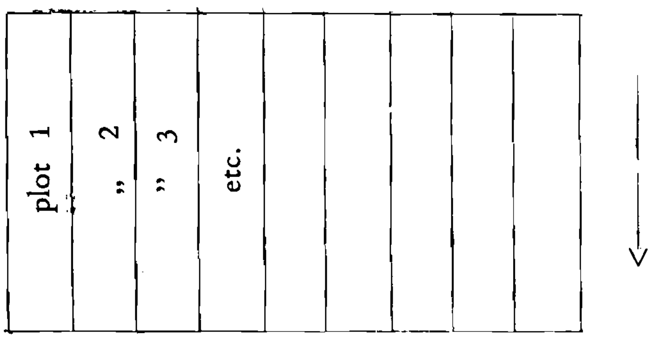
Hathaway and Williams (2) recognised that, not only are the variance estimates of plots of size x units subject to different degrees of variation depending on the number of observations upon which the variance is based, but also these estimates will be correlated since they are formed from the same set of data. They therefore modified Smith's regression technique to take this effect into account thus finding the estimate of b^1 with asymtotically maximum efficiency. Few subsequent papers seem to have used this method although it is capable of achieving substantial gains in efficiency in some cases and it affords a statistically precise means of testing the fit of Smiths regression model to the data. They suggest a technique for estimating optimal plot size graphically when there is a lack of fit in Smith's model. The technique can be adapted to the methods used on both uniformity trials and experiments with an hierarchial design. It does not appear, however, to be able to utilize all information contained in data from a uniformity trial since it can only use variance estimates from hierarchial experimental designs superimposed on the data. This means that smaller plots must be completely contained inside plots of larger size, or equivalently, larger plots must be multiples of the smaller ones.

Little theoretical work seems to have been performed on the subject of optimal plot size since Hathaway and William's (2) paper.

DETERMINATION OF PLOT SHAPE

The theory involved in the determination of optimal plot shape is rather more simple than that involved in the determination of plot size, provided one has already decided that the field plot should be rectangular or square.

If there exists a fertility gradient in the site, one should arrange the plots as long rectangles, their length being along the direction of the fertility gradient, or along the direction of greatest variation. This ensures that the greater variability is contained within the plot whilst between the plots there will be a lesser amount of variability. One should look for factors on the site which might cause a fertility gradient, or greater variability, in one direction. The classical example is that of the slope of the land causing more rapidly changing conditions down the slope compares with those across the slope. The plots should then be rectangles with their length in the direction of the slope.



Direction of slope or fertility gradient

At the U.W.I. Field Station in Trinidad much of the land is in the form of camberred beds and thus the most efficient arrangement is to have long narrow plots across the bed. This cannot always be done because of cultural practices.

One can be very specific about plot shape, size and orientation if a uniformity trial has previously been performed on the land and a soil fertility map has been constructed. Plots in the same block should be placed in areas of similar fertility(not necessarily adjacent) and their shape and orientation should be such that they fit in well with the fertility contours.

When there is a direction of greater variability this will affect the determination of optimal plot size, but the method still holds for comparing plots of different sizes which have the same shape.

In the absence of a fertility gradient, the plot shape is largely at the choice of the experimenter, but as a general rule square plots will be more efficient than rectangular plots.

PROPOSED RESEARCH INTO METHODS OF DETERMINING OPTIMAL PLOT SIZE AND SHAPE

It must be recognised that Smith's model is only an hypothesized situation dependent upon certain assumptions and as such, will break down for some sets of data. In fact, Smith performed his analysis on data from several uniformity trials and found that in at least three cases the relationship appeared to curve upwards. It is proposed to use Hathaway and William's technique extensively for testing the model and where lack of fit occurs, to attempt to detect the reason and to build alternative models to fit these situations. The model in its present form does, however, appear to be adequate for most applications.

Since extensive use is to be made of Hathaway and William's technique, it would be useful if the theory can be modified such that we can abolish the restriction that the plots of various sizes must come from an hierarchial design superimposed on the uniformity trial. Thus some research will be directed towards this.

Smith's method necessarily refers to square or rectangular plots, whereas a new regime of experimental designs are becoming available which do not use such shapes. One such is Nelder's Systematic Spacing Design (the fan design). The optimal plot size is still a relevant question in these designs. The optimum plot size is basically dependent upon a measure of "localized" variance compared to overall variance in the field. Using a direct measure of this, it may be possible to develop an entirely new method of determination of optimal plot size which is not shape-dependent. In 1915 Harris (1), defined such a measure called the intra-class correlation coefficient which Smith mentioned but did not find useful since it was not developed into a tool for determining optimal plot size. For the reasons above it timely to attempt to do this.

One of the biggest hazards of using small plots is that of the high occurrence of disease and missing plants. A large proportion of these in a small plot can obliterate the yield or make the result highly unrepresentative of the usual situation thus rendering it to be a missing plot. The current methods described for finding optimal plot size do not take this factor into account and therefore some research will be done on determining minimal plot size such that the probability of such an occurrence is low.

From uniformity trials, soil fertility maps can be constructed. These will show up any prominent direction of greatest variation and indicate the desirability of using long plots elongated along that direction. However, the direction of greatest variation may not be so prominent in some cases and will not be detectable from eye inspection of the map. In this case, it may be desirable to fit a simple surface to the results and to analytically determine the direction of greatest variability across this surface. The simplest surface would be a plane and the direction of greatest variation would be the line of greatest slope. This would then give an insight into the best orientation for non-symmetrical plots and blocks.

DATA COLLECTION AND DATA PROCESSING IN THE O.D.A. RESEARCH PROJECT

We hope to use data from uniformity trials, hierarchial experimental designs and simple designs in which the plots are large and are harvested in smaller sub-plots for our investigations. We hope to investigate as many crops as possible and over as many regions as possible in the Caribbean. A similar recent study in Mexico involved over 1300 separate experiments; this conveys an idea of the magnitude of the work involved in order to obtain a fully comprehensive set of results. We hope that as many agricultural research workers as possible from all regions of the Caribbean will contribute towards our programme.

A pertinent question to ask in the data analysis is: "does the type of crop affect the value of the parameter in Smith's, or any alternative, model?" An equivalent question is to ask whether b is a measure of soil heterogeneity alone, or can some characteristic of the crop also affect its value. If b is crop-independent, then the optimal plot size would still depend on the crop and type of experiment to be performed due to economic differences but once b is found for a given site, the optimal plot size for any experiment to be performed there can be found. This would make the proposed service much more feasible. The question could be resolved by performing successive trials on the same site on different crops.

Another pertinent question to ask is whether the value of b can be characterised, at least to some extent, by soil type and possibly by climatic conditions and the location of the experimental site in a certain region. If this is true then at least some rough recommendation as to optimum plot size can be given without any prior information as to the behaviour of the experimental area in question.

Apart from finding the b coefficient of heterogeneity from each set of data we receive, in the case where uniformity trials have been conducted, a soil fertility map will be constructed and recorded. Thus we will instigate a record-keeping service of this information. The sites where this will be most useful are those where experiments are continually being performed, such as at Agricultural Research Stations. A continuous monitoring system of the behaviour of the soils at these sites would be desirable.

SPECIALIST FIELDS OF STUDY AND DIVERSIFICATION OPTIMUM SAMPLE SIZE

Although most of this project is by its nature directed towards annual field crops, other disciplines will be investigated if and when the need for it becomes apparent. The field of study for which the theory will be almost identical is that of perennial crops, including tree crops. These will certainly be involved in the programme. In general, any field of study requiring more specialist application of the theory will require more consultation between the Biometrics Unit and the experimeter involved. We are hoping for approaches from anyone who has problems of this kind in any field of study.

A problem closely related to that of optimal plot size is that of optimal sample size. This has a very varied field of application, some of which are described below:

(a) Livestock studies – what is the optimum number of animals to include in one experimental unit? One regards this as a "sample" of animals.

(b) Entomological studies – how many insects should be included in one unit in laboratory studies, or how intensively should we sample in field studies?

(c) Soil studies – how large should a soil sample be, and how should it be taken from an experimental unit?

(d) Nematodes – how intensively should the soil be sampled for nematodes around the plant and what pattern of sampling should be made?

One can see this is a very diverse subject, but it is hoped to investigate the areas which are having most problems in finding a satisfactory sampling technique.

REPLICATION

Having decided upon the plot size the expected variability of the results should be known in order to establish how much replication is needed in order to obtain experimental results of the required precision. It is proposed to compile a record of the coefficients of variation of experiments performed in the region and consequently assess the variability to be expected from an experiment performed on a specified crop, at the specified plot size under the conditions at the specified experimental site. Information from the experiments conducted to investigate plot size will be relevant in this respect, as will results of other experiments found in past records as well as those which are yet to be performed.

With such information compiled and analysed, recommendations of the amount of replication can be given to a good degree of accuracy. This will then complete the service of the Biometrics Unit to agricultural research workers with respect to the arrangement of plots in experimental design in the Caribbean region.

CONCLUSION

Many experimenters in the Caribbean region have expressed their desire to have knowledge on optimum plot size and the amount of replication needed for their experiments.

The programme set up in the Biometrics Unit, U.W.I., to investigate these problems can only do so efficiently if a large amount of information is obtained from uniformity trials, experiments of an hierarchial design, and other experiments which are harvested and recorded in small sub-plots. Also, the programme needs information on the variability encountered in all types of experiments performed in the region.

If sufficient information is forthcoming then in all probability, this programme would make a significant contribution to agricultural experimentation in the Caribbean.

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A SYSTEM OF PROJECT REGISTRATION DESIGNED TO FACILITATE INFORMATION RETRIEVAL

by

ROGER F. BARNES
and
BASIL G. F. SPRINGER

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

SUMMARY

The registration of projects is mandatory in an efficient agricultural research programme. A proposed registration system, with facilities for information retrieval by computer is discussed. This system is designed primarily for use in the Faculty of Agriculture at The University of the West Indies, but it is hoped that with adequate organisation and cooperation, it will be eventually extended to encompass all agricultural research programmes in the Caribbean region.

INTRODUCTION

The Science Information Exchange (SIE), under the aegis of the Smithsonian Institution (Washington D.C.) since 1953, provides the scientific community with timely information about currently active scientific research. This natural registry of research in progress collects and provides information to facilitate effective planning and management of scientific research at all levels of responsibility, and for all organisations concerned with the support and conduct of scientific research. The SIE provides broad coverage of basic and applied research in all fields of biology, medicine, sociology, psychology, agriculture, and the physical sciences.

A project registration office is an essential element in any research organization. It is an office in which new projects are registered and existing projects updated and from which information can be retrieved, so as to facilitate coordination and evaluation of the research work carried out in the organization.

The Faculty of Agriculture at the University of the West Indies is currently in the process of setting up a project registration office and to this end a system of project registration and information retrieval has been designed. The objectives are similar to those of the SIE except that registration will be limited to agricultural projects in the Caribbean region, initially from within the Faculty but ultimately it is hoped that all agricultural research institutions in the Caribbean area will contribute to the pool of information.

The obvious benefits from such a system will extend to leaders of research programmes, funding organizations and should considerably lessen the areas of duplication of research effort.

The system is designed for the storage of information on magnetic tape and its retrieval by computer.

Project registration

Each project is identified by a registration number and the following information is stored:-

(i) Date of registration,
(ii) title of project,
(iii) responsible individual,
(iv) Cooperators,
(v) address of responsible individual,
(vi) location of project,
(vii) funding organization,
(viii) expected starting date,
(ix) duration of project

The objectives of the project are then stated, followed by the procedure to be adopted. There is provision for additional remarks.

When the project is received in the project office Key words, as are to be found in a Key word index, are assigned to a project. There is also a section on the form which gives information on the status of the project. The project office, by seeking information from the individual responsible for the project at regular intervals is able to record the current status of any project. Any publications which may have been produced are also recorded at this time. A sample project registration form is shown in Table 1.

Other information, including a costing of the project, distributed under various heads, and a breakdown of an individual researcher's time, may also be included in a project registration form. The analysis of such information is sometimes invaluable to the administration of a research institution.

Information retrieval

Information is registered and stored for the purpose of retrieval at some later stage. It is envisaged that the main users of the system would be research workers desirous of finding out what other researchers are pursuing in a particular field of interest. Examples of other requests may be to list the projects (a) funded by a given organisation or (b) in which a given individual is participating.

In the case of a researcher making a request for all projects concerned with crop protection with regard to onion production in the Caribbean, for example, he will have access to the Key word index and will make his request with reference to a number of Key words. There will be a choice of output either complete as recorded in the project registration form or abbreviated, giving only basic information e.g. title, and responsible individual's name and address.

Projects will be kept in the system at least until they have been terminated in some way. At which time they may have to be removed to another file.

Table 1

U. W. I. Faculty of Agriculture and Other Regional Institutions

PROJECT DESCRIPTION – RESEARCH RESUME

Date of Registration	Registration No. ☐☐☐☐☐
Title	
Responsible Individual (Surname first)	Other Participant (s)
Dept. of Responsible Individual	
Territory	
Funding Organisation	

Expected Starting Date Expected Termination Date

Not yet in Progress ☐ In Progress ☐ Discontinued ☐

Extended ☐ Revised ☐ Pending ☐ Terminated ☐

Remarks

Publications (give authors and references)

Objectives Approach ("Approach" should follow "Objectives")

Key words

Programming aspects of system design

The system is designed to run on the University computer at St. Augustine, an ICL 1902 A with 16K immediate access store, magnetic tape, and magnetic disc backing store.

The design philosophy from the programming standpoint is based on the relatively small amount of information to be handled, the expected continued development in sophistication of the system, and the provision of a human rather than a machine-oriented interface with the client.

The information for each project is stored uncoded in a single record of 2352 characters. Each record contains different length fields relating to different items of information such as starting date, the name of a person involved, or a keyword. The amount of space in the fields is generous to allow for future extra information to be added without extending the total record length, yet details of over 5000 projects could be stored on one reel of magnetic tape. This open uncoded format is useful because it allows the single file to serve as a master print file for producing selected reports and to be searched for statistical purposes.

As the system grows in size and sophistication it will be possible both to separate the search procedures from the printing operations, and to transfer selected parts of the operation to magnetic disc instead of tape. The system is also designed openly enough to use ICL software programmes wherever this will effectively save programming time.

The presentation of a human-oriented interface to those people who will use the system is perhaps the most important factor in the successful implementation of the project registration/retrieval scheme. It is also the most interesting and difficult from the programming standpoint.

Human beings interpret instructions with some latitude; computers do not. Human beings, in general, do not repeat their actions precisely, but computers do. Thus to human beings computers appear inflexible and inhuman, while to computers (if they could think) human beings appear to be error-prone!

The solution to this antipathy between the machine and the user must be a compromise. It is reasonable to expect a fairly high standard of accuracy and the caution or care to avoid ambiguity on the part of the user, but the machine must be programmed to allow for (and thus correct automatically) as many 'errors' as possible. In this way the machine appears bearably human to its users.

A simple example of the kind of technique that is being used concerns the format of keywords. Different users requiring information on pod set might write their request as 'PODSET', or PODSET, or 'POD SET'. Each of these three sets of characters would normally be seen by the computer as a different keyword. In our system they would all be accepted as equivalent, thus relieving the personnel writing keywords for new entries or inputting queries to the search programmes from having to use (and memorise) a unique representation.

Cooperation

It is hoped that, when the project is well established within the Faculty of agriculture, individuals and organisations engaged in agricultural research in the Caribbean region will contribute to the information in the system and in turn request information from the information pool to keep in touch with their counterparts in other territories.

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PLANT PARASITIC NEMATODES ASSOCIATED WITH VEGETABLE CROPS IN ANTIGUA

by

CHELSTON W. D. BRATHWAITE,
Research Fellow in Nematology,
The University of the West Indies,
St. Augustine, Trinidad.

ABSTRACT

A survey of nematodes associated with vegetable crops on seven estates in Antigua revealed 15 genera of plant parasitic nematodes. These included reniform nematodes *Rotylenchulus* spp., root knot nematodes *Meloidogyne* spp., lance nematodes, *Hoplolaimus* spp., stylet nematodes *Tylenchorhynchus* spp., and spiral nematodes *Helicotylenchus* spp., all of which are known to be economically important in crop production in other parts of the world. Moreover, the population density at which the nematodes occur in soil samples suggest that they could be limiting factors in vegetable production in Antigua.

INTRODUCTION

Antigua is one of the chain of islands enclosing the Caribbean Sea. For many years, agricultural production in the island has been based primarily on the production of sugarcane and cotton. However, because of the rapid increase in population and in tourism and the associated demand for additional food supplies, attention is now being paid to local vegetable production.

Because plant parasitic nematodes have been recognised as major pests of vegetable crops in many parts of the world (5) a survey was carried out to determine whether plant parasitic nematodes were associated with vegetable crops in the major vegetable-producing areas of the island.

MATERIALS AND METHODS

Soil and root samples were collected from tomato *(Lycopersicon esculentum)*, sweet peper *(Capsicum annuum)*, egg plant *(Solanum melongena)*, cabbage *(Brassica oleracea* var. *capitata)*, carrot *(Daucus carota)*, cucumber *(Cucumis sativus)* and okra *(Hibiscus esculentus)* on the following estates:— Bethesda, Cassada Gardens, Claremont, Diamond, Collins, Green Castle and Parham (Fig. 1.) An area planted with a specific crop was sampled by collecting rhizosphere soil and small feeder roots from five to ten plants selected at random. Soil sub-samples were combined to give a composite sample. If a crop represented a large acreage on an estate or where several cultivars of the same crop were planted on an estate, 2 or 3 composite samples were taken. Samples were maintained in an ice-cooled container during sample collection. The nematodes were extracted from 200 cc of the soil samples by a combination of Cobb's sieving method and a modified Baermann Funnel technique (6). Root samples (10 gm) were blended with 100 cc of water and extracted in the modified Baermann Funnels. The nematode suspensions were collected after 24hr. and fixed in TAF (2). Nematodes were identified as to genus with the assistance of the taxonomic keys of Mai et al. (4) and Throne (7). The populations of the various genera in soil samples were expressed as a numerical index in which 1 = 10 or fewer specimens per 100 cc soil, 2 = 10–100, 3 = 100–1000, 4 = 1000–2000 and 5 = 2000 or more. Indices of 1 or 2 were considered to represent low population densities while indices of 3, 4 or 5 were considered to represent high population density of the particular genus. The occurrence of a genus in root samples was expressed by an asterisk (*) over the index. Roots were examined in the field and the degree of galling was expressed as a root-knot index on a 0-5 basis (6).

RESULTS

The results are presented in Table 1. Fifteen genera of plant parasitic nematodes were associated with vegetable crops in Antigua.

Reniform nematodes (*Rotylenchulus* spp.) occurred most frequently in both root and soil samples and were usually the most abundant nematodes in soil samples. The widespread occurrence of *Rotylenchulus* spp. in Antigua supports the increasing importance being attached to this genus in tropical crop production. Root knot nematodes, (*Meloidogyne* spp.) were second in abundance while other genera occurred less abundantly. Population density of the various genera were usually higher for tomato than for other crops. Severe galling of roots was not widespread except on tomato. However, stubby-root symptoms were commonly observed and the presence of a servere form of this symptom on eggplant and pepper at Green Castle and Collins, respectively, may be associated with the presence of stylet nematodes, (*Tylenchorhynchus* spp.) in these areas.

CONCLUSION

The results indicate that plant parasitic nematodes occur in the major vegetable-producing areas of Antigua. Various species of the genera encountered have been reported as pests of vegetable crops in other parts of the tropics (1, 3). Consequently there is need for the implementation of nematode control measures in vegetable production in the island to determine *inter alia* the profitability of nematode control in vegetable production.

ACKNOWLEDGEMENTS

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TABLE I

Plant Parasitic Nematodes Associated with Vegetable Crops in Antigua

Crop	Estate	Cultivar	Genera of Plant Parasitic Nematodes															
			Aphelenchoides	Aphelenchus	Criconemoides	Helicotylenchus	Hoplolaimus	Longidorus	Meloidogyne	Paratylenchus	Pratylenchus	Rotylenchulus	Rotylenchus	Tylenchorhynchus	Tylenchus	Trichodorus	Xiphinema	Root Knot Index
Tomato	Collins	Indian River	–	–	–	3	–	–	3*	–	–	4*	–	–	–	–	1	5
”	Green Castle	”	–	–	–	1	1	1	2*	–	–	3*	–	–	2	–	–	2
”	Cassada Gardens	Manalucie	–	1	–	2	–	–	3*	–	–	3*	–	–	1	–	–	4
”	Parham	Indian River	1	–	–	–	–	–	1*	–	–	1*	–	–	1	–	–	1
”	Bethesda	”	1	–	–	–	–	1	2*	–	–	3*	–	–	–	–	–	2
”	Diamond	Tropi-Gro	–	–	–	–	–	–	–	–	–	3*	–	–	1	–	1	0
”	”	Indian River	–	–	–	–	1	–	–	–	–	3*	–	–	–	–	–	0
”	”	Better Boy	–	–	–	1	1	–	–	–	–	4*	–	1	–	–	1	0
”	Claremont	Indian River	–	–	–	–	–	–	2*	–	–	3*	–	–	1	–	–	22
Sweet Pepper	Cassada Gardens	Yolo Wonder	1	–	–	–	–	–	–	–	–	–	–	2	1	–	–	0

TABLE 1 — *Cont'd*

Plant Parasitic Nematodes Associated with Vegetable Crops in Antigua

Crop	Estate	Cultivar	Genera of Plant Parasitic Nematodes															
			Aphelenchoides	Aphelenchus	Criconemoides	Helicotylenchus	Hoplolaimus	Longidorus	Meloidogyne	Paratylenchus	Pratylenchus	Rotylenchulus	Rotylenchus	Tylenchorhynchus	Tylenchus	Trichodorus	Xiphinema	Root Knot Index
Sweet Pepper	Parham	Yolo Wonder	–	1	–	–	–	1	–	–	–	–	–	–	–	–	1	0
"	Collins	"		1	–	3	–	–	1*	–	–	2*	–	1	–	–	–	0
"	Bethesda	"	–	1	–	–	–	–	2*	–	–	2*	–	2	1	–	–	0
"	Claremont	"	–	–	–	–	1	1	2*	–	–	–	–	–	–	–	–	0
"	Diamond	"	–	–	–	–	–	–	2*	–	–	–	–	–	–	1	–	0
Egg Plant	Cassada Gardens	'Freetown White' #	–	–	–	–	–	–	2*	–	–	4*	–	–	–	–	–	1
"	Green Castle	'Purple and White' #	–	–	–	2	–	1	–	–	–	3*	–	1	1	–	–	0
"	Parham	'Local'#	–	–	1	–	–	–	–	–	1	3*	–	–	–	1	1	0
"	Bethesda	"	–	2	–	–	–	–	3*	–	–	3*	–	1	–	–	–	2

Local Names

TABLE 1 — *Cont'd*

Plant Parasitic Nematodes Associated with Vegetable Crops in Antigua

Crop	Estate	Cultivar	Genera of Plant Parasitic Nematodes															
			Aphelenchoides	Aphelenchus	Criconemoides	Helicotylenchus	Hoplolaimus	Longidorus	Meloidogyne	Paratylenchus	Pratylenchus	Rotylenchulus	Rotylenchus	Tylenchorhynchus	Tylenchus	Trichodorus	Xiphinema	Root Knot Index
Egg Plant	Diamond	'Purple and White' #	–	–	–	–	–	1	–	–	–	3*	–	–	–	–	–	0
Cabbage	Cassada Gardens	All seasons	–	–	–	1	–	–	2*	–	–	2*	–	1	–	–	–	1
,,	Parham	,,	–	–	1	1	–	–	2*	1	–	3*	–	1	–	–	–	2
,,	Claremont	,,	–	–	–	–	–	1	1*	1	–	3*	–	1	–	1	–	1
Carrot	Cassada Gardens	Danvers half long	1	–	–	–	–	–	2*	–	–	1*	–	1	–	–	–	1
,,	Green Castle	Chantenay red core	–	–	–	–	1	–	–	–	–	2*	–	–	–	–	–	0
,,	Parham	,,	–	1	–	–	–	–	2*	–	–	1*	–	–	–	–	–	1
Cucumber	Green Castle	Ashley	–	–	–	1	–	1	–	–	–	–	1	2	–	–	–	0

Local Names

TABLE 1 — *Concluded*

Plant Parasitic Nematodes Associated with Vegetable Crops in Antigua

Crop	Estate	Cultivar	Genera of Plant Parasitic Nematodes															
			Aphelenchoides	Aphelenchus	Criconemoides	Helicotylenchus	Hoplolaimus	Longidorus	Meloidogyne	Paratylenchus	Pratylenchus	Rotylenchulus	Rotylenchus	Tylenchorhynchus	Tylenchus	Trichodorus	Xiphinema	Root Knot Index
Cucumber	Parham	Ashley	–	–	1	–	–	–	2*	–	1	–	–	1	–	–	–	2
,,	Bethesda	'Local' #	–	–	–	–	–	–	1*	–	–	3*	–	–	–	–	–	0
,,	Diamond	Ashley	–	1	–	–	–	–	1*	–	–	2*	–	1	–	–	1	0
Okra	Cassada Gardens	Clemsons Spineless	–	–	2	–	–	–	2*	–	–	1*	–	–	–	–	1	2
,,	Parham	,,	–	–	2	–	–	–	2*	–	–	2*	–	–	–	–	1	1

Local Names

EFFECT OF PLASTIC MULCH AND PLASTIC CANOPY ON NEMATODE POPULATION AND SOUTHERN BLIGHT OF TOMATO

by

N. D. SINGH

and

M. S. SANDHU

Department of Crop Science
The University of the West Indies
St. Augustine, Trinidad, W.I.

ABSTRACT

Effects of black plastic mulch and clear plastic canopy on the nematode populations and southern blight of tomato were investigated at the University Field Station, Trinidad. The results showed significant differences ($p = 0.05$) in the effectiveness of the various treatments against populations of *Rotylenchulus reniformis*, *Aphelenchus avenae*, *Meloidogyne incognita* and *Tylenchus* sp. The incidence of southern blight (*Sclerotium rolfsii*) was reduced in the black plastic mulch and mulch plus clear plastic canopy treatments but greatly increased in the clear plastic canopy treatment when compared with the control.

Much of the reduction in yield of agricultural crops in the Eastern Caribbean has been partly attributed to plant parasitic nematodes either directly or in association with other soil borne disease-causing organisms e.g. *Fusarium*, *Sclerotium rolfsii* Sacc. and *Pseudomonas solanacearum* Sm. (1, 2, 7).

The conventional practice of vegetable crop rotation and other cultural practices e.g. fallowing, occasional flooding and use of organic manure do not seem to be effective in preventing the build-up of plant pathogens. Soil fumigants have been found to be effective in significantly reducing nematode populations (11) but because these fumigants are expensive their use is restricted to high value crops. The effects of plastic mulch on the nematode populations and on southern blight have not been investigated in the Eastern Caribbean. Sandhu and Dalal (10) recently reported the effects of black plastic mulch and clear plastic canopy on the soil properties and their relationship to tomato yield in low-land tropics. The beneficial effects of plastic mulches and/or clear plastic canopies have been reported by other workers (4, 6, 9).

The purpose of this study was, therefore, to investigate the effect of black plastic (polyethylene) mulch and clear plastic canopy on nematode population and southern blight of tomato.

MATERIALS AND METHODS

The experiment was carried out on River Estate sandy clay loam soil at the University Field Station, Trinidad. The site selected was infested predominantly with *Meloidogyne incognita* (Kofoid and White) Chitwood, *Pratylenchus zeae* Graham, *Helicotylenchus dihystera* (Cobb) Sher, *Rotylenchulus reniformis* Linford and Oliveira, *Tylenchus* sp. *Tylenchorhynchus* sp. and *Criconemoides* sp. Less abundant plant parasitic nematodes were *Aphelenchus avenae* Bastian and *Xiphinema* sp. Southern blight caused by *Sclerotium rolfsii* Sacc. was also prevalent at this site. The treatments included (i) black polyethylene used as a mulch, (ii) clear polyethylene row cover (canopy), (iii) combined mulch and canopy, and (iv) control. The method for laying down the polyethylene sheet and setting up the canopy with its supporting frame were as described by Sandhu and Dalal (10).

A randomized complete block design with six replicates was used. Each plot was 2. 75 m x 1. 52 m in size with a buffer row between each treatment. Six-week old tomato plants var. Floradel were transplanted in

TABLE 1

Effect of Plastic Mulch and Plastic Canopy on Nematode Population and Southern Blight of Tomato (mean of six replicates)

Treatments	Number of Nematodes per 200 ml Soil								
	Pratylenchus zeae	Helicotylenchus dihystera	Tylenchus sp.	Tylenchorhynchus sp.	Rotylenchus reniformis	Aphelenchus avenae	Criconemoides sp.	Meloidogyne incognita	Southern blight[1]
Mulch plus Canopy	196 ab[2]	142 a	134 a	104 a	11288 c	36 b	855 a	83 b	5.5
Mulch	138 a	128 a	121 a	74 a	7599 bc	18 a	775 a	48 a	10.0
Canopy	313 b	80 a	177 ab	76 a	4909 ab	48 b	1240 b	124 b	47.7
Control	260 b	71 a	225 b	103 a	4005 a	38 b	1103 ab	118 b	14.0

1. Mean percent of plants infected with southern blight.

2. Means in columns flanked by a letter in common do not differ significantly ($P > 0.05$)

rows spaced 0.3 m apart. Soil samples were taken from each plot two months after transplanting for nematode counting (8). Each sample (200 ml) was processed by modified Cobb's decanting and sieving method (5). Duplicate samples consisting of ten percent of each nematode suspension, were examined under the stereo-microscope and generic counts made. Species identification was done under the compound microscope with specimens fixed in TAF (5).

RESULTS

When the nematode population counts were analysed using Friedman's Non-Parametric Analysis of Variance with a ln (x + 1) transformation (3) there were significant differences (P = 0. 05) in the effectiveness of the various treatments on populations of *Rotylenchulus reniformis, Tylenchus* sp., *Aphelenchus avenae* and *Meloidogyne incognita* (Table 1).

Using Duncun's Multiple Range Test on the transformed data, *R. reniformis* was significantly increased with mulch alone and mulch plus canopy compared with the control. On the other hand, *Tylenchus* sp. was reduced in the mulch alone and mulch plus canopy treatments *M. incognita* and *A. avenae* were significantly reduced (P = 0. 05) in the mulch only treatment. Canopy alone had no significant effect on any nematode population.

Symptoms of southern blight first appeared at the time of flowering and continued to spread throughout the period of fruit development. The incidence was greatly increased in the canopy treatment compared with the control (Table 1). On the other hand, mulch alone and mulch plus canopy reduced the incidence of southern blight.

DISCUSSION

It has been reported that plastic mulch and/or clear plastic canopy bring about changes in soil moisture level, soil and air temperature, plant nutrient uptake, weed and disease development (6, 9, 10). These factors are also known to affect nematode population. Therefore it would be difficult under field conditions to separate the effects of plastic mulch and/or clear plastic canopy on the nematode populations from those of the other biotic and soil physical factors. However, Overman and Jones (9) reported that soil conditions under plastic mulch did not reduce root galling but alleviated the damage to tomato by root knot nematodes. The results obtained in her study cannot be compared quantitatively since in almost all cases nematode population counts were not reported. On the other hand, Jones *et al* (6) found that plastic mulch reduced the severity of *S. rolfsii* in tomato. This difference in southern blight control has been attributed to the high nitrogen regimes and moisture levels as well as microorganisms antagonistic to *S. rolfsii.*

The increase in the population of *R. reniformis* with polyethylene mulch may result in greater crop damage. It may be important therefore, to consider the integrated research recommended by Overman and Jones (9) where use of polyethylene mulch, high analysis soil fertilizers, seep irrigation and broad spectrum soil fumigants is required to assure high quality yield of tomato in soil of low fertility infested with nematodes and other soil borne disease organisms.

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STUDIES ON THE AGROMYZID LEAF-MINERS IN BARBADOS

SPECIES, HOST PLANTS AND PARASITES

by

BADAR MUNIR, *Entomologist,*
Ministry of Agriculture, Science and Technology,
Barbados, W.I.

INTRODUCTION

The Agromyzid leaf-miners occurring in Barbados have, hitherto, remained relatively unknown. The only account of Agromyzids found in this island is by Tucker (1952), who recorded *Agromyza* sp. from cow-pea, and *Agromyza sorosis* from corn. It was, therefore, considered worthwhile to study the Agromyzid leaf-miners, their hosts plants, relative abundance and natural enemies in Barbados, to establish their economic status, and if found necessary, to explore the possibilities of their biological control.

MATERIALS AND METHODS

An extensive survey was carried out throughout the island and infested leaves of cultivated as well as of the wild plants were brought into the laboratory to rear the adults of leaf-miners and their parasites. Intensity of attack was determined from the number of puparia obtained from a random sample of 25 infested leaves kept singly. Incidence of parasitism was recorded from the total number of emergents reared from a large number of infested leaves kept in bulk. Identification of the specimens was accomplished through the courtesy of British Museum and United States Department of Agriculture.

The studies were initiated in January, 1972.

RESULTS AND DISCUSSION

Results obtained so far have indicated the presence of *Liriomyza munda* Frick, *Liriomyza trifolii* (Burgess), and *Calycomyza* sp. in Barbados. Specific determination of some of the species is still awaited.

Liriomyza munda Frick, was described by Frick (1957) from some solanaceous plants, such as *Datura meteloides, Lycopersicum esculentum* and *Solanum tuberosum* in California. Subsequent studies by many workers including Oatman (1959) indicated that this species has a wide range of host plants. Stegmaier (1966) has listed 37 plants of 10 families as hosts of *L. munda.* It has been recorded attacking *Moringa* sp. in Jamaica (Spencer, 1965), and has also been found infesting various vegetable crops in Venezuela (Spencer, personal communication).

Because of taxonomic complexities, the pattern of distribution and the range of host plants of *L. munda* are not clear. For instance, *L. guytona* Freeman, which was previously known as a serious pest of tomatoes, beans, crucifers and cucurbits in the southern parts of the USA is now regarded as a synonym of *L. munda* (Steyskal, 1964). *L. pusilla* (Mg.) which is a serious pest of many cultivated crops in the USA, Central and Northern Europe, Italy, Sicily, and Egypt, has often been mistakenly identified with *L. munda* (Frick, 1957). Similarly *L. pictella* (Thompson) and *L. eupatorri* (Kalt.) have also been mixed up with *L. munda* (Stegmaier, 1966).

During the present survey in Barbados, *L. munda* has been found to be well distributed all over the island. On cultivated plants it has been found infesting *Allium cepa, Beta vulgaris, Brassica oleracea, Cajanus cajan, Cucumis melo, Cucumis sativa, Cucurbita moschata, Daucus carota, Gossypium barbadense, Hibiscus esculentus, Lactuca sativa, Lycopersicum esculentum, Phaseolus vulgaris, Raphanus sativus,* and *Solanum melongena.*

Amongst the wild plants it has been reared from *Amaranthus dubius, Centrosema pubescence, Cleome viscosa, Commelina diffusa, Cordia curassavica, Crotolaria retusa, Desmodium* sp., *Eclipta prosterata, Emilia sonchifolia, Herpatica alata, Indigofera suffruticosa, Ipomoea* sp., *Jasminum multiflorum, Kallestroemia* sp., *Melicoccus bijugatus, Phyllanthus fraternus, Physalis angulata, Ricinus communis, Solanum nigrum, Stachytarpheta jamaicensis, Tridax procumbens,* and *Wedelia trilobata.*

Males and females of *L. munda* are very common in the cultivated crops in Barbados. Swarms of adults can be seen in sugar cane fields which are obviously visited for feeding on nectar secreted by the Hemipterous pests of that crop.

Injury to the plants is caused by the maggots which devour the parenchymatous tissue, thus depriving the plants of a considerable amount of photosynthetic area. The growth and movement of the maggot result in a typical serpentine mine. In the case of severe attack the leaves become curled and start drying up. According to Wolfenbarger (1966) the presence of 640 mines on a plant with an average of 40 leaves can reduce the yield of the plant by 50%. The oviposition punctures made by females are also potential source of injury, as pathogenic organisms can make their entry into plant tissue through these holes to cause various diseases.

In Barbados, *L. munda* breeds continuously throughout the year with several over-lapping generations. The most obvious reasons for its uninterrupted multivoltine annual cycles seem to be its polyphagous nature and equitable climate of Barbados.

The populations of *L. munda* remain more or less stable throughout the year in Barbados. Among the abiotic mortality factors affecting its populations, heavy rains during the wet season is the most important factor which causes catastrophic destruction of adults. Biotic mortality factors include parasites; some birds which prey upon maggots in the mines; spiders which feed on adults; soil inhabiting anthropods and pathogenic organisms which destroy puparia in soil.

Parasites rank as the most important of all the mortality factors. Harding (1965) has recorded about 20 species of parasites attacking *L. munda* in Texas. Stegmaier (1966) reared 5 species of hymenoptera as parasites of *L munda* in Florida.

In Barbados, about 7 species of parasites of *L munda* have been recorded so far. These are *Halticoptera* sp. nr. *patellana* (Dalm.) (Pteromalidae); *Diglyphus* sp., *Achrysocharella* sp., *Chrysocharis* spp. (probably three species) (Eulophidae); and an unidentified species of Eucoilidae. Incidence of parasitism was as high as 52.3%.

The intensity of attack (maximum number of puparia obtained from a single leaf) on different plants, and incidence of parasitism are presented in Table I.

Table I

Intensity of attack of *L. munda* on different plant species, and incidence of combined parasitism in Barbados.

Host plant	Maximum number of puparia developed from a single infested leaf	Parasitism (% age)
Allium cepa	3	2.0– 3.9
Brassica oleracea	11	20.0–32.0
Cucumis sativa	41	4.3–50.4
Cucurbita moschata	12	18.3
Daucus carota	19	15.6–20.0
Gossypium barbadense	11	5.0– 9.0
Hibiscus esculentus	8	2.0
Lactuca sativa	9	18.6
Lycopersicum esculentum	37	16.0–52.3
Phaseolus vulgaris	28	7.4–47.0
Solanum nigrum	3	20.0

Although the population *L. munda* is relatively stable throughout the year in Barbados this pest does pose a potential threat to the cultivated crops especially tomatoes, cucumbers and beans, particularly under present circumstances where indiscriminate insecticidal spray may eliminate an important mortality factor by destroying the natural enemies. In many parts of the world the leaf-miner problem has become significantly worse since the widespread introduction of modern insecticides. Such a situation has been observed in Venezuela where *L. munda* has started causing considerable concern (Spencer, personal communication). Therefore much care should be exercised in the use of insecticides. Moreover leaf-miners of common cultivated plants are likely to become established in new areas through transportation with their hosts, especially in the egg stage which is undetectable. To avoid this danger, strict quarantine measures are very important.

To complement the effect of native parasites, some exotic parasites, e.g. *Chrysocharis* sp., *Diglyphus* sp. and *Opius* sp. from Pakistan have been introduced into Barbados recently.

Liriomyza trifolii (Burgess)

Liriomyza trifolii was described by Burgess from specimens reared from *Trifolium repens* in the District of Columbia (Spencer, 1965). There has been much controversy regarding the exact taxonomic status of this species also. Frick (1953) considered *L. congesta* (Beck) which attacks leguminous crops in Europe, as a synonym of *L. trifolii,* but Spencer (1965) regarded this proposal as "inaccurate both nomenclatorily and taxonomically". Spencer placed *L. alliovora* Frick, and *L. archboldi* Frost as synonym of *L. trifolii.*

In Barbados, *L. trifolii* has been recorded from *Cucumis sativa* and *Peperomia pellucida,* and is generally extremely insignificant as compared to *L. munda.*

Calycomyza sp.

This Agromyzid attacks *Peperomia pellucida,* a common weed of cultivated fields in Barbados. Eggs are deposited singly in the tissue near-the tip of the leaf at the side of the midrib. On hatching, the maggot moves towards the midrib and makes a straight mine along the midrib downwards the base of the leaf. A blotch is caused by feeding activity of the maggot. Pupation also takes place within the blotch at the base.

Calycomyza sp. is also very rare and does not attack any cultivated plants in Barbados.

SUMMARY

Agromyzid leaf-miners occurring in Barbados were hitherto almost completely unknown. Present studies on leaf-miners in Barbados have so far indicated the presence of *Liriomyza munda* Frick, *Liriomyza trifolii* (Burgess) and *Calycomysa* sp., of these, *L. munda* is the most important pest. It is a polyphagous species and remains active throughout the year with several overlapping generations.

About seven species of parasites, some birds and disease are keeping the populations of *L. munda* in check in Barbados. But even a slight change in the natural balance by the elimination of any of the mortality factors might result in the outbreak of this species. Several exotic parasites are being introduced to complement the effect of native parasites.

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PIGEON-PEA POD BORERS IN THE CARIBBEAN[1]
(A REVIEW)

by

S. PARASRAM
Entomologist
Department of Crop Science,
The University of the West Indies,
St. Augustine, Trinidad.

INTRODUCTON

Pigeon pea (*Cajanus cajan*) (L). Millsp. is an important legume in the West Indies forming a vital source of protein. The plant is attacked by several insects of varying importance – *Diphaulaca* sp. in Trinidad causes damage to the leaves (Barrow, 1968). In St. Vincent, leaf-hoppers of the genus *Empoasca* Delong cause severe leaf curl, and flower drop. Lace-wing bugs, red spider mites, and several species of Membracids also occur and cause damage.

This paper deals with the insects attacking the pods and their control.

MATERIALS AND METHODS

A survey was conducted to determine the main species of insects involved, their distribution and alternate hosts. For purposes of survey, pigeon pea growing in different parts of the islands were chosen at random. Samples

[1] A paper prepared for the Eleventh Annual Meeting of the Caribbean Food Crops Society held in Barbados from 1st to 7th July, 1973.

of mature green pods were examined at bi-weekly intervals. The pods were examined singly for borer damage and separated into damaged and undamaged. The damaged pods were opened and the percentage of damaged seeds, and the number of larvae, kind of larvae and their stages noted.

RESULT AND DISCUSSION

The main pod borers encountered are listed below:–

(1) *Ancylostomia stercorea* (Zeller)

(2) *Heliothis (choridea) virescens* (F.)

(3) *Heliothis zea* (Boddie)

(4) *Fundella cistipennis* (Dyar)

(5) *Maruca testutalis (Geyr.)*

(6) *Heliothis armigera* (Hubner)

The eggs of the above species are laid mainly on the young emerging pods just as the petals begin to shrivel. In Trinidad *Maruca testutalis* lays eggs mainly on the young buds. The larvae on hatching feed on the developing flowers and cause flower drop.

Table 1 shows the egg laying of *Ancylostomia* based on observation of eggs in fields with infestation of 20% and 65% but with large number of pods present. No eggs were found on the buds. There were a large no. of buds in these fields. However, where few buds are available and the insect population is high, as many as 10–12 eggs are found on an un-opened bud.

Table 1

Egg counts on different stages of fruit in Dec. – Jan. (Infestation 20%) and April – May (Infestation 65%).

Stage	No. Examined	Dec.–Jan.	% Eggs laid April–May
Unopened bud (Green stage)	2000	0.00	0.00
Opened bud (Petals closed)	2000	0.00	0.00
Flowers (Petals opened)	2000	0.00	0.00
Young pods	2000	57.05	35.30
Medium pods	2000	41.23	63.60
Mature green pods	2000	1.72	1.10

Table 11

Instar/pods	Young	Medium	Mature
1	37	37	1
2	12	18	3
3	1	16	12
4	1	11	17
5	Nil	4	33
Total Larvae/200 pods	51	83	66

Eggs of *Ancylostomia* hatch in 3 days, and the larvae pass through 5 larval instars with a total larval period of 15 days. Examination of pods of different ages and noting the instar of the larvae present also provide information on the time of attack by the larvae. Table 11, shows that most of the newly hatched larvae were present in the young and medium pods while mature pods contained 4th and 5th instar larvae. This therefore corroborates the information in Table 1.

The knowledge of the egg-laying of *Ancylostomia* has proved of great benefit in the formulation of any control programme. Parasram (1970) has shown that 3 spray applications of chemical sprays at 3-day intervals beginning when approximately 75% of the pods begin to emerge gave significant control of *Ancylostomia* in the semi-dwarf varieties which are determinate. Sprays thus timed give better control than those applied at weekly and bi-weekly intervals, throughout the bearing life of the plant.

In indeterminate ones, because of the availability of all stages of the insect and the pods and flowers on the plant for a prolonged period, chemical control even if successful in controlling the pest would be uneconomical because of the large number of applications that will be necessary. Alternative methods of control must therefore be examined. The data given in Tables 111 and 1V show that pod-borers are serious pests if left uncontrolled.

Dominique C. (Pers. Communication) has shown that pupae of *Ancylostomia* which are subjected to long daylight in the larval stages take 41 days for pupation compared to the normal 10.4 days. Pupae collected from the fields around May–June also show this behaviour. There seems therefore to be a suggestion of diapause. Table V lists some 31 legumes which were carefully examined for stages or damage due to *Ancylostomia.* No signs of the insect were found in the field, although larvae feed on the seeds when exposed in the laboratory. The author could not confirm the finding of Heinrich (1956) that the larvae fed on *Cicer arietenum* and species of *Dolichos.*

If one takes into consideration (a) the high level of infestation around March, (b) that pupal diapause is not exhibited during this period, (c) the apparent lack of preferred host plants, there appears the possibility that the termination of the pigeon pea crop around March would reduce if not eliminate the population of *Ancylostomia* in the subsequent crop around October of that year. Several species may attack the same crop of pigeon peas and *Ancylostomia* may not be the most important species. This would suggest the need for work along the above trend for the other species of pod borers as well. Such work is in progress at the University.

Biological control of the pod borers should be investigated. Especially as many parts of the Caribbean grow the indeterminate varieties and it has already been suggested that the use of chemicals on such varieties would be uneconomical.

Bennet F. D. (1960) has recorded the following species from *Ancylostomia* in Trinidad:- *Apanteles etiellae* (Vier), *Phanerotoma bennetti* Mues., *Bracon thurberiphagae* (Mues.), *Bracon cajani* Mues., *Eiphosoma annulatum* Cress., and *Perisierola* sp. The C.I.B.C*, Trinidad has also been rearing and shipping parasites to many of the West Indian islands mainly for the control of *Heliothis* spp. In 1972, an egg parasite *Trichogrammatoidea armigera* and *Eucelatoria* adults (larval parasite) were sent to Barbados, Grenada, St. Vincent, St. Lucia, Dominica, Montserrat and St. Kitts. In addition an egg parasite found by M. M. Alam in Barbados – *Telonomus remus* has been released in Trinidad and St. Kitts by the Institute. Yasheen (1972) has not reported any recovery of the parasites of *Heliothis* released. It is well known that due to several problems in the islands, releases are not done carefully enough. This could lead to problems in their establishment.

It is evident therefore that for a crop like pigeon peas, the use of integrated control of the pod borers should be investigated.

***Commonwealth Institute of Biological Control.**

Table III

% Pigeon pea-pod Infestation in the Eastern Caribbean

Island	Location	Dec./ Jan.	March/ April	Year	Main sp.	Other	Collaborator
Barbados	Haggatts	3.6	37.0	1967	*Heliothis*	Fundella	Pschorn-Walcher
	Vaucluse	1.6	14.0	,,			
	Fisherpond	0.0	6.6	,,			
	Sayes Court	7.6	36.5	,,			
	Fairy Valley	0.0	29.5	,,			
Grenada	Botanic Garden	1.4	6.2	,,	*Heliothis*	*Ancylos-tomia*	A. Donelan
	Marigot	2.6	3.0	,,			
	Grand Bacolet	0.6	7.2	,,			
	Mt. Moritz	11.6	5.2	,,			
	Cottage	18.0	–	1973	*Ancylos-tomia*	*Heliothis*	
	Mirabeau	12.0	–	,,	,,	,,	

Table III – Cont'd.

% Pigeon pea-pod Infestation in the Eastern Caribbean

Island	Location	Dec/ Jan.	March/ April	Year	Main sp.	Other	Collaborator
St. Vincent	UNION ESTATE	4.4	22.0	1967	*Ancylos-tomia*		C. deFreitas
	Palmiste	19.0	35.8	"	"		
	Wallilabou	21.3	5.8	"			
	Rose Hall	8.0	–	1973			
St. Lucia	UNION	44.0	–	1972	*Heliothis*	*Ancylos-tomia*	
	Beau Sejour	50.0	–	"	"	"	
Montserrat	Rileys		20.0	1973	*Ancylos-tomia*	*Heliothis*	
	Gauges		60.0	"	"	"	

Table IV

% Pigeon pea-pod Infestation in Trinidad

Location	Dec./ Jan.	March/ April	Year	Main sp.	Other
Texaco Demonstration Farm	2.0	76.0	1965	*Ancylostomia*	*Heliothis Maruca*
	11.0	33.5	1967	"	"
	22.0	65.0	1969	"	"
St. Augustine Nursery	24.7	87.50	1967	*Ancylostomia* *Heliothis*	
Centeno	7.25	47.0	"	*Ancylostomia*	"
El Carmen	2.85	24.25	"	"	"
Mayaro (3 sites average)	12.6	51.0	"	"	"
Ecclesville	0.2	20.0	"	*Heliothis*	*Ancylostomia*

Average % seed damage was 60

Table V

Species of legumes examined for immature stages or damage of *Ancylostomia*

Species	Stage or damage
Andrea sp.	Nil
Bauhinia megalendra	Nil
Bauhinia pauletia	Nil
Bauhinia purpurea	Nil
Bauhinia sp.	Nil
Brownea sp.	Nil
Caesalpinia pulcherrima	Nil
Calpogonium sp.	Nil
Canavalia ensiformis	Nil
Cassia fistula	Nil
Cassia frutescora	Nil
Cassia javenica	Nil
Cassia occidentalis	Nil
Cassia tora	Nil
Centrosema pubesenis	Nil
Clitoria terrata	Nil
Crotolaria retusa	Nil
Delonix regia	Nil
Desmodium affine	Nil
Desmodium frutescens	Nil
Desmodium sp.	Nil
Dolichos lab lab	Nil
Glycine max	Nil
Indigofera teysmanii	Nil
Myroxylon sp.	Nil

Table V —Cont'd.

Species	Stage or damage
Phaseolus vulgaris	Nil
Pithecellobiym unguis-cati	Nil
Samanea saman	Nil
Tephrosia candida	Nil
Vigna sinensis	Nil
Vigna sp.	Nil

SUMMARY

The distribution and abundance of the two main pod-bores – *Ancylostomia stercorea* and *Heliothis* sp. are given. Pod borers are important pests in many areas. Other pod-borers and insects in general on Pigeon peas are listed. The control methods – Cultural, chemical and biological are discussed.

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THE EFFECT OF LOCAL CLIMATE AND SOIL FACTORS ON IRISH POTATO *(Solanum tuberosum)* YIELDS IN ST. LUCIA

by

F. S. LEONCE*

INTRODUCTION

The importation of Irish potatoes into St. Lucia had increased steadily during the 1960's. In 1964, St. Lucia imported 620,000 pounds of potatoes valued at $47,531.00 EC. In 1965 the Agricultural Department decided to embark upon a programme of investigations directed at determining the feasibility of producing Irish potato locally.

A temperate climate is generally considered to be more favourable for the production of the potato. Attempts to grow this crop commercially in the tropics have resulted in varying degrees of success (GOODING, 1961; CHAPMAN, 1965).

Under the climatic conditions of the Tropics, the Irish potato completes its growth period in a relatively short time. Thus climatic and soil conditions must facilitate the rapid growth and tuberization required to produce tuber yields at economic levels.

The soils of St. Lucia vary rather widely in physical and chemical characteristics. (STARK *et al,* 1966). On the low coastal lands the average daily mean temperature is about 25°C and varies by about 2°C between the coldest and the warmest months of the year. Temperature records for the higher altitudes are inadequate but it is known that temperature

*Formally Research Officer, Agriculture, Ministry of Trade, Tourism and Agriculture, St Lucia. Presently Fruit Quality Agronomist, Windward Islands Banana Research Scheme.

decreases with increase in altitude. Annual rainfall varies from about 127 cm at coastal locations in the North and South to 406 cm in the mountainous south-centre of the island (STARK *et al*, 1966). It was anticipated that such climatic and edaphic variation would provide agronomic conditions of varying degrees of suitability for the production of this crop.

Accordingly a number of field experiments were conducted with the following objectives:

(1) In 1966 – To relate the performance of five cultivars of this crop to the climate and soil properties at 10 sites.

(2) In 1967 – To evaluate the influence of various fertilizer treatments on the yields of two cultivars at two sites with marked ecological differences.

This paper discribes these experiments and summarises the major findings.

METHOD

The potato crops were grown during the dry season period, extending from January to May.

1966 Experiment:

The five potato cultivars were Arran Consul, Green Mountain, Sebago, Kennebec and Red La Soda. The location of the sites and the properties of the soils are given in Table 1.

Rainfall during crop growth was recorded for the various sites.

The experimental plots varied in size from about 0. 05 to 0. 10 hectares. The experimental designs consisted of randomized complete blocks with 3 to 5 replications.

The plots were tilled, ridged and whole 'seeds' planted in the ridges at a spacing of 30 cm within the row and 90 cm between the rows and at a planting rate of about two tons per hectare. An 8:12:25 ($N:P_2O_5:K_2O$) complete fertiliser (widely used for bananas then) was applied at the rate of 1,100 kg per hectare by hand 10 cm to the side of the plant row about two weeks after the plants had emerged.

Crop protection measures consisted of spraying Peronox or Dithane mixed with Sevin at 10 day intervals. Hand weeding was carried out as required and the plots were each moulded once.

The two experimental sites in the Delcer area (No. 6 and 7) were attached to the open drain irrigation system which was operational in this area. Once a week water was allowed to flow through the open channels which crossed each plot in amounts sufficient to provide a wet soil surface throughout the plot. The Desruisseaux plot was watered once weekly through sprinkler irrigation.

Tubers were harvested shortly after the foliage showed the first signs of senescence and this was generally about 12 weeks after planting.

1967 Experiments:

Two of the most successful cultivars of the 1966 trials, Green Mountain and Kennebec were used for these experiments.

The location and soil properties of the two sites are given in Table 2. The crops were planted on the 17th and 18th of January at Belle Plaine and Balembouche respectively.

The experimental plot in both areas was about 0. 10 hectare in size and the plots were similar in geometry. The experimental layout was a split-plot design with cultivar as main plot with four replications. Six fertilizer treatments made up the sub-plot units. The levels of NPK and S in the fertilizer treatments are given in Table 4. The compositions of the fertilizer treatments were obtained by mixing the required supplements of ammonium sulphate, triple superphosphate and muriate of potash with the 'complete' 8:12:25 fertilizer. This high analysis 'complete' fertilizer was known to contain a negligible amount of sulphur and was used alone in treatment No. 4.

Whole 'seeds' were planted in furrows at a spacing of 31 cm within the rows and 76 cm between rows and at a rate of about two tons per hectare. Pre-emergence herbicides Lorox and T.C.A. were applied immediately after planting. The fertilizer treatments were side handed about one week after plant emergence. Crop protection measures consisted of fortnightly spraying with a cocktail of Peronox and Sevin. Hand weeding and moulding were carried out once at each site.

A sprinkler irrigation system was installed at the drier, low altitude site at Balembouche. Water was supplied whenever plant moisture stress was indicated through the plants developing a temporary state of wilt.

Time to harvest was determined as described for 1966 experiments.

RESULTS

1966 Experiments:

Relatively good yields were obtained for at least some cultivars at Belle Plaine (sites No. 1, 2 and 3) and at Giraud (site No. 4) (Table 3). Green Mountain was generally the highest yielding cultivar, producing yields of about 20 tons per hectare in the Belle Plaine (average over the three sites) and Giraud areas. The altitude of these two areas ranged from about 360 to 200 m and so the sites are referred to as 'middle' attitude sites. The weather was relatively cool during the experimental period. Rainfall during the crop growth period was well distributed and ranged from about 322 mm to 178 mm at the four sites (Table 3). The soil at each site was a sandy clay loam and was quite suitable for the required tillage practices.

Poor yields were obtained from sites No. 5, 6, 7, 8 and 9 which were located at altitudes below about 12 m. At Site No. 10 (near Quilesse) which was located at the highest altitide (550 m), the crop was completely devastated by disease symptomatic of 'late blight'.

Measured rainfall was quite low for sites No. 6 and 7, at Delcer. Rainfall for site No. 8 – Desruisseaux, was also apparently inadequate. At these sites, plants were often observed to be in an apparent state of physiological wilt during the day and the foliage of many plants dried up relatively early. Wilting was generally more evident after the flowering stage. Marble sized tubers formed most of the culls recorded for these sites in Table 3. Normal size tubers were obtained only from plants which were in wetter portions of the fields. A fungus whose white mycellium surrounded the base of the stem and the roots was associated with many plants which died at site No. 8 at Desruisseaux.

At site No. 5 (at Palmiste), mainly small sized tubers were produced by the Arran Consul cultivar and many of the larger tubers of this and other cultivars were knobby in shape. Although no rainfall data were available for this site, no dry spell was known to have existed in this area during the crop growth period. Mechanical analysis of soil samples taken during the experiment indicated that the soil type was clay loam (Table 1). STARK *et al* (1966) classified the site as having a loamy sand with fair water holding capacity and free to rapid drainage. Observations made during the study, support the drainage characteristics described by these authors.

At site No. 9, Union, disease and insect pest problems contributed to the low yields. The clay loam soil was heavy to work and the associated high water content under the high rainfall (Table 3) may have promoted the tuber rots and root diseases observed. It was noted that two of the blocks which were most severely affected by wilt problems coincided in location with a former tomato growing site.

The failure to carry out regular spraying for crop protection allowed the foliage disease to get out of control at site No. 10 near Quilesse. This is one of the wettest areas in St. Lucia.

1967 Experiments:

Measured rainfall at the 'middle' altitude site at Belle Plaine was about 620 mm (Table 2) and there was no indication of water stress at any time during the crop growth. Although the measured rainfall at the 'low' altitude site at Balembouche was as high as about 400 mm, it was still necessary to irrigate on two separate occasions. The lower values for rainfall and total number of rain days reflect the more sunny conditions observed at Balembouche than Belle Plaine during that period (Table 2). Measured maximum and minimum temperature were also higher at Balembouche than at Belle Plaine.

At both sites there was a significant response to fertilizer application and the cultivar Green Mountain produced significantly higher yields than the other cultivar, Kennebec (Table 4). There was no significant cultivar-fertilizer interaction in yield at either site.

According to the Duncan Multiple range test, the mean yields for control and fertilizer treatments fell into three groups (a, b and c) at Balembouche and two groups (a and b) at Belle Plaine. At Belle Plaine, treatment No. 4 which represented the highest levels of P and K, second highest level of N but negligible S did not produce significantly higher yield than Control. The other treatments, including No. 2 which consisted of less P and K, about same amount of N but more S than treatment No. 4, produced significantly higher yields than Control.

At Balembouche all fertilizer treatments produced significantly higher yields than Control. The mean yield from treatment No. 6 was significantly higher than treatments 2, 3 and 4 but not 5. There was no significant difference in yields among treatments 2, 3, 4 and 5. Only treatment No. 6 represented increases in N, P, K and S over treatment No. 2. As treatment No. 6 was also the only fertilizer treatment which produced significant yield increase over treatment No. 2, the importance of nutrient balance at Balembouche is indicated.

Commercially good yields were obtained for Green Mountain cultivar at both sites for all the fertilizer treatments applied (Nos. 2 to 6). The highest yields obtained for the two cultivars at both sites were associated with the 2:1:2 and 3:2:4 ratios of NPK (Table 4). Treatments 2 and 5 at Belle Plaine and treatment 6 at Balembouche produced yields of just under and above 20 tons per ha respectively for the Green Mountain cultivar.

DISCUSSION

In the 1966 experiments generally good yields were obtained from the Irish potato cultivars only at the four 'middle' altitude sites. These sites were generally cool and rainfall was well distributed during crop growth. The highest average cultivar yield for these sites was obtained from Green Mountain and this was about 20 tons per ha.

Poor yields were obtained for the cultivars at the five 'low' altitude sites. It was evident through soil conditions and wilting characteristics of the plants that water stress contributed to limiting yields at three of the latter sites which were located in the Delcer and Desruisseaux areas. The conditions of low rainfall, prevalence of sunny skies and exposure to blowing winds which characterised these sites would be expected to favour a high level of potential evapotranspiration (VAN BAVEL, 1966; SKIDMORE *et al*, 1969). Under these conditions the water supplied through irrigation as practised proved to be inadequate. The prevalence of moisture stress after the flowering stage as indicated by the wilted condition of the plants may have been responsible for the large percentage of marble sized tubers obtained at these sites. Lack of water after flowering and tuber set is reported to be reflected mainly in the small size of tubers. (SALTER and GOODE, 1967). The 'knobby' shaped tubers obtained at Palmiste, particularly from the cultivar Arran Consul, suggested the existence of an irregular supply of available water during tuber bulking (IVINS and MILTHORPE, 1963; SALTER and GOODE, 1967). The apparent low water holding property of the soil at this site may have been mainly responsible for the suggested periodic low available moisture supply. At the other low altitude site, Union, moisture supply was evidently ample for plant growth but the low yields were at least partly due to the disease and insect problems. The heaviness of this clay loam soil was also clearly unsuitable for the required tillage practices.

Although the four 'middle' altitude sites were cooler than the 'low' altitude sites, the effect of ambient temperature *per se* on yields obtained in 1966 could not be evaluated as the poor yields at the latter sites were also associated with other unfavourable factors discussed above.

In the 1967 experiments both the texture and the water supplying characteristics of the soils at the 'low' and 'middle' altitude sites were considered to be favourable for the production of the potato. Plant water stress was kept to a minimum through the adequacy of rainfall at the 'middle' altitude site and the supplementing of the water supply from rainfall with irrigation at the 'low' altitude site. Both maximum and minimum temperatures were higher at the low altitude site (Table 2). The pattern of yields obtained for the different fertilizer treatments at the lower Balembouche site indicated that when the supply of nutrients was adequate, the yield levels were as high as the highest obtained from the more elevated and cooler Belle Plaine site. Thus yields of about 20 tons per ha were obtained from Green Mountain for treatments representing the more balanced levels of NPK and S applied at both sites. Unlike the Balembouche site, there was no response to the higher levels of N, P, K, S in treatment 6 over treatment 2 at Belle Plaine. This result reflects the higher nutrient status of the Belle Plaine site which was indicated in Table 2.

The suggestion of response to sulphur by the two Irish potato cultivars in the 1967 experiments was supported by the findings of MESSING (1969). In pot experiments he obtained response to sulphur application by tomatoes grown in some soil types associated with the Balembouche and Belle Plaine sites of the 1967 experiments; viz. Avrogne and Balembouche soil types respectively (STARK *et al* 1966).

CONCLUSIONS

Studies carried out on the production of Irish potatoes in St. Lucia in 1966 and 1967 indicated that yields of about 20 metric tons per hectare (about 9 tons per acre) are obtainable from some potato cultivars, such as Green Mountain, grown on medium textured loam soils.

The main factors which were found to influence yields at the experimental sites representing a wide range of ecological conditions were: potato cultivar; the availability of soil moisture, particularly after the flowering stage; the levels of nutrients NKP and S supplied; and the efficacy of the crop protection measures adopted.

SUMMARY

Five cultivars of Irish potatoes *(Solanum tuberosum)* were grown at ten sites in St. Lucia between January and May, 1966.

Good yields (about 20 metric tons per hectare) were obtained from the cultivar Green Mountain at four sites with medium textured soils and located at altitudes ranging from about 200 to 360 m. At these sites the weather was cool and moist during crop growth.

Poor yields were obtained at the five sites located at 'low' altitudes (120 m and below) and the site at the highest altitude (550 m). Inadequacy of soil moisture appeared to have contributed to the poor yields at four of the lower sites. Disease and insect pests contributed to the poor yield at the other low site. Disease destroyed the crop at the highest site where crop protection measures were not properly carried out.

The studies carried out in 1967 showed that when water and nutrients, N, P, K and S were adequately supplied, yields of about 20 tons per hectare were obtainable from Green Mountain cultivar at both a 'low' and a 'middle' altitude site.

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Table 1

Location and soil properties of the sites for the 1966 Irish Potato experiments

Site		Location	Approx* Altitude (in metres)	Soil Type**	Chemical Analysis of Soil							
					pH	m.e. per 100 gm			% Base	%	C/N	ppm P
No.	Name					Ca	Mg	K	Sat.	N	Ratio	(Truog)
1	Bath Nursery	Belle Plaine	360	Sandy Clay Loam	5.9	8.9	2.0	0.47	85	0.21	11.4	8
2	Bath Nursery	Belle Plaine	360	Sandy Clay Loam	5.4	7.2	1.2	0.22	86	0.12	10.8	35
3	Beausejour	Belle Plaine	360	Sandy Clay Loam	6.2	6.7	0.2	0.61	100	0.16	9.4	5
4	Giraud	Giraud	200	Sandy Clay Loam	6.7	10.3	2.0	0.67	89	0.17	10.6	10
5	Palmiste	Palmiste (near Soufriere)	10	Clay Loam	6.4	11.6	2.2	0.23	100	0.11	7.3	77
6	Industry	Delcer	100	Sandy Clay Loam	7.3	9.4	3.0	0.34	100	0.08	8.8	144
7	La Pointe	Delcer	90	Sandy Clay	6.7	8.7	2.6	0.30	100	0.07	17.1	3
8	Desruisseaux	Desruisseaux	120	Clay	6.2	5.3	1.4	0.22	67	0.17	11.2	2
9	Union	Union Agric. Station	10	Clay Loam	–	–	–	–	–	–	–	–
10	Savanne Edmund	near Quilesse	550	Clay	5.1	1.7	0.8	0.51	12	0.55	6.5	2

*Determined from map of St. Lucia.

**Determined through mechanical analysis of soil samples taken during the study.

Table 2

Location and soil properties of the sites for the 1967 Irish Potato experiments and Meteorological data for growth period

Site				Chemical Analysis of Soil						Climatic Data for Crop Growth Period			
					Me. per 100 gm			%		Ave. Tem.		Rainfall	
No	Name	Approx.* Altitude (in metres)	Soil Type**	pH	Ca	Mg	K	Base Sat.	ppm P	C^0 Max	C^0 Min.	Total	No. of days
1	Balembouche	15	Gritty Clay Loam	6.5	6.3	0.9	0.22	81	9	28.9	22.2	400	53
2	Belle Plaine	360	Clay Loam	6.0	8.4	1.4	1.56	76	12	25.6	20.0	620	77

*Determined from map of St. Lucia

**Determined from Soil and Land Use Survey report No. 20 – St. Lucia.

Table 3

Yield of tubers of five potato cultivars grown at 10 sites in St. Lucia – 1966

Site No.	Area Located	Date Planted	Rainfall (mm)	Average tuber yield (Tons/ha) and percentage weight of Culls (in brackets). Arran Consul Yield	Green Mountain Yield	Kennebec Yield	Sebago Yield	Red La Soda Yield
1	Belle Plaine	26/1/66	322	13.3(8)	14.8(8)	9.6(11)	10.6(7)	12.4(10)
2	Belle Plaine	17/2/66	294	20.0(4)	24.5(7)	22.7(8)	8.7(10)	–*
3	Belle Plaine	25/1/66	322	17.3(4)	18.0(4)	10.9(4)	14.3(4)	19.0(10)
4	Giraud	18/2/66	178	13.8(11)	20.5(4)	17.1(4)	16.1(14)	–*
5	Soufriere	25/1/66	–**	4.7(**)	12.4(**)	6.7(**)	6.9(**)	9.6(**)
6	Delcer	26/1/66	53	4.0(24)	6.4(27)	5.4(12)	5.4(25)	5.4(17)
7	Delcer	27/1/66	53	3.5(30)	3.0(25)	3.0(20)	3.0(20)	4.7(23)
8	Desruisseaux	26/1/66	102	0.1 (about 90)	0.1 (about 90)	0.1 (about 90)	0.1 (about 90)	0.1 (about 90)
9	Union Agric. Station	8/2/66	444	3.2(6)	3.0(10)	5.9(9)	4.2(9)	3.0(9)
10	near Quilesse	26/1/66	470	0.0(–)	0.0(–)	0.0(–)	0.0(–)	0.0(–)

*Not Planted **Not determined

Table 4

The effect of different fertilizer treatments on tuber yields of two potato cultivars at two sites in St. Lucia

Treat No.	Nutrient Level (kg/ha)				Approx. Ratio			Average Tuber Yield (Tons/ha)					
								Balembouche			Belle Plaine		
	N	P	K	S	N	P	K	Green Mtn.	Kennebec	Mean*	Green Mtn.	Kennebec	Mean*
1	0	0	0	0	0	0	0	7.9*	8.8	8.3 c	12.7	8.6	10.6 b
2	83	37	69	68	2	1	2	15.3	11.5	13.4 b	19.3	16.5	17.9a
3	134	29	56	142	5	1	2	16.3	10.8	13.6 b	17.9	14.3	16.1 a
4	90	58	232	neg	3	2	8	16.0	12.5	14.3 b	15.5	11.9	13.7 ab
5	90	58	116	54	3	2	4	18.6	14.4	16.5 ab	19.3	15.3	17.3 a
6	134	58	116	109	2	1	2	22.2	14.6	18.4 a	18.3	15.0	16.6a
								S.E. =± 0.44**			S.E. =± 0.54**		

*Within each experimental site, values for mean yields flanked by a letter in common are not significantly different ($P > 0.05$)

**For fertilizer treatment means of corresponding site.

A SIMPLE TECHNIQUE OF CONTINUOUS IRRIGATION FOR HYDROPONIC SAND CULTURE

by

J. BROCHIER

Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières (I.R.A.T.) – Cayenne – French Guyana

SUMMARY

A technique of hydroponic sand culture of vegetables has been recently developed in French Guyana with a surface irrigation based on a drip system.

Efforts to simplify this method have led to the use of a porous tubing buried in the sand of the cultivation tank. Two experiments are described for the development of such technique. The choice of a proper water pressure allows it to irrigate continuously. The flow rate of irrigation water through the porous material of the tubing is increased or reduced by the water tension in the sand. Curves of water use compared with the evapotranspiration show a close relation.

INTRODUCTION

Hydroponic sand culture is now widely used in French Guyana, for vegetable production.

Research was continued for helping growers to solve their problems when using such a method, and also for improving this technique of sand culture which has been recently developed in this country. The main purposes are the reduction of investments, further simplications of the management, and higher yields.

Recently large improvements in simplication and reduction of production cost were obtained by the technique of drip or trickle irrigation, (1) which gave very significant reduction in investment (2) because of the possible use of cheap materials such as plastic sheets to build the cultivation tanks. This technique of drip irrigation on sand culture is already used with success by some vegetable growers of French Guyana. Nevertheless in the long run, some problems appeared with clogging; this is mainly due to salt deposits from the nutrient solution which dries up between the daily irrigations; this involves frequent inspection.

Another problem remaining to be solved was the amount of water needed for irrigation. This can change from 1 litre/m2 to 9 litres/m2 for the same crop per 24 hours. Weather conditions in French Guyana change so fast during a short period of time, that irrigation must be adjusted every day, based on the observation of the sand moisture.

Those problems are to be solved, keeping in mind that the main advantage of the drip irrigation system must remain.

These are as follows:

The irrigation water must be rapidly available to the plant.

Water movements in the sand should be extremely reduced for preventing soil borne pest dissemination.

The slope of the tank should not be a critical requirement because of unstable soils.

The cultivation tank and irrigation system must be cheap to build and easy to manage.

This paper will describe two of the trials made to solve those problems with the use of a porous plastic tubing.

TRIAL NO. 1

MATERIAL AND METHOD

Three cultivation tanks under plastic greenhouse with open sides are built in the following way:

A trench is excavated, 1 metre broad, 10 cm deep and 25 metres long. A slope of 0.25% is leveled, in the bottom of the trench. The edges are made with excavated soil and have a 45^{o} angle.

A 200 microns sheet of black plastic is laid in the trench, covering largely the edges.

At the bottom of the tank is laid perforated PVC pipe, as drainage.

A 12 cm layer of beach sand is leveled in the tank (80% of its particule size weight is in the range of 400 to 800 microns). It is washed with water to leach the salt.

A porous irrigation plastic tubing type "VIAFLO"* is buried in the sand, 5 cm deep. One tubing for one row of crop, in one cultivation tank.

The two other cultivation tanks are provided with twin wall hoses for drip irrigation, one per row of crop.

Tomato seed, variety FLORADEL, was sown on November 20th and planted in the cultivation tank on December 20th, spaced by 60 cm between the lines and 30 cm on the row. The plants were pruned and trained. The first harvest was made on February 6th and ended by April 2nd.

Chemicals pest control treatments were made weekly with a mixture of Dicofol and Tetrafidon for aphid control.

* produced by DU PONT DE NEMOURS.

IRRIGATION

The two cultivation tanks irrigated with the twin wall hose system received a daily irrigation of 120 1 of nutrient solution – 4.8 litres/m2.

The porous tubing was fed continuously with a nutrient solution. A float kept a constant water level in a barrel set at one metre over the cultivation tank surface. This one kg pressure was maintained during the whole cycle without any change. The water thus used in the cultivation tank was daily recorded, by measuring the change of level in a large nutrient solution tank, which was feeding this cultivation tank.

As meteorological data, Piche evaporation, maximal and minimal temperature were daily recorded.

RESULTS AND DISCUSSION

Observation

The plants were severely stunted during the early stage by crease stem. This physiological disorder was due to the use of a nutrient solution generally applied during the rainy season. The plants recovered but setting and maturity were delayed. The weather, during this trial, had been exceptionally warm and dry.

The yield was severely reduced as compared with what we get generally (around 10 kg/m2 for trickle irrigation with the twin wall hose). The porous tubing gave a somewhat smaller yield than the drip irrigation with the twin wall hose, considering the crease stem incidence, this difference will not be considered as meaningful.

Nevertheless our main purpose was to study this irrigation and water consumption.

The yields are as following:

	Twin wall hose		*Porous tubing*
Yield per tank (g)	90 300	59 350	63 050
Yield per m2 (g)	3 612	2 374	2 522
Yield per plant (g)	516	361	370
Average yield per m2 (g)	2993		2522

The water consumption is recorded from *January 28th.* The first of April shows a total amount of 320 mm per m2. The compared evapotranspiration (ETP) calculated by HOUCHET formula*, for the same period of time shows a total of 316 mm. Penman formula would be better but all the data were not available for its calculation.

Graph No. 1 shows the variations given by the daily average of water consumption and ETP of five day periods.

The two curves show some similarities, nevertheless the lower water consumption at the end of the cycle as compared with the ETP remains unexplained. It may be that ETP calculated by BOUCHET formula during this period with comparatively dry and windy weather was higher than in the reality.

The most spectacular result is in the great variation in the rate of water released from the porous tubing, as shown in graph No. 2. The water

*ETP = Ep (0)

ETP = evapotranspiration in mm/day

EP = Piche evaporation in 24 h(mm)

= 0.37

= coefficient related to temperature 0 (table)

$= o\,m + \frac{OM - Om}{4}$

flow can change from 2 to 7 and sometimes up to 10 mm per m2, as water is needed in the cultivation tank. Water daily consumption curve generally follows ETP curve. The water released from the porous tubing is increased as the suction increases in the sand. An attempt to get some suction data with tensiometers did not succeed because the sand was too coarse.

CONCLUSION

This system of continuous irrigation does work. Under the conditions of this experiment, other yield data show similar yield performances as compared with other drip irrigation systems. It is a great improvement as far as management is concerned. It is simple, safe, and without clogging problems. It saves time, since no care is needed as long as nutrient solution is available to feed the irrigation system.

Other trials remain to be done to control the water needed with more accuracy and to compare it with water provided by the porous tubing, as well as to know more exactly the performances of this material.

TRIAL NO. 2

The purpose of this trial is to test the porous tubing irrigation system with a long size tank: 100 metres long.

MATERIAL AND METHOD

The cultivation tanks are built with the same material and the same method as in the first trial, but the cultivation tank is 100m long with 1 m broad.

The lettuce variety *NORAN* was sewn in a germination flat on April 17th then transplanted in the nursery and was planted in the cultivation tank on May 12th with a plant spacing of 20 cm x 20 cm. The lettuce was harvested on June 7th.

IRRIGATION

A water pressure of 3 kg was empirically determined. The first ten days 300 litres of nutrient solution or 3 l/m2 were applied; then 500 litres were daily applied until harvest. No pesticide treatment was made. The water outflow was 100 l/hour.

RESULTS AND DISCUSSION

Observation:

The row of lettuce in the centre of the tank was not sufficiently irrigated, showing a very poor development owing to lack of water and nutrients.

The other rows were correctly irrigated and produced lettuce of good quality.

Yield

The total yield was 92,600 kg or 926 g/m2 – this is low as compared with the yield obtained with the variety NORAN grown with sand culture capilarity or trickle irrigated, which produced 1.5 kg/m2. This was mainly due to the poor irrigation of the central row of the cultivation tank. This could be corrected by a higher water pressure.

The yield along the tank appeared very irregular and showed a lower production at the lower part of the cultivation tank (graph 3). This could also be corrected by a higher water pressure.

CONCLUSION

This trial shows that irrigation with the porous tubing system may be promising for cultivation tanks as long as 100 metres. Nevertheless a rather high water pressure must be used, up to 4 kg. With such water pressure this irrigation system cannot be used continuously, its management must be based on daily observations of the sand moisture level.

The porous tubing irrigation has the advantage over the other trickle irrigation systems in avoiding clogging and consequently in simplifying the management.

* * *

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EVALUATION OF CHEMICALS FOR THE CONTROL OF NEMATODE POPULATION IN CABBAGE

by

N. D. SINGH
Department of Crop Science, the University of the West Indies, St. Augustine, Trinidad, W.I.

ABSTRACT

There were significant differences in the effectiveness of the chemicals, Lannate 90% W.P., Dowfume (MC–2), Mocap 10% G, Nemagon 75% E.C. and Nemagon 92% G for the control of plant parasitic nematodes, *Helicotylenchus dihystera, Meloidogyne incognita, Pratylenchus zeae, Tylenchorhynchus* sp and *Rotylenchulus reniformis* in cabbage. Dowfume and Mocap were more effective in controlling the nematode populations.

INTRODUCTION

Cabbage *(Brassica oleracea* var. *capitata)* is a high income cash crop cultivated intensely in the Commonwealth Caribbean. Reduction in yield of cabbage has been attributed partly to plant parasitic nematodes. Many farmers practise vegetable crop rotation but this method does not seem to be effective in preventing the build up of nematodes. Most of our cultivated fields are infested with large numbers of plant parasitic nematodes (1, 2, 8, 9, 10). Control of these parasites is essential especially where high-value vegetable crops are to be successfully grown.

The purpose of this investigation was to evaluate the effectiveness of different chemicals for the control of plant parasitic nematodes in cabbage.

MATERIALS AND METHODS

The experiment was carried out on River Estate sandy clay loam soil at the University Field Station, Trinidad, during the months of March through the 1st week of June, 1972. A sample of the top 20 cm of soil comprised 55 percent sand, 22 per cent silt and 23 per cent clay and had a pH of 4.5 and a cation exchange capacity of 8 me per 100 g soil. The site selected was infested predominantly with *Pratylenchus zeae* Graham 1951; *Helicotylenchus dihystera* (Cobb, 1893) Sher, 1961; *Rotylenchulus reniformis* Linford and Oliveira, 1940; *Tylenchorhynchus* sp and *Meloidogyne incognita* (Kofoid and White, 1919) Chitwood, 1949. Treatments included 1, 2 – Dibromo – 3 – chloropropane and other halogenated hydrocarbons (Nemagon 75 per cent E.C. and Nemagon 92 per cent G at 22.46 1 and 34.72 kg a.i. per ha respectively); O – ethyl, s, s – dipropyl phorodithioate (Mocap 10 per cent G at 13.44 kg a.i. per ha); methy bromide 98 per cent plus chloropicrin 2 per cent (Dowfume MC – 2 at 813.12 kg per ha).

Nemagon 75 per cent E.C. was injected 20 cm deep at loci 20 cm apart in a diamond-shaped pattern. A Shell hand gun was used to apply the liquid and holes were sealed with the shoe heel. Grandular materials (Mocap 10 per cent G and Nemagon 92 per cent G) were spread by hand on the soil surface and incorporated with a hoe. Lannate 90 per cent W.P. was mixed with water and applied as a soil drench. Methyl bromide (MC–2) was applied under a polyethylene cover which was removed after 48 hours.

A randomized block design with four replicates was used. Each plot was 6.1 m long by 1 m wide. Two weeks after soil treatments, six-week old cabbage (var. Green Express) seedlings were transplanted in double rows with spacing 0.6 m apart by 1 m wide in each plot. The plants were sprayed twice weekly with "Dipel" against cabbage "Loopers", *Trichosplusia* sp. (7)

Soil samples were taken from each plot at 2 months after soil treatments for nematode counts (5). Each sample (200 ml) was processed by modified Cobb's decanting and sieving method (4). Duplicate samples consisting of ten per cent of each nematode suspension were examined under the stereo-microscope and nematode counts made. The fresh weight of cabbage was also recorded in the early stages but later discontinued due to praedial larceny.

RESULTS AND DISCUSSION

The analysis of Variance with a ln (x+1) transformation (3) of nematode counts showed significant differences (P =0.05) in the effectiveness of the chemicals against populations of *Pratylenchus zeae, Helicotylenchus dihysteria, Rotylenchulus reniformis, Tylenchorhynchus* sp. and *Meloidogyne incognita* (Table 1). Dowfume (MC–2) and Mocap 10% G were most effective in controlling all nematodes at two months after soil application. Except for *P. zeae,* Nemagon 75% E.C. significantly reduced all other nematode populations. Previous studies have shown that Lannate 90 per cent W.P. and Nemagon 20 per cent G were least effective on the nematode populations in sweet pepper (10). Similarly, Laughlin et al (6) found that Lannate 10 per cent G did not affect *Pratylenchus* sp. in cabbage. Lannate, a systemic insecticide-nematicide, was ineffective against *Trichosplusia* sp. when applied as a soil drench. Foliar application might have been effective (7).

In the absence of yield data, it was not possible to show any correlation between reduction of the nematode populations due to the various chemical treatments and the yield.

No evidence of phytotoxicity was observed in plants growing in the treated plots.

Table 1

Effect of Chemical Treatments on Reduction of Nematode Population in Cabbage (Mean of four replicates)

Chemical Treatment	Rate per Hectare (active)	Percent Reduction in Nematode Populations				
		Pratylenchus zeae	*Helicotylenchus dihystera*	*Rotylenchulus reniformis*	*Tylenchorhynchus sp.*	*Meloidogyne incognita*
Lannate 90% W.P.	5.6 kg	11 bc[2]	32 b	23 bc	38 c	2 c
Mocap 10% G.	13.44 kg	89 ab	87 a	90 b	92 b	76 ab
Dowfume MC–2	813.12 kg	100 a	98 a	97 a	100 a	86 a
Nemagon 75% E.C.	22.46 1	74 abc	89 a	89 b	87 b	77 a
Nemagon 92% G.	34.72 kg	60 bc	48 b	38 bc	32 c	24 abc
Control	–	35[3] c	233 b	1924 c	308 c	66 c

1 **Based on counts from non-treated controls.**

2 **Means in columns flanked by a letter in common do not differ significantly (P >0.05)**

3 **Number of nematodes per 200 cc soil sample for controls.**

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A GREENHOUSE TRIAL OF THE EFFICIENCY OF VITAMON D AND ENMAG AS SLOW RELEASE FERTILIZERS USING PANGOLA GRASS *(Digitaria decumbens)*[1]

by

B. R. COOPER

Department of Crop Science, The University of the West Indies, St. Augustine, Trinidad.

INTRODUCTION

There has been increasing interest in recent years in the development of fertilizers with the property of controlled, gradual release of nutrients, in the hope that they might provide a more efficient supply, especially of nitrogen and also reduce or eliminate the need for multiple applications during the season (Lunt *et al,* 1962). One approach to the problem has been to encapsulate the fertilizer grannule in some hydrophobic substance, thus reducing its rate of dissolution. Another approach has been the search for less soluble compounds that are only gradually broken down in the soil. (Army, 1963).

Tests of these new materials have met with varied success. (Dahnke, *et al,* 1963, Forbes, 1966 and Lunt, 1968). Best results appear to have been obtained on light soils, under crops responsive to high nitrogen fertilization, such as forage grasses and maize (Lunt, 1968, Mays and Terman, 1969). Efficient nitrogen supply to soils of the humid tropics has up to now been managed by frequent applications of fertilizer in order to reduce losses by leaching and denitrification. The use of controlled release fertilizers suggests itself as a possible alternative under certain circumstances.

[1] A paper prepared for the Eleventh Annual Meeting of the Caribbean Food Crops Society held in Barbados from 1st July to 7th July, 1973.

The present trial was set up to investigate the efficiency of two fertilizers of this type. Vitamon d is a polyvinyl chloride encapsulated compound fertilizer and Enmag a magnesium ammonium phosphate type. Pangola grass was selected as a good indicator of nitrogen supply as it is known to respond to heavy fertilization, both in the field (Vicente-Chandler et al, 1964) and pots (Eves, 1971).

MATERIALS AND METHODS

The work was carried out in an open sided greenhouse at St. Augustine. Pangola grass obtained from the University Field Station was planted as root sets, six per metal Mitscherlich pot containing about 6.2 kg of a dry loamy sand with an average composition of 0.1, 2.1 and 0.6 meq. of exchangeable K, Ca and Mg respectively, 64 pots arranged in a randomized complete block of 16 treatments included four replications. The 16 treatments comprised one control with no fertilizer added, and three levels each of the following fertilizer treatments:– normal compound fertilizer 13-7-13 plus 4% MgO (F); Vitamon d 13-7-13-4 mixed with the soil (v); Vitamon d applied to the surface (VS); Enmag 5-24-10-16.6 mixed with the soil (E) and Enmag applied to the surface (ES). Levels 1, 2 and 3 of each fertilizer supplied 0.26, 0.53 and 1.05GN per pot equivalent to 84, 168 and 336 KgN/per ha respectively. 300ml of tap water was supplied to the pots three times per week or more often as required from observation of the pots. The amounts of water added were calculated to approximate local rainfall rates.

Top growth of the grass was harvested every five weeks by cutting at 2.5 cms. above soil level. Fresh and dry weights were determined before the material was ground and ashed for analysis of the major nutrients.

The volumes of the leachate from the pots comprising one complete block were measured before submitting samples for chemical analysis. The grass was sprayed every 10–14 days with Malathion to protect against insect attack.

RESULTS

Fresh and Dry Weight Yields:

All tests of significance between means were made at the 5% level using the Duncan's Multiple Range Test. It will be seen from Tables 1 and 2 that maximum yields were obtained from harvest 2, the amount decreasing steadily in later harvests. Establishment was obviously not complete by harvest 1, no treatment being significantly greater than the control. It appeared as though the higher rates tended to show a depression of early growth. By the second harvest establishment was complete and growth was rapid, however, there was no significant difference between treatments or levels except between the control and all other treatments. Maximum yield was shown by E2S. Unfortunately no dry weight data were obtained for this harvest.

The 3rd harvest began to show up some differences between treatments although all mean yields had decreased relative to the 2nd harvest. On a fresh weight basis E3 showed maximum yield and significantly out-yielded F3, V3 and V3S. E3S also out-yielded these three treatments. All treatments except E1S were significantly greater than the control. On a dry weight basis, however, F3 showed maximum yield owing to a much higher per cent dry matter, but was only significantly greater than the control and the F2, V1, V1S, V2S, E1S and E2S treatments.

By the 4th and 5th harvests the plants were showing successively poorer growth and some definite signs of nutritional deficiency. Fresh and dry weight yields of E3 were highest in the 4th harvest, and fresh weight yield of E3 was highest in the 5th harvest also; however V3 yielded slightly higher dry weight than E3 in this harvest. All level-3 treatments significantly out-yielded the control at the 4th harvest while only the highest levels of the slow release fertilizers V3, V3S, E3 and E3S were significantly greater at the 5th harvest. Fresh weight of E3 in the 4th and fresh and dry weights in the 5th harvest were significantly greater than F3. V3S also out-yielded F3 on both counts in the 5th harvest.

TABLE 1

Mean fresh weights of pangola grass tops (g/pot) after different fertilizer treatments

Treatment		HARVEST					
Fertilizer	N applied Kg/ha	1	2	3	4	5	Total
	Control	19.6	28.2	22.3	16.3	7.7	94.1
13-7-13	84	23.6	58.5	44.6	25.3	12.6	164.6
+4% Mg	168	13.8	63.4	40.3	20.9	9.5	147.9
	336	14.6	58.9	39.9	44.6	14.7	172.7
Vitamon d	84	19.6	63.6	39.1	28.4	9.7	160.4
mixed with soil	168	20.3	67.4	47.6	34.1	17.2	186.6
	336	17.5	64.8	38.0	51.2	19.5	191.0
Vitamon d	84	24.6	52.6	37.7	32.4	8.3	155.6
applied to	168	16.3	57.1	38.8	38.0	16.7	166.2
Surface	336	16.6	64.9	40.4	53.8	26.2	201.9
Enmag mixed	84	24.0	64.4	46.1	29.4	12.8	176.7
with Soil	168	16.2	62.6	39.9	41.9	14.8	175.4
	336	13.2	61.4	53.4	64.2	29.0	221.2
Enmag applied	84	19.5	63.1	27.7	21.3	8.0	139.6
to Surface	168	17.0	72.3	38.8	28.8	13.7	170.6
	336	9.6	61.6	52.6	45.7	21.3	190.8
Overall Mean		17.9	60.3	40.5	36.0	15.1	168.8

TABLE 2

Mean Dry Weights of Tops (g/pot)

Treatment	HARVEST				
	1	2	3	4	5
Control	2.7		4.0	2.5	1.4
F1	3.4		8.8	4.5	2.2
F2	2.3		8.1	3.7	1.8
F3	2.3		11.6	8.2	2.7
V1	2.8		7.3	4.7	1.7
V2	3.0		9.1	5.9	3.0
V3	2.7		8.8	8.1	3.8
V1S	3.5		7.3	5.1	1.6
V2S	2.5		7.8	6.2	2.8
V3S	2.5		10.0	8.6	4.5
E1	3.3		9.4	5.0	2.2
E2	2.6		11.0	7.4	2.6
E3	2.4		11.6	9.9	4.9
E1S	2.8		5.3	3.0	1.4
E2S	2.5		7.9	4.4	2.3
E3S	1.6		9.8	7.7	3.3
Average	2.7		8.6	5.9	2.6

Table 3

Tissue Analysis, Nitrogen (% ODM)

TREATMENT	HARVEST			
	1	2	3	4
0	2.86	1.46	1.16	1.23
F1	2.77	2.17	0.87	1.18
F2	2.93	1.82	1.12	1.24
F3	2.92	2.32	1.45	1.21
V1	2.90	1.87	1.05	1.40
V2	2.75	2.09	1.24	1.43
V3	2.92	2.46	1.80	1.78
V1S	2.91	1.40	1.02	1.37
V2S	3.05	1.89	1.10	1.56
V3S	2.97	2.33	1.49	1.34
E1	2.93	1.87	0.91	1.00
E2	2.83	2.45	1.04	0.99
E3	2.79	2.75	2.04	1.68
E1S	2.81	1.35	1.00	1.62
E2S	3.07	2.23	1.13	1.23
E3S	3.15	2.28	1.83	1.05
Average	2.91	2.05	1.27	1.33

Tissue Analysis: Data for harvests 1 through 4 only are available

NITROGEN

Nitrogen content of the tops decreased steadily from a maximum at the first harvest where the average overall treatments was 2.9% N. to 1.3% N at the 4th harvest (see table 3). Few significant differences were observed at the first harvest only E3S at 3.15% N showing significantly higher concentration than F1, V2 and E3.

E3S was again highest at the second harvest with an N concentration at 2.04% N, a significantly higher concentration than was obtained from either F3 or V3S treatments; E3S was also significantly greater than these two treatments. V3, but not V3S, was also significantly higher than F3. All slow release fertilizer treatments at the highest level gave N concentrations significantly greater than either their low or middle levels. F3 was significantly higher than F1 but not F2.

By the 4th harvest the pattern had changed somewhat, V3 providing the highest N concentration of 1.8%, with E3 slightly less, both treatments yielding concentrations significantly greater than F3, V3S and E3S. The poor growth of E1S was evidently not related to low N concentration in the tissues as this treatment ranked next below V3 and E3 at 1.6%.

OTHER ELEMENTS

Owing to the fact that fertilizer compositions were different except in the case of Vitamon d and the mixed fertilizer, amounts of the elements other than nitrogen added to the pots at corresponding levels of the different treatments were not the same. Therefore, consideration is restricted to the comparisons of the mixed fertilizer and Vitamon d treatments:

(a) Phosphate – Concentrations averaged over all treatments ranged from 0.32% P to 0.16% in the 1st and 4th harvests respectively. No very significant pattern was observed except that higher fertilizer levels generally produced greater concentrations in the plant tissues. There was a slight tendency for F treatments to yield greater tissue concentrations than V or VS treatments at the same level.

(b) Potassium – At the 1st harvest, concentrations of potassium were high, averaging 4.0% but decreased steadily to 2.2% by the 4th harvest. In all except the 2nd harvest, V3 supplied higher concentrations of K than F3 but differences were not significant except in the 4th harvest. There was no observable difference between VS and V treatments.

(c) Calcium – The average calcium content decreased from 0.47% at the 1st harvest to 0.33% at the second, after which it remained fairly constant at about 0.37%. In the first harvest only, calcium levels were significantly higher in all V and VS treatments than in F1 and F2 treatments. Differences between F3 treatments were not significant. In later harvests few significant differences between F and V or VS treatments were observed.

(d) Magnesium – Average magnesium levels decreased steadily from 0.39% in the 1st harvest to 0.26% in the 4th. No consistent pattern of any significant differences between levels of Mg obtained by any of the three sources F, V or VS could be detected.

Leachate Analysis

Results obtained from analysis of the leachate at intervals during the 25 week period produced some indication of the concentration of the nutrients being lost from the pots by this route. However, results were rather variable and no duplication of samples was possible. Results obtained indicated that there was a heavy initial loss of N in the leachate collected from F treatments, increasing markedly with the level of fertilizer applied (see tables 4 and 5) reaching almost 2000 ppm

N from the F3 treatment, a level 7 to 20 times the concentration from the slow release treatments at similar levels.

This high initial concentration decreased rapidly in the first few weeks and by week 8 had dropped in all treatments to 10 ppm or less, and to less than 5 ppm from most treatments by week 11. The loss of nitrogen in the first 3 weeks amounted to approximately 80% of that added in F3 treatment, and only 2–3% for the VS and V3S treatments. Enmag behaved similarly.

Increasing levels of nitrogen supplied in the slow release fertilizers did not cause any marked increase in the concentration of N in the leachate in contrast with the results observed for the three F treatments.

Surface application of the fertilizer did appear to reduce slightly the initial loss of N but this tendency was not maintained in subsequent samples.

Recovery Data

Nitrogen recovery data were estimated for the second harvest on the basis of an assumed mean dry weight percentage of 16% fresh weight. The overall recovery figures for the first four harvests are shown in table 6. Consistently high recovery figures for the lowest level treatments were observed and in all cases, percent recovery decreased as rates of nitrogen increased. At 336 kg, N/ha recoveries ranged from 51 to 70%.

Table 4

Concentration of Nitrogen in leachate (ppm)

Period ending Week	TREATMENT					
	0	F3	V3	V3S	E3	E3S
3	72	1870	76	68	324	58
6	40	292	34	36	64	82
8	7.8	6.6	2.6	1.6	1.6	2.0
11	4.8	4.4	4.4	1.6	1.8	3.2

Table 5

Cumulative amounts of Nitrogen lost in leachate (mg N)[1]

Period ending Week	TREATMENT					
	0	F3	V3	V3S	E3	E3S
3	37.8	842.0	21.3	29.9	128.0	28.4
6	53.6	972.0	34.9	28.4	162.2	65.8
8	59.0	974.7	36.4	49.0	162.9	67.0
11	65.1	974.9	37.4	49.1	163.4	68.9

[1] Initial soil nitrogen was 5,600 mg N/pot.
1,050 mg N was added as fertilizers to all pots except control (0)

Table 6

Estimated nitrogen recovery by pangola grass from soil given various fertilizer dressings

Treatment	Harvest mg N/pot				Total N Recovered mg N/pot	% N Recovered
	1	2	3	4		
0	77.2	68.8	46.2	30.3	222.5	–
FI	93.9	203.0	77.2	53.1	427.2	164
F2	67.3	185.6	90.9	45.2	389.0	73
F3	67.1	218.0	167.7	98.8	551.6	53
VI	81.6	190.2	76.5	65.6	413.9	159
V2	83.7	225.5	113.2	84.1	506.5	96
V3	78.5	255.0	158.9	144.6	637.0	61
VIS	101.4	117.8	74.5	69.6	363.3	140
V2S	75.2	172.7	85.9	97.0	430.8	81
V3S	75.6	242.0	148.2	114.7	580.5	55
EI	98.0	203.4	85.2	49.9	436.5	168
E2	72.0	244.8	114.2	73.0	504.0	95
E3	65.6	270.0	235.1	165.7	736.4	70
EIS	78.1	136.9	53.0	48.7	316.7	122
E2S	75.2	258.0	88.6	53.4	475.2	90
E3S	50.9	225.0	179.3	81.2	536.4	51

DISCUSSION AND CONCLUSIONS

The results indicate that both Vitamon d and Enmag fertilizers were capable of producing greater fresh and dry weight yields of Pangola grass than the controls under the conditions of the trial. The effect was significant at the highest levels of fertilization after 20 weeks of growth. Enmag appeared to be somewhat more effective than Vitamon at the highest rate. More clear cut results would probably have been obtained had a slightly more fertile soil been used. There were signs of micro-nutrient deficiency symptoms in some treatments in later harvests, especially in the re-growth following harvesting. High soil temperatures – 89° to 90° were measured in several pots under normal weather conditions. At these temperatures, dissolution of the nutrients from the slow release fertilizers is expected to be considerably more rapid than at temperate soil temperatures (Lunt, 1962).

Results of yields, tissue nitrogen concentrations and leachate nitrogen indicate that at least some slow release of nitrogen was maintained by these fertilizers. Nitrogen recovery data, though approximate, do not indicate any striking correlation with the slow release fertilizer treatments. Figures are comparable to those of conventional fertilizers obtained by other workers in both greenhouse (Eves, 1971) and field experiments (Whitney and Green, 1969). Surface placement, particularly of Enmag, does not appear to be as satisfactory as incorporation with the soil.

These results agree with successful tests of other coated fertilizers tested under Trinidad conditions (Ahmad and Whiteman, 1969; Shand, 1973), and suggest that further testing of a variety of slow release fertilizer types in the field and greenhouse with a variety of crops could be well worthwhile.

SUMMARY

Vitamon d, 13-7-13-4, and Enmag, 5-24-10-16.6 were compared with a normal fertilizer mixture as nitrogen sources in a pot experiment

on a loamy sand soil in a randomized block design. A control and three levels of each fertilizer supplying the equivalent of 84,168 and 336 Kg N/ha were combined with mixed and surface placement treatments in four replications. Yields of Pangola grass *(Digitaria decumbens)* were obtained at five week intervals. Tissue analyses of the tops for N, P, K, Ca and Mg were carried out, along with the analysis of samples of leachate collected from a selection of pots.

Despite much variability and poor growth of the grass after the 15th week, at the highest rates tested, Enmag showed significantly greater yields (at the 5% level) at the 20th and 25th weeks, and Vitamon at the 25th. Tissue analysis confirmed a greater uptake of N from slow release sources at the 15th week. Rapid loss of N in the leachate from the normal fertilizer treatments was observed. Losses were considerably less from the slow release fertilizers.

Further evaluation is necessary to determine the economic importance of these fertilizers.

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MEASUREMENT AND ESTIMATION OF EVAPOTRANSPIRATION IN FRENCH WEST INDIES

R. BONHOMME, C. VARLET GRANCHER

Station de Bioclimatologie, I.N.R.A.

Petit-Bourg Guadeloupe F.W.I.

SUMMARY

Measurement of maximal evapotranspiration (ETM) of crops are compared with potential evapotranspiration (ETP) computations from Penman, Thornthwaite, Blaney–Criddle, Turc, Makkink. Correlations between ETM and solar radiation, insolation or pan evaporation are also calculated for 1966–1969 period. The validity of ETP estimates is discussed either for planned regional irrigation or for water used by crops over short periods.

INTRODUCTION

In tropical areas agriculture have more and more recourse to irrigation. Thus it becomes necessary to know water requirements of crops to be irrigated. We used potential evapotranspiration (ETP) to estimate water requirements of a plant cover because these two data are always correlated for a given locality. Measurements of water use of a crop (maximal evapotranspiration ETM) were compared to results from calculation to verify the validity of several formulae.

MATERIAL AND METHODS

I.N.R.A. Experimental Station has eight square lysimeters (2 m^2 each one) planted with pangola grass *(Digitaria decumbens)* kept in good growing condition. ETM are measured during a minimal 10 days period. This equipment is completed by a meteorological station: OMM screen, anemometers (2 m and 15 m), heliograph (Campbell – Stokes), pyranometer (Moll), pan evaporation (Class A), rain-gauge.

Formulae used for calculation were chosen according to respective parameters:

THORTHWAITE and BLANEY – CRIDDLE: temperature and daylength,

TURC and MAKKINK: radiation and temperature,

PENMAN: radiation, temperature, humidity, wind and insolation.

Some simple correlations between ETM and global radiation, insolation and pan evaporation were also carried out.

RESULTS AND DISCUSSION

Measured values for ETM (1966 to 1969) were relatively constant from April to September (4 – 5 mm), outside of this period they are lower and more variable (figure 1).

ETP values for 1968 obtained from calculation with different formula and ETM measurements are showed by figure 2. More accurate comparisons are given for the four considered years (Table 1).

Relationships between ETM and

- measured global radiation G
- estimated global radiation G' from insolation (BONHOMME, VARLET GRANCHER, 1973)
- pan evaporation E

were also calculated (Table 2).

Evapotranspiration estimates used to plan regional irrigation and water resource development require only annual ETP. In this case use of BLANEY–CRIDDLE or TURC formulae give very good estimates but other means for calculation gives too low estimates.

To evaluate the water requirements of a crop it is important to estimate ETP with a sufficient accuracy into short periods (10 days for instance). Then it appears that no formula give a very good result and each one has to be adjusted. It therefore seems easier to use relationships between ETM and global radiation or insolation or pan evaporation (Table 2). However these statistical adjustments are not valid in all conditions and the ability to extrapolate these results for other areas has to be checked.

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Figure 1

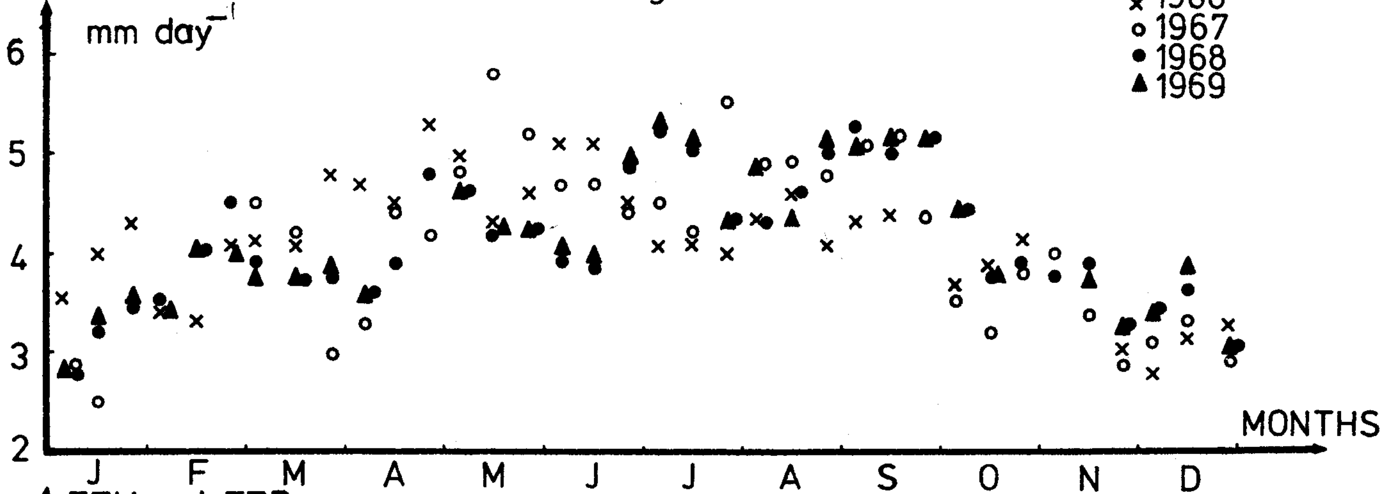

Figure 2

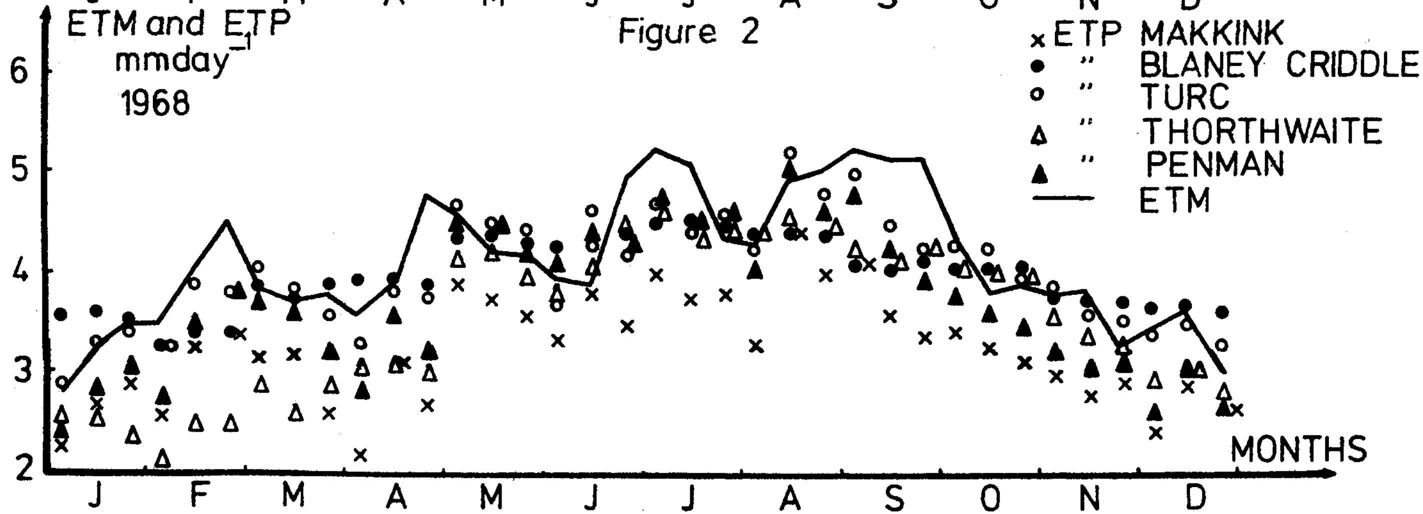

Table 1

Correlations between ETP (computed) and ETM (measured) 1966 – 1969

ETM = a ETP + b; daily mean for a period of ten days; n = 150

r: regression coefficient

$\sigma_{y,x}$: standard deviation from regression

ETP	a	b	r	$\sigma_{y,x}$	Annual ETM/ETP
PENMAN	0,72	1,5	0,72	0,5	0,88
MAKKINK	0,97	0,9	0,72	0,5	0,79
BLANEY–CRIDDLE	1,18	– 0,7	0,72	0,6	0,99
TURC	0,86	0,6	0,67	0,6	0,98
THORTHWAITE	0,63	1,8	0,62	0,6	0,88

Table 2

Relationships between ETM and climatic factors 1966 – 1969

ETM = a X + b; daily mean for a period of ten days
n = 150

X	a	b	r	$\sigma_{y,x}$
global radiation G measured cal cm^{-2} day^{-1}	0,008	0,6	0,74	0,5
global radiation G' estimated from insolation ⁎	0,008	0,5	0,68	0,6
Pan evaporation E "Class A", mm day^{-1}	0,54	1,5	0,73	0,6

⁎ $G' = G_o (0,26 + 0,51\ s/s_o)$ for Guadeloupe
G_o (extraterrestrial radiation) and s_o (daylight) given by tables; s measured by heliograph.

SOME ASPECTS OF AVOCADO PROPAGATION AND DISEASES ASSOCIATED WITH NURSERY SEEDLINGS IN BARBADOS

by

ROBERT D. LUCAS
Agronomist, Soil Conservation, Ministry of Agriculture.

SUMMARY

Propagation of avocado seedlings was started on a large scale at Soil Conservation, Haggatts in 1971. Propagation is done either by budding or grafting on to seedling rootstocks. Grafting and budding is normally done between December and April. Shield budding is done when the rootstock is red-brown in colour and still undergoing active growth from the seed. Once the seedlings have become green in colour and have 'hardened off' grafting is the method adopted. No grafting is done during the hot summer months: the rootstocks at this time have developed a white, corky and brittle pith and the percentage take is quite low.

Seeds are sown directly into polythene bags; thus reducing transplanting to a minimum. All seeds are hot water treated and the soil fumigated with methyl bromide, before being sown. Nursery seedlings are affected by root rot caused by *Phytopothora cinnamomi*, and by collar and fruit rot fungii. Further work is being done on collar rot -- *Botoyodiplodia theobromae* – and fruit rot Phomopsis sp.

INTRODUCTION

Propagation of Avocado is normally done by budding or grafting of selected varieties onto seedling rootstocks. "Plant derived from seed take a long time to come into production and in some cases never do so." "The Avocado in Puerto Rico". R. J. Griffith. (1923). In any case, seedling trees vary extremely in yield and fruit type and this is not acceptable from a marketing point of view.

Disease of Avocado seedlings can result in an appreciable loss of plants. Seedlings are expensive to produce and therefore it is essential to have a spray programme implemented. Diseases which so far have affected avocado seedlings are root rot caused by *Phytopthora cinnamomi* and collar rot caused by *Botoyodiplodia theobromae.*

SEED SELECTION

At Haggatts, seed for rootstock production is obtained from many sources. Little work has been done on the influence of rootstock on scion, and therefore rootstocks are selected on the basis of vigorous growth rates.

Rootstocks are germinated from seeds: large seeds being used in preference to small ones. Where there is a shortage of seed material, seeds are cut into halves. All seeds are hot water treated before planting; seeds being held in water at 50°C for thirty minutes. This kills the seed borne spores of the fungus *Phytophthora cinnamomi.* In addition, the seed bed or germinating medium is fumigated with methyl bromide at the rate of 1.36 kg/2.83 m^3 (3 lbs per 100 cubic feet) of soil, before seeds are sown.

SEEDLING PRODUCTION

Two methods of producing rootstock seedlings are used. They are as follows:—

(1) Direct sowing of seeds into prepared seed beds. Seeds are sown 5cms (two inches) apart.

(2) Sowing of seeds direct into black polythene bags.

In both cases, seeds are sown with flat ends down, leaving the top flush with the Soil surface. Germination can be hastened by cutting a thin slice off the tip of the seed. Once seed has been sown, a thin layer of soil is spread over the seed bed. This prevents the drying out of seeds. Shade for the young seedlings is provided by using 50% saralon netting. "This prevents the young sprouts from being sunburnt". 'Propagation of Avocado'. Platt and Frolich (1965). It is necessary to keep the rooting medium moist at all times. This is done by watering seed bed or polythene bags once daily. Germination normally takes 30 days.

Direct sowing of seeds into polythene bags is preferred at Haggatts. It reduces labour costs considerably and also the area used for seed bed preparation can be put to some other use. This is particularly important where availability of land is a limiting factor.

TRANSPLANTING SEEDLING:

When the seed bed method of producing rootstock seedlings is used, all germinated seedlings are transplanted into polythene bags one week after germination. Care is taken to ensure that seeds remain attached to seedlings, otherwise growth rate is reduced. The seed bed is thoroughly wetted before transplanting takes place, thus ensuring that seedlings do not undergo physiological wilting.

Holes for planting seedlings into polythene bags are usually made with a wooden peg, which has one end tapered into a point. The peg is about 22.5cms. (9 inches) long. The holes are made deep enough to accommodate the entire root system.

BUDDING AND GRAFTING BACKGROUND PROBLEMS:

Budding and grafting of selected varieties onto seedlings is done between the five day old stage and the six month old stage. Availability of bud wood from varieties such as Lula, Pollock and Simmonds is the main limiting factor in the production of improved varieties. There are only a few trees of the above varieties locally.

The bulk of budding and grafting is done between the months of December and April, with a main peak in late January and early February. This is necessitated by a number of factors which are as follows:–

(1) Availability of Seeds. These generally become available in late September and October.

(2) Some workers visit the U.S.A. and Canada in the late months of the year – November – as migrant workers. This is followed in December by Christmas vacation for workers.

(3) In the hot summer months, the rootstocks have 'hardened off' and have developed white, brittle pith. The percentage take from budding or grafting onto such plants is quite low, "Plant grafting Techniques for Tropical Horticulture". W. Pennock (1970).

(4) During the hot summer months, the inserted bud tends to 'shed its eye'. Platt et al (1965).

SELECTION OF BUD MATERIAL

This is the most difficult part of the entire operation. Poor choice of bud material can result in 100% failure of buds. Buds are selected from mature terminal growth which is not producing new growth. Buds near the terminal end are preferred. Plump dormant buds are selected in preference to the thinner ones which have a tendency to dry out before union of rootstock with scion is effected. "Buds which have broken into growth should be avoided so should those from which the outer bud scales have dropped. This is indicative of old wood and such buds when inserted, frequently "shed their eyes". "Budding and Grafting of Avocadoes" T. W. Beddoe (1971).

SHIELD BUDDING

This is most successful when the stocks are small and full of vigour. 'Annual Report Soil Conservation'. (1971). Once the plants develop a green coloured stem, the sap is less abundant and great difficulty is experienced in getting bud to grow.

The incision is made 5–7.5cms (2–3") into the stem of rootstock above ground level. The incision is either an upright T or an inverted T. The rootstock should be about pencil size in diameter and it is at this stage that all off-type plants are discarded. The back of the knife blade is used to prise away bark from the stock. The cut bud is then gently inserted. Thin strips of transparent plastic are then used to hold the bud in place.

Wrapping is either done from a point below or above the point of insertion of the bud. If wrapped from below, upward overlaps of tape are used to seal the bud in place, care being taken to ensure that the bud eye is left exposed. If wrapped from above, downward overlaps of the tape are used. This method of wrapping the tape prevents water from seeping through the tape and entering the junction of the union of the scion with the rootstock.

TECHNIQUE OF CUTTING BUD

The thick end of budstick is held between thumb and fore finger of the left hand and the other end extends over the centre of the wrist and is supported from below by the fleshy base of the thumb. The bud is cut with a sliding motion of the knife. If the sliding motion is prolonged, the cut extends for some distance. To avoid this, and to terminate the shield, a second cut is made in a transverse direction to the first cut; about 1.9cms away from the point of initial incision. It is essential to use a thin, sharp, clean knife. A piece of cotton wool dipped in alcohol is used to keep the knife clean. Badly cut buds do not fit securely in the incision on the rootstock and bud failure is high. The bud is normally cut about 1.9cm (¾") in length.

POST BUDDING CARE OF PLANT

Three weeks after inserting bud, the plastic tape is loosened. By this time, the bud has united with the rootstock. Constriction of rootstock takes place especially in rapidly growing plants if tape is not loosened.

In order to force bud into growth, the tip of rootstock is pinched off. This forces lateral buds to develop and sets up an active flow of sap in the bud direction. Once bud has initiated growth, cutting back is done in stages. Rapid cutting back results in dieback of rootstock and scion. Where bud grows in a horizontal direction, tying to rootstock is done to promote a good growth habit. When bud has grown to about a foot; rootstock stump is completely removed.

GRAFTING TECHNIQUES

The majority of avocado rootstocks are grafted at Haggatts. The Cleft Graft to the top and to the side are the methods used. These techniques are used on seedlings which have 'hardened off'; but which do not have white, brittle pith formation. "It is essential that the pith remains succulent and has a translucent, slightly greenish appearance. Pith regeneration is of the utmost importance in avocado grafting." Pennock. (1970).

CLEFT GRAFTING TO THE TOP

Seedlings are decapitated 7.5–10cm (3–4inches) above the level of the soil. A vertical incision is made into the decapitated rootstock. The upper end of the scion is held – between the thumb and fore finger whilst the lower end of the scion is pivoted on the base of the thumb. The incision is made into the scion, with the knife held at an oblique angle to the body. As the knife slides into the scion, the latter is gently pulled against the direction of the knife cut. The scion is cut into a long slender wedge by tapering cuts on each side. Care is taken to ensure that the cut portion of the scion is not touched by the hand. The scion is then quickly inserted into the rootstock and tied in place.

CLEFT TO THE SIDE

The top of the rootstock is retained. Instead a sloping downward cut is made, diagonally half way or less into the rootstock. The cut is made 7.5–10cms (3–4 inches) above ground level. The wedge shaped scion is then inserted.

SELECTION, PLANTING AND CARE OF AVOCADO SEEDLINGS

In selecting plants for establishment of orchards, one should choose only healthy, vigorous plants. Plants with weak bud unions are discarded as these tend to break easily under gusty conditions.

Seedlings are planted in June with the start of the rains. This allows the plant to firmly establish itself by the start of the next dry season. Planting holes should be dug in advance with the size of hole being 45cms x 45cms x 45cms (18"x18"x18"). Holes are filled in with well rotted down pen manure. Before planting the contents of the hole are thoroughly mixed and made into a mound with a hollow in the centre. The spacing distance used is generally 6ms x 7.2ms (20ft x 24ft).

PLANTING OF SEEDLING

The potted plant is lifted by the bag; it is never lifted by the stem. Lifting the plant by the stem can damage it. The polythene bag is removed and the seedling planted in such a manner; so that the level of the surface of the earth around the plant roots, lie flush with the top of the surrounding mound. The earth is then tamped in around the tree after it has been placed in the hole. This is done to ensure firm contact between plant roots and the soil. The plant is then immediately watered.

At Haggatts, newly planted trees are irrigated once daily for the first two weeks; after which regularity of irrigation is reduced, until by the eighth week irrigation is done twice weekly.

Immediately after planting, all plants should be staked. This serves a two fold purpose.

1. Helps to train the growth habit of the plant.

2. Reduces the damage done by wind.

At six weeks, an application of 29gms (1 oz.) of 8:5:5 fertilizer is applied to the trees. At this stage, the plant roots should have become firmly established and capable of fully utilizing the applied fertilizer.

DISEASES OF AVOCADO SEEDLINGS

So far, avocado seedlings have been affected by P. *cinnamomi* which causes root rot; and by the collar and fruit rot fungi B. *theobromae* and *Phomopsis* sp.

AVOCADO ROOT ROT

This disease is commonly found in avocado producing areas. It affects trees of all sizes. It is generally found present under the following conditions:

(1) Where spores of the fungus are present in the soil.

(2) Where soils are poor draining or have excess moisture.

Only when these two conditions are present, will the disease occur. 'Avocado Root Rot' Zentmyer, Paulus and Burns. (1967).

GENERAL SYMPTOMS

The leaves of infected plants are smaller than usual; being normally pale or green yellow in colour. There is a general reduction in new growth by the plant. Many of the small feeder roots become black and eventually die.

CONTROL MEASURES

At Haggatts preventive measures are mainly used to control the disease and these are as follows:–

(1) Hot water treatment of all seeds.

(2) Fumigation of soil with methyl bromide.

(3) Addition of sand to rooting medium. This improves soil aeration.

(4) Use of soil fungicides. The fungicide normally used is Dexon. This is applied as a soil drench to seedlings in polythene bags. 2 teaspoons/4.5 litres (2 teaspoons/1 gallon) is the normal application rate. Repeated applications are necessary as the fungicide is rapidly inactivated by sunlight.

(5) Destruction of all plants with root rot symptoms.

COLLAR ROT AND FRUIT ROT FUNGI

Botoyodiplodia theobromae the agent of collar rot, and *Phomopsis* sp. the agent of fruit rot, have been consistently isolated from seedlings which developed necrotic lesions, following the cutting back of rootstock when the seedlings were kept under damp conditions.

SYMPTOMS

A progressive drying back of rootstock from below the point at which the stock has been cut back. Symptoms are similar to those obtained when the rootstock is rapidly cut back. The rootstock first shows black discolouration from the point of cut back, instead of the formation of a normal healthy callus layer. The colour spreads rapidly down the stem of the rootstock; merging from dark brown in the senescent areas to a dirty green brown above the uninfected part of the rootstock. This progressive drying results in the death of the rootstock, and it is not uncommon to see a dead rootstock with a still green and healthy scion attached to it.

CONTROL MEASURES

These are as follows:

(1) Destruction of all severely infected plants. This has to be done as spores are spread by wind.

(2) Use of wound healer – such as Thionex – at the cutting back stage. This allows the development of callus layer before fungal spores can penetrate through the exposed surface of the plant.

(3) Tree surgery: Where the disease is not far advanced the rootstock is cut 5–7.5cms (2–3 inches) below the lesions. Thionex or wax is then applied to the exposed area. Where symptoms appear near the union of the scion, but where the scion is still unaffected; infected parts are removed by cutting and scraping away all affected tissue. This is done by removing all discoloured tissue. The exposed part of the plant is then sprayed with thionex.

(4) 2 teaspoons of Benlate /4.5 litres (2 teaspoons/gallon) applied to the soil and foliage of plants.

The number of avocado propagated has increased considerably since 1971. As with all new ventures, problems have been encountered. Most of these have been overcome. The improvement in propagation methods as well as in disease control, augurs well for the future of avocado production.

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A PRELIMINARY REPORT ON ONION BLAST DISEASE IN BARBADOS

by

L. W. SMALL

Plant Pathology Unit – Ministry of Agriculture, Science and Technology.

SUMMARY

A leaf spotting and tip dieback disease of onions identified as Blast was first recorded in Barbados in early 1971. It re-appeared in 1972 and caused quite serious yield losses to some farmers. A preliminary study of this disease, in which parasites were eliminated as causal factors, indicated that the initial symptoms of blast in Barbados were not caused by incompatibilities between benlate and other crop protection chemicals, as was suggested by some observers, but were more likely incited by adverse weather conditions or by some other physiogenic agent.

Historical Background

Leaf blight or blast disease of onions was first described by Whetzel from America (7) in 1904. Whetzel considered the disease to be due to wet weather and poor drainage. Doran and Bourne (1) in Massachussetts 1931 and Jones (5) in Connecticut also concluded that the disease was incited by a non-parasitic agent because investigations prior to his own failed to show the presence of a living pathogen when the plants exhibited the first signs of injury, and because the disease developed in bright sunshine and low humidity, in marked contrast to the inception and spread of parasitic diseases. He concluded, in similar vein to Doran and

Bourne, that blast results from too rapid a loss of water from tissues exposed to the sun after an abnormal development in subdued light, high relative humidity and high temperatures.

In 1965, R. L. Engle et. al. (3) on the basis of:

(a) weather and disease measurement,

(b) anatomical studies of flecking and mechanical induction of disease,

(c) ozone fumigation of onion seedlings and fully expanded onion leaves and

(d) correlations of ozone with ambient rainfall,

provided evidence that a disease with symptoms essentially identical to onion blast was incited by high levels of ozone only in Wisconsin. He also found that onion varieties differed in susceptibility to blast (4).

Small (1970) found that an outbreak of blast disease on onions at St. Clothilde, Quebec, Canada, was due entirely to adverse weather conditions. The disease developed after a period of overcast rainy weather was followed by a few days of high temperatures, low relative humidity and low cloud cover. After the outbreak of the physiogenic blast disease the weakened onion leaves were infected with *Botrytis squamosa*, the agent of Botrytis leaf blight.

Symptomatology and Epidemiology of the Disease in Barbados

In 1971, symptoms of a leaf disease of onions were first noticed at Friendship Plantation, St. Michael and later at a number of other plantations in Barbados. The economic effects of the disease were negligible in that year. In early 1972 a more serious outbreak of the disease occurred and the author found that the morphological symptoms of this disease were identical to those of the blast/leaf blight disease of onions seen in Quebec, Canada.

In Barbados, as in Canada, the disease was evidenced in practically all cases by the sudden appearance of white spots on the leaves around the stomata. These spots generally enlarged and the leaves in addition, died back from the tips. Older leaves were in all cases more severely affected than younger leaves and the disease generally occurred after a period of rainy weather.

The Barbados disease differed from the Quebec one in that, in Barbados, in a few cases only, there were apparent foci of infection and in some of these cases the disease tended to move at a slow rate against the wind direction. In Quebec, on the other hand, the disease affected whole fields at its inception without any foci of infection. In addition, in Barbados, the spots tended to be concentrated on the sides of leaves facing the wind direction. Although no reliable estimates of losses due to this disease in Barbados are available one assessment from an estate in the Parish of St. Michael in 1972 placed losses at 50%.

Observations and Experiments on the Etiology of the Disease

In an effort to elucidate the etiology of the disease in Barbados, numerous samples of diseased leaves were collected and pieces of necrotic leaf tips and pieces of leaves with spots were cultured on potato dextrose agar. *Stemphylium* sp. and *Alternaria* sp. were isolated from the necrotic leaf tips on a number of occasions and *Oedacephalum* sp. was isolated on one occasion only. *Botrytis-squamosa* and other species of Botrytis were not isolated at any time. The fungi isolated did not produce blight symptoms on the healthy leaves of green house-grown plants. It was therefore concluded that fungi were not the causal agents of the initial symptoms of the Barbados leaf blight disease. Suspensions of macerated diseased leaf tissue were sprayed on healthy leaves in an effort to transmit the disease. No symptoms of the disease resulted.

Rhizosphere soil samples and roots of diseased plants were sampled for nematodes. No plant parasitic nematodes were found that were likely to have caused the leaf blight symptoms.

The Plant Virologist of the University of the West Indies, Dr. S. Haque, inspected affected plants and concluded that the leaf blight symptoms were not of pathogenic viral origin.

The Entomologist (Biological Control) of the Barbados Ministry of Agriculture, Science and Technology, Mr. M. Badar, examined diseased onions for possible causal insects and found none.

Nematodes, viruses and insects were, therefore, also eliminated as causal agents and it was concluded that the initial symptoms of the leaf blighting disease on onions in Barbados were most likely incited by a nonparasitic agent and the disease could properly be termed blast disease of onions.

The most likely non-parasitic factors which could have been influential in causing onion blast disease in Barbados were:

(a) soil nutrient imbalances,

(b) adverse soil and/or air temperatures,

(c) inadequate drainage,

(d) mechanical abrasion by relatively large dust particles,

(e) incompatibilities between chemicals used in the 1971 and 1972 spray programmes,

(f) toxic ozone or other air pollutant concentrations in the atmosphere and

(g) meteorological factors similar to those associated with the condition in the U.S.A., Canada and England.

Factor (a) was investigated by Dr. D. Norse (O.D.A. Plant Pathologist), Dr. B. Eavis (O.A.S. Horticulturist) and Dr. L. Smith (Ministry of Agriculture, Science and Technology Soil Scientist). They found that soil nutrient imbalances were unlikely to have been the initial cause of onion blast in Barbados (personal communications). Dr. L. Smith also investigated factor (b), the influence of adverse soil and air temperatures on onions and again got negative results. Factor (c) was thought to be unlikely as blast symptoms were seen on both well drained and poorly drained sites. Factor (d), the mechanical abrasion of leaves by relatively large dust particles, would explain the wind oriented pattern of distribution of the spots on onion leaves. However this factor appears unlikely to be the cause of onion blast as in the majority of cases blast was noticed when the soil was damp and wind movements would not have been capable of projecting the soil particles against onion leaves. In addition blast did not appear under conditions of dry soil and high winds which would have been ideal for mechanical abrasion.

During the middle of 1972 it was thought by some workers that the 1972 spray recommendations for onions might have included some chemicals (notably Benlate or Benzimidazole) which could have been incompatible when mixed with others, thus giving rise to phyto-toxic blast like symptoms on onion leaves. In addition, some workers also felt that the stickers recommended in the 1972 spray recommendations could have caused phytotoxicity on their own accord.

In order to test for possible phytotoxic effects of chemical spray an experiment was laid down at the Central Agronomic Research Station, Graeme Hall, in which 19 different combinations of all the recommended crop protection chemicals for onions were compared with respect to the incidence of onion blast.

The rates of chemicals used were as recommended by Eavis 1972 (2). Insecticides were applied every 7 days and the foliar nutrients and fungicides every 14 days.

There was no incidence of blast disease of onions throughout the four months growth of the onions in this experiment. Onion blast was recorded, however, on other crops of the same variety in other parts of the island during this period. It was therefore concluded that incompatibility between the chemicals recommended by Eavis 1972 (2) was not responsible for the blast disease symptoms seen on onions during 1972 and that neither Benlate nor the Stickers were responsible for the inception of blast disease symptoms either by themselves or combined with other chemicals.

During December 1972 a number of plantations reported blast after experiencing a period of weather conditions similar to those stated as favouring the inception of blast. Some plantations recorded blast while others in the same general area did not. Also, in some cases, e.g. Fairy Valley Plantation, blast developed on one part of the field only and did not spread. Many of these plantations were advised to spray with a dithiocarbamate fungicide and those which followed this recommendation reported a check in the development of the disease.

CONCLUSIONS

A consideration of the facts presented above leads one to the conclusion that the initial symptoms of onion blast disease in Barbados are incited by a non-parasitic agent and that possibly either toxic concentrations of ozone or other air pollutants, or adverse weather factors, such as periods of rainy, humid, overcast weather followed by clear but non-humid days, might be involved in inciting the disease.

Observations on the onset and development of blast and the apparent control of its spread by the application of Dithane M 45 indicates that a likely hypothesis on the epidemiology of the disease in Barbados is as follows:

The development of blast symptoms on onion plants depends on the following factors.

1. The severity of adverse weather factors or air pollutant concentrations, i.e. a threshold value only of adverse weather or air pollutant concentrations will result in the appearance of minimal symptom expression on susceptible onion plants, while severe pollutant concentration or continuing adverse weather would result in extensive symptoms on the same plants.

2. The susceptibility of the onion phenotype to blast injury. (Engle et. al. (1965) stated that some varieties of onions

were extremely susceptible to ozone incited tipburn whereas others were resistant).

3. The health of the onion plant.

4. A possible cumulative effect of adverse weather factors and/or air pollutant concentrations in inciting disease symptoms.

Thus, adverse weather conditions or toxic air pollutant concentrations would initiate blast disease symptoms suddenly on an area-wide scale. On a field scale, where onion plants are homogenous with respect to predisposing conditions of susceptibility, health etc., the blast symptoms appear widespread over the whole field, with no apparent foci of infection. In other cases, where fields are heterogenous in terms of fertility, drainage etc., the weakest or most susceptible plants would show in symptoms. If weather and/or pollutant conditions are not suitable for disease development there is little spread of the symptoms. If conditions are suitable the disease advances slowly along a fertility or susceptibility gradient which in some cases could be against the direction of prevailing winds. In addition to the non-parasitic spread of blast symptoms there is also the possibility of a slow parasitic spread of dieback symptoms as a result of the weak parasite, *Stemphylium* sp., infecting weakened older leaves, again mainly along a fertility or susceptibility gradient. Applications of a dithiocarbamate fungicide would therefore, check the secondary parasitic spread of the disease by means of its control of *Stemphylium* sp.

FUTURE RESEARCH ON BLAST

Research on onion blast in 1973 and thereafter should include the following projects:-

1. Continuous monitoring of micrometeorological factors such as hours of dew duration, soil and air temperatures, rainfall, relative humidities, wind speed etc, in a number of onion fields to obtain accurate information on the weather conditions leading up to the onset of blast.

2. Continuous monitoring of the ozone content of the atmosphere above selected onion fields to investigate whether or not there is any correlation between the onset of blast and ozone concentrations in the atmosphere.

3. Growth chamber experiments in which onion plants at all stages of growth would be exposed to varying concentration of ozone and the type and extent of damage noted. The effect of Dithane M 45 and other fungicides including Benlate on blast development on onions exposed to ozone would also be studied in this series of projects.

4. Epidemiological studies on *Stemphylium* sp. and other isolates from necrotic onion tips to determine if these isolates are capable of infesting healthy onion leaves or increasing symptom expression on onion leaves with incipient dieback.

5. Field studies on various chemicals to control blast.

6. Field studies on the epidemiology of blast to investigate whether or not blast symptoms do start on weaker plants in heterogenous onion fields.

7. Field studies to determine whether or not some onion varieties are more resistant to blast disease than others and if so to select resistant varieties.

8. Field studies to determine the range of losses caused by this disease at different growth stages of the host.

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ONION PRODUCTION, IMPORTS, EXPORTS AND RESEARCH FOR PUERTO RICO

by

GEORGE C. JACKSON

Associate Horticulturist, Agricultural Experiment Station, Univ. of Puerto Rico, Mayaguez Campus, Rio Piedras, P.R.

STATISTICS

The onion (*Allum cepa* L.) is an important vegetable item in Puerto Rico. During fiscal year 1969–70 the apparent local consumption was 9,878.4 metric tons with an estimated consumption per capita of 3.7 kgs (8.1 lbs). The total declared import value for this period was $1,327,217.00 (U.S.).

In Table 1, data are presented showing total local production, imports, exports and local consumption for the decade ending 1969–70. This reflects an average annual increase of 141.4 metric tons in onions consumed during this ten year period.

Table 2 shows in U.S. dollars the declared value of local, import, and export onions during the last ten years, reflecting an annual average increase of $76,456 (U.S.).

The source of Puerto Rico onion imports is expanded in table 3, indicating that the bulk is from the United States. Imports have also been made, during the last ten years from Argentina, Canada Dominican Republic and Holland. Also included in this table is advanced figures on local production and imports for 1970–71 and 1971–72. All import data are not available (N/A) at this writing, sum totals are not indicated for these last two periods.

For an Island that produced in 1969–70 only 1.2 metric tons of onions, and during the same year "Exported" 369 metric tons, makes it rather clear that Puerto Rico assumes an important role as a distribution center in the Caribbean. Table 4 indicates that onion exports from Puerto Rico during the last ten years were made to the Dominican Republic, French West Indies, Jamaica, Leeward and Windward Islands, Netherlands Antilles and U.S. Virgin Island.

RESEARCH

Nolla (1925) in the Fall of 1923, tested seven varieties at Fajardo. Red Bermuda, Yellow Bermuda, White Bermuda, White Crystal Wax and Australian Brown were rated as best. Australian Brown yielded superior bulbs over the Bermuda types, but are not adaptable to clay soils. Under good conditions yield is 3.6 metric tons (80cwt) per acre.

Riollano (1943) conducted a screening trial at Isabela in 1939 with eleven varieties. Louisiana Red Creole, Yellow Bermuda, and White Bermuda were the best yielders in this test. During the following season, these three varieties were again tested, yielding 97, 87 and 66% marketable bulbs. Best growing season was determined to be from September to March. Onion thrips *(Thrips tabaci* Lindeman) were considered a limiting factor to production.

Childers, *et al* (1950), recommends the Bermuda types and Louisiana Red Creole as best onion varieties for Puerto Rico with planting made in the fall of the year.

Casseres (1966), in his textbook on vegetable production, recommends the Bermuda types, Louisiana Red Creole, Texas Grano series, Crystal Wax and the Granex hybrids as being particularly well adapted to the conditions of the Caribbean, Central America and Mexico.

With the restructuring of the vegetable research program of the Agricultural Experiment Station, investigation with onion as a potential market crop has resumed. Rico (1972) has tested and evaluated varieties and planting seasons. Of the varieties tested at Isabela, Granex 33 and Texas Grano 502 have yielded 8.3 and 5.2 metric tons, respectively from November plantings. Higher yields are reported from December planting at Fortuna.

Direct seeding with the Stanhay MK II Precision Seed Spacing Drill, utilizing plain rubber belt, hole size 10, Base A, Choke T and tractor speed of 2.4 k.m.h. has been almost successful. Good plant stand, as in all crops, depends on preparation of field, depth of planting and adequate irrigation. Pelleted seed and taped seed deserve attention for future experimentation with this crop.

Planting distances, fertility requirements, and fertilizer placement are still in process of evaluation and sufficient data are not available for comprehensive reportings.

Jackson *et al* (1972), tested Chloropropham, (Chloro-IPC); CDAA, (Randox); DCPA. (Dacthal); Chloroxuron, (Tenoran); and Nitrofen (Tok) as preemerge herbicide on direct-seeded onion (Texas Grano 502). Dacthal exhibited sufficient onion selectivity and is the only herbicide presently recommended for use by growers on direct-seeded onions. Many of the herbicides were injurious when applied before crop emergence.

Field work this past fall involved the testing of Tenoran and Tok as postemerge herbicides on direct-seeded onions. Commercially acceptable control was obtained from both materials with application made after onion plantlets were in the third true leaf stage and before emerged weeds had attained more than 3 inches in height.

DISCUSSION

For the decade ending 1969–70 the annual increase was 141.4 metric tons of onions consumed locally. This makes our 1975 short-fall requirement 10,603.4 metric tons, for the Island market only.

Knott (1962), reports that the approximate average yield per acre for the United States is 8.1 metric tons. Using this figure, Puerto Rico would require 1,636 acres to produce a 75% acceptable grade of 10,603.4 metric tons to meet the 1975 projected requirement. Well managed farms in neighbouring Dominican Republic yield about 5.3 metric tons of onions per acre. This would require 2,500 acres for the same yield at 75% grade.

The economics, logistics and organization required to operate farms of this size, make it highly improbable that Puerto Rico will ever be auto-sufficient in onion production to avoid year around imports. Other crops may serve as an example. Tamatoes are now produced in adequate quantities that Puerto Rico no longer needs to rely on imports from December to March to fulfil her local market demands. The same holds true for sweet peppers from November through April. With concerted effort, fresh dry onions could be produced in sufficient amounts that the Island would no longer need to be dependent on imports from mid-March through mid-June to satisfy her local requirements.

The declared value for one metric ton of fresh dry onions in 1959–60 was $66.30 (U.S.). The same ton in 1969–70 was $138.43 (U.S.). If the annual price average increase continues at this modest pace, as it has for the past ten years, a metric ton of onions will cost $174.48 by 1975.

Can we grow onions? The answer is yes. The questions should be: In what quantity? Will the operation be profitable?

SUMMARY

Tabular statistics present local production, total imports, imports by country, total exports, with exports by country in metric tons with value in U.S. dollars for the last decade ending in 1969–70. Review of research indicates that fresh dry onions may be produced with yields higher than the U.S. average when planting is carried out from mid-November to mid-December, using the short day varieties Granex 33 and Texas Grano 502. Dacthal and Tenoran are the best recommended preemerge and postemerge herbicides for direct seeded onions. Tok is not registered for use on onions. A high degree of success has been obtained in

direct-seeding using the Stanhay planter. Research on planting distances, fertility requirements and fertilizer placement is incomplete and not reported. Puerto Rico could produce sufficient quantities of fresh dry onions from mid-March through mid-June and not have to rely on imports to meet the Island's consumer requirements for that period of the year.

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Table 1

Puerto Rico: Onions, Fresh, Dry, Total Local Production, Imports From United States and Foreign Countries, Exports, Apparent Local Consumption in Metric Tons*.

Year	P.R.	U.S.A.	Foreign	Total	Export	Apparent Local Local Consumption	Apparent Consumption per capita
1959–60		8,484.2		8,484.2	1.8	8,482.4	3.7 Kg.
1960–61	2.8	8,848.2	0.1	8,851.1	18,0	8,833.0	3.7 Kg.
1961–62	16.0	9,294.3	0.2	9,310.5	352.8	8,957.7	3.7 Kg.
1962–63	11.0	8,099.7	50.7	8,161.4	83.5	8,077.9	3.3 Kg.
1963–64	4.4	9,649.2		9,653.6	114.8	9,538.8	3.8 Kg.
1964–65	4.4	10,172.9		10,177.3	282.3	9,850.0	3.8 Kg.
1965–66	3.3	10,876.7		10,880.0	218.7	10,661.3	4.1 Kg.
1966–67	4.6	11,152.4		11,157.0	290.9	10,866.1	4.1 Kg.
1967–68		11,909.8	203.7	12,113.5	429.0	11,684.5	4.3 Kg.
1968–69	3.3	9,324.3	1343.1	10,670.7	333.4	10,337.3	3.8 Kg.
1969–70	1.2	10,246.2		10,247.4	369.0	9,878.4	3.7 Kg

*One metric ton equals 2240 pounds.

Source: Boletin Mensual de Estadisticas Agrícolas, Depto. de Agricultura, Oficina de Estadística1 Agrícolas, and External Trade Statistics, P. R. Planning Board, Bureau of Economic and Social Analysis.

Table 2

Puerto Rico: Onions, Fresh, Dry, Declared Value; Local, Import and Export, in Dollars (U.S.).

Year	P. R.	U.S.A.	Foreign	Total	Export	Local
1959–60		562,775		562,775	240	562,657
1960–61	409	641,316	30	641,755	2,867	640,447
1961–62	3,286	956,640	50	959,976	31,943	923,604
1962–63	2,196	682,095	4,455	668,746	16,557	661,902
1963–64	916	880,335		881,251	17,009	870,765
1964–65	1,007	942,979		943,986	42,279	917,796
1965–66	765	940,201		940,966	33,691	922,051
1966–67	1,130	1,307,314		1,308,444	53,987	1,274,315
1967–68		1,422,111	30,254	1,452,365	64,937	1,401,028
1968–69	568	1,120,074	155,816	1,276,458	53,076	1,236,577
1969–70	397	1,419,006		1,419,403	73,904	1,327,217

Source: Boletín Mensual de Estadísticas Agrícolas, Departamento De Agricultura, Oficina de Estadísticas Agricolas, and External Trade Statistics, P. R. Planning Board, Bureau of Economic and Social Analysis.

Table 3

Puerto Rico: Onions, Fresh, Dry, Local Produce and Imports in Metric Tons* by Country.

Year	P. R.	U.S.A.	Arg.	Can.	D. R.	Hol.	Total
1959–60		8,284.2					8,284.2
1960–61	2.8	8,848.2			0.1		8,851.1
1961–62	16.0	9,294.3			0.2		9,310.5
1962–63	11.0	8,099.7	2.5	48.2			8,161.4
1963–64	4.4	9,649.2					9,653.6
1964–65	4.4	10,172.9					10,177.3
1965–66	3.3	10,879.7					10,880.0
1966–67	4.6	11,152.4					11,157.0
1967–68		11,909.8		127.9	2.8		12,113.5
1968–69	3.3	9,324.3		1,127.5	215.6		10,670.7
1969–70	1.2	10,246.2					10,247.4
1970–71	0.6	9,203.6	N/A	N/A	0.6	N/A	N/A
1971–72	0.8	10,219.6	N/A	N/A	1.9	308.9	N/A

*One metric ton equals 2240 pounds

Source: Boletín Mensual de Estadísticas Agrícolas, Departamento de Agricultura, Oficina de Estadísticas Agrícolas; and External Trade Statistics, P. R. Planning Board, Bureau of Economic and Social Analysis.

Table 4

Puerto Rico: Onions, Fresh, Dry, Exports in Metric Tons* by Country

Year	D.R.	F.W.I.	Jamaica	L & W Is.	N.A.	U.S.V.I.	Total
1959–60		1.8					1.8
1960–61						18.0	18.0
1961–62						352.8	352.8
1962–63				4.9	2.6	76.0	83.5
1963–64					4.0	110.8	114.8
1964–65	139.6				6.3	136.4	282.3
1965–66				1.5	1.1	216.1	218.7
1966–67	11.6	17.4	3.3	15.3	4.5	238.8	290.9
1967–68	8.9			16.6	7.6	395.9	429.0
1968–69		1.3		25.6	18.2	288.3	333.4
1969–70		26.4		38.1	6.3	298.1	368.9

* One metric ton equals 2240 pounds.

Source: Boletín Mensual de Estadísticas Agrícolas, Departamento de Agricultura, Oficina de Estadísticas Agricolas; and External Trade Statistics, P.R. Planning Board, Bureau of Economic and Social Analysis.

ONION PRODUCTION IN BARBADOS 1967 TO 1973

by

W. DeC. JEFFERS

and

B. W. EAVIS

(Ministry of Agriculture, Science and Technology)

Onion production in Barbados started as a result of small handplanted trials laid down in 1966-67 by Jeffers, Williams and Alleyne at Sayes Court and Bullens research stations. Subsequently in 1968 commercial production was attempted by the introduction of direct-seeding with precision seed spacing drills. In 1968-69 thirty acres were planted by the Ministry on ten farms throughout the island (Eavis and Jeffers 1969). Since 1969 many farmers purchased their own planters and acreage has expanded to about 200-250 acres a year (Table 1).

The potential market for locally produced onions in the eastern CARIFTA countries is estimated at about 560,000 bags (of 50 lbs) a year worth $5.6 million EC at the new CARIFTA price of $10.00 per bag f.o.b. At present, therefore, less than one tenth of the market is supplied by Barbados production. As with any crop which is essentially foreign to the region, new problems continuously present themselves for solution. The more important constraints have been pests and diseases, weeds, seasonality of production, post-harvest keeping quality and the element of risk. Attention has therefore been directed to solving these problems in an attempt to supply a larger proportion of the CARIFTA market, thus displacing some of the extra-regional imports.

TABLE 1

Increase in acreage and production of onions from 1968 to 1973

Year of harvest	Acreage planted	Production (total)	Local sales (bags of 50 lbs)	Exports to CARIFTA	Price per lb f. o. b.	Total Value (EC doll.)
1968	2	800	800	nil	(7c)*	2,800
1969	153	8,000	8,000	nil	(8c)*	32,000
1970	90	11,000	8,500	2,500	15c	82,500
1971	153	35,000	18,000	17,000	15c	262,500
1972	250	50,000	20,000	30,000	16c	400,000
1973 (until June)	200	36,000	16,000	20,000	16c	288,000

*to the farmer

VARIETY AND SEASON

Over 70 varieties have been tested in trials laid down by Frances Roach, Richard Hoad, Merland Burke, Wynter Headley and Brian Eavis, plantings being made both in the normal season (September to November) and out-of-season in January, February and May and June.

Daylength and seasonal effects on bulbing have been evaluated both for short-day and medium-day varieties. Granex F1 Hybrid is the recommended variety for planting between October and 15th January and has also performed well when planted in April, May and early June. Dessex is a promising variety for planting in August and September to supply the market from mid November to mid February giving better bulbing and thinner necks than Granex in the short days at this time of year. Also of promise for this period are R10 Hybrid and Beth Alpha Autumn from Israel. None of the above varieties keeps well and the most promising variety for storage is a red variety introduced to us by I.N.R.A. Guadeloupe from Niger in Africa called Violet de Galmi. Possibly of promise are the Yellow Creole selections now being made by some seed companies in the U.S.A. which combine yellow colour with the reputed storage characteristics of Red Creole.

Good commercial yields of onions have been obtained in plantings between 15th September and 15th January for reaping over the period January to mid May (bulb size decreasing with the later planting date). Plantings in February and March have given low yields due to the small size of the bulbs so that June and July production has not proved economic. In 1970 and 1971 good results were obtained at Graeme Hall by planting in May and early June and reaping from mid August to mid October but subsequently the problem of 'blast injury' has prevented commercial attempts to grow the crop at this time of year. Harvesting in the wet months needs further investigation and artificial drying is essential with the present varieties.

PESTS

Three major pests encountered when we went from small-scale plots to larger commercial plantings were a leaf eating caterpillar

TABLE 2

Barbados' Imports Of Onions 1969–72

	1969		1970		1971		1972	
	lbs	EC dol	lbs	EC dol	lbs	EC dol	lbs	EC dol
January	N.A.	N.A.	225,000	30,986	222,249	22,713	142,550	12,048
February	N.A.	N.A.	267,290	39,467	346,257	35,412	225	101
March	N.A.	N.A.	nil	nil	1,225	191	nil	nil
April	N.A.	N.A.**	nil	nil	107	84	500	107
May	124,050	11,707	240,725	50,633	nil	nil	160,498	15,873
June	481,402	66,439	218,588	42,412	458,723	72,370	420,450	63,653
July	199,797	25,273	414,623	73,320	387,454	56,677	308,744	54,344
August	322,497	43,722	436,413	67,010	352,644	50,559	324,221	62,899
September	414,611	43,109	391,440	44,835	327,523	33,316	511,308	79,797
October	301,365	29,843	326,069	33,850	436,535	43,494	153,493	22,239

** Imports between Jan. and Mar. 1969 were normal, but in April 1969 there was some local production for the first time.
N A – Figures are not available.

TABLE 2 *Concluded*

Barbados' Imports Of Onions 1969–72

	1969		1970		1971		1972	
	lbs	EC dol	lbs	EC dol	lbs	EC dol	lbs	EC dol
November	148,558	13,590	196,620	21,315	168,114	13,641	392,191	59,083
December	433,609	52,372	475,350	50,260	413,713	38,892		

Total Imports Ahd C. I. F. Value

year	lbs	EC dollars	Average price per lb (cif)
1969	3,498,470	390,095	11cts
1970	3,192,118	454,088	14cts
1971	3,114,544	367,349	12cts
1972	2,827,893*	432,201*	15cts

*December 1972 is estimated. (*Source:* Government Trade Statistics Department)

(Spodoptera sunia), leaf miner *(Liriomyza munda)*, and onion thrips *(Thrips tabaci)*. In the first ten acre field planted at Graeme Hall in 1968, the caterpillar nearly wiped out the crop in the seedling stage and a regular series of sprays with DDT, Lannate or Folothion were found essential. Leaf miner also resulted in disappointing yields in some early plantings and continues to give trouble unless the fields are regularly sprayed with Lannate or Dimethoate. Onion thrips proved to be the worst pest until it was found that high volume spraying (sometimes twice a week) with DDT or Lannate could give good control. Occasional outbreaks of grasshoppers (locusts) have caused serious losses.

By following one of two alternative spray programmes (see Ministry of Agriculture's Vegetable Crop Recommendations) good control of insect pests is now obtained (where vigilance is high).

WEEDS

Owing to the small size of the seedling and its slow initial growth rate, high standards of weed control are mandatory. An important reason for the success of commercial production in Barbados is the use of clean land which has been taken out of sugar cane. Attempts to grow onions in rotation with other vegetables have not proved successful due to the weed problem. However, fairly good control of seedling grasses and broadleaf weeds is obtained by using pre-and-post-emergence sprays of Dacthal W75 and Tribunil; and Bensulide (Prefar) shows distinct promise. Creeping weeds such ad *Euphoribia prostrata*, and vegetatively propagated *Brachiaria sp.* and *Portulaca oleracea* (which come back from pieces as well as from seed) are difficult to control except by hand, whilst *Cyperus rotundus* (nutgrass) and onions just do not mix.

DISEASE PROBLEMS

Fasarium sp. caused some major losses in 1970-71 crop, but in the years since has not proved a problem. This is thought to be due to the regular use of Benlate as recommended by D. Norse and W. Small of the Plant Pathology Department. *Sclerotium rolfsii* can be serious on onions harvested in wet weather causing an external slime (unlike *Fusarium* which causes internal rotting). Bacterial neck rot *(Erwinia carotovora)* has been a major problem in some years (e.g. 1972) but was practically absent in dry years (e.g. 1973). Rapid drying (artificially in wet weather) is necessary to prevent neck rot; the thickness of the neck of the onion is an important factor in obtaining satisfactory rates of drying. *Aspergillus niger* has caused serious post-harvest losses especially up to 1971 when Benlate was introduced. Regular Benlate sprays appear to give good control.

QUALITY CONTROL

First attempts to export onions from Barbados were disastrous. In 1972, to save the onion industry from self destruction, and elaborate programme of quality control was launched in which all onions for export were examined by inspectors within three days of shipment. Bags were sampled at random and the onions were examined on portable tables designed for grading. The most important standard was a maximum of 2 percent of onions with any signs of rot or incipient rot. At first nearly all onions failed the inspection test, since piece work in the field was not conducive to good grading. Later, largely through the efforts of Mr. O. Parris, Mr. Trotman, Mr. Blackman and other inspectors, good standards have been maintained and reports from Trinidad are favourable.

ARTIFICIAL DRYING AND CENTRAL GRADING

Due to problems in 1972 in drying and grading onions in the field, a small pilot plant was set up by the Agricultural Development Corporation at Codrington in 1973, to examine the feasibility of central drying and grading. The pilot plant handled 170 tons of untopped, ungraded onions in 1973. The capacity of Lister SR4 driers was determined and storage in ventilated bins was attempted to determine weight losses from drying and spoilage. It is hoped that artificial drying will lead to extended production in the wetter months and that increased production will be also encouraged by relieving farmers of the arduous task of grading.

BLAST INJURY

At present, a problem known as 'blast injury' threatens further expansion in onion production and many growers are turning instead to carrot production. The symptoms of 'blast' are necrotic lesions on the older leaves towards the windward side, and particularly on plants which are bulbing. The leaves collapse and yields are severely reduced. No primary pathogen can be found (Small 1973) and all fungicide applications have failed to give control. Outbreaks seem to accompany changes in weather, occurring particularly when cloudy weather gives way to hot sunshine. However, the symptoms occur in patches in fields and are not evenly distributed as would be expected if climatic factors were the cause. Trace element deficiency has been investigated as another possible cause with negative results. Blast injury has occurred in all parts of the island but seems worse in the wetter areas. It was first noted at Jordans in 1969 and then at Friendship, Mount Gay and Bourbon in 1971. In 1973 the loss of crop was worth ¼ million EC dollars.

Therefore, further progress in onion growing in Barbados largely depends on first solving this particular problem.

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A PRELIMINARY REPORT ON THE COMPARATIVE PERFORMANCE OF SOME SOUTHERN TYPE VARIETIES AND HYBRIDS OF ONIONS IN THE U.S. VIRGIN ISLANDS

by

RUDOLPH SHULTERBRANDT

and

DARSHAN S. PADDA

Commissioner of Agriculture, and Director of Marketing and Crop Production respectively.

Department of Agriculture – St. Croix.

INTRODUCTION

Onions are among the most popularly used vegetables in the Virgin Islands. An annual importation of onions into the U.S. Virgin Islands ranges from approximately 800,000 to 1,000,000 pounds. (See Table 1) Although the agro-climatic conditions are suitable for crop production, the growing of vegetables is discouraged by lack of enough farm labor and irrigation water. As the labor and water requirements for onions are relatively less, there are better chances for its adoption by the growers.

The degree of change in natural photoperiod is the most reliably consistant factor in a plant's environment. Onion is basically a long-day plant. All kinds bulb on long-days but luckily some varieties tolerate shorter long days than others. This variation in varieties has led to the development of short-day bulbing kinds for the tropics. This paper reports a study of comparative performance of thirteen (13) short-day varieties and hybrids of onions on St. Croix.

MATERIAL AND METHODS

The material comprised thirteen (13) short-day varieties and F–1 hybrids supplies by Northrup King and Company, Minneapolis, Minnesota, and Dessert Seed Company, Elcentro, California. The seedlings of these varieties were transplanted on January 13, 1973 in a randomized block design with three replications at the Agricultural Station of the V.I. Department. The plants were spaced at 36 inches between rows and 3 inches between plants in rows giving a plant population of 58 thousand per acre. Duration of sunlight and mean daily maximum and minimum temperature during various months of the year 1972 for St. Croix are presented in Table 2. The soil type of the experimental site was loamy clay with a pH of 7.5. The crop was harvested in the last week of April. Observations were recorded on five (5) randomly selected plants for maturity, bulb shape, bulb color, top-bulb ratio, and yield.

RESULTS AND DISCUSSION

Data on maturity, bulb characters, top-bulb ratio and yield of five (5) varieties and eight (8) F–1 hybrids are presented in Table 3. Hybrids--Yellow Cranex, Dessex Yellow, and Golden Creole were early in maturity. Hybrids Tropicana Red and Red Creole were late and all others were medium in maturity. On St. Croix the length of day increases from 11.18 hours in January to 13.14 hours in June. The late maturing varieties might have longer day requirements for bulbing and therefore would be expected to yield higher if planted later than January or left in the field a little longer. McClelland (2) in 1928 was first to add onion to the list of photoperiodically sensative plants. And in 1937 Magruder and Allard (1) observed that the time when an onion plant will start to bulb is determined by the length of day and the critical light period for bulbing ranging from twelve (12) hours for the extra early varieties to about fifteen (15) hours for the late types is a varietal characteristic.

The bulb shape and color is a matter of choice. Since all the varieties bulbed satisfactorily, consumer demand for any color or shape can be met.

Top-bulb ratios indicate the proportion of tops out of the total weight. Since the bulb is the main economic product, the varieties with smaller percentages are preferable. Late varieties Tropicana Red and Red Creole had the highest top-bulb ratio. This could be due to the reason that these varieties were not yet ready for harvest.

There was enough variation in yield between varieties. All the varieties gave satisfactory yields. Varieties Texas Early Grano 502 and Yellow Grano New Mexico Strain produced the highest yield of 22.5 tons per acre. Varieties Texas Early Grano, Yellow Grano, White Granex, White Grano, Tropicana Red and Alamo White out yielded the standard variety Yellow Bermuda.

In order to make final recommendations about variety and time of planting, further testing over three-years period will be necessary. Traditionally, one crop of onion is raised on St. Croix. This crop is planted in September and is harvested in January. The present study offers the possibility of raising two crops of onions a year. The first crop from September to December and the second from January to April.

SUMMARY

In order to find the best variety for the Virgin Islands, thirteen (13) southern-type varieties and F–1 hybrids were planted on January 13, 1973 in a randomised block design with three (3) replications. All the varieties under test bulbed satisfactorily. Varieties Texas Early Grano 502 and Yellow Grano New Mexico Strain gave the highest yield of 22.5 tons per acre and were followed by White Granex with 20 tons per acre. These studies indicate a definite possibility of raising a successful spring crop of onions on St. Croix, and the varieties exist to meet the varied consumer demand for size, color, and shape.

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Table 1

THE QUANTITY AND VALUE OF FRESH ONIONS IMPORTED INTO THE U.S.V.I. 69–72

YEAR	POUNDS	VALUE
1969	993,227	$69,478
1970	1,024,985	86,867
1971	1,021,165	85,867
1972	835,674	62,226

Table 2

DURATION OF SUNLIGHT AND MEAN DAILY MAXIMUM AND MINIMUM TEMPERATURE DURING VARIOUS MONTHS AT ST. CROIX, U.S. VIRGIN ISLANDS

MONTH	AVERAGE HOURS OF SUNLIGHT	MEAN DAILY MAX. TEMP.	MEAN DAILY MIN. TEMP.
January	11.18	83.1	70.0
February	11.54	83.2	70.0
March	12.02	84.3	70.7
April	12.52	85.6	72.5
May	12.96	86.4	74.3
June	13.14	87.8	75.7
July	13.09	88.0	75.8
August	12.72	88.5	75.7
September	12.26	88.1	75.0
October	11.80	87.6	74.8
November	11.32	85.9	73.3
December	11.05	84.3	71.7

Table 3

MATURITY, BULB CHARACTERS, TOP-BULB RATIO AND YIELD OF THIRTEEN VARIETIES

VARIETY	MATURITY	BULB SHAPE	BULB COLOR	TOP-BULB RATIO (%)	ESTIMATED YIELD PER ACRE POUNDS
Texas Early Grano 502	M	Top	Yellow	3.01	45,000
Yellow Grano N.M. STR.	M	Top	Yellow	6.76	45,000
White Granex F–1	M	Thickflat	White	5.49	40,312
White Grano N.M. STR.	M	Flat. Globe	White	2.66	34,687
Tropicana Red F–1	L	Globe	Red	25.0	32,812
Alamo White F–1	M	Flat	White	2.98	30,932
Yellow Bermuda	M	Flat	Yellow	2.96	30,932
Yellow Granex F–1	E	Thickflat	Yellow	1.61	29,062
Robust White F–1	M	Thickflat	White	6.45	27,182
Dessex Yellow F–1	E	Thickflat	Yellow	1.78	26,250
Majestic White F–1	M	Granex	White	5.0	17,812
Red Creole	L	Thickflat	Pink	23.40	16,875
Golden Creole F–1	E	Semi-globe	Yellow	3.33	14,062

ONION GROWING IN JAMAICA

by

J. H. Donaldson

ONIONS *(Allium sepa)*

Records available go back to only 1927. It reveals that a Rev. Ward of a St. Mary address (a parish in Jamacia) made application to the then Director of Agriculture for funds to be provided to the Jamaica Agricultural Society to purchase onion seeds in order that he may undertake experimental work on onion production. So as not to leave you in suspense wondering whether these funds were provided, let me say now that the request was refused.

To my knowledge, the next effort was made by yours truly about 1954. The idea arose due mainly because of a frequently asked question, namely, why did not the small onions purchased in the local shops produce bulbs when planted? Another question was, why don't we grow our own onions? I was not sure I knew the answers and so I got myself some onion seeds.

There may be some who will sympathise with what I say next. The first efforts were very indifferent. The spacing was bad, the soil type was stony and the water was always insufficient, and a novice was in charge. Meanwhile, it was recalled that Eskallion was a thriving business on the soil types in St. Elizabeth, i.e., South-West Jamaica, and maybe on these soils would be a good place to do some trials.

Beginning about 1963, seeds of three varieties, namely, Texas Early Grano 302, Granex Hybrid Yellow, Red Creole, were obtained and in co-operation with a farmer, who was persuaded by the man's own wife, a small project was started by providing the seeds, fertilizer, chemicals for pest and disease control, a sprayer, and remuneration for his labour. Except for token amounts as samples to provide positive proof, the farmer was allowed to retain and dispose of the crop to his own benefit.

Each month a small area was planted out and for well over a year this practice continued.

At the end of this period, it was decided that onions would prosper in St. Elizabeth and the project was handed over to the Agricultural Development Corporation. This ended only the St. Elizabeth phase of the onion-growing activity. Attention was transferred more seriously to the Muck and Peat areas of South-West Jamaica, i.e., the Springfield, Westmoreland.

The first season showed some success but subsequently rains caused the water-table to rise so high that the crop failed due to flooding. This happened twice.

Further activity was confined for a time to the Research Station itself and gradually to a number of growers in selected areas. These persons were given the seed, chemicals and everything necessary. Some did not participate for long.

A scheme developed whereby the Agronomy Division, more particularly the speaker, was required to produce all seedlings and these seedlings in turn were distributed to farmers. This was done for some 3 years, after which the following change was made. Instead of producing all seedlings at the one nursery, namely, Lawrencefield, other nurseries were introduced at Yallahs Valley, Falmouth and Santa Cruz Land Authorities.

Orders for seedlings were always at short notice. It took at least 100,000 seedlings to have 1 acre transplanted. This could not b counted, so representative samples of 1,000 seedlings were harvested ana weighed in order to enable a reasonable estimate to be obtained.

Even with 15 to 20 persons harvesting seedlings, it took the best part of a day to bring in 100,000 seedlings and weigh. Pulling the seedlings 24 – 36 hours before delivery resulted in a drying out even though the seedlings were placed on wire-bottom trays in amounts of 6,000.

A Land Rover could take only 12,000 at a time, and when a bigger vehicle was used the economics required that as much as 400,000 were taken. At such time the trays were not sent along, as experience showed the previous ones were not returned. The larger vehicle always turned out to be a stone truck or dump truck with a deep body.

The seedlings were set in layers with sheets of old news-paper between each layer, and where possible a fixed number of seedlings were separated from each other. These large quantities of seedlings usually had to travel one hundred miles even if the vehicle left in the afternoon hours, by the time they reached their destination, some 24 hours later, invariably half of the number of seedlings had gone bad.

The procedure to produce seedlings was as follows:

The land was cleared of the remains of cane cultivation. This was best done by burning the debris above ground and so lessen the trash that would foul the seeders. Next, the land was ploughed then harrowed. A rotavator was employed to replace the harrow subsequently.

Fertilizer 11-11-11 ratio mixed with 20 lbs. Zinc Sulphate per acre is applied at the rate of 5 cwt. per acre. The herbicide Eptam 6E at 2-2/3 qts/acre is sprayed on the soil with a boom sprayer. As it is being sprayed on, a harrow or rotavator follows behind in order to incorporate the herbicide.

It is important that the Eptam be applied on fairly dry soil. The treated area is allowed to remain undisturbed for 5-6 days after which the land is again harrowed or rotavated in order to release any fumes that may have been entrapped. As soon as possible after this second rotavation, the seed is planted. The seeders (four in number) are set 15½ inches apart so that they fit between the wheels of the tractor. The tractor used is a Massey Ferguson 135 high clearance. The front tyres are 600 x 16 and the rear wheels are 600 x 48, both sets of wheels are set 72 inches apart.

The seeders are Planet Junior mounted on a bed-shaper which throws up soil so as to provide a raised bed some 5ft. 6inches at the upper surface. If a nursery to produce seedlings is required a set of narrow-row Planet Junior seeders are used. Each of these seeder units sets down 3 rows two inches apart using the plates with a number 6 hole. These plates use 40 lbs. of seed per acre. If only the normal field planting is to be done, the single-hole plate – this time No. 7 or No. 8 – is used. This uses 6-7 lbs. of seed per acre, depending on the speed of the tractor and size of the seed.

The seeded field is wetted as soon as possible and when it becomes sufficiently dry to accommodate a tractor the field is sprayed with the herbicide Tok E 20 at the rate of 1 gallon per acre. The surface is kept moist for as long as it takes the seedlings to break through the surface as the soil forms a crust when dry. The germination requires five days. Two weeks after planting the seedlings are again sprayed with Tok E at the same rate. It is suggested that Dacthal would be kinder to the seedlings at this stage, but we have not tried it as it has been found any departure from accustomed practice results in a difficult situation, sometimes disaster, due to poor mixture by the operator.

Two weeks after the seedlings emerge the irrigation frequency is reduced to alternate days. then later twice per week.

Regular weekly applications of insecticides mixed with fungicides are made, and may be Malathion, Gardona, Dipterex or Sevin mixed with Dithane M45, Manzate D or some other fungicide

Thrips are the main problems and Tip Browning the only other affliction of the growing plants so far.

Invariably each year the same area has to be planted twice as rain damage is high at some places. The bed arrangement has helped to reduce this loss.

Late September/October and November are the months during which this onion-planting venture is undertaken.

Harvesting, if any, is possible in March following. At this time it is inadvisable to leave the bulbs out in the field due to the likelihood of rains and praedial larceny.

Prior to 1963, little attention was paid to the production of the crop locally, although a few farmers had started growing it on a small scale in the Pedro Plains area where virus infection had prevented the usual production of tomatoes.

As of 1963, however, attention was given to the crop, particularly in the Pedro Plains area. The varieties grown at this time were Red Creole and Granex hybrids, and these were grown on red bauxitic soils.

Between 1963 and 1970, several onion varieties were tested, and as a result of these tests Texas Early Grano, Granex F1 hybrid, Yellow Excel, Red Creole and Tropicana Red varieties were found satisfactory in bulbing potential and acceptability for quality and flavour. (See list of varieties tested).

1967: Early Lockyer White
Early Flat White
Early Grano Brown
Red Globe
White Globe
Hybrid Granex White
Extra Early Flat White
Crystal Grand White
Hybrid Granex Brown
Red Creole
Elite
Eclipse
Hybrid Granex White
Crystal Grand Brown
Byn Shemen?
Saemak?
White Silverskin
Extra (?) Yellow Rio Grano

1968: White Globe
Silverskin Shino
New Mexico White Grano
Granex Brown
Granex White

1968:
Cont'd. Crystal Grand White
Early Lockyer White
Lockyer Brown
Lockyer White
Silverskin?
Haemak
Silverskin B
Benshemen
Hybrid Grano White
Hybrid Yellow
Grano Brown
Early Yellow Leo Grano
Imperial White Spanish
Extra Early Flat White
Early? White
? Grano Brown
Yellow Creole
Alamo White
New Mexico Yellow Grano
Excel 986
Eclipse
Early Bermuda
Dessert.

PRIMARY SCREENING OF NEW UNREGISTERED PREEMERGE VEGETABLE HERBICIDES

by

GEORGE C. JACKSON

and

CARMELO SIERRA[1]

INTRODUCTION

With the rapid release of new unregistered preemerge herbicides with a potential of weed control activity, the necessity arises for a simultaneous evaluation of a number of materials on a wide spectrum of vegetable crop in the shortest time possible. Furtick and Romanowski (1971) have described such a system. It consists of planting on the flat, one row each of the vegetable crops to be tested, and then applying the herbicides at right angles over the crop. Banding is made at the desirable width and at any concentration, and may or may not be replicated with the inclusion of as many check plots as considered necessary. An experiment was established at the Fruit Substation, at Juana Díaz, Puerto Rico, on March 8, 1973, evaluating nine new materials at three levels on twenty vegetable crops. Only the level recommended by the manufacturer will be reported in this paper.

1 Associate Horticulturist and Assistant Agronomist, Río Piedras and Fortuna Substation, respectively, Agricultural Experiment Station, University of P. R., Mayaguez Campus, Río Piedras, P. R.

MATERIALS AND METHODS

The planting was established on a well prepared field of Paso Seco Loamy Sand (Loam 39%, Sand 39% and Clay 22%). Soil pH was 7.16, with 2.39% organic matter and a base exchange capacity of 25.3 meq. per 100 grams.

Seeding was accomplished with a Stanhay MK II precision seed spacing drill, using the correct size belt for each vegetable planted and depth depending on variety. Planting speed was 2.4 kph (1.5 m.p.h.). Tractor Ford Series 3000 was power source. Seeding was extra heavy to assure a good stand of crop, with between row spacing of 0.45 m. (1.5 ft.).

One row each of the following crops, variety in brackets, were included in the test: Sorghum (C–17), Sweet corn (Hawaii 68), Rice (Sinaloa), Onion (Texas Grano 502), Collard (Georgia), Cabbage (Stonehead), Chinese Cabbage (Michihli), Radish (Scarlet Globe), Bushbean (Contender), Pigeon Pea (Kaki), Okra (Drawf Long Green Pod), Eggplant (Florida Market), Tomato (Pink Deal), Sweet Pepper (Yolo Wonder), Watermelon (Charleston Sweet), Cantaloupe (Edisto), Endive (Broad Leaved Batavian), Head Lettuce (Great Lakes 659), Leaf Lettuce (Salad Bowl), and Sunflower (Mammouth Gray Stripe).

All herbicides were tested for preemerge activity at manufacturers recommended rate. Materials and rates were: Hercules–22234 al 1.36 Kg. Ai/Ac., Bay Kue-2236 at 0.68 Kg. Ai/Ac. Bay-94337 at 0.24 Kg. Ai/Ac, Gulf S–6044 at 1.81 Kg. Ai/Ac, Gulf S–6797 at 3.63 Kg. Ai/Ac, Mobil 4379EC at 0.68 Kg. Ai/Ac, Mobil 4379WP at 0.34 Kg. Ai/Ac, IMC–3950 at 2.72 Kg. Ai/Ac, and Ansul–56477 at 2.72 Kg. Ai/Ac.

All herbicides were applied using a Chem-Farm Sprayer with P.T.O. pump powered and transported by a Ford 3000 tractor. Four NW–5 nozzles adjusted to spray a band 1.83 meters (6.0 ft.) were used, with each nozzle delivering 1395 cc/min at 10 psi. Pressure was maintained using a tachometer setting of 1500 rpm and a speed of 2.4 Kmh (1.5 mph). Plots were sprayed at 90° to crop rows. Each plot was 12.7 x 1.8 meters (42 x 6 ft). Sprayer was washed out throughly between treatments using water a/o ammonia detergent solution.

Quality of water used for mixing chemicals applied is as follows: a pH of 7.07, Na 4.82 meq/L, Ca & Mg 2.78 meq/L, a conductivity of 0.76 mmhos/L, and a temperature of 31°C. (88.2° F).

The day was partly cloudy with wind south east at 16.8 Km/Hr (10.2 mph), air temperature 30.8°C (87.5° F.), relative humidity 45%, soil temperature at 5.1 cm. (2 in.) 33.3°C. (92° F).

All irrigation was applied overhead. First irrigation was sufficient to saturate field to puddling and then turned off. Analysis or irrigation water gave a pH of 7.45, Ca & Mg 6.89 meq/L., with conductivity of 0.60 mmhos/cm. All irrigations were applied as required but to the point of run-off only. Total rainfall for duration on test was 1.52 cm (0.60 in.) with 1.19 cm. (0.47 in.) precipitation recorded on March 29.

The crop and weed responses to herbicides were evaluated primarily with the use of the following subjective rating system.

Crop Tolerance Ratings	*Weed Control Ratings*
1. No injury	S–Susceptible
2. Slight injury	I–Intermediate
3. Moderate injury	T–Tolerant
4. Severe injury	
5. Dead	

The procedure for subjective rating was to study all the control plots before making the ratings; subsequently, the plots were rated without knowledge of treatments applied. This unbiased method often resulted in ratings greater than "S" because of variable weed stand and crop growth. When more data were thought necessary, stand counts were thought necessary, stand counts were made to measure degree of weed control activity.

RESULTS

Results obtained were encouraging from the performance tests with most vegetables. The trial clearly showed that many of the herbicides were phytotoxic under the test conditions. Table 1 contains a generalized summary of the test results. Weed control rating was largely to compare the herbicide treatments when considering crop tolerance and to the control when interpreting weed response. The data are presented in table 2 for more detailed study. Latin plant names are used for weed species encountered. Due to the variation of common plant names in the various Caribbean Islands, the reader is referred to Cardenas *et al* (1972) for English-Spanish description and color photographs of the species.

SUMMARY

Nine new unregistered preemerge herbicides were tested on twenty vegetable crops. Test duration was twenty-eight days evaluating the crop plant for phytoxic resistance and weed plant for susceptibility. Self-explanatory data is summarized in two tables, indicating chemical effect on crop-weed plants.

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Table 1

Primary Screening of New Unregistered Preemerge Herbicides
Effect of Chemical on Germination

CHEMICAL / CROP	Hercules 22234	Bay Kue 2236	Bay 94337	Gulf S-6044	Gulf S-6797	Mobil 4379EC	Mobil 4379WP	IMC 3950	Ansul 56477
Sorghum	2*+	1	2	3	1	2	1	2	2
Sweetcorn	1	1	1	1	1	1	1	1	1
Rice	3	1	2	3	1	1	2	1	1
Onion	2	2	3	1	5	4	3	1	1
Collard	1	5	5	4	5	3	3	1	1
Cabbage	1	5	5	4	5	3	4	2	2
Chinese Cabbage	1	5	5	3	5	3	3	1	1
Radish	1	5	5	2	4	3	3	1	1
Bush Bean	1	2	3	3	2	2	3	1	1
Pigeon Pea	2	4	2	1	1	2	1		
Okra	1	4	4	3	2	3	4	1	1
Eggplant	1	2	1	1	2	2	3	1	1
Tomato	1	5	1	1	5	3	3	1	2
Sweet Pepper	1	1	1	1	1	2	1	1	1
Watermelon	2	4	3	1	2	1	1	1	1
Cantaloupe	2	4	3	3	3	1	1	1	2

Table 1 — *Concluded*

Primary Screening of New Unregistered Preemerge Herbicides
Effect of Chemical on Germination

CROP / CHEMICAL	Hercules 22234	Bay Kue 2236	Bay 94337	Gulf S–6044	Gulf S–6797	Mobil 4379EC	Mobil 4379WP	IMC 3950	Ansul 56477
Endive	1	5	5	3	5	2	2	1	1
Head Lettuce	1	1	4	1	5	2	2	1	1
Leaf Lettuce	1	1	5	3	5	3	3	1	2
Sunflower	1	2	2	1	1	1	1	1	1

* Crop Rating: 1 – No Injury, 2 – Slight Injury, 3 – Moderate Injury, 4 – Severe Injury, 6 – DEAD

Table 2

Primary Screening of New Unregistered Preemerge Herbicides. Control of Prevalent Weed Species encountered in the Experiment

CHEMICAL / WEED SPECIES	Hercules 22234	Bay Kue 2236	Bay 94337	Gulf S–6044	Gulf S–6797	Mobil 4397EC	Mobil 4397WP	IMC 3950	Ansul 56477
Echinochloa colonum	S*	S	T	S	S	S	S	S	S
Eleusene indica	S	T	S	S	S	I	I	T	S
Sorghum balpense (seedling)	S	S	I	I	I	T	T	I	S
Triathema portolacastrum	S	S	S	S	S	S	I	T	S
Amaranthus dubius	S	S	S	S	S	S	S	I	S
Cleome speciosa	S	S	S	S	S	S	S	S	S
Ipomoea tiliaceae	S	S	S	I	I	S	S	I	I
Euphorbia heterophylla	S	S	S	S	I	S	S	S	S
Chamaecrysta aeshynomene	S	S	S	S	S	S	S	S	S
Crotolaria striata	S	S	S	S	S	S	S	S	S
Boerhaavia decumbens	S	S	S	S	S	S	S	I	S
Portulaca oleraceae	S	S	S	S	S	I	S	I	S

*Weed Tolerance: T – Tolerant to the Herbicides
I – Intermediate
S – Susceptible

SYSTEM FOR FIELD MEASURE OF EROSION, RUN OFF, AND OBLIQUE DRAINAGE IN FERRALLITIC SOILS ON GRANITIC MATRICES IN FRENCH GUIANA

by

PHILIPPE BLANCANEAUX

Soil Scientist, ORSTOM, Cayenne, French Guiana.

INTRODUCTION

This note is the presentation of an experimental system for qualitative and quantitative measures of the run off erosion and oblique drainage in soils (in situ). In French Guiana, as in many other humid tropical countries, an improverishment of the colloidal fraction in the top horizons of the profiles is generally observed. The term "impoverishment" in the French classification introduced by AUBERT (G.) and SEGALEN (P.) (1966) is used for the colloidal part and "LIXIVIATION" for movements of bases and silica. "LEACHING" is reserved for the movement of iron and clay from an impoverished layer to an enriched one. In many cases, in French Guiana, leaching of the colloidal part (and more specifically of the clay fraction) down from top horizons is observed without any accumulation in deeper layers. These soils are classified as "impoverished" in opposition to the "leached" ones which show an accumulation layer at a variable and generally small depth.

The aim of the experimental device we present here is an approach to the dynamics of elements moving under the influence of water, *in* and *on* the soil, the evaluation of each responsible factor (erosion, run off, oblique drainage), the hydrologic balance-sheet estimation characterizing these soils in relation to the climate; in short, to reach a quantitative evaluation, worked out for each of these factors, and defining their role in pedogenesis.

Agronomically, these measures may be used to obtain information about fertilizers and lixivation velocity, as well as to glimpse the most convenient time and the optimal granulometric characteristics for their application.

This survey is a working part of a vast research programme on erosion, colloidal impoverishment, hydrological and chemical balance-sheet in equatorial and subequatorial countries under natural or cultivated vegetation. It started in 1964 and including experimental plots at ADIOPODOUME (ORSTOM) ANGUEDEDOU (IRCA), AZAGUIE (IFAC) DIVO (IFCC), BOUAKE, MAN, FERDESSEDOUGOU (IRAT), KORHCGO (ORSTOM), OUAGADOUGOU (CTFT).

THE EXPERIMENTAL DEVICE

(a) Description

A plot of 25 metres long and 6 metres wide has been set out on a slope of about ten per cent by boards (25 cm) driven approximately 10 cm into the soil, so that trickling water can not come in or go out. This plot lies in undisturbed primary forest vegetation. Lower down on the slope, below the plot, we dug two distinct pits in order to collect trickling water and to intercept oblique drainage. This experimental disposition has been thought out by E. J. ROOSE (1968).

On the lower parts of the plot, just above the pits, we have directly plastified the soil in order to realize a run off drainage channel conducting the water towards two casks. The first one contains 15 distributors, one of them discharging into the second tank having a capacity of 225 litres. The entire stocking capacity thus is of 3,375 litres. This system may be insufficient to contain water issued from rainfall higher than 100 mm. Perhaps we may have to increase the number of distributors and to increase the casking volume.

During the rainy season, run off is so important on granitic soils that the ditches, though covered by a roof, quickly fill up with water, so we shall have to dig a special channel to drain the excess water away out of the experimental area.

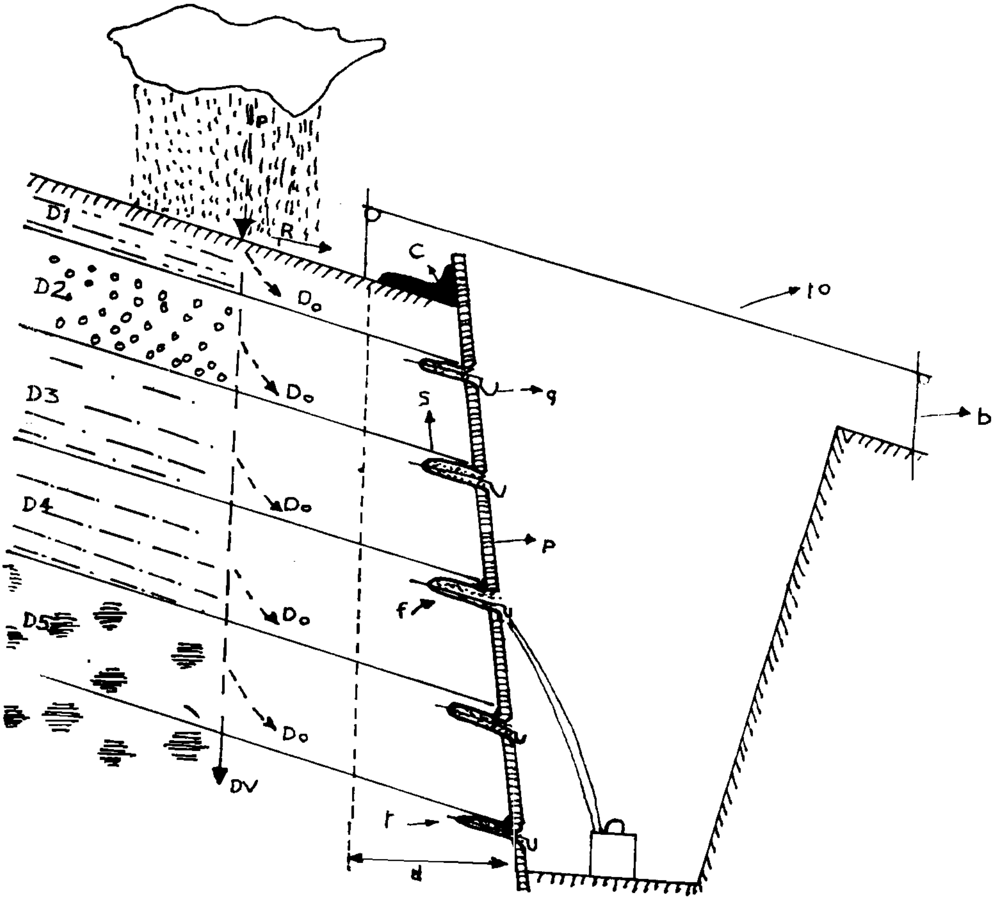
Pluviometry is measured on the spot by a set of pluviographs being placed in different points on the soil. Forest interception of rainfall is deduced from values registered by self-recording rain-gauges situated in a clearing on top of the hill.

(b) Water movement in the soil owing to gravity

Preponderantly, soils on granitic matrices in French Guiana show, at a moderate depth (50cm), a layer that is relatively less permeable than the top horizons. When a certain quantity of rain (P) falls on such a soil, one part of the water will run off the surface (R) and another part will infiltrate vertically; this is the vertical drainage (D.V.)

But when the soil capacity of the top horizon is reached, a part of the free water infiltrating vertically in this horizon will start an oblique movement following the slope. This is the oblique drainage (D.O.). At the less permeable level a temporary and perched ground-watertable may come into being, drying up again several days after the end of the rainfall.

In our "ERLO" hut – name of the whole experimental device – a slice of soil about 30 centimetres wide and situated above the oblique drainage ditch is protected from rainfall by a galvanized iron roof: water collected in the run off channel therefore can only come from the oblique drainage of the water moving freely inside the plot. We do not collect water implied in vertical drainage. This can be measured in situ by another appropriate system.



Diagrammatic representation of water flow and of an oblique drainage case. (E.J. ROOSE 1968).

P = rain.
R = run off.
D.v. = Vertical drainage.
D.o. = oblique drainage.
D 1,2,3,4 = Pedological horizons.
C = run off drainage channel.
G = gutter.
t = sheet.

f = crack.
S = washed sand.
d = slice of soil protected by the run off drainage-channel (C) and by the roof (t^0).

b = frame supporting the roof.
P = board.

Run off

Run-off directly depends on rainfall intensity; it stops quickly when rainfall ceases; it's a rapid flow on the soil surface.

Ground-watertable

This factor is responsible for the basic level-flow of a permanent river by means of invisible sources. It is the more general case of water flow in a soil constituted by a permeable level over a very impermeable layer.

Interflows

These flows are situated between the proceeding types. We distinguish among them:

(1) Subsurface run off.

This run off may occur in certain soils showing at little depth, a level clearly less permeable than the superficial part of the profile. Rainfall chokes the porous horizon and saturates it. When the soil surface is not level, temporary perched micro-ground-watertables may form, the head-waters of which will flow obliquely to the less permeable level; this flow could explain the white-washed sands in the top horizons of some soils, this hypodermic run off is slightly retarded with reference to the surface run off.

(2) Oblique drainage.

It is the most usual internal water flow when permeability gradually decreases with depth in a soil profile Small free water accumulation may then occur under each horizon.

According to the slope, there may be oblique water movement; these flows are limited and generally stop some minutes after the end of the rainfall.

(3) **Perched watertables.**

Their existence is due to a layer of total impermeability (lateritic shield, layer of bed-rock alteration, clay accumulation layer etc...) surmounted by one or several porous and permeable horizons. Infiltrating water, the vertical drainage of which is stopped, thus accumulates at this level; flows supplied by those watertables may continue to run several days after rainfall has ceased. This case seems to be very usual in French Guiana on such types of soils.

CHOICE OF THE IMPLANTATION SITE FOR THE "ERLO" HUT

Situation

The plot where this work has been undertaken and will continue during 3 years, is situated in the experimental ORSTOM watershed station of Crique Gregoire on the Sinnamary river. A pedological map (1/30.000) of this catchment area has been made. The whole watershed ($24 km^2$) lies on a matrix of Caribbean granito-gneiss. We note that granites are the geological formations most largely represented in French Guiana and cover about 33,000 km^2 on a total of 90,000 km^2.

Climatology

Average annual rainfall for the period 1968 – 1970 at Gregoire was 3,375 mm.

In 1969 maximal percipitation during 24 H, in mm are:

Year	J	F	M	A	M	J	J	A	S	O	N	D
1969	56.5	105.5	111.5	32.5	78.0	95.5	20.5	31.0	29.0	14.5	60.0	23.5

August, September, and October are the "dry" months of the year. Pluviometric curves show a deflection at the end of February ("little summer of March"); yet, atmospheric precipitation remains about 250 mm during these two months and in consequence these soils are maintained in a quite completely saturated condition. The implications for soil erosion also are clear.

The average annual temperature is about 26° C. Average relative humidity is about 97%.

Vegetation

The water catchment area is covered by primary tropical Rain Forest. Many uprooted trees are observed, most frequently on hilltops. With regard to the flora the forest is dominated by the same plant families as nearly everywhere in the Guiana's: Leguminosae Lecythidaceae, Lauraceae, Burseraceae, Sapotaceae in the first places.

The soil

On the plot, soil is ferrallitic, highly unsaturated in B, leached modal (ultisol) and on granito-gneiss. The general landscape of these granito-gneissic formations is strongly undulating. Slopes are up to 35%. Under the summits, many holes, originating from the uprooting of trees (Djougoung-Pété), filled with water and organic matter are generally observed. Run off is strong and easily visible when it rains heavily; most of the watershed soils are leached as well as eroded. Rejuvenation is remarkable in the great majority of the profiles. Actual erosion is hampered by intense root development at the soil surface; however, it is visible and the surface water flows carry a heavy load of organic matter. The bedrock is always rather near the surface (about 2 metres deep).

ANALYTICAL DETERMINATIONS BEING UNDERTAKEN

- Volume of run off and drainage water
  - Run off
  - Oblique drainage.
- Analytical characteristic of collected water
  - Physical
    - Run off water
      - Turbidity
      - Erosion.
    - Oblique drainage
      - Leaching of colloidal Clay.
  - Chemical
    - pH
    - Conductivity
    - Organic matter
    - Fe_2O_3, Al_2O_3, SiO_2
    - Ca^{++}, Mg^{++}, Na^{+}, K^{+}

Working start : March 1973.

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THE EVALUATION OF CABBAGE *(BRASSICA OLERACEA* VAR *CAPITATA)* VARIETIES IN THE LEEWARD ISLANDS[1]

by

St. C. M. FORDE[2]

INTRODUCTION

In 1971 work was begun to evaluate the performance of certain varieties of cabbage in the Leeward Islands. In St. Kitts and Montserrat the cultivar commonly used by farmers is Copenhagen Market, while in Antigua, the variety preferred is All Seasons.

MATERIALS AND METHODS

At least eight trials were established in the Islands to compare the performance of the cultivars Copenhagen Market, Early Round Dutch, Ferry Round Dutch, Golden Acre, Globe 62 M. y.r., Green Back y.r. and Marion Market y.r. Four of these could not be carried to completion because of the effects of severe drought conditions at certain periods during the growth of the crop and heavy infestations of *Plutella* which could not be controlled even by twice weekly spraying with Basudin (Diazinon). The four trials completed were sited at Mt. Pleasant Estate, St. Kitts.

The seedlings were first grown in nursery beds and transplanted to the field. Each plot consisted of 128 plants in rows 4.9 m long and 60 cm

1. Paper presented at the 11th Annual Meeting of the Caribbean Food Crops Society, Barbados, July 1973.

2. Research Fellow, University of the West Indies P.O. Box 444, St. John's Antigua.

apart with the plants 46 cm apart within the row. At transplanting the soil was treated with Dacthal (or Dymid) at the rate of 5.7 kg/ha to control weeds. Subsequent weed control was by hand. A basal dressing of 12-12-12 NPK fertilizer was applied at 578 kg/ha when the transplants became fully established.

The plants were sprayed at weekly intervals with either Basudin, Lannate or Toxaphene to control insect pests. The fungicides Dithane M 45 or Kocide 101 were incorporated into the spray.

RESULTS AND DISCUSSION

It was difficult to establish these experiments satisfactorily because of limiting moisture conditions at critical stages (e.g. immediately after transplanting) in the growth of the crop. The control of *Plutella* by the use of the insecticides Basudin or Lannate was not satisfactory. From other investigations with cabbage it appeared that this insect could be controlled quite effectively with Dipel *(Bacillus thurigensis).*

The mean yields of marketable cabbage in tons/hectare are shown in Table 1. Yields were generally low, with the size of heads small. Splitting was most pronounced in the Golden Acre and Copenhagen Market varieties particularly when rainfall was unevenly distributed. It was aparent that under a rainfed system of production, fruit size quality and yield could be seriously affected by adverse weather conditions.

Treatment differences were not significant, but the data summarised over the four trials (Table 2 show) that Marion Market was the best performer.

It is planned to continue this work and to include hybrid varieties such as Head Start, Market Prize, Market Topper as well as Japanese hybrid varieties into the programme.

Table 1

Means Yields of Marketable Cabbage in Tons/hectare (Means having the same letters are not significantly different at the 5.0% level by Duncan's Multiple Range Test)

Expt. No.	Design	Planting Date	Variety	Yield	Average Wt. fruit kg.	Notes
1	7x5 RCB	1 Sept.1971	Marion Market	10.0	0.41	Size of heads generally small but splitting negligible. Spraying had to be done twice weekly.
			Globe 62–M	9.9	0.43	
			Ferry Round Dutch	8.0	0.38	
			Green Back	7.7	0.41	
			Copenhagen Market	7.1	0.29	
			Early Round Dutch	6.6	0.35	
			Golden Acre	6.2	0.27	
2	7x3 RCB	17 Sept. 1971	Green Back	10.1	0.53	
			Marion Market	7.6	0.44	
			Copenhagen Market	6.7	0.33	
			Globe 62–M	5.7	0.41	
			Ferry Round Dutch	5.5	0.39	
			Early Round Dutch	5.5	0.35	
			Golden Acre	4.6	0.26	
3	7x4 RCB	1 Oct. 1971	Marion Market	15.9	0.74	Expt. suffered from water-loging in some areas due to poor
			Early Round Dutch	12.9	0.60	
			Globe 62–M	11.4	0.67	

Table 1 — *Cont'd.*

Means Yields of Marketable Cabbage in Tons/hectare (Means having the same letters are not significantly different at the 5.0% level by Duncan's Multiple Range Test) — *Cont'd*

Expt. No.	Design	Planting Date	Variety	Yield	Average Wt. fruit Kg.	Notes
3	7x4 RCB	1 Oct. 1971	Green Back	10.8	0.70	drainage. Incidence of Plutella very severe limit-marketable yields and quality.
			Ferry Round Dutch	10.7	0.62	
			Copenhagen Market	10.6	0.50	
			Golden Acre	10.5	0.46	
4	7x4 RCB	25 Oct. 1971	Early Round Dutch	7.7	0.32	Severe drought conditions. Problem with the control of Plutella.
			Marion Market	7.1	0.39	
			Copenhagen Market	6.8	0.32	
			Golden Acre	6.1	0.30	
			Green Back	5.3	0.37	
			Ferry Round Dutch	4.6	0.28	
			Globe 62–M	4.2	0.38	

Table 2

Mean yields of marketable cabbage (averaged over four trials)

Variety	Yield Tons/ha
Marion Market y.r.	10.1
Green Back y.r.	8.5
Early Round Dutch	8.2
Copenhagen Market	7.8
Globe 62 M y.r.	7.8
Ferry Round Dutch	7.2
Golden Acre	6.8

SUMMARY

Four trials were carried out to evaluate the performance of seven cultivars of cabbage. *(Brassica oleracea* var. *capitata)* in St. Kitts. Limiting soil moisture conditions and heavy infestations by *Plutella,* affected yields which were generally low. Treatment differences were not significant but the yields of marketable fruit in tons/hectare summarised over the four trials were: Marion Market, 10.1; Green Back, 8.5; Early Round Dutch, 8.2; Copenhagen Market, 7.8; Globe 62–M, 7.8; Ferry Round Dutch, 7.2; and Golden Acre, 6.8.

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EVALUATION OF CUCUMBER *(CUCUMIS SATIVUS)* VARIETIES IN THE LEEWARD ISLANDS.[1]

by

ST. C. M. FORDE[2]

INTRODUCTION

The production of cucumbers in the Leeward Islands, has until recently been seriously affected by Powdery Mildew *(Erysiphe cichoracearum)*. However, with the introduction of the fungicide, 'Benlate' the incidence of the disease has been arrested and it is now possible to grow the crop successfully. With the elimination of the disease problem, it was decided to compare the performance of Ashley, (long regarded as the best variety for the region) with five other commercially available varieties on an all year round basis.

MATERIAL AND METHODS

Nine trials were laid down either with 6 x 4 randomised complete block or 6 x 6 Latin Square designs to compare the performance of the following varieties:– Ashley, Cherokee (hybrid), Gemini (hybrid), Marketer, Palomar and Poinsett.

1. Paper presented at the 11th Annual Meeting of the Caribbean Food Crops Society, Barbados, July, 1973.

2. Research Fellow, University of the West Indies, P.O. Box 444, St. John's Antigua.

There were 144 experimental plants per plot in six rows 90 cm apart with the plants spaced 30 cm apart within the row. An application of 12-12-12 NPK fertilizer was made at the rate of 568 kg/ha at the 3–4 leaf stage of development.

The crop was protected against insect and disease pest attack by spraying with Dipterex and/or Basudin (Dizdinon) together with Benlate. Dithane M 45 was used at times to guard against Powdery Mildew.

The experimental sites were as follows:–

Island	Location	Soil Type
Antigua	Diamonds	Fitches clay (Grumusol)
St. Kitts	Mt. Pleasant	Sandy Bay Loam (Protosol)

RESULTS AND DISCUSSION

The planting dates of the nine trials carried out extended from 24 May 1971 to 1 March 1972 with harvesting periods from 19th July to 15th May 1972. There were at least three other trials which would have supplied information for the complete year 1971–72 but the data could not be analysed statistically because of losses due to praedial larceny and in one case poor establishment when birds destroyed the young seedlings.

However, it can be seen that cucumber can be produced all year round provided that soil moisture conditions are not limiting. The most important insect pest was a serpentine leaf miner, but this was controlled to a reasonable extent by weekly spraying with Basudin. The variety Marketer was always seriously affected by Angular Leaf Spot *(Pseudomonas lachrymans)* particularly in St. Kitts. In Table 1, the mean yields of marketable cucumbers together with information on rainfall, dates of planting and harvesting are shown. The hybrid varieties gave yields that were significantly higher than the standard Ashley.

If the yields of the six varieties are averaged over the nine trials, then the results are as follows:

Variety	*Tons/hectare*
Gemini	39.1
Cherokee	37.7
Poinsett	34.3
Ashley	33.1
Palomar	32.5
Marketer	32.1

With regard to fruit quality, the hybrids were more uniform with more fruit in the US Grade 1 class, and earliest compared with the others. It is therefore recommended that the hybrids Gemini and Cherokee be used in commercial production since they have multi-resistance or tolerance to a wide range of diseases of cucumber (Gemini is not resistant to Powdery Mildew), and the plant protection programme should be less costly than would be the case using the other cultivars evaluated.

SUMMARY

Nine trials were carried out in Antigua and St. Kitts during the period May 1971 to March 1972 to compare the performance of six varieties of cucumber *(Cucumis sativus).* The results averaged over the nine trials showed the mean yields of marketable cucumber in tons/hectare to be Gemini 39.1; Cherokee, 17.7; Poinsett, 34.3; Ashley, 33.1; Palomar, 32.5; Marketer, 32.1.

ACKNOWLEDGEMENTS

The author wishes to thank Messrs James Spencer and C. Quashie, Technical Assistants of the Regional Field Experimental Programme, University of the West Indies for the assistance given in the carrying out of this work.

Table 1

Mean Yields of Marketable Cucumbers in Tons/hectare (Means having the same letters are not significantly different at the 5.0% level of Duncan's Multiple Range Test)

Expt. No.	Design	Date		Varieties	Yield	Average Wt. fruit Kg	Notes & Rainfall
		Planting	Harvesting				
1	6 x 4 RCB	24 May 1971	19 July – 30 August 1971	Ashley	50.7	0.26	Established during dry period but yield satisfactory. No fertilizer applied (9.03 inches).
				Cherokee	49.7	0.23	
				Gemini	48.2	0.28	
				Palomar	47.4	0.27	
				Marketer	47.4	0.27	
				Poinsett	45.2	0.22	
2	6 x 6 Latin Square	5 July 1971	25 Aug – 7 October 1971	Gemini	23.8a	0.31	(13.44 inches)
				Poinsett	20.1ab	0.38	
				Cherokee	19.7ab	0.28	
				Palomar	14.9 bc	0.31	
				Marketer	13.2 bc	0.24	
				Ashley	12.5 bc	0.28	
3	6 x 6 Latin Square	28 July 1971	13 Sept– 11 November 1971	Gemini	73.8a	0.38	Fruits attacked by an insect borer in late stages of harvest. Hybrids were earliest. (16.67 inches)
				Poinsett	72.8a	0.38	
				Cherokee	68.8ab	0.39	
				Ashley	65.9ab	0.38	
				Marketer	59.2ab	0.36	
				Palomar	54.1 b	0.35	

Table 1 *Cont'd*

Mean Yields Marketable Cucumbers in Tons/hectare (Means having the same letters are not significantly different at the 5.0% level of Ducan's Multiple Range Test)

Expt. No.	Design	Date		Varieties	Yield	Average Wt. fruit Kg	Notes & Rainfall
		Planting	Harvesting				
4	6 x 4 RCB	5 August 1971	20 Sept– 8 November 1971	Cherokee	41.2a	0.25	Some plants damaged by herbicide spray but recovered. (15.26 inches)
				Palomar	36.3ab	0.28	
				Gemini	36.3ab	0.25	
				Poinsett	35.1ab	0.22	
				Marketer	33.6 b	0.28	
				Ashley	29.9 b	0.24	
5	6 x 6 Latin Square	29 Sept. 1972	15 November – 22 December 1971	Cherokee	36.3a	*	(15.92 inches)
				Gemini	32.5a		
				Ashley	34.9a		
				Palomar	25.6ab		
				Poinsett	25.6 b		
				Marketer	17.5 b		
6	6 x 4 RCB	21 Oct. 1971	7 December 1971 – 17 Jan. 1972	Cherokee	62.2a	0.25	Good performance despite very uneven distribution of
				Gemini	57.6ab	0.32	
				Poinsett	51.0ab	0.26	
				Palomar	43.9 b	0.30	

Table 1 — *Cont'd*

Mean Yields Marketable Cucumbers in Tons/hectare (Means having the same letters are not significantly different at the 5.0% level of Duncan's Multiple Range Test)

Expt. No.	Design	Date		Varieties	Yield	Average Wt. fruit Kg	Notes & Rainfall
		Planting	Harvesting				
6	6 x 4 RCB	21 Oct. 1971	7 December 1971–17 Jan. 1972	Ashley	43.2 b	0.29	rainfall; 1.62 in. in Nov. and 8.07 in. December. Plants were waterlogged in December. (15.32 inches).
				Marketer	43.0 b	0.31	
7	6 x 5 RCB	9 Nov. 1971	31 Dec. – 31 Jan. 1 972	Palomar	11.6	0.29	(8.86 inches)
				Poinsett	11.1	0.27	
				Gemini	11.1	0.28	
				Cherokee	9.8	0.26	
				Marketer	8.7	0.28	
				Ashley	7.6	0.28	
8	6 x 4 RCB	3 Dec. 1971	17 Jan. – 13 March 1972	Marketer	54.4	0.27	(16.05 inches)
				Gemini	45.6a	0.25	
				Palomar	45.5a	0.26	
				Ashley	39.7ab	0.24	
				Cherokee	35.5 b	0.21	
				Poinsett	35.2 b	0.21	

Table 1 — *Concluded*

Mean Yields Marketable Cucumbers in Tons/hectare (Means having the same letters are not significantly different at the 5.0% level of Duncan's Multiple Range Test)

Expt. No.	Design	Date		Varieties	Yield	Average Wt. fruit Kg.	Notes & Rain-fall
		Planting	Harvesting				
9	6 x 6 Latin Square	1 March 1972	20 April – 15 May 1972	Gemini	20.5	0.27	Only 2.11 inches of rain in April; Early die back of plants; (9.35 inches).
				Cherokee	16.2a	0.21	
				Poinsett	13.6ab	0.21	
				Ashley	13.2ab	0.22	
				Palomar	13.1ab	0.24	
				Marketer	11.6 b	0.24	

THE INFLUENCE OF PLANT DENSITY ON SWEET PEPPER *(CAPSICUM ANNUM)* YIELDS IN ST. KITTS. [1]

by

St. C. M. FORDE [2]

INTRODUCTION

In this paper the results of a sweet pepper spacing trial carried out in St. Kitts during 1971 are represented.

MATERIALS AND METHODS

On 25 May 1971 a 5x4 RCB spacing trial was established at Mt. Pleasant Estate, St. Kitts using the sweet pepper cultivar California Wonder 300. There were 144 experimental plants to each plot with the following treatments.

Treatment	Distance		Density
	Between row	Within row	Plants/hectare
A	45.7	30.5	71,736
B	45.7	45.7	47,881
C	45.7	61.0	35,868
D	61.0	30.5	53,734
E	61.0	61.0	26,874

1. Paper presented at the 11th Annual Meeting of the Caribbean Food Crops Society, Barbados, July, 1973.

2. Research Fellow, University of the West Indies, P.O. Box 444, St. John's, Antigua.

Seedlings were raised in nursery beds, and soon after transplanting, an application of 12-12-12 NPK fertilizer was made at the rate of 5.7 kg/ha. Dacthal was also applied at the rate of 5.7 kg/ha. A routine spray programme was carried out using Sevin or Dipterex at weekly intervals. The fungicides Dithane M 45 or Antracol were at times added to the spray.

RESULTS AND DISCUSSION

Analysis of the data was on the basis of single plant yields in order to overcome the problem of introducing errors by correcting yields to represent the original stand count in plots where experimental plants were lost. The results are shown in Table 1, where mean yields of marketable sweet pepper fruit in tons/ha are given according to treatment.

It would seem that at low plant densities (26,874 plants/hectare) the yield of fruit per plant was significantly higher than that obtained at higher densities (71,736 plants/hectare). However, the difference in single plant yield did not produce a higher yield per hectare, for in terms of total yield per hectare, the higher densities were significantly better. The density 47.5 x 30.5 cm seems a satisfactory spacing for sweet peppers.

SUMMARY

The optimum density for sweet pepper in St. Kitts was determined using the cultivar California Wonder 300 at five densities, viz:

Between Row	Within Row	Plants/ hectare
cm	cm	
45.7	30.5	71,736
45.7	45.7	47,881
45.7	61.0	35,868
61.0	30.5	53,734
61.0	61.0	26,874

At low plant densities the yield of fruit per plant was significantly higher than at high densities, but this difference was not high enough to make up for the greater yield per hectare at the higher densities. The density 45.7 cm x 30.5 cm (71,736 plants/hectare) seems a satisfactory spacing for sweet peppers.

ACKNOWLEDGEMENT

The author wishes to thank Messrs C. A Quashie and T. Caines Technical Assistants, Regional Field Experimental Programme, University of the West Indies for their help in carrying out this work.

TABLE 1

Mean Yield of Sweet Pepper fruit per plant (kg) and estimated yields tons/ha

Between Row cm	Within Row cm	Density Plants/ hectare	Mean Yield Fruit per plant (kg)	Estimated Yield in Tons/ha
E 61.0	61.0	26,874	0.43 a	11.5
C 45.7	61.0	35,868	0.42 ab	14.6
B 45.7	45.7	47,881	0.39 ab	18.7
D 61.0	30.5	53,734	0.32 bc	17.2
A 45.7	30.5	71,736	0.28 c	20.1

Note: Means having the same letters are not significantly different at the 5.0% level of Duncan's Multiple Range Test.

A PRELIMINARY REPORT ON THE DEVELOPMENT OF AVOCADO AS A TREE CROP AND ON FACTORS AFFECTING YIELD IN BARBADOS

by

ROBERT D. LUCAS

Agronomist, Soil Conservation Department,
Ministry of Agriculture, Barbados.

SUMMARY

The development of organized plantings of Avocado is new to Barbados. Prior to 1972, there was only one area where a pure stand of more than twenty trees could be found. Since then, this number has risen by eight. The newly planted areas consist either of grafted plants or seedling trees. The yield per tree is low and this is mainly due to poor management; the Avocado being related to the position of a backyard tree.

It is hoped that with the production of an increasing amount of grafted plants, and an improvement in management practices, that ultimately Avocado production in the island will increase.

INTRODUCTION:

The Avocado is grown extensively in Barbados as a backyard plant. As such, little care is given to it and this results in low yields. Recently, an effort has been made to encourage the production of Avocado as a cultivated crop; consequently there has been an increase in the area devoted to its production.

HISTORICAL BACKGROUND:

In 1961, there were approximately 8,500 Avocado trees in the island. "Scotland District of Barbados" O.A.S. Report (1971). Of these 1,300 or 15.3% were to be found scattered throughout the Scotland District. 242 trees of the 1,300 were scattered over an area of 36.45 hectares (ninty-one acres) in the St. Joseph Forest. This represented the largest concentration of trees in any one area in the Scotland District.

Outside the Scotland District, only two areas of twenty or more Avocado trees could have been found. One area consisted of a pure stand of 38 mature seedling type trees situated at Kendal Plantation in St. John on approximately 0.13 hectare (one third of an acre).

The other was located at Claybury Plantation St. John, and consisted of 28 trees scattered over 2 hectares (five acres). Elsewhere, trees were found scattered in twos and threes.

PRESENT SITUATION:

In 1971, a propagation programme was started by the Ministry of Agriculture at Haggatts, St. Andrew. The aims of the programme were to promote the selection of superior local varieties, to import where necessary proven varieties and to set up pilot planting schemes.

In 1972, the first trial planting was carried out at Haggatts, where some 77 grafted trees were planted. These plants in addition to locally made selections, consisted of varieties such as Pollock, Lula and Simmonds. The Agricultural Development Corporation in conjunction with the Soil Conservation Department also planted an orchard later in 1972, at Bruce Vale, St. Andrew. At present only 37 trees were planted there, but two hundred have been allocated to the Agricultural Development Corporation by the Nursery at Haggatts, for planting in 1973.

The trend towards increasing the area under Avocado production, has not been restricted to Government Agencies only. Quite a few private individuals have already planted, or have purchased plants with the view to establishing their own orchard during this rainy season.

Six new areas of twenty or more trees were established in 1972. These plantings consisted either of grafted trees, or of seedlings which are to be grafted at a later date. So far this year, plans have been made to establish two new orchards of twenty or more plants, whilst additional plants are to be added to areas already planted. (See Table 1).

Most of the areas have been planted with provep varieties but some have been planted with local selections, which have been grafted onto seedling rootstock. (See Table 11).

YIELD OF AVOCADO:

It has been estimated that the average Avocado tree in the Scotland District yields 62 fruits, whereas outside this area the average tree yields 44 fruits. "Scotland District of Barbados" O.A.S. Report (1971).

Many factors are responsible for low yields. All are associated with the fact that the Avocado is not considered as a commercial tree crop. It is normally grown as a backyard tree or occurs naturally along roadsides. Management needs to be improved. Very little if any fertilizer is applied. Little irrigation is practised and no regard is given to the correct spacing of the plants. There is also a lack of any proper insect or weed control programme.

Physiological factors also affect yield. Poor fertilization – which may be caused either by poor pollination or pollen incompatibility – results in premature dropping of the flowers. This has a direct effect on the number of flowers available for fruit formation. It is a common sight to see a large number of flowers strewn beneath trees.

There is also a high incident rate of fruit shedding. This seems to result largely from competition between fruits for limited food supplies and moisture. The formation of abscission layers to some extent also result in fruit sheeding. Improved management would undoubtedly reduce fruit shedding.

There is a further reduction in yields due to pests such as the monkey. In areas such as the St. Joseph Forest and Skeete's cul de sac, St. Andrew, loss of fruit due to simian damage is quite high.

For further development of the Avocado as a tree crop in Barbados certain guidelines have to be followed.

These are:

(1) The use of improved varieties grafted or budded onto seedling rootstock.

(2) An increase in the area under Avocado cultivation.

(3) Improved cultural practices.

(4) Use of imported varieties to extend harvesting period.

LITERATURE CITED:

(1971) "Scotland District of Barbados". Evaluation of the problems and treatment of erosion and unstable ground. Organization of American States. P. 37.

Table I

A List of the areas where 20 or more Avocadoes have been established or are being established

Individual or Agency	No. of Trees	No. Planted	No. to be Planted	No. Grafted	No. of Seedlings	Area
Agricultural Development Corporation	237	37	200	237	–	Bruce Vale , St. Andrew
Dr. L. Campbell	70	–	70	70	–	Rowans, St. George.
Da Costa Edwards	20	20	–	20	–	Norwoods, St. James
Farmer Bim	55	55	–	35	20	St. Phillip
Soil Conservation M.A.S. & T.	108	77	31	108	–	Haggatts, St. Andrew.
Kendal Plantation	38	38	–	–	38	St. John.
Moncrieffe Plantation	20	20	–	–	20	St. John
Graemc Hall, M.A.S. & T.	23	23	–	21	2	Christ Church.
D. A. Kinch	100	100	–	–	100	St. Phillip.

Data compiled from Records of the sale of plants at Soil Conservation.

Table II

Some of the Avocado varieties used in a local orchard

Rowans

VARIETY	NO. OF PLANTS
LULA	20
POLLOCK	12
SIMMONDS	15
COLLINSON	12
KENDAL*	5
ST. SIMONS*	6

*Selections made locally.

THE PEPPER FLOWER BUD MOTH IN THE CARIBBEAN —

(an Evaluation)

by

S. PARASRAM

Department of Crop Science,
The University of the West Indies,
St. Augustine, Trinidad.

INTRODUCTION

Peppers of the genus *Capsicum* L. are attacked by a Gelechiid moth *Gnorimoschema capsicum* (Bradley & Povolny), now referred to as *Symmetrischema capsicum* Povolny. Fennah (1947) previously described this pest as *Phthorimaea gudmanella* (Zell.) occurring in the Lesser Antilles.

Alexander (1970) reported that the life cycle of S. *capsicum* averaged 29-38 days and there are 4 larval instars with a prepupal stage. Des Vignes (pers. comm.) indicated that the eggs of the moth are laid singly with few exceptions on the young leaves. Damage is done mainly to the flower buds which are eaten by the larvae causing the buds to absciss.

In Trinidad S. *capsicum* is found infesting hot pepper, *Capsicum annuum* L., bird pepper, C. *minimum* L. and sweet pepper, C. *grossum* L. The moth has also been recorded on peppers in the Virgin Islands (Wilson, 1923) Puerto Rico (Sein, 1944), Montserrat W.I. and the Rio Grande Valley, Texas (Schuster, 1960).

The larvae S. *capsicum* is parasitized mainly by the hymenopteran *Copidosoma capsicum* Leiby and to a lesser extent by *Enderus* sp.

Chelonus sp., *Apanteles dignus* (Muesbeck). Alexander (1970) found that the average percentage parasitism in Trinidad of fields randomly sampled were as follows: St. Augustine – 39.0%; UWI Field Station – 32.3%; Aranguez – 23%. In all instances there was an increased incidence of the moth over the period December – January.

This paper details a brief survey conducted in some of the West Indian islands to determine the levels of infestation.

MATERIALS AND METHODS

For the purposes of the survey buds were chosen at random in pepper plots in different areas and examined for the presence of the larvae.

RESULTS AND DISCUSSION

The results of the survey are given in Table 1. The results indicate that S. *capsicum* is present in several West Indian islands. When the infestation is of the order of 90-100% there is a severe effect on the yield as evidenced in Questelles, St. Vincent where fruit production was negligible. When infestation is of a lower order it is difficult to ascertain at what level of infestation economic damage occurs.

Many of the pepper flower buds produced fall off under normal conditions. Sein (1944) theorized that the thinning out of the flowers by the bud-moths lead to larger fruit size. While there may be merit in such a suggestion it is also true that heavy infestations affect yield. It is not unusual to find one larva per bud. When the attack is early in the crop cycle and the food supply is depleted before full larval development occurs, larvae will migrate to other buds. Several generations may be found on a pepper crop which may last for six months (sweet pepper) or continue for more than a year (hot & bird peppers).

Parasram (1971) has shown that the use of chemicals can keep the infestation at very low levels even where the population density is high.

Table 1

% INFESTATION IN DIFFERENT ISLANDS

Island/Area			% Infestation	Year	Classification
Trinidad	–	St. Augustine	48.0	1973	Bird pepper
	–	U.W.I. Field Station	33.3	1972	Hot peper
	–	Texaco Food Crops Dem. Sta.	90.0	1972	Hot pepper
St. Vincent	–	Campden Park	90.0	1972	Sweet pepper
	–	Questelles	100.0	1970	Hot pepper
	–	Clare Valley	80.0	1970	” ”
	–	Clare Valley	94.0	1972	” ”
	–	Clare Valley	94.0	1973	” ”
	–	Crichton (ArnosVale)	60.0	1973	” ”
Grenada	–	Mirabeau	33.0	1973	” ”
St. Lucia	–	Balambouche	90.0	1972	Sweet pepper
	–	Balambouche	80.0	1972	Bird pepper
Dominica	–	Grand Bay	93.0	1973	Sweet pepper
	–	Castle Bruce	100.0	1973	Hot pepper
	–	Island House area	100.0	1973	” ”
Antigua	–	Carlisle	30.0	1973	Sweet pepper
	–	Dunbars	90.0	1972	” ”
	–	Dunbars	70.0	1972	” ”
	–	Diamond	0.0*	1973	Hot pepper
Montserrat	–	Cavallah Hill	79.5	1973	Hot pepper
	–	Rileys	0.0	1973	Sweet pepper
	–	Paradise	84.0	1973	” ”

* Could not be ascertained whether area was sprayed.

Diazinon (R), Dipterex (R), Rogor (R), Perfekthion (R) and Malathion (R) have given significant control. As stated in the introduction parasitism of larvae occurs and in Montserrat recently a very high level of parasitism due to a pteromalid was noticed during a joint visit with Dr. F. Bennett of CIBC*. The level of bud infestation in this field was high (about 79.5%).

It is felt therefore that the proper use of an integrated programme i.e. biological & chemical measures would aid in the successful control of *S. capsicum.*

* (R) – Trade Name.

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This work was funded by the R. R. C. of the University of the West Indies.

SUMMARY

The pepper flower bud moth occurs in most of the West Indian islands. In some areas it is an economic pest while in others there is potential of its becoming one. Parasitism of the larva occurs to varying extents in the region. Diazinon, Rogor, Perfekthion, Dipterex and Malathion keep the population of the insect at a very low economic level. Some suggestions of future lines of work are given.

* Commonwealth Institute of Biological Control.

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POSSIBILITIES OF ONION BULB AND SEED PRODUCTION IN THE FRENCH CARIBBEAN

(Guadeloupe – Martinique)

by

G. ANAIS

Station d'Amelioration des Plantes
Centre de Recherches Agronomiques des Antilles et de la Guyane
Institute National de la Recherche Agronomique (France)
97–1 PETIT–BOURG (GUADELOUPE)

Onion is a very interesting crop for production in the Caribbean, because the consumption of this product is very high.

It is the second largest of our vegetable imports after Irish Potato (The imports in 1971 were 4,500 tons of Potato and 1,256 tons of Onion).

Moreover this crop can be grown without irrigation when planted from October to December.

The best situations for this crop are the dry areas with alkaline soils: Barbados, Antigua, Grande-Terre and Marie-Galante in Guadeloupe, and some locations in the south of Martinique.

A. — Bulb Production:

Three possibilities for bulb production were tried, namely:–

Direct seeding
Transplanting
Planting of sets.

1. Direct seeding:

This is the most economical method but requires some technique in soil preparation, the need of special equipment, and the use of herbicides. It however permits the total mechanization of the crop.

2. Transplanting:

The seeds are transplanted about 40 days after sowing seeds. This method demands much hand labour, but the soil preparation can be less careful than for direct seeding. It is suitable to small family farms on which chives and leek are grown and where hand labour is traditionally used.

3. Planting of onion sets:

The sets used were produced at the end of the previous dry season (Seeding January 18th set April 12th 1972) Seeding March 3rd sets April 21st) 1972. The onion sets were then planted on January the 16th 1973 and the bulbs harvested on April 6th 1973.

For the local growers it is the method which seems to be the most suited.

It requires less specialized soil preparation and planting can still be mechanized.

B. -- Seed Production:

In view of testing the possibility of breeding onion varieties for the Caribbean area, onion seed production was tried in Guadeloupe. Bulbs of several varieties were planted on October, 11th 1972.

Varieties from Niger, kindly received from M. NABOS of the IRAT Agency, flowered and seeded in good conditions.

The seeds obtained were of very good quality, showing that onion production and variety breeding is possible in our conditions.

SUMMARY

In our experiments three possibilities were used for onion bulb production: Direct seedling, Transplanting, Planting of sets. The direct seeding is more economical but requires special equipment. Transplanting is labour consuming. Planting of sets requires less specialized soil preparation than direct seeding but can also be mechanized.

Seeds can be obtained by planting bulbs of the previous year.