PROCEEDINGS

OF THE

CARIBBEAN FOOD CROPS SOCIETY

12th ANNUAL MEETING
JAMAICA

1974

VOLUME X11

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TECHNICAL PAPERS AND SUMMARIES

CARIBBEAN FOOD CROP SOCIETY

OFFICERS 1973-74

President	Hugh C. Miller	Jamaica
Vice-President	A.G. Naylor	Jamaica
Secretary	George Jackson	Puerto Rico
Treasurer	Dr. George Samuels	Puerto Rico

BOARD OF DIRECTORS

Chairman	W. DeC. Jeffers	Barbados
Member	R.A. Baynes	Barbados
Member	G. Anais	Guadeloupe
Member	Hansel Beckford	Jamaica
Member	H.A.D. Chesney	Guyana
Member	L. Cross	Trinidad & Tobago
Member	C. Walters	Antigua

MINUTES OF THE BUSINESS SESSION - JULY 5, 1974

The business session was called to order by the President, Mr. Hugh Miller at 2.15 p.m. on Friday July 5, 1974 at the Pegasus Hotel, Kingston, Jamaica.

1. Presidential Address

In a brief presidential address Mr. Miller extolled the efforts of the officers of the Society and the committee members who had worked so hard to assure success of the Twelfth Annual Meeting. He pointed to the growing number of scientific associations covering the Caribbean region and suggested that more attention be given by the Society in future to exploring areas of possible co-operation with such groups. He suggested that in view of growing interest in the production and utilisation of root crops a special yam study group be set up to identify research needs in yam production and utilisation, to secure a co-ordinated approach to the problems of yam research in the Caribbean area, and to facilitate exchange of information between research workers in the several territories comprising the Caribbean area.

2. Treasurer's Report

The Treasurer's report as below was presented and duly accepted.

(i)	Balance Bank Statement June 30, 1973	U.S.$3,493.71
(ii)	Receipts* July 1, 1973 - June 20, 1974	1,478.27
	Sub-Total	U.S.$4,971.98

(iii) Expenses July 1, 1973 to June 20, 1974

Barbados meeting - 1973		
Travel & Hotel	$424. 80	$
Funds to cover local committee deficit	481. 00	905. 80
Printing 1970 proceedings	350.00	
Printing 1972 "	783.75	1133. 75
Newsletters		76. 31
Professional Register		75. 00
Postage		160. 38
Stationery		37. 50
Addressograph work		47. 88
Advance to Jamaica meeting		101. 00
	Total	$ 2,537.62

(iv) Balance June 20, 1974 2,434.36

Receipts*

Membership fees collected Barbados meeting (86 members)	$ 430.00
Membership fees collected by mail (43 members)	215.00
Sustaining members fees (3)	300.00
Transfer of funds from Trinidad meeting	533.27
	1,478.27

3. Proposal for the setting up of Yam Study Group

This proposal was enthusiastically adopted by the meeting and the study group was duly set up.

Asked to serve on the study group were:

Dr. T. Ferguson	(Trinidad)	Chairman and Convenor
Mons. L. DeGras	(Guadeloupe)	
Dr. L.A. Wilson	(Trinidad)	
Dr. L.B. Rankine	(Jamaica)	
Miss G. Hickling	(Jamaica)	
Mr. J.P. Jeffers	(Barbados)	

4. Membership Fees

The meeting next considered a proposal that the fees for active membership in the Society should be increased from US$5.00 to US$10.00 per annum effective as from year beginning July 6, 1974. Notice of this motion had been given at the 11th Annual Meeting in Barbados and the proposal was approved unanimously.

5. **Election of Officers and Board of Directors 1974-75**

The following were elected to serve on the 1974/75 administration:

President	Dr. Syed G. Haque	Trinidad
Vice-President	Dr. Laurie Wilson	Trinidad
Secretary	Mr. G.C. Jackson	Puerto Rico
Treasurer	Dr. George Samuels	Puerto Rico

Board of Directors

Chairman	Mr. Hugh Miller	Jamaica
Member	Mr. Ronald Baynes	Barbados
Member	Mr. H. Beckford	Jamaica
Member	Mr. L.A. Cross	Trinidad
Member	Mr. L. DeGras	Guadeloupe
Member	Dr. Fenton B. Sands	U.S. Virgin Is.
Member	Dr. Carl J. Walter	Grenada

Location of 13th Meeting - Caribbean Food Crop Society

It was proposed by Dr. L.A. Wilson and unanimously approved that the 13th Annual Meeting of the Society be held in Trinidad.

Registered Participants in 12th Annual Meeting - Caribbean Food Crop Society

Country	Name	Country	Name
Antigua	J.W. Cusworth (ODA)	Guyana	Dr. Amawale
	E.D. Metcalf (ODA)		Dr. C. Walter
Barbados	M.M. Alam	Martinique	G. Richard
	E. Cumberbatch		G. Rimbaud
	R.V. Harris	Montserrat	J.H. Green
	T.P. Jeffers	Puerto Rico	G. Jackson
	V.A. Sargeant		M.A. Lugo-Lopez
	Lionel Smith		G. Samuels
	E.T. Wilmot		R. Woodbury
			G. Spain
Dominican Republic	Gerry Dupay	St. Vincent	G. White
	Miguel Gonzalez		
Guyana Francaise	P. Blancaneau	U.S. Virgin Is.	F.B. Sands
Guadeloupe	M. Clairon		R. Shulterbrandt
	M.L. DeGras		
	M.P. Fournet		
	M.F. Kaan		
U.S.A.	H. Bartoo		
	G. Dalton		
	L. Deleon		
	S. Sehgal		
	R. Walter		

Country	Name
Trinidad	R. Barrow
	B.R. Cooper
	R.C. Dalal
	T.U. Ferguson
	L. James
	George Sammy
	N.D. Singh
	J. Sanchez
	G. Taylor
	D. Walmsley
	L. Wilson
	A. Brewer
	F. Lauchner
	S. Haque
	J. Spence
	D. Ari
Jamaica	H.C. Miller
	F. Mitchell
	G. Morgan
	C.J. Morrison
	A.G. Mullings
	R. Murillo
	A.G. Naylor
	H. Payne
	Hugh Payne
	N. Prendergast
	L. Rankine
	R.E. Pierre
	C. Reckord
	Janice Reid
	V.S. Reid
	W.D. Roberts
	V.W. Rochester
	V. Royes
	W. Shirley
	J. Simpson
	D. Stone
	S. Soutar
	J. Stainburn
	D. Stanford
	J. Suah
	G. Thomas
Jamaica	G.H. Barker
	C.C. Barrett
	H. Beckford
	B. Bean
	W. Bryce
	E. Burton
	A.V. Cameron
	J. Carrington
	M.A. Carty
	P. Chen
	E. Christie
	D. Chung
	C. Clarke
	C.A. Clemetson
	H.B. Crawford
	M.R.L. Davidson
	A. DaCosta
	L.B. DeLisser
	F.D. Dempster
	W. Dixon
	J.H. Donaldson
	H.J. Duval
	H. Fraser
	W.J. Gabay
	C. Gardener
	C.D. Gill
	Dr. M. Gurney
	Dr. L. Hammerton
	J.H. Haughton
	Dr. C.E. Henry
	C.W. Hewitt
	G.E. Hickling
	R.W. Howell
	R. Humphrey
	D.G. Hutton
	P.E. Jackson
	A. Johnson
	Dr. S.K. Kazimi
	S. Lakasingh
	P. MacIntosh
	E.R. Martin
	A.C. MacDonald

Country	Name
Jamaica (contd)	A.A. Thompson
	A.E. Thompson
	C. Tobisch
	B. Topper
	C.V. Turnbull
	M.P. Turner
	Dr. T.W. Turner
	Whervin Van
	K.R. Walker
	L.A. Walker
	E.P. Weller
	L.D. Wellington
	Dr. A.D. Williams
	H.R. Wilson

GENERAL PROGRAMME

Sunday 30th June	Arrivals and welcome - Cocktails, Courtesy Antilles Chemical Company
Monday 1st July 8.30 a.m.	Registration
9.30 a.m.	Opening Session
	Address: Hon. Keble Munn - Minister of Agriculture, Jamaica
	Message from Hon. Galo Plaza - Secretary-General, OAS delivered by Mr. C. Braggiotti, OAS Representative, Jamaica
11.00 a.m.	Technical session 1 (3 papers)
12.30	Lunch
2.00 p.m.	Technical session 2 (2 papers)
3.00 p.m.	Refreshment break
3.30 p.m.	Technical session 3 (2 papers)
7.00 p.m.	Cocktail Party hosted by Hon. Keble Munn - Minister of Agriculture
Tuesday 2nd July	
9.00 a.m.	Technical session 4 (6 papers)
10.30 a.m.	Refreshment break
11.00 a.m.	Technical session 5 (6 papers)
12.30 p.m.	Lunch
2.00 p.m.	Technical session 6 (7 papers)
3.30 p.m.	Refreshment break
4.00 p.m.	Technical session 7 (5 papers)
Wednesday 3rd July	
7.45 a.m.	Departure for Field Tour covering Bodles Research Station - Farming reclaimed lands at Battersea by Alcan - Root crops growing in the Christiana area and the Grove Place Research Station.
Thursday 4th July	
9.30 a.m.	Technical session 8 (6 papers)
10.30 a.m.	Refreshment break
11.00 a.m.	Technical session 9 (6 papers)
12.30	Lunch
1.45 p.m.	(a) Excursion to Agricultural Marketing Corporation and Food Technology Institute of Jamaica Industrial Development Corporation.
	(b) Excursion to Hi-Bred Tropical Breeding Station and Vegetables and Tree Crops Research Station at Lawrencefield.
8.00 p.m.	"A Jamaica Evening" - hosted by Shell Co. (W.I.) Ltd.
Friday 5th July	
9 00 a.m.	Technical session 10 (6 papers)
10.30 a.m.	Refreshment break
11.00 a.m.	Technical session 11 (7 papers)
12.30 p.m.	Lunch
2.00 p.m.	Business meeting
8.00 p.m.	Conference 12th Anniversary Banquet.

TECHNICAL PAPERS

AND

SUMMARIES

Some Economic Aspects of Root-Crop Production in Jamaica

Lloyd B. Rankine

Faculty of Agriculture, U.W.I. Mona
Jamaica

SUMMARY

In terms of total production as well as yields per acre the Yam (Dioscorea spp.) is the most important root-crop in Jamaica and a major component of the sub-sector commonly designated "Domestic agriculture."

In 1962 this sub-sector contributed %15.5 million to the GDP. By 1972 this had increased to $24.9 million having achieved an annual growth rate of 5.4% while the agricultural sector as a whole grew at only 3.2% per annum and the economy as a whole achieved a growth of 5.3%.

Yam production over the period 1965 - 1972 represented between 50% (1965) and 64% (1968) of the production of the major root-crops grown in Jamaica including sweet potatoes, irish potatoes and others, and averaged 50% over the period. Production of Yams rose from 56.6 thousand tons in 1965 to 164,000 tons in 1972.

Yams as an Earner of Foreign Exchange

Reports by the Agricultural Marketing Corporation disclose that for the period 1964 - 1971 approximately 14.3 million lbs. of Yams were exported by that Corporation bringing in approximately $0.71 million in foreign exchange. Private traders also are believed to have exported significant quantities.

Varieties

Among the ten (10) most popular varieties of Yams grown in Jamaica - Yellow yams have been predominant, averaging annually 33,000 tons over the period 1965 - 1972 or 35.6% of the total Yam production, with Negro yam 21,800 tons of 23.7%, Renta yam 1,760 tons or 14.9% and Lucea yam 7,600 tons or 8.2%.

Employment

It is estimated that 28, 018 acres devoted to Yam production in 1972 provided 3,299,679 man days of employment on farms in that year. Additional employment opportunities were provided by marketing and processing activities in the public and private sectors.

Status of Yams as a Food Item

Yams constitute a major food item in the local dietary. The nutritional value of yams compares favourably with that of Irish potatoes and other root-crops.

One thousand grams can supply just under ½ the daily requirements of calories for an adult male, approximately 30% of the protein requirements, nearly ½ the fat required and more than adequate iron, nearly twice the requirement of Vitamin C and also some trace of Vitamin A.

Linkages with Manufacturing: Examples of linkages cited are -

(1) the manufacture of Instant Yam in Barbados consisting of yam flakes

(2) current investigations into the incorporation of Yam Flour into Baking Flour and use of root-crops as animal feeds.

Characteristics of the Root-Crops Industry

Production is seasonal - periods of abundance allowed by periods of scarcity with corresponding price fluctuations.

Research inputs are small and spasmodic without fefined policy objectives. Only small increases have been noted in yields/acre from year to year.

Effect of Government Policies

Establishment of the AMC providing a guaranteed market at guaranteed prices for root-crops and initiation of a subsidy programme are considered to be largely responsible for the expansion of production of root-crops between 1969 and 1972. During this period yam production increased from 68,900 tons to 163,900 tons.

The AMC has done much to develop the export of Yams and presently handles between 10 and 20 per cent of all domestic food crops produced in Jamaica.

The Agricultural Subsidy Programme provided a subsidy limited to $16 per acre of Negro yam (*D. rotundata*) White yam (*D. alata*) or Yampie (*D. trifida*) grown by small farmers and to a limit of 2 acres per farmer. Subsidies paid out over the period 1969-1972 totalled $208,812 for Negro yams (13,050 acres) $10,825 for Yampies (676 acres) and $8,834 for White yams (552 acres).

It appears that approximately 75% of all Negro yams planted received subsidy, 37% of the Yampies and 40% of the White yams planted.

Trends, Acreage and Yields

The Paper presents Tables which indicate continuous annual increases of acreages planted to Tellow yams, Negro yams, Renta and Yampies between 1967 and 1972.

White yam after showing marked increases between 1970 and 1971 showed a slight decrease between 1971 and 1972. This might be due to depradation by nematodes and disease problems.

Preliminary data for 1973 indicate the likelihood of a decrease in all yam acreage harvested during 1973. This may be partially attributable to a prolonged perio of low prices combined with spiralling input costs and partially to pest and disease infestation.

Comparison of yield per acre from one year to another show variations upwards and downwards which may reflect weather effects. However, over the six year period 1967-1972 the average annual production of Lucea yam increased to 5.34 tons from 4.97 tons per acre in 1967.

Negro yam at an average of 5.64 tons showed no appreciable change, neither did Renta or White yams averaging 4.79 tons. Yellow yams with an average 4.38 tons showed variations upwards and downwards, but Yampies at 2.75 tons per acre showed an increase over the 1967 average of 2.54 tons. Other varieties showed no significant change.

The Author suggests that the deficiency in research inputs directed towards development of a complete package of technological improvements may have been responsible for the rather static position of Yam yields in the country.

Production System

The bulk of the island's yam planting takes place January to March and harvesting is continuous between September and January. However, owing to climatic variations some Yams are available at all seasons of the year.

Lucea yams are grown chiefly in the Grange Hill Land Authority area while Negro yam and Yellow yam are concentrated mainly in the Christiana area.

Yams are most commonly planted on hills with spacing varying between 3 x 3 and 7' x 6'. Small tubers, heads or bits are normally used for planting.

Yams are staked using Bamboo or Hard wood poles - and cultivation practices are normally restricted to weeding, twining of the yam vines around the stakes and application of fertilizer. Chemical weed control is rarely practiced. Great care is exercised in harvesting to avoid damage to tubers - a pointed stick is commonly used. After reaping, the yams are exposed to the sun for drying - this facilitates removal of excess earth and promotes healing of any tubers damaged during harvest. The system of yam production adopted is highly labour intensive and little use is made of mechanical equipment. Production units are often fragmented.

Economics

Data provided by the Agricultural Planning Unit and from a survey conducted 1968-1970 involving 98 farms, suggests that Yam growing was only marginally profitable in two Land Authority areas while other areas showed losses up to 9 cents per lb. These returns are based on Farm Gate prices ranging between 4 and 6 cents per lb. which are closely related to prices paid by the Agricultural Marketing Corporation.

Cost of production varied between 4 cents per lb. in the May Pen area to 14 cents in the Grange Hill area. The average overall being 7 cents per lb.

Labour expenses varied between 33% and 60% of total costs. Land preparation involved the highest labour inputs ranging between 44 to 66 man days per acre.

Planting involved an average of 11.5 man days per acre ranging between 5.85 in Christiana to 25.5 in Grange Hill. Weeding and other cultural operations, excluding fertilizer application, averaged 19.56 and 12.59 man days respectively.

Harvesting involved an average of 15.95 but ranged between 11.50 and 24.50. Total man days required per acre per crop ranged between 91.62 to 152 man days.

Family Labour

Family labour contributed an average of 45 man days per acre but ranged between a low of 28.25 and 74.62 man days.

Yield Per acre ranged between an average of 3.5 tons in some areas to over 5 tons per acre in others.

It is concluded that there is considerable scope for improvement in the majority of the farms surveyed (these were mostly on farms of less than 5 acres in size).

Labour Productivity

The survey indicated that the overall average productivity per man day employed on the farm was 69.43 lbs. of yam ranging between a low of 40 and a high of 99 lbs.

Marketing Aspects

While retail price to consumers varied between 10-25 cents per lb. prices paid to farmers ranged between 4.29 and 7.38 cents in 1972 and between 6.33 and 10 cents in 1973. A Table is presented showing monthly prices paid to farmers by the AMC between 1967 and 1973 for six different varieties and another showing annual average price paid. The latter indicates a steep increase in the prices for Yellow yam between 1972 and 1973 (from 4.29 cents to 10 cents) and modest increases in other varieties, following six years of virtual price stagnation.

The Table of monthly prices indicates wide fluctuations depending on availability of supplies - Lucea yam for example ranging between a low of 5.50 cents in January to a high of 10 cents in July and Yellow yams from a low of 3.91 cents in January to a high of 6.86 cents in August.

The Export Market

Between 1964 and 1970 over six million lbs of Yams were exported to the U.S.A., the U.K., Canada and other Caribbean islands. Between 1971 and 1973 another 3.9 million lbs. were exported but a decline which started in 1971, has developed - due, it is suggested, to competition from Africa and other Caribbean countries.

The Author proposes that in order to expand the export market it will be necessary -

(1) to change the form in which the product is now available

(2) to increase the protein content of yams

(3) to secure greater co-ordination of export activities between Caribbean exporting countries

Long Term Development Planning

The Author suggests that in order to promote sound development of the Yam industry it will be necessary -

(1) to effect the utilization of land with high production potential than those now commonly used for the crop

(2) to mobilise resources of research to develop a package of improved production techniques.

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AGRONOMIC TECHNIQUES IN YAM (DIOSCOREA SPP.) PRODUCTION IN THE CARIBBEAN REGION

Theodore U. Ferguson

Faculty of Agriculture
University of the West Indies
St. Augustine, Trinidad.

INTRODUCTION

Yams are one of the more important food crops which can be found growing throughout the region. Yams are particularly valuable in the economies of Jamaica, Barbados, and St. Vincent. Jamaica is by far the largest grower, producing over 150,000 tons. Production in Barbados is estimated to be 15,000 - 18,000 tons (Gooding, 1970). Production in St. Vincent is estimated to be less than 500 tons.

In this paper various aspects to the agronomy will be examined and suggestions for improvement made.

VARIETIES

Varieties belonging to all the major edible species can be found throughout the region. The major edible species are *Dioscorea rotundata*, *D. cayenensis*, *D. alata*, *D. trifida* and *D. esculenta*. Each of these five species contain a large number of varieties which carry local names. Ferguson (1970) noted that the same variety may carry the same name in different areas and varieties of the same name may be of different species. This confusion has led to difficulties in the identification and classification of varieties. The work of Gooding (1960) has gone a long way in helping to sort out this problem. Martin (personal communication, 1972) has recently made a world collection of all the major edible species and is in the process of classifying them. Degras *et al.* (1973) have collected and described a large number of varieties in Guadeloupe.

Table I lists some of the more important varieties found in cultivation in the Commonwealth Caribbean region. The Chinese yam has been recognised as a variety with great potential (Ferguson and Haynes, 1970a) but it is still to be cultivated widely.

TABLE I SOME IMPORTANT VARIETIES OF YAMS AND THEIR DISTRIBUTION IN THE CARIBBEAN REGION

Variety	Species	Area(s) of importance
White /isbon (Farm Lisbon Crop Lisbon)	*D. alata*	Barbados, Trinidad St. Lucia, Leeward Is.
Coconut Lisbon	*D. alata*	Barbados
Oriental	*D. alata*	Barbados
Renta [1]	*D. alata*	Jamaica, Tobago
White	*D. alata*	Jamaica
Hard	*D. alata*	Jamaica
Sweet	*D. alata*	Jamaica
Water Yam	*D. alata*	St. Vincent
St. Vincent (Barbados)	*D. alata*	Jamaica
Statia	*D. alata*	Leeward Islands
Bottle-neck	*D. alata*	Leeward Islands
Negro	*D. rotundata*	Jamaica
Lucea	*D. rotundata*	Jamaica
Portugese	*D. rotundata*	St. Vincent
Eboe	*D. rotundata*	Tobago
Antoine	*D. rotundata*	Dominica
Yellow	*D. cavenensis*	Jamaica
Yellow Guineau[2] (Yam-a-tou-temps)	*D. cavenensis*	Grenada, Trinidad
Round Leaf Yellow	*D. cavenensis*	Jamaica
Cush Cush (Yampie [3])	*D. trifida*	Trinidad, Guyana, Jamaica
Chinese (Sweet, Fancy China)	*D. esculenta*	Of minor importance in Trinidad, Windward Islands and Jamaica.
Pana	*D. esculenta*	Tobago

[1] May be different varieties in Jamaica and Tobago.

[2] May be the same as Yellow yam in Jamaica.

[3] Called Yampie in Jamaica.

PLANTING MATERIAL

Yams are propagated commercially by using either whole underground tubers or pieces of underground tubers. The propagules are called setts. The type of sett used and its method of production vary with species.

(i) D. esculenta

For D. esculenta (e.g. Chinese yam), small whole tubers are normally used. These tubers may vary in size from 25 - 100 gm. They are usually the small unmarketable tubers of the previous crop.

(ii) D. trifida

For D. trifida (e.g. Cush-Cush or Yampie), small tubers or pieces of tubers of about 50 - 100 gms are used. Ferguson (1973) noted that tubers decompose rapidly after cutting and suggested that unless suitable methods could be found to prevent this rapid decomposition the use of cut pieces of D. trifida should be avoided.

(iii) D. alata

For D. alata most farmers in the region use setts ranging in weight from 100 gms. to 300 gms. In Barbados, St. Kitts and Trinidad the sett size for the White Lisbon variety is normally in the range of 115 - 175 gms. However in Jamaica setts of up to 3 Kg are often used for some varieties.

Setts of D. alata may be pieces of large tubers or whole tubers of the appropriate weight. Pieces of large tuber (called "bits" in Jamaica) may be taken from any part of the tuber. Those from the head or top section (proximal to the vine) are called heads, those from the middle section, middles and those from the bottom or tail section, tails. Heads are generally preferred to middle and tail setts. Ferguson (1973) found that heads of White Lisbon yam are very efficient and setts as small as 57 gm will give good yields. Small whole tuber of D. alata are often preferred by farmers. However, experim-experimental evidence indicates that whole tubers of equivalent size of heads, middles or tails are inferior to these setts (Gooding and Hoad, 1967; Ferguson, 1973). One possible disadvantage in using small whole tubers is the probability of selecting for genetically low yielding clones (assuming some genetic variation within a given popluation) and diseased material. For best results it is recommended that setts should always be taken from large healthy tubers of varieties of D. alata.

Aerial tubers of yams are not normally used as setts in c ommercial production. Ferguson (1973) has shown that yields of over 40 tons per ha can be obtained using aerial tubers as setts in White Lisbon yam. Aerial tubers are however secondary carbohydrate sinks and assimilates are only diverted to these when the primary sinks (the underground tubers) have achieved their maximum bulking rate. As a result only a limited amount of aerial tubers are normally produced and the majority are very small (less than 30 gms). The writer is of the opinion that it is physiologically possible to develop a system which will allow for greater aerial tuber production in some D. alata varieties. This is an obvious area for future research activities.

(iv) D. rotundata

The system of obtaining setts for propagat on of D. rotundata differs markedly from those described for D. alata, D. trifida and D. esculenta. Varieties of D. rotundata are normally propagated by setts which are called yam heads locally. A yam head is the secondary underground tuber produced by the yam plant and harvested 3 - 5 months after the primary tuber(s) is harvested. In this system, at 6 - 8 months after planting the hill (most of the D. rotundata yams are grown in hills) is carefully dug on one side so as to avoid destroying many roots. The primary tuber(s) is removed by slitting just below the primary nodal complex (cf. Ferguson, 1973). The hill is then remade and left intact for another 3 - 5 months. During this time the plant produces another tuber(s) which is harvested as the yam head. Great variation exists in shape and size of yam heads so produced. They may vary in weight from 0.5 Kg to 5 Kg. These are often planted without any selection. Farmers in Jamaica seem to prefer yam heads in the range of 0.75 - 2 Kg for Negro and Lucea Yam.

The primary tubers of D. rotundata may also be left in the soil undisturbed for 9 - 12 months and then harvested. When this is practiced the head section is cut off (junked) and used as a sett. The size of these setts are usually in the range of 0.5 - 3 Kg.

It is the writer's opinion that under good growing conditions such large setts are not necessary. It is his view that the size of yam heads in Jamaica has increased over the years through an unconscioue attempt by farmers to combat the plant parasitic nematode problem (to be discussed in more detail later in this paper). This is an area which requires immediate investigation not only to increase yields but to reduce the financial outlay for the large quantity of setts required.

In some varieties of D. rotundata (e.g.Lucea) it is possible to use pieces of large tubers other than from the head region as setts. However they do not sprout as readily as head setts and more failures are likely to occur after planting. They are only recommended for general use when there is a shortage of head setts.

(v) D. cayenensis

For D. cayenensis, setts are usually collected by taking the head section of mature tubers (i.e. head setts as a result of junking). As for D. rotundata these are large (1-4 Kg) and sometimes consist of 50% or more of the primary tuber. Some varieties are also cut (slit) early and yam heads allowed to develop. Again these are large (1-4 Kg). Indications are that the nematode problem may be greater in this species.

TIME OF PLANTING

There are two main periods in which yams are planted in the Caribbean region - April to June and November to March. Varieties belonging to D. alata, D. esculenta normally planted in ther period April to June and varieties belonging to D. rotundata planted in ther period November to March. Many varieties of D. cayenensis (e.g. Yellow yam, Yam-a-tou-tempa) can be planted all year round. They are however mostly planted in the period April - June.

The tubers of all edible yams have a dormant period which may vary from 3 weeks (Yellow yam) to 3 months (White Lisbon). As a general rule all yam tubers should be planted just before they begin sprouting towards the end of their dormant period.

Yams are often planted late in the Caribbean. Late planting has been shown to result in low yields (Gooding & Hoad, 1967; Enyi, 1970). In later planting, setts are often taken from sprouted tubers. Substantial amounts of carbohydrates, minerals and other growth factors would have moved into the growing sprout from the tuber. Setts taken from such a tuber, in which the sprout is usually broken off, are obviously weakened setts and can only produce a poor plant which will most likely give a poor yield.

In Trinidad and Barbados where the White Lisbon yam is grown it is essential that all yams be planted before the end of May which represent the end of the dormant period in this variety.

It should be noted that good agronomic practices are unlikely to compensate for poor setts planted late.

Early planting of D. alata by the breaking if dormancy in tubers with 2 - chloro-ethanol is possible (Campbell et al, 1962; Ferguson, 1969). The commercial feasibility of this approach is however still to be demonstrated.

LAND PREPARATION

There are two distinct systems of land preparation for yams in the Caribbean - the hill (mound) system and the ridge system.

(i) The hill system

Hills are used extensively throughout the region. Barbados is one of the few territories where they are hardly used.

In this system a hole which may vary in width and depth from 0.5 - 1m is dug. the hole is then refilled with loose soil and trash or trash alone and then mounded up with soil. The hills may vary in height from 20 cm to 90 cm. Two to six yam setts are planted around the top of the hill depending of variety.

In Jamaica, where large quantities of yams are grown and most of these on hills, the preparation of the yam hill is a key operation in their system of production. Digging yam hills as it is called is considered to be one of the more expensive and laborious operations.

On heavy soils the holes are often dug and the soil so removed left to dessicate for a few weeks before the hole is refilled. Dessication of the soil seems to offer two advantages:

(a) The structure of the soil is improved by weathering in the open and
(b) some plant parasite nematodes are likely to be killed by the drying of the of the soil.

The soil between hills is often forked and intercropped.

Two of the major problems encountered in using hills are the limitations of mechanisation and the aggravation of soil erosion on sloping land. Hills are not easily made mechanically and as a result their formation will most certainly continue to be manual. The high labour input will greatly restrict the acreage any one farmer can handle. The use of hills on steep hillsides is common throughout the Caribbean. Soil erosion is greatly increased when hills are formed on such slopes. The soil erosion problems in the yam growing areas of Christiana and Lucea in Jamaica are well known. The introduction or increased use of soil conservation measures and/or the moving of yams (and other root crops) off the very steep hillsides are topics warranting immediate attention.

(ii) The ridge system

Ridging has been in use in Barbados for many years. In that country yams are traditionally planted on wide ridges (1.68 m) which are prepared for sugar cane cultivation. It has been shown that higher yields can be obtained with ridges at 0.48 m apart (Gooding and Hoad, 1967). However, only very few Barbadian farmers use narrow ridges.

Ridges are also used to a limited extent in St. Kitts, Antigua, Puerto Rico and Jamaica.

Ridging is an operation that is very easy to mechanise. It is also substantially cheaper than forming hills. Forming ridges on the contour on hillsides is one way of reducing the soil erosion problem.

Before ridging it is recommended that the land should be ploughed, harrowed and rotavated.

PLANTING

Planting of yams is normally a manual operation in all Caribbean territories whether ridges or hills are used. Setts are usually planted to a depth of 5 - 8 cm. In Jamaica 2 or 4 setts are planted per hill. The total weight per hill is usually in the region of 3 - 5 kg.

Mechanical planting of yams has been tried in both Trinidad and Barbados. In Trinidad a modified potato planter is used with some success for White Lisbon yams. However, the spacing of that planter is fixed at 68 cm which is perhaps too narrow for yams. In Barbados, Chandler (1973) has built a planter specially for yams and has had good success planting White Lisbon yams on ridges 1.68 m apart.

SPACING

Spacing between hills range from 1.5m x 1.5m to 3.0m x 3.0m. This gives a range of 1,110 to 4,440 hills per hectare and plant population will range from 3,330 to 13,320 plants per hectare when three setts are planted per hill.

In Barbados yams are usually planted on ridges 1.68m apart and spaced 0.75

to 1.50m apart in the row. Closer ridge spacing of 0.84m and setts spaced at 0.75 in the row has been shown to give higher yields (Gooding and Hoad, 1967). Most farmers however still persist in using wide ridges because the yam as grown in Barbados is a secondary crop grown in a system intended for sugar cane.

Ferguson (1973) showed that in White Lisbon yam spacing is closely interrelated with sett size in its effect on yield. The total amount of setts planted per acre is the seed rate and it can be varied by changing either sett size or pacing. As asymptotic yield response curve is got when seed rate is increased. Head setts are more efficient and the optimum seed rate for head setts is lower than the optimum seed rate for middles.

STAKING

Yams are normally staked in the wetter territories. They are not staked in Barbados, Antigua and St. Kitts. In Jamaica and St. Vincent, two wet territories, there are some varieties which are grown without stakes. For example the White Yam (F. alata) in Jamaica and Water Yam (D. alata) in St. Vincent are not usually staked. In both these countries some highly valued D. rotundata varieties are always staked (e.g. Negro and Lucea in Jamaica and Portuguese in St. Vincent).

Staking has been shown to increase the yield of D. alata in Trinidad (Chapman, 1965) and D. rotundata in Puerto Rico (Caro-Costas & Servando, 1968). Increases in yield by staking are not always economic and the recommendation for a particular area must always take into consideration the variety, the cost of staking and the local climatic conditions.

The traditional system of staking involves the use of individual poles. These may be bamboo or some readily available wood. In the hill system one pole is normally used per hill and where ridges are used on pole may serve 2 - 4 plants. Poles may vary in height from 1m to over 6m. In Jamaica short poles (1-2m) are used for Sweet yam whereas poles for Negro, Lucea and Yellow yams are often over 3m.

Staking by the use of individual poles is another expensive and laborious operation. In Trinidad, Haynes (1967) described a trellis system of staking developed at the University of the West Indies. It involves the use of slung wires which are supported by teak poles and bamboos. This system has been modified by Payne (1971) and introduced to Jamaica for use on D. rotundata and D. cayenensis. Not many farmers have adopted this system and some likely reasons are:

(1) Lack of ready cash or credit for the high initial capital required.

(2) The small acreage grown by the farmer may not justify the use of this system.

(3) It is not suited to the hillsides where most of the yam farmers are located.

(4) It does not stand up to high winds.

(5) Some farmers (in Jamaica especially) already have expensive hard wood stakes.

WEED CONTROL

Practically all weed controls in yams in the Caribbean region is done by hand. Generally at least two hand weedings are required during the life of the crop. In Barbados yams are planted in fields which are more or less weed-free as a result of being in sugar-cane for the previous 4-5 years. Under such circumstances only one hand weeding may be necessary. In Trinidad on the other hand, weedy fields are the rule and crops are sometimes weeded as many as seven times (Newhouse & Wilson, 1969). In Jamaica crops are usually given 2 or 3 weedings.

The herbicides atrazine (Gesaprin 80) at 2+Kg/ha is recommended for weed control in yams (Kassasian & Seeyave, 1968). It is used regularly by a few farmers in Barbados. In other territories it is rarely used. Christie (1973) recommended the use of either ametryne (Gesapax - Combi 80 WP) at 4.5 - 6.7 Kg/ha or atrazine (Gesaprim 500 FW) plus ametryne (Gesapax 500 FW) at 1.2 - 1.9 liters/ha each for weed control in Yellow yams.

MULCHING

Mulching is practiced to any great extent only in Jamaica. Banana leaves green trash may be used. Mulching helps by reducing weed growth and conserving moisture. It may also have some benefit in the moderation of soil temperatures and possibly on the reduction of plant parasitic nematode population. This is an area which requires some investigation.

FERTILIZER USE

The status of fertilizer use in yams in the Caribbean is somewhat confusing. In Trinidad. although fertilizers are recommended for use in yams, they are hardly used. In the Windward Islands fertilizers intended for use on bananas are often used indiscrimately on yams. In Barbados some farmers use sulphate of ammonia and muriate of potash applying about 190 Kg/ha of each. In the Leeward Islands fertilizers are often not used. In Jamaica some farmers use 0.25 Kg to 0.50 Kg of 6:18:27 or 6:6:18 per hill.

Ferguson & Haynes (1970b) noted that different varieties respond differently to the same fertilizer application. It is therefore important to know the response potential of a particular variety before firm fertilizer recommendations could be made. Recommendations will of course have to vary with soil type and local climatic conditions.

Chapman (1965) and Ferguson & Haynes (1970b) found that the yield of the White Lisbon yam increases with increasing nitrogen application. Chapman (1965) recommended nitrogen application at 3 months after planting but Ferguson and Haynes (1970b) presented evidence which indicates that the plant may be able to utilise added nitrogen from about eight weeks.

Payne (1971) recommended the use of 630 Kg/ha of the NPK fertilizer, 12:24:12, for negro yam on the red and brown bauxite soils of Jamaica.

PRUNING

The pruning of side shoots of yams has only been observed on Negro and Yellow yams in Jamaica. The side shoots at the base of the main stem and weak stems are removed. In relation to the labour input involved this operation seems to be of questionable value. Farmers claim benefits from the increased amount of light reaching the hill and the increased ability of the main vines to climb the stakes. This is another area for research.

PLANT PROTECTION

Field observations indicate that nematode damage (locally called tuber "burn") is rampant in many areas of Jamaica. Yellow yam and Yampie appear to be among the more susceptible varieties. Nematodes in addition to reducing yield may reduce the life and lower the quality of the tubers in storage and greatly reduce the quality of the setts.

Although there is no published data (at least to the writer's knowledge) on the magnitude of the nematode problem in yams it is the writer's firm opinion that this could be one of the most important factors affecting yam production in Jamaica. There is immediate need for

(1) a survey of all yam growing areas for plant parasitic nematodes to establish genus and species of nematodes, involved, varietal susceptibility, variations according to soil types and other climatic conditions, etc.

(2) the development on a field scale of a system of producing nematode-free planting material.

(3) the control of nematodes in the field.

Fungal leaf diseases pose real problems in Jamaica, Barbados, St. Vincent and Trinidad. The most serious disease is the black spot on leaves. This disease if of a complex nature and two of the casual organisms have been identified to be *Phyllosticta* spp. and *Collecotrichum* spp. Control is achieved in Trinidad with regular sprays of Miltox and Dithane M45. Benlate is recommended for use in Barbados. Control measures are however not widespread among farmers.

Another serious disease of importance in the region and which has at times assumed edpidemic proportions in Barbados is the internal brown spot of tubers. A research project is now in progress on this disease, which is believed to be caused by a virus, at the University of the West Indies. It is discussed in more detail in a paper elsewhere in these proceedings.

CROPPING SYSTEMS

Intercropping yams with wide range of food crops is the normal practice in most Caribbean territories. Crops such as corn, pigeon (gungo) peas, red peas, irish potatoes, tannias, sweet potatoes, calaloo (*Amaranthus* spp.) are often used.

In Jamaica yams are often rotated with a fallow period. Yams are usually grown for 3 - 5 years and followed by a fallow period 1 - 2 years.

Little attention has been given by agronomists or agricultural economists to these traditional cropping systems. Some of them merit some study as they may help us in understanding the versatility of many of our small farming systems.

In Barbados where yams are grown on a more extensive basis they are rotated with sugar-cane. The sugar-cane is grown for 4 or 5 years and theland is then "thrown-out" of sugar-cane. It is normally cultivated as for sugar-cane and planted with yams on ridges 1.68m apart at about May/June. Sugar-cane is then planted in the furrows in about October/November. The yams are harvested in January/February. The land preparation for the yams is normally charged to the cane crop and the yam is considered to be the secondary crop. The merits of this system are that farmers get two crops for the cost of a single land preparation and a crop of canes is established well before the onset of the dry season when it would otherwise be difficult. The major disadvantage of this system is that yams cannot be harvested mechanically because of the presence of young canes in the furrows. However, until such times that an economical package for mechanical harvesting can be offered to the farmers they may be justified in intercropping with canes.

HARVESTING

Harvesting of yams is practically all accomplished with the use of hand implements. These implements may be garden forks, machetes, hoes or simply digging sticks. The tool used will depend on the soil type, territory and method of production. Hoes are used on the light soils of St. Kitts to harvest yams on ridges. In Jamaica a digging stick is used on lighter soils and a machete or garden fork on the heavier soils. In Barbados, Trinidad and the Windward Islands the garden fork is the tool most often used.

Harvesting of yams is considered to be the most laborious operation i yam growing in Barbados and Trinidad. Mechanical harvesting has been attempted with some success in both these countries. Campbell (1967) has developed a side-lifter which has given very promising results with White Lisbon and Chinese yam in Trinidad and with White Lisbon yam in Barbados. Jeffers and Harvey (1973) reported good results with a harvesting aid in Barbados.

We are still a long way from mechanised harvesting in *D. rotundata* and *D. cayenensis.*

Research into mechanical harvesting of yams is an area for continued and increased research input.

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PRODUCTION OF IRISH POTATO (SOLANUM TUBEROSUM) IN JAMAICA

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SUMMARY

Until recently Irish potato production in Jamaica was limited to areas of high elevation (range 1200 to 3000 ft. a.s.l.).

In these areas success of the crop depends mainly upon the incidence of favourable rainfall during the growing period and in the area of most extensive production (the Christiana area) the crop is normally grown March to June each year. Production on a smaller scale based on a growing period November to March is also normal in the Guys Hill and Darliston areas.

Variations in rainfall patterns from year to year have created problems for crop forecasting and marketing. Experimental plantings using overhead irrigation on Newell Clay Loam (Soil type No. 67) at an elevation of 250 ft. a.s.l. have produced yields of 10 tons per acre from each of the Dutch varieties "Spunta" and "Arka" planted in early December and reaped in early March.

IMPROVEMENT OF THE YIELD POTENTIAL IN CARIBBEAN SWEET POTATO CULTIVATION

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INTRODUCTION

Tropical root crops, including sweet potato, yams, edible aroids and cassava are fairly extensively cultivated in the Caribbean for domestic consumption and small quantities are exported to U.K. and U.S. markets. The demand for tropical tubers for processed human foods (e.g. instant yam flakes) and for livestock feeds, as well as for starch for industrial utilization (e.g. in bauxite, textile and adhesive industries) is likely to increase rapidly in the next decade. However, root crop cultivation in the Caribbean is characterised by unestablished systems of production, with high labour inputs, which result in low and inconsistent yields and seasonal availability of tubers. In addition, uncertain market requirements and poor marketing arrangements for fresh tubers often lead to wastage and low profitability to the farmer. As a result, the number of farmers engaged in root crop cultivation is steadily declining (Rankine, 1972). Moreover, the inherently poor storage capacity of tropical tubers limits the economic possibilities of the fresh tuber trade.

In these circumstances, a more stable market based on processed end-products would seem to be necessary to ensure more efficient utilization of root crop tubers, in the expectation that such efficient utilization will not only stimulate root crop production, but also increase the profitability of root crop enterprises. However, the demands for raw material in prospective processing industries far exceed current root crop production levels. It is suggested, therefore, that systems designed to achieve massive increases in root crop production through increase both in the productivity and acreage of root crop cultivation are urgently required, if current decline in the number of practising root crop farmers is to be reversed and root crop cultivation in the Region is to survive and expand. The major inputs to such systems are

(a) availability of superior cultivars with increased yield potential

(b) established packages of cultural practices for individual root crops.

In this paper, existing levels of productivity in sweet potato and biological constraints to increasing them are discussed, and sweet potato compared with other tropical root crops as staple sources of carbohydrate in the Caribbean.

RESULTS AND DISCUSSION

A COMPARATIVE ACCOUNT OF SWEET POTATO TUBER PRODUCTIVITY.

Data (Table 1) shows that sweet potato productivity in Japan (20 m.tons/ha) is from four (x4) to ten (x10) times that of the level for Caribbean farmers at 2 - 5 m.tons/ha, if considerations of relative cropping periods, daily radiation and other climatic factors are ignored.

Productivity on the Texaco Farm in Trinidad (Haynes and Wholey, 1971) under semi-commercial conditions was, however, much higher (x2.8 - x4.5) than that for commercial farms. Record experimental yields (e.g. in Uganda), which more precisely reflect the yield potential of the species, are some 2.5 times higher than commercial yields in Japan. The highest yielding Caribbean cultivar so far studied (A28/7) gave an experimental yield of 35 m.tons/ha and single plants of this cultivar produced yields equivalent to 46 m.tons/ha (Table 1), but plant to plant yield variability precludes consistent achievement of such yield performance either in experimental or commercial production.

On the basis of calculations for more efficient light utilization, de Vries et al (1967) predicted that the genetic potential for tuber yield in the sweet potato species is in the region of 140 m.tons/ha. However, the terminal components of yield in tuberous crops are the mean weight and number of tubers per plant at a defined plant spacing, and increased yield could be achieved only by increasing one or both of these components. Thus data (Table 2) shows that a 5-fold increase in sweet potato yield (9-46 m.tons/ha) is achieved by approximately 1.7 and 3.0-fold increases in mean tuber weight and tuber number, respectively. Realization of the predicted genetic potential of the species (140 m.tons/ha) at the highest tuber number recorded (11) and at a spacing of 50 x 10^3 plants/ha, necessitates a 1.4-fold increase in the highest recorded mean tuber weight in our experiments.

Removal of the constraints to yield improvement in sweet potato requires an understanding of the inter-relationships between terminal components of yield, so that they may be manipulated to achieve increased yields. These constraints will be considered in terms of the existing gap between commercial and experimental yields as well as that between record single plant yields and experimental yields. Strategies for achieving the predicted yield potential of the species are excluded from this presentation.

CONSTRAINTS TO YIELD IMPROVEMENT

The three types of biological constraints to sweet potato yield improvement chosen for discussion are related to different aspects of yield determination. Thus, agronomic constraints are defined as those which preclude realization of experimental yields in commercial production. Physiological constraints refer to those factors which limit the yield potential of experimental plots compared with that of single plants, and genetic constraints are the problems involved in first defining individual heritable characteristics associated with high yield and then combining these characteristics in a single superior cultivar. Although these constraints are discussed separately, it is only by the collective solution of the problems resulting from all constraints to yield improvement that highest yield performance will be obtained.

Agronomic Constraints

Agronomic constraints generally result from the more precise cultural practices that can be applied to the small experimental plot compared with larger commercial acreages. However, the proper selection of available cultivars and adoption of established practices also seem to be major agronomic constraints in Caribbean sweet potato cultivation. Evidence for the existence of yield constraints in the following aspects of sweet potato cultivation is presented:

TABLE I. Comparison of commercial experimental and predicted yields in sweet potato.

	Yield (m.tons/ha)	Reference	
Commercial			
West Indies (farmers)	2-5	Rankine	(1972)
(U.W.I.)	9-14	Haynes & Wholey	(1971)
Japan (country average)	20	Tsuno	(1971)
Experimental			
West Indies (c.v. A28/7)	35	Lowe & Wilson	(1974)
Single plant	46	Lowe & Wilson	(1974)
In coconut fibre dust	65	Wilson	(1964)
Congo	41	DeVries et al	(1967)
Uganda	50	T.P.I.	(1973)
Predicted Yield	140	de Vries et al	(1967)

TABLE 2. Components of total yield in sweet potato at different levels of tuber yield.

Cultivar	Yield (m.tons/ha)*	Yield (gm/plant)	Mean tuber (wt.gm/plant)	Tuber No.	Reference
049	9	180	67	2.7	1
049	14	281	88	3.2	1
049	22	454	142	3.2	2
049	30	600	140	4.3	2
C9/9	32	670	105	6.4	2
A28/7	35	722	150	4.8	2
A28/7 (single plant)	46	950	119	8.0	2
Predicted	140	(2850)	(259)	(11)	3a
	140	(2140)	(195)	(11)	3b

* at a population of 50×10^3 plants/ha. (approx.)
1 calculated from Haynes & Wholey (1971)
2 Lowe & Wilson (1974)
3a based on calculated productions from de Vries et al (1967)
3b calculated at spacing of 75×10^3 plants/ha. (approx.)

(1) Planting Material

Variety

Vine cuttings

(2) Management of the soil/crop/environmer

Soil type and land preparation

Fertiliser application

Water regime

Spacing

(3) Crop Protection

Weed control

Pest control.

<u>Planting Material</u>

Although several high yielding cultivars with a range of morphological and physiological characteristics likely to make them suitable to different niches in the Caribbean ecosystem have been selected at UWI (St. Augustine), local varieties still to a large extent form the basis of sweet potato cultivation e.g. Black vine in St. Vincent and Nylon in Jamaica. Thus, extensive trials are necessary to establish the best variety for a particular environment. Preliminary work (Haynes 1969; Baynes 1972) suggests that the following cultivars are suitable for specific soil types in the listed territories:

049	- Trinidad
A26/7, T.25	- St. Vincent
A26/7, 06/56/23 Cricket Gill	- Grenada
A26/7	- Barbados.

In St. Vincent, A26/7 gave yields which were 585% that of the commercial variety (Black vine). Data is not available for similar trials in Jamaica. It is significant to note that high performance cultivars produced in Trinidad (e.g. 049) do not always outyield local varieties in other regions.

Godfrey-Sam-Aggrey (1974) demonstrated 41% and 54% increases in tuber yield with increasing length of vine cuttings, in the range 23 to 61 cm in two sweet potato varieties with low and high vine/tuber ratios respectively, (Table 3), thus illustrating the importance of cutting length as a determinant of tuber yield. Longer cutting lengths resulted in reduced vine/tuber ratios. Twelve to fifteen in.(30-38 cm) cuttings are normally used for cultivation in the Caribbean. Although in these experiments (Table 3) the length of vine cutting buried in the soil at planting was kept constant at 5 cm., Lowe and Wilson (1974) showed that from 80% - 100% of total yield was normally produced on the first four subterranean nodes (Table 4), and that small unmarketable tubers produced at lower nodes (5-8) were responsible for considerable plant-to-plant variability in tuber yield. Conversely, occurence of plants with less than four subterranean nodes in normal cultivation led to reduction in yield.

It is concluded, therefore, that both the choice of variety and the length of stem cutting could be important agronomic constraints to sweet potato yield improvement.

TABLE 3. Effect of length of vine cutting on yield and vine/tuber ratio of two sweet potato varieties.

Cutting length (cm)	Yield (tons/ha)		Vine (tuber/ratio)	
	Missis	Madam	Missis	Madam
23	2.08	7.50	8.16	2.70
31	2.74	7.63	6.29	2.73
46	2.91*	9.79*	6.58*	2.11*
61	3.21**	10.57**	6.99**	2.08**

After Godfrey-Sam-Aggrey (1974)

* and ** indicate significantly different from 23 cm value.

TABLE 4. Distribution of tuber yield on subterranean nodes of six sweet potato cultivars.

Node No.	Yield (gm/plant)						
	049	A28/7	C9/9	I62	AI6/15	03/62	Mean
Node 1	72	84	120	124	87	22	85
Node 2	218	62	176	97	105	37	116
Node 3	56	118	57	49	76	26	64
Node 4	76	90	68	26	38	28	54
Total (Nodes 1-4)	422	354	421	296	306	113	319
Total Yield	472	443	363	353	343	114	348
% total yield at Nodes 1-4	89	80	100	84	89	100	92

After Lowe and Wilson (1974)

Soil Type and Land Preparation

The important soil constraint to sweet potato tuber yield is the mechanical resistance to tuber expansion and growth effected by heavy clay soils. Yields are generally higher on lighter loams which in addition ensure an adequate oxygen supply, known to be critical for sweet potato tuberisation. Accordingly, low yields (1.8 m.tons/ha) on the Micoud Gritty clay in St. Lucia indicate the unsuitability of this soil type for sweet potato cultivation. Comparable experiments on the Balambouche Gritty Clay Loam gave yields of up to 11 m.tons/ha i.e. a 520% increase over the Micoud Gritty Clay (Baynes 1974). Moreover, the highest sweet potato yields recorded in the Caribbean (65 m.tons/ha) were achieved in a coconut fibre waste artificial medium where resistance to tuber growth is reduced to a minimum and maximal oxygen supply to the root system ensured (Wilson 1964). The physical soil constraint to sweet potato tuber yield is therefore quite considerable. However, the adverse effects of soil type may be to some extent overcome by adequate soil preparation, including deep ploughing, harrowing, rotavating and use of ridges at least 46 cm (18 in.) deep, separated by furrows for rapid drainage in the wet season. Thus, although similar experiments have not been conducted with sweet potato, ploughing, harrowing and rotavating air-dry soil gave a 10% increase in White Lisbon Yam (Dioscorea alata) yields over that from soils which were only ploughed and harrowed (Ferguson & Gumbs 1974).

Fertilizer Application

Although precise fertilizer recommendations must be developed for each soil type, it has been adequately demonstrated that yield responses to NPK are obtained for sweet potato on many Caribbean soils. Generally, levels of N-application (36 kg/ha) and high levels of K-application (180 kg/ha) give best yields (Haynes 1968). Cross (1964) and Baynes (1974) also obtained significant yield responses to P-applications of 45 kg/ha. In these experiments, sweet potato yields were shown to be increased some 100% by NPK fertilizer application. However, supra-optimal levels of N-application are known to reduce sweet potato yield at normal harvest dates by postponing the advent of tuber bulking (Haynes et al. 1967). There is also some evidence for differential responses to N-application by different sweet potato varieties. Thus, Tsunoda (1965) claimed that low leaf area types were N-responsive but yield was reduced by nitrogen application in high leaf area types. Moreover, Haynes (1969) classified St. Augustine cultivars into N-responsive, N-depressing and N-indifferent types on the basis of yield responses to 80 lb. N/acre.

Water Relations

Like all vegetatively propagated crops, sweet potato vine cuttings require an adequate supply of water for establishment and rapid early growth. However, the process of tuber initiation which occupies the period 2 - 8 weeks after planting (Lowe and Wilson 1974) is adversely affected and early tuber growth is suppressed by waterlogged conditions. Accordingly, tuber yields are often reduced in wet season cultivation (May-June) by the occurence of waterlogging during early growth, and irrigation is necessary for crop establishment and further growth, if high yields are to be obtained in dry season cultivation. Irrigated dry season crops are known to give higher yields than wet season crops. (Walter 1966) and Lowe (1971) demonstrated a 37% increase in yield in an irrigated dry season crop compared with a wet season crop.

Spacing

Given adequate soil and land preparation, fertilizer application and water relations, a most important agronomic constraint to the achievement of maximal yields is use of the optimal plant spacing for the variety cultivated. Such optimal spacing would optimize the use of radiant energy, fertilizers and "tuber space" in the soil. Thus, there is a wide range of vegetative habits to be found among sweet potato cultivars ranging from types with high leaf areas and long, trailing much-branched stems, to short stemmed low leaf area types with a "gathering" habit. Clearly, closer spacings will increase yields in the latter types. On the basis of spacing/fertilizer trials by Haynes (1968), the spacing recommended for cv. 049 in Trinidad is 31cm (12") intervals along rows 69cm (27") apart (i.e. a plant density of 50,000 plants per hectare or 20,000 plants per acre). This plant density can no doubt be increased with lower leaf area cultivars.

Crop Protection

Weed Control

The weed constraints to the achievement of highest sweet potato yields is adequately demonstrated in experiments by Seeyave (1969). Applications of paraquat (0.6 kg/ha or 0.5 lbs/acre) to keep a sweet potato crop weed-free for the first three weeks of growth resulted in yields which were 93% of weed-free controls. Unweeded plots gave yields that were only 20% of those of weed-free controls. The percentage increase in tuber yield obtained by maintaining weed-free conditions during the first three weeks of the sweet potato crop was therefore 365%.

Pest Control

The major pests of sweet potato in the Caribbean are the Pyralid moth *Megastes grandalis* (Guen) in Trinidad and *Euscepes* in the rest of the Caribbean. Effective methods for the control of both of these pests have been established by Parasram (1968). Thus, for *Euscepes* control, a combination of the soil insecticide chlordane and foliage insecticide Lebacid increased yield some 45% over untreated controls in a St. Vincent trial. The practice adopted for *Megastes* control in Trinidad includes dipping stem cuttings in 0.5% dieldrin before planting followed by alternate two-weekly sprays of either dieldrin and Sevin or Lannate and Malathion. Such treatment has been shown to result in up to 100% increases in tuber yields over untreated controls. In seasons with severe *Megastes* infestation no marketable tubers are obtained from plots in which *Megastes* is uncontrolled.

Recently, Braithwaite (1974) demonstrated that nematodes are also serious pests of sweet potato in Trinidad. Among six species found in association with sweet potato roots the Reniform nematode *Rotylenchus reniformis* was the most abundant. Application of DD soil fumigant (a mixture of dichloropropene and dichloropropane) at a rate of 72 litres/ha resulted in a 92.6% increase in yield over untreated controls.

Evaluation of yield increase due to removal of agronomic constraints

Data (Table 5) shows some experimentally established yield increases due to removal of agronomic constraints. Increases due to use of appropriate varieties and suitably cultivated planting material, soil type as well as pest and weed control are notably high. Although the interaction of agronomic practices for the production of optimal yields are clearly not expressed by a simple additive equation, there is an interesting but perhaps fortuitous coincidence of the approximately 1900% increase in yield between the 1 m.ton/ha sometimes obtained in Caribbean sweet potato cultivation (Rankine 1972) and the 20 m.tons/ha reported for Japanese sweet potato yield.

It is often stated that small under-capitalized Caribbean farmers cannot be persuaded to invest the additional capital involved in proper crop management. It is interesting to note, however, that constraints such as choice of variety and soil type could probably be removed at little cost, and indeed both fertilizers and insecticides are regularly, though often improperly, used.

Data (Haynes & Thomas, 1967) also show that a considerable proportion of the total cost of a sweet potato crop:-

Collection of cuttings	5.7%
Planting	22.8%
Vine turning	9.1%
Harvesting, collection and preparation of soil	24.3%
TOTAL	61.9%

is usually supplied as the manual labour input by the small farmer. It is difficult to believe that such a high percentage of the total cost of production will not benefit from capitalisation in the form of loans to the farmer for the remaining cultural practices necessary to remove critical agronomic constraints to sweet potato yield improvement.

TABLE 5 : Evaluation of Yield Increases Due to Removal of Agronomic Constraints

1 - for yams
2 - estimated

Agronomic Constraint	% Yield Increases	Reference
Variety/Planting Material	585	
Variety	585	Baynes (1972) (St. Vincent)
Cutting	54	Godfrey-Sam-Aggney (1974) (Sierra Leone)
No. Subterranean Nodes	200	Lowe and Wilson (1974) Trinidad
SUBTOTAL	839	
Management of Soil/Crop/Environment		
Soil Type	520	Baynes (1974) (St. Lucia)
Land Preparation	10[1]	Ferguson & Gumbs (1974) Trinidad
Fertilizer Application	100	Cross (1974) (Trinidad)
Water Relations	37	Lowe (1971) (Trinidad)
Spacing	50[2]	Haynes (1968) (Trinidad)
SUBTOTAL	717	
Crop Protection		
Pest Control		
Euscepes Control	45	Parasram (1968) (St. Vincent)
Megastes Control	100	Parasram (1968) (Trinidad)
Nematode Control	93	Braithwaite (1974) (Trinidad)
Weed Control	365	Seeyave (1968) (Trinidad)
SUBTOTAL	603	
GRANDTOTAL	1,859	

Physiological Constraints

Some causes, effects and implications

a) Competition and Yield Variability

Physiological constraints to crop production as here defined are related to the inter-plant competition which results from the growth and development of plants in a crop community compared with that achieved by the individual plant. Such competition may limit the availability of the following growth requirements to each plant in the community:

(1) Inorganic raw materials for growth and development from

(i) the aerial environment (e.g. carbon dioxide), and

(ii) the soil environment (e.g. water, essential mineral nutrients, oxygen).

(2) Radiant energy

(3) Aerial space for foliage development as well as soil space for root and tuber development.

In turn, limitation of the above-mentioned requirements leads to plant competition, which results in plant-to-plant variation in tuber yield. This variability expresses the random capacity of individual plants in the community to compete for growth requirements. The highest yielding cultivar, therefore, will be the one which could effect the most efficient conversion of limited growth requirements per unit area into final tuber yield, thus minimizing competition and concomitant variation in tuber yield.

Data (Table 6) show that in experiments with six cultivars, the high yielding cultivars 049 and A28/7 had much lower yield variabilities over three crops than the low yielding cultivars AI6/15 and 03/62.

TABLE 6 : Total and marketable yields and yield variabilities in six sweet potato cultivars (average of three crops).

Cultivar	Total Yield		Marketable Yield	
	(gm/plant)	(C.V.%)	(gm/plant)	(C.V.%)
049	508	36	444	44
A28/7	598	46	417	68
C9/9	493	47	282	97
I62	449	58	259	98
AI6/15	422	40	139	134
03/62	271	91	156	159

C.V. % - Coefficient of Variation

After Lowe and Wilson (1974)

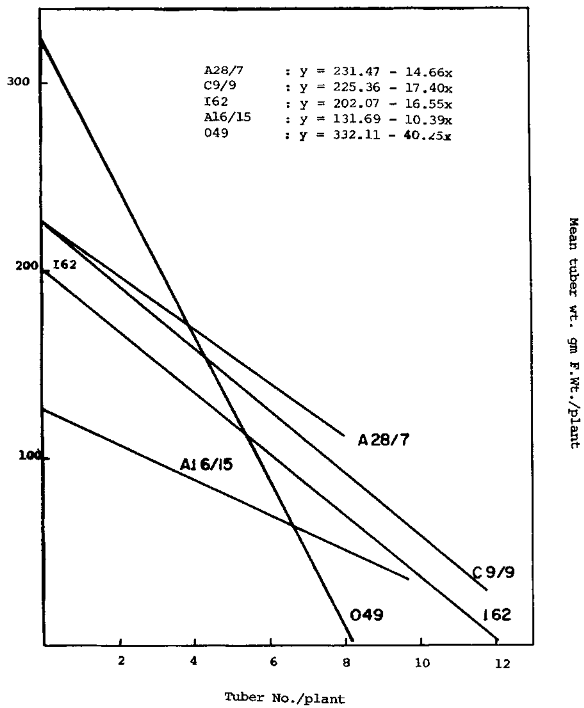

FIG. 1. Regressions of mean tuber wt. on tuber number in five sweet potato cultivars.

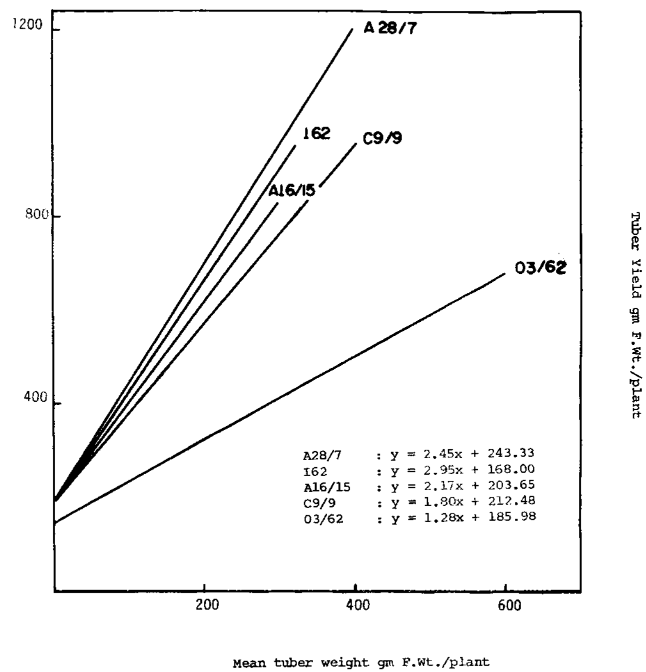

FIG. 2. Regressions of tuber yield on mean tuber weight in five sweet potato cultivars.

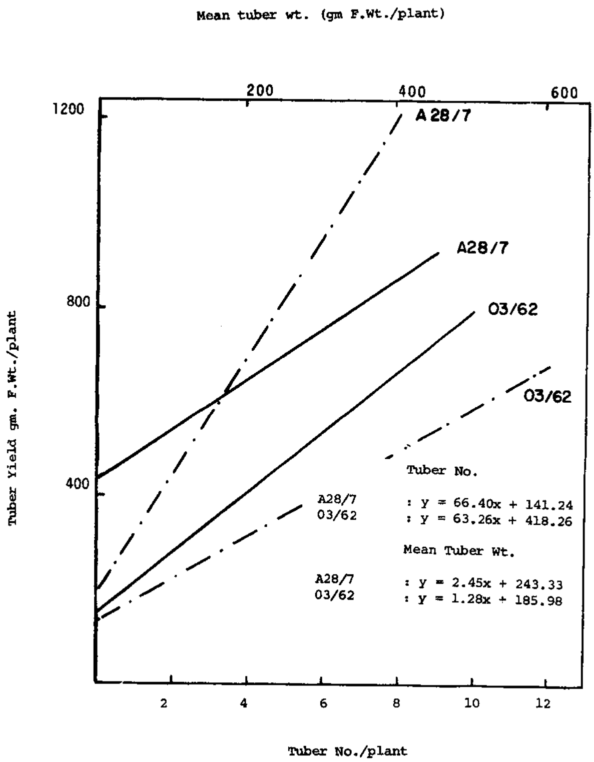

FIG. 3. Regressions of tuber yield on tuber no. and mean tuber wt. in two sweet potato cultivars.

b) Yield Component Compensation

Since the terminal components of yield in sweet potato are the mean weight and numbers of tubers per plant, then physiological constraints can be expected to influence yield through effects on these components. But yield components develop sequentially : tuber initiation, which determines tuber number, occurs before tuber growth which determines final tuber size and weight (Wilson and Lowe, 1973). However, such sequential development leads both to the interdependence and integration of yield components in the determination of final yield. Accordingly the sequential, interdependent and integrated development of yield components result in the phenomenon of yield component compensation, whereby increase in the value of one component (e.g. tuber number) leads to a decrease in the other (e.g. mean tuber weight).

Such yield component compensation has been demonstrated at different degrees of intensity in the same six sweet potato cultivars (Lowe and Wilson, 1974), as is shown by negative regression coefficients between mean tuber weights and tuber number (Fig. 1). Yield component compensation was highest in the high yielding cultivar 049, where increase in tuber number by one reduced mean tuber weight by 40 g. (approx.). However, cv A28/7 with the highest total yield showed the lowest yield component compensation.

Yield component compensation illustrates the developmental plasticity inherent in developing plant organs which affords alternative developmental pathways for the attainment of final yield, thus maintaining more stable and less variable plant yields in the crop community. It is not surprising therefore that although highest total yield was recorded in cv. A28/7, marketable yield of cv. 049 was superior, suggesting that strongest yield component compensation leads to least variability and highest marketable yields.

Despite the existence of yield component compensation among plants of the same variety in the crop community, there is evidence that the ratios of mean tuber weights to tuber numbers of the six cultivars, were cultivar characteristics. Thus, a significant negative regression of mean tuber weight on tuber number was demonstrated for the mean values of these components for five of the six cultivars over three crops (Fig. 2).

Data (Fig. 2) also suggested that cultivars with higher ratios of mean tuber weight or tuber number e.g. 049, A28/7 were higher yielders, and that yield component compensation also operated at the genetic level as has been found by Edwards and Cooper (1961) for leaf size and leaf number in *Lolium*.

c) Relationship between yield components and yield

Sweet potato yield potential could only be increased by increasing either or both the terminal components of yield, tuber number and mean tuber weights, in such a way as to optimize the relationship between these components consistent with highest total yields (Grafius 1956). However, the strategy for yield increase depends on the relationship between either component and yield. Thus, data (Figs. 3, 4) show that the six sweet potato cultivars studied could be classified according to the relationship between either component and yield, expressed by positive regression coefficients into:

A. Tuber number/tuber weight types (i.e. A28/7, 03/62) in which both components were significantly correlated with yield.

B. Tuber weight types (i.e. C9/9 I62, AI6/I5) in which tuber weight was significantly correlated with yield.

C. A random type (i.e. 049) in which neither component was significantly correlated with yield.

These results are interpreted to mean that there may be genetic lines within the sweet potato species where yield may be increased by (a) increases in both tuber number and tuber weight or in (b) tuber weight alone.
In addition, there may be a third line (e.g. cv 049) in which yield component compensation at the genetic level is so strong as to preclude yield improvement.

The relationship between yield components and yield also explains the expression of plant competition in yield variability referred to earlier. Thus, data (Table 7) shows that the existence of significant positive regressions of total yield on tuber number in cvs A28/7 and 03/62 accounted for 16-26% of the yield variabilities of these cultivars. Alternatively, where there were significant positive regressions of yield on mean tuber weight in C9/9, I62, A28/7, 03/62 and AI6/15, 16-48% of yield variabilities were ascribable to these regressions. Moreover, regressions of yield on mean tuber weight and tuber number accounted for more than 60% of yield variability in cv A28/7, whereas the low yield variability of 049 may be due to the absence of significant regressions of total yield on either component, in this cultivar. Therefore, variability which is an expression of plant competition, can be either intensified or ameliorated by the relationship of yield components to total yield.

TABLE 7. Percentage of total variability due to regression of yield on yield components.

	% Total yield variability						
	C9/9	I62	A28/7	03/62	AI6/15	049	Crop Mean
Mean Tuber Weight							
Dry season crop	22	44	22	21	n.s	n.s	18
Wet season crop	48	33	33	32	31	n.s	30
Cultivar Mean	35	39	28	27	16	n.s	24
Tuber Number							
Dry season crop	n.s	n.s	23	32	n.s	n.s	n.s
Wet season crop	n.s	n.s	29	n.s	n.s	n.s	n.s
Cultivar Mean	n.s	n.s	26	16	n.s	n.s	n.s

Metabolic consequences of physiological constraints

Physiological constraints resulting from limitations in external growth requirements in the plant community result in metabolic deficits which restrict the growth and development of individual plants in the crop community. These deficits include (i) soluble carbohydrates, (ii) amino acids, and (iii) plant growth substances. But a clear distinction must be made between the effects of these deficits on growth, development and final yield. Thus, soluble carbohydrates and amino acids are the organic substrates for growth, development and storage and hence their reduced availability would restrict the yield potential of the individual plant. However, limited availability of plant growth substances would curtail the capacity for realization of the tuber yield potential defined by the availability of organic substrates. Such restricted capacity for yield potential realization often results in alternative forms of growth e.g. premature sprouting of "Pencil roots" and young tubers in developing sweet potato crops subjected to waterlogged soil conditions.

There is evidence to show that metabolic limitations resulting from physiological yield constraints in sweet potato differ in different cultivars. In some cultivars the limitation is in organic substrates (e.g. soluble carbohydrates resulting from photosynthesis), whilst in others the limitation is in the hormonal requirements for tuberisation. It is the task of the breeder to produce a superior cultivar in which both types of limitations are removed by means of judiciously chosen hybridizations.

Genetic Constraints

The major genetic constraint to yield improvement in sweet potato is the restricted possibilities for hybridization among varieties in the species effected by cross incompatibility. The establishment of pure lines by selfing is also restricted by the phenomenon of self-incompatibility. Establishment of inter- and intra-compatible groups of cultivars is therefore the first step in the removal of this constraint. However, the great variation in vegetative characteristics in the sweet potato species suggests that several characteristics associated with high yield may be obtained within a single compatible group of cultivars.

Comparative productivity of some tropical crops.

De Vries, Ferweda and Flach (1967) analysed average world production data for a number of tropical food crops (Table 8) and emphasized the following points:

1. Although root crops produced more bulk than grain crops, because of their higher water content, the average energetic food value of root crops (121 Cal/100 g) amounted to only 34% that of grain crops (354 Cal/100 g).

2. However, when differences in the percentage edible yield as well as the relative period of vegetation are taken into consideration, then the average crop efficiency of root crops (38.5×10^3 Cal/ha/day) is only slightly lower than that for tropical grain crops (44.5×10^3 Cal/ha/day).

3. The crop efficiency of sweet potato - 48×10^3 Cal/ha/day - was second only to maize at 56×10^3 Cal/ha/day.

Further comparisons of crop efficiency calculated from highest experimental yields (Table 9) showed that the average crop efficiency of cassava and sweet potato (215×10^3 Cal/ha/day) was some 43% higher than that for tropical grains at 150×10^3 Cal/ha/day. Also, sweet potato crop efficiency (180 x 10^3 Cal/ha/day) was only 10% less than maize (200 x 10^3 Cal/ha/day) but cassava efficiency (250 x 10^3 Cal/ha/day) was some 40% higher than that for sweet potato.

Despite the high crop efficiency of cassava, however, sweet potato offers advantages of (a)a shorter crop, leading to more efficient land utilization, (b) better distribution of tubers in the soil thus allowing for mechanical harvesting and the concomitant reduction of production costs, and (c) longer retention of high protein foliage which can be utilized both for human consumption and animal feeds.

TABLE 8. Average world production of a number of tropical food crops.

Crop	Tons/ha	Cal./100g	Edible portion	Cal./ha x 10^6	Period of growth	Cal./(ha.day) x 10^3
	(1)	(2)	(3)	(4)	(5)	(6)
Rice	2.0	352	70	5.0	150	33
Wheat	1.2	344	100	4.1	120	34
Maize	2.1	363	100	7.6	135	56
Cassava	9.1	153	83	11.6	330	35
Sweet potato	6.5	114	88	6.5	135	48
Yam	8.0	104	85	7.1	280	25
Colocasia	5.8	113	85	5.5	120	46

After de Vries et al (1967)

TABLE 9. Maximum yields in selected experiment stations in the tropics

Crop	tons per ha per harvest	tons per ha per year	Cal./(ha.day) x 10^3	Rate of breeding
	(1)	(2)	(3)	(4)
Rice	16.4	26.0	176	***
Wheat	3.9	11.7	110	*
Maize	5.5	20.0	200	**
Cassava	77.0	71.1	250	**
Sweet potato	41.0	65.2	180	*
Banana	39.0	39.0	80	-

(From De Vries et al 1967)

CONCLUSIONS

It is concluded that sweet potato yields can be increased in the Caribbean by removing agronomic constraints to yield improvement. Further, current understanding of the physiological and genetic constraints to yield improvement could lead to the future development of superior sweet potato cultivars with increased yield potential, which would make this crop a highly competitive source of cheap carbohydrate.

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DISEASES OF ROOT CROPS IN JAMAICA

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DISEASES OF YAMS (DIOSCOREA spp.)

Yams are somewhat disease tolerant, and although they are affected by many diseases, farmers are usually able to obtain a crop with few disease control practices. As more attention is given to the crop it has been realised that diseases and pests particularly anthracnose and nematodes cause severe loss yams crops in Jamaica. Loss in storage is also high.

Nematodes which are mostly carried on the planting materials or remain in the soil from year to year constitute a severe threat to the profitable growing of the crop in many areas of the island. A separate paper deals with the problem of these pests on yams.

Some of the disease problems of yams and methods of control are as follows:-

Anthracnose which is caused by a species of *Colletotrichum* fungus produces black necrotic areas on leaves and vines. The tips of affected vines usually die back and growth may be greatly restricted. The disease is often severe on white yams and to a less extent on other varieties especially when they are growing under wet conditions.

Staking the plant and spraying with a copper fungicide (such as Kocide, Cupravit Blue and Perenox), with Captan 2½ lb/acre or Benlate 1 lb/acre helps in controlling the disease. Five or more treatments at two weekly intervals should be applied, depending on severity of the disease. The white yam (*D. alata*) is much more susceptible than the yellow (*D. cayenensis*) or negro (*D. rotundata*) varieties and the former should be avoided in wet areas.

Black rot is caused by a fungus *Rosellinia* sp. which produces a white mycelial mat and black slightly raised structures of the fungus on the outer portion of the tubers. If affected tubers are cut, fine black streaks will be seen radiating from the outer portion to about 1 inch into them. The disease is usually observed at high elevations and in heavy or poorly drained soils.

Removal of all infected material from the soil, trenching the area, applying white lime to the soil and rotation with a non root-crop will help to control the condition. Care must be taken in planting not to use affected tubers. No chemical soil treatment appears, so far, to control this disease.

Leaf spots caused by species of *Cercospora* fungus are quite common but are not generally serious. Yams maturing at higher elevantions sometimes become severely spotted and the leaves die prematurely. Some varieties are more susceptible than others and these should be avoided in wet areas or at high elevations. This condition is not much of a problem if it occurs on plants nearing maturity but young plants should be treated with fungicides as recommended for anthracnose, if the disease is observed on them.

Viruses - Yams, in particular yampiee (cush-cush), *Dioscorea trifida*, are often affected by viruses which produce mottled and distorted leaves. Infection, however, does not appear to reduce plant growth severely. As no work has been done on this problem in Jamaica the amount of loss or the extent of occurrence of the disease is not known.

The occurrence of diffuse dark brown spots inside yam tubers is suspected to be associated with virus infection. A condition in which the underground portion of the yam becomes rounded like a pumpkin and is inedible is also thought to be caused by a virus.

Planting materials should not be taken from affected plants to establish new fields.

DISEASES OF SWEET POTATOES

Sweet potatoes in Jamaica appear fairly free of serious disease problems. The crop is affected by a rust fungus which produces brown pustules covered with yellow spores on the underside of leaves. There is also a condition known as white rust, caused by a *Cystopus* species of fungus, which is often observed but does little harm to the crop.

Symptoms of virus diseases are sometimes seen on sweet potato plants. Affected leaves are mottled with yellow white and green colours and are crinkled and deformed. No work has been done on this condition as it is not commonly observed.

Sweet potato tubers are seriously affected by soft rot which is caused by the mould fungus *Rhizopus stolonifer*. Proper curing and storage appear to control this condition adequately.

The major problem of growing sweet potatoes in Jamaica is the high incidence of the sweet potato weevil *Cylas formicarius*.

IRISH POTATOES

This crop in Jamaica suffers from a number of serious diseases and great difficulty is enountered when it is grown in wet areas, under very damp conditions or when replanted in same field for successive years. Some of the principal diseases of the crop are as follows:-

Late blight

The fungus *Phytophthora infestans* causes this condition which can destroy a field in one week. The disease first appears on the leaves as watersoaked areas that quickly develop into irregular brown shrivelled patches, usually at the edges. In wet weather or with heavy dew the white fluffy growth of the fungus may be seen on the lower surface of affected leaves. The fungus not only affects the leaves but also the stems, so that the whole plant may become dark brown and die. The spores of the fungus may be washed into the soil by rain, affecting the tubers which become brown with a purplish discolouration below the skin. These tubers are liable to rot in storage, and must never be used as seed for planting as the fungus will be carried in them to the new field.

Disease development can be controlled by regular weekly applications of fungicides such as Maneb and/or Zineb, Polyram-Combi, Difolatan and Copper (Kocide or Cupravit Blue) at 2-3 lb/acre. Application of the fungicides with low volume mist sprayers is usually more effective than with high volume equipment. Care must be taken to protect the lower surface of leaves. If the weather is wet, spraying may have to be done twice a week starting as soon as the plants germinate.

Early blight

This disease is caused by a fungus (*Alternaria solani*) which produces small brown spots on affected leaves and stems. These spots enlarge to form circular lesions up to ½ inch in diameter with a series of concentric rings.

Some varieties such as Red Pontiac are very susceptible. The more resistant varieties such as Aran Consul, Kennebec and Sebago should be planted in areas subject to this condition. The same spray treatments recommended for the control of late blight will also control early blight.

Fusarium wilt and Stem end Rot

These diseases are caused by soil-borne species of Fusarium. Affected plants have discoloured stems at and below ground level, accompanied by yellowing of leaves, wilting and ultimate death. If mature plants are dug up, the brown discolouration on the stem may be seen to extend down to the point of attachment of tubers. Affected tubers have external brown stem-end lesions and such tubers usually have a pale brown discolouration about ¼ inch below the skin.

Fusarium wilt and Stem end Rot are usually worse on clay soils than on those that are free draining. If severe, the affected field should not be used for growing potato for two or three years. Diseased tubers rot easily and so should not be stored for any length of time, nor should they be used for planting . Chemical soil treatments have had little effect on controlling these diseases.

Scab

Scab of potato is caused by a soilborne organism, *Streptomyces scabies*. This organism lives on decaying plant materials and under dry conditions can attack potato tubers producing a "callous" or rough growth on the skin. Scab in superficial and affected tubers are safe for eating although they look unsightly and may crack and spoil easily.

Where *Streptomyces scabies* is present the disease is rarely serious in acid soils but can be severe under neutral or alkaline soil conditions. Affected tubers should not be used for planting and soils heavily infested with the causal agent should not be used for potato growing for two or more years. Some varieties are much more resistant than others and should not be used in areas where the disease is prevalent. If there is rain or the soil is kept moist during early tuber formation the incidence of scab will be greatly reduced.

Black Rot

A soil-borne fungus - *Rosellinia* sp. causes black rot which exhibits its presence by a white growth over the tubers and black pin-like streaks in the cut tubers similar to that described as occurring in yams. Tubers from affected fields should never be used for planting.

As the causal fungus remains in the soil for years a long rotation with non-susceptible crops such as corn, grass, bananas or leafy vegetables should not be practiced.

Sclerotium or Southern wilt

Southern wilt is caused by the fungus *Sclerotium rolfsii* which attacks potato plants at ground level causing a sudden wilt. The white fan-like mycelium and seed-like sclerotia can be seen on the soil around affected plants. Diseased plants should be taken out of the field and destroyed. This condition is difficult to control as the fungus affects a wide range of plants.

Virus Diseases

Several viruses e.g. potato virus X, potato virus Y, leaf roll virus, mosaic and other viruses can attack potato plants resulting in mottling, spotting, crinkling or curling of leaves, retarded growth, an unhealthy appearance and reduced yields. Affected plants in a young field should be rogued, otherwise the viruses can be spread from diseased to healthy plants either mechanically or by insects such as aphids. Spraying with a systemic insecticide such as Rogor or Perfekthion to control insect vectors may help to reduce spread of the disease. All of the above mentioned viruses are carried in tubers and so the use of healthy certified virus-free seeds for planting cannot be overemphasized. Locally produced seeds are often affected by viruses and should not be used for planting. Most of the potato seeds used for planting in Jamaica are imported from Canada.

Root Knot Nematodes

Potato tubers are sometimes affected by eelworms, *Meloidogyne* sp., which produce 'water bumps' or galls on affected tubers. Soils known to be heavily infested with these nematodes should be treated with a nematicide before planting. Cultivating the soil a couple of times and leaving it exposed to the sun for several weeks will reduce its nematode population. Affected seeds should not be used for planting. A grass crop such as corn should be used in the rotation. Crops susceptible to attack by root-knot eelworms should be avoided.

CASSAVA

Leaf Spots

Cassava leaves in Jamaica are often affected by two leaf spot diseases. Large brown spots, up to half an inch in diameter, caused by the fungus *Cercospora henningsii*, are quite common. Smaller angular spots with a light brown centre and dark-brown margin, due to *Cercocpora caribaea*, may also be found. Neither occurs extensively except on cassava which is grown under adverse conditions. Improving the growth of affected plants by good cultural practices and application of fertilizer will help to control these leaf spots. If severe, the disease can be controlled by spraying with a dithiocarbamate fungicide, copper or Benlate.

Black Rot

Black rot disease is caused by the same kind of *Rosellinia* fungus that produces this condition on yams and potatoes. It is difficult to control. Fortunately it is rarely observed in Jamaica.

Leaf Mottling

A very marked yellow mottling of cassava leaves is sometimes mistaken for a mosaic disease. This may be due to thrips or other insect injury and is found chiefly on plants lacking in vigour. The exact cause of the condition has not been ascertained.

In dry weather, cassva plants may shed the greater portion of their leaves due to attacks by red spide mites which cause the remaining leaves to develop a mottled, a silvery or brown colour. With the recurrence of rain or with irrigation the plants recover. If attacks are severe the plants can be given a spray treatment with Kelthane or Rogor at 1 pint per acre or one of the other miticides.

DASHEENS AND COCOS (*Colocasia* and *Xanthosoma*, spp.)

This group of aroids does not suffer severely from diseases in Jamaica. Occasionally plants can be seen with *Rosellinia* black rot damage. Dry rot caused by a fungus *Vasculomyces* sp. sometimes occurs and leaf spotting may be seen, but these appear to do little damage to affected plants. Leaf chlorosis, mottling and what appears to be deficiency symptoms are sometimes observed but their exact cause and methods for their control have not been ascertained.

A condition has recently been encountered in which fine brown streaks occur throughout the tubers. The cause of this has not been identified.

Nematodes (*Helicotylenchus*, *Meloidogyne* and *Pratylenchus* spp.) have also been isolated from the roots of cocos and dasheens. Growth of plants was markedly better in a section of a field treated with DD nematicide than in an untreated section.

EFFECTS OF CURING ON STORAGE OF YAMS

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INTRODUCTION

Exposure of certain tubers to high temperature and humidity has long been known to bring about rapid wound healing by encouraging suberization and wound periderm formation (Appel, 1906; Artswager 1927 and Artswager and Starrett 1931). It is now standard commercial practice to cure potatoes (Artswager, 1927) and sweet potatoes (Lutz and Simmons, 1958) before storage. Apart from report from Gonzalez and Callazo de Rivera on Dioscorea alata L. there is little information on the effects of curing yams prior to storage.

Farmers in Jamaica successfully store D. alata tubers under ambient conditions for up to ten months after placing them in direct sunlight for three days to two weeks. Cut surfaces are usually brushed with lime or crushed broad bean (Vicia faba) leaves immediately after harvest. In West Africa, exposure of yams to direct sunlight is considered to have a detrimental effect on storage (Coursey and Nwankwo, 1968). In Jamaica few attempts are made at long term storage of any species other than D. alata.

Yams are probably the major staple food grown in Jamaica and export of D. rotundata Poir and D. cayenensis Lam. tubers to North American markets has been increasing. Both species, especially the latter, are characterized by high wastage on arrival at export markets (Burton,1970) and even in local markets. In addition both species are available in certain seasons only while there is a year-long demand.

The investigations reported in this paper were carried out to determine what effects curing under different conditions had on the storage of D. rotundata and D. cayenensis.

MATERIALS AND METHODS

Tubers of D. rotundata and two varieties of D. cayenensis - Roundleaf and Bottleneck - were used. All experimental material was harvested and transported in the traditional manner. Except in one experiment (Expt C, Table I) all tubers were selected, washed, air-dried, cut to remove the "head" - that end to which the vine is attached - numbered and individually weighed. In experiment C tubers were unselected and cured in a semi-commercial two ton quantity whereas in other experiments 20 to 30 tubers per treatment were used. Curing temperature ranged from 19°C to 45°C and relative humidity from 52 to 100%. After curing, which lasted from one day to seven days, tubers were stored at ambient or 13°C. During storage tubers were weighed at regular intervals and scored for surface mould on a scale of 0 to 5, where 0 = absence of mould and 5 = complete coverage. Necrosis was assessed at the end of each experiment after cutting each tuber in two longitudinally. Anatomical studies were done on fresh and preserved material.

RESULTS

The results obtained from the five experiments considered here were typical of those obtained from a large number of experiments carried out over a three-year period.

Anatomy

The anatomy of the D. cayenensis tubers is similar to that of D. rotundata described by Ayensu (1970). Wound healing was normal in most ways and suberization always preceded wound periderm formation. When a tuber was cut the peripheral layers of cells lost their starch grains and became suberized under ideal curing conditions. The outer most layers composed largely of cut or injured cells retained their starch grains. A cambium developed within the starch free zone and cut off cells to the outside only and these became suberized and formed the wound periderm.

The rapidity with which wound healing took place depended on humidity and temperature. When humidity was low, less than about 70% relative humidity, suberization and wound periderm formation were delayed, the cut surface dried out and a thick scab formed; there was a wide suberized starch free zone and a deep seated cambium. If the temperature was low - less than 26°C - suberization was delayed; if high - above 35°C - periderm formation proceeded rapidly, the starch free zone was narrow and the cambium superficial.

Weight loss

Bottleneck tubers cured at high temperature and humidity, above 35°C and 90% relative humidity, lost 30% fresh weight after 105 days storage and this was significantly less than 45% lost by tubers cured under ambient conditions (Expt A, Table I). Similar results were obtained in Expt. C and to a lesser extent in Expt. B (Table I). Curing for more than two days at 36 °C and 95 to 100% relative humidity did not seem to significantly affect weight loss at ambient. Roundleaf tubers cured under ambient conditions lost more weight than those cured at high temperature and humidity, but the differences were not as marked as with the Bottleneck.

Curing D. cayenensis tubers under different conditions did not seem to significantly affect the pattern of the rate of weight loss during storage at ambient - an early high rate, then a decline until about the sixth or seventh week and a gradual increase.

The effects of curing on weight loss of D. rotundata tubers were similar to those on Bottleneck tubers. Curing at high temperature even when the relative humidity was low significantly reduced weight loss during storage at ambient, Table 2, Expt E. There was some indication, however, that after about two months' ambient storage the effects of curing weight loss were not very marked. Curing at high temperature and humidity followed by storage at 13°C resulted in lowest weight loss. The pattern of rates of weight loss were similar to that of D. cayenensis, but cured tubers stored at 13°C did not show an increase in rate.

Mould

When tubers of both species were selected and trimmed before curing at 35°C to 42°C and 95 to 100% relative humidity they were free from surface mould growth during storage at ambient but not at 13°C (Tables I and 2). Superficial moulds grew on 47% of the unselected, untrimmed Bottleneck tubers cured at 36°C to 38°C and 75 to 87% relative humidity and stored at ambient (Table I, Expt C) and on 100% of those stored at 13°C. In the same experiment all t[illegible]ers cured at ambient had surface mould. Most moulds which grew on tubers cured at high temperature and humidity were saprophytic and generally dried up after two or three weeks storage. Those which grew on tubers cured at ambient, mostly Penicillium and Aspergillus, were associated with necrosis. Tubers of D. rotundata and Roundleaf cured at ambient also had superficial mould growth during curing and storage.

Necrosis

Bottleneck tubers cured at high temperature and humidity (Table I) consistently had significantly less necrotic tissue than those cured under ambient conditions. The effects of curing were not as pronounced on Roundleaf (Table I, Expt A). Curing at high temperatures also reduced necrosis in D. rotundata tubers (Table 2).

Sprouting

There was some indication that curing at high temperature prior to storage at ambient hastened sprouting. After about three or four weeks storage, a number of small protuberances, associated with root development, were evident on the tubers and these became larger as storage progressed. Storage at 13°C suppressed sprouting regardless of curing conditions.

DISCUSSION

Yams (Dioscorea spp.) were cured at different temperatures and humidities and stored under conditions comparable to those in cellars and sheds where local farmers store their crops, at 13°C.

Suberization and wound periderm formation, normal in most ways, were favoured by high temperature and humidity - 35°C to 40°C and 95 to 100% relative humidity. Curing under these conditions for one to seven days gave best results: it significantly reduced weight loss and rotting, usually prevented growth of moulds and extended storage of Yellow Yams (D. cayenensis Lam.) from one week to six weeks. The traditional method of sun drying prior to storage was found to have beneficial effects.

Consumers showed a preference for cured tubers.

Because of harvesting difficulties, careless handling and the practice of saving a portion of the tuber for planting, few damage-free yams enter commerce. The cut surface of a tuber offers a very suitable medium for growth of micro-organisms and decay follows rapidly if changes in cell walls beneath do not take place to form a barrier to impede the progress of pathogens. A temporary yet effective barrier is secured through suberization of peripheral cells, but wound periderm is more permanent and offers a more effective protection against entry of pathogens (Weimer and Harter, 1921; Lauritzen and Harter, 1929 and Priestley and Swingle, 1929).

The reduced weight losses, small amounts of necrosis and reduction of mould growth after tubers had been exposed to high temperature and humidity for as little as one day, were probably a consequence of rapid wound healing. Because of delayed wound healing under ambient conditions pathogens were able to penetrate the tubers with resulting increased rotting and weight loss and shortened storage.

The good results obtained when tubers were exposed to direct sunlight prior to storage suggest that drying out of injured cells, like in sweet potato (Weimer and Harter, 1921), may exert some retarding or inhibiting action against organisms.

The increase in rate of weight loss of D. cayenensis tubers after 50 days storage at ambient appeared to be associated with sprouting. This was supported by the tendency of the rates of weight loss of cured and uncured tubers to convergo during storage since curing hastened sprouting. Weight loss of cured D. rotundata was also partly associated with sprouting. For tubers that sprouted an increase in the rate of weight loss was associated with time of sprouting whereas this increase was absent when tubers did not sprout.

The presence of superficial mould on tubers stored at 13°C suggested either incomplete curing or low temperature injury.

Over 80% of the D. cayenensis grown in Jamaica is of the Bottleneck variety which has a storage life of generally less than a week and cannot be exported by air. We have found that properly cured Bottleneck tubers can be successfully marketed locally even after six weeks storage at ambient conditions. Tubers stored for periods longer than this are normally unattractive becaus of protrusions associated with sprouting and shrivelling due to increased weight loss.

Tubers not sold on the fresh market can subsequently be used as seed material since they remain relatively free from rotting and sprouting is normal

Curing, in addition to reducing wastage on the local market, makes it possible to export D. cayenensis by sea.

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TABLE 1. Effects of curing on certain storage parameters of D. cayenensis tubers.

	Cultivar	Curing °C	Curing RH(%)	Curing days	Storage °C	Storage RH(%)	Storage days	%fresh weight loss	% tubers with mould	% necrosis
Expt A	Roundleaf	35-40	95-100	1	25-34	64-92	105	18.8C	0C	15B
	Bottleneck	"	"	"	"	"	"	30.3B	0C	22B
	Roundleaf	25-34	64-92	"	"	"	"	22.4BC	36B	21B
	Bottleneck	"	"	"	"	"	"	44.5A	78A	55A
Expt B	Bottleneck	36	95-100	1	21-31	55-77	98	20.6B	0B	1.6BC
		"	"	2	"	"	"	18.7B	0B	2.5B
		"	"	3	"	"	"	18.7B	0B	1.8B
		"	"	4	"	"	"	18.1B	0B	1.2C
		23-31	55-77		"	"	"	35.1A	80A	5.1A
Expt C	Bottleneck	36-38	75-87	2	19-21	65-83	30	14.7	46.7B	2.9± 1.0C
		"	"	"	13-14	-	"	13.2	100.0A	3.7± 0.6C
		19-21	81-83	"	19-21	65-83	"	16.4	100.0A	40.0± 4.3A
		"	"	"	13-14	-	"	-	100.0A	20.4± 3.3B

Figures followed by the same letter do not differ significantly (P = 0.05).

TABLE 2. Effects of curing on certain storage parameters of D. rotundata tubers.

	Curing °C	Curing RH(%)	Curing days	Storage °C	Storage RH(%)	Storage days	%fresh weight loss	fungal score	% necrosis
Expt D	36-40	96-100	1	13	95-100	106	18.1B	2.2	7B
	"	"	"	21-31	52-68	"	29.7A	0.0	2B
	24-31	56-68	"	13	95-100	"	32.1A	2.6	64A
	"	"	"	24-31	52-68	"	30.4A	0.0	17B
Expt E	Direct sunlight		7	29-33	90-94	60	22.5B	0.9B	7B
	38-42	95-100	"	"	"	"	20.9B	0.0C	6B
	29-33	90-93	"	"	"	"	36.1A	1.3A	21A
	24-29	58-71	"	"	"	"	35.5A	1.0B	27A

Figures followed by the same letter do not differ significantly (P = 0.05).

ROOT-CROPS PROCESSING RESEARCH

AT THE

UNIVERSITY OF THE WEST INDIES

ST. AUGUSTINE, TRINIDAD

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INTRODUCTION

The nutritional requirements of man may be broadly classified as carbohydrate, protein, fat, vitamins and minerals, of which carbohydrate forms the greatest single item. Carbohydrate foods are basically starches and sugars. On a global scale, rice, wheat and other cereal grains form the bulk of our carbohydrate foods, nevertheless root-crops play an important role. Of the root-crops, white potato (Solanum tuberosum) records the greatest production (301 million metric tons per annum 1970) with cassava (Manihot esculenta) following (88.2 million metric tons); all others together account for a mere 25 per cent of the total world production of the major root-crops (Kay, 1973).

The advantages of cereal grains over root-crops are low moisture content (and therefore better keeping quality), longer shelf life, ease of obtainability, better nutritional value, relatively lower unit cost per edible portion. Traditionally grains are used wherever possible and this possibility for the Commonwealth Caribbean has been extended to the importation of cereal grains to a large extent. Total cereal imports for 1972 for the CARIFTA region were $139.3M (E.C.) of which $44.5M was intra-regional, while $94.8M was extra-regional (Sammy, 1974). Within reasonable limits we may assume that the extra-regional imports were for wheat and wheat-flour only. When we consider that at present wheat cannot be grown in the Caribbean, then it would seem that there is considerable potential for the development of a carbohydrate source to replace wheat. This will be in the areas of tropical cereals and root-crops.

Alexander (1967) indicated that the demand for starchy roots may be indirectly affected by:

1) limited ways of preparation
2) method of marketing and merchandizing
3) uncertainty about product quality; and
4) high wastage in preparation

It would seem to us that the way to remove these limitations would be by the development of processed products. A study of the resources spent on root-crops development will show that the greatest expenditure is on Agronomy, with very little on processing and utilization. This is clearly indicated by a study of the proceedings of the First and Second International Root-Crops symposia and the programme of the Third.

The First Symposium identified the importance of processing and utilization through a Study Group. At the Second Symposium two papers on processing were presented, while at the Third six papers were slated for presentation. Indications are that the study of processing and utilization are gaining momentum but not at a sufficient rate.

We are convinced that tropical root-crops will not be able to make any significant impact unless their usage is extended. This can only be done through research and development in processing and utilization. A greater proportion of the resources expended on root-crop research must therefore be channeled into processing and utilization.

Research on the processing of tropical root-crop was started at the University of the West Indies, Trinidad, in 1969 through participation in the Root-crop Programme of the Faculty of Agriculture. The Root-crop Programme at this time was financed through a grant from the Rockefeller Foundation. At present the Programme is financed through the International Development Research Centre (IDRC). Emphasis is placed on the root-crops - sweet potato (Ipomaea batatas) and yams (Dioscorea spp.), but some preliminary work is being done with breadfruit (Artocarpus communis).

The object of the research is to study the processing potentials of tropical root-crops having the greatest possibilities for commercial utilization and thus of greatest economic benefits to the "Caribbean Region". Work is being done in the following areas; preparation of "composite flours" for bread and baked goods, canning, instant products (pre-cooked drum-dried) and breakfast foods.

COMPOSITE FLOURS

The object is to study the baking potential of composite flours made from wheat flour by dilution with varying quantities of root-crop flours, using the baking methods in existence in Trinidad and Tobago. It is felt that any major changes in the baking industry would have to be gradual. Because of this we are searching for composite flours that would have baking properties and produce products similar to those obtained from wheat flour. The products obtained in the experiments were considered acceptable only when the taste panel recorded a 100 per cent acceptance. Studies have been conducted using composite flours containing sweet potato, yam and breadfruit flours.

Two studies were conducted using a composite flour containing sweet potato flour. One study was of two cultivars (049 and C9) grown in Trinidad and Tobago, for baking potential. (This work was published "Studies in Composite Flour - 1. The Use of Sweet-potato Flour in Bread and Pastry Making" by G.M. Sammy, in Trop. Agri. Trin., 47, (2) 1970). The other was a comparative study of seventeen sweet potato cultivars for bread-making potential. This work was presented as part of the Paper "The status of Composite Flour Research at the University of the West Indies" at the International Conference on the Production and Marketing of Composite Flour, Baking and Pasta Products" held in Bogota, Columbia, 23-27th October, 1972. From this first study it was found that of the two cultivars studies 049 had good baking properties for dilution up to 15 per cent for bread, 20 per cent for cakes and 30 per cent for cookies, while C9 had poor baking properties. Tables 1 and 2 summarises these baking properties. In the preparation of sweet potato flour, peeling was found unnecessary, while treatment with one per cent sodium metabisulphite improved the colour of the flour. Addition of one per cent glyceryl monostearate or monopalmate only slightly improved the baking properties. Addition of five per cent fish protein concentrate or cotton seed flour had little or no effect on the baking properties.

The latter study showed that bread-making potential varies with different cultivars. There seemed to be a direct relationship between crude protein content and the baking potential. Tables 3 and 4 give summarised results. Further to the laboratory studies, one hundred pound batches of composite flour made up of 15 per cent sweet-potato flour and 85 per cent wheat flour were given to two local bakeries for baking trials. Bread of the pan-loaf and butter-bread types were readily produced, and proved to be highly acceptable by a consumer acceptance test. However, the preparation of "hops" which is a crusty loaf, proved difficult at a 15 per cent dilution. Addition of 0.5 per cent "Emplex" (a Patco Product of sodium and calcium Stearoyl - 2 Lactylate), strengthened the dough and permitted the production of acceptable "hops". Straight dilution without additive for the production of "hops" was below 10 per cent.

The work on composite flour with yam flour and breadfruit flour has not yet been published. Experimental results have shown that yam composite flour produces a fully acceptable loaf at a dilution of up to 25 per cent. The quality and storage life is better, for a loaf made with 25 per cent dilution as compared with a loaf made with 100 per cent wheat flour (white). Table 5 gives the summarised results.

Bread made from breadfruit composite flour had poor baking qualities as compared with sweet-potato and yam. The highest dilution for an acceptable loaf was 5 per cent. Table 6 summarises the results.

CANNING

Studies have been carried out on the canning of sweet-potato (049) and yam (Lisbon, coconut and oriental - D. alata), portuguese (D. rotundata), cush cush (D. trifida) and chinese (D. esculenta) in brine. They were canned as ¼ and ½ inch cubes (diced) and as chunks. Further, sweet potato was canned as small whole potatoes unpeeled.

The canned cubes and chunks showed considerable starch leaching and, especially with the sweet potato, disintegration. The leaching was so heavy that after one month storage the total liquor in the can became a pasty mess.

Blanching of the cubes before filling, and the addition of 0.1 to 0.5 per cent calcium chloride give little improvement. The canning of small (2.4-4.0 cm dia.) whole unpeeled sweet-potato in brine gave a good product with little or no starch leaching. The canning liquor remained relatively clear after six months of storage. The skin of the potato posed no problem as it was easily removed before serving. This product had a high acceptability on a random taste-panel of 150 consumers.

"INSTANT PRODUCTS"

The idea here is to prepare a pre-cooked instant type product similar to that marketed for Irish potato (Solanum tuberosum). A brief description of the process is as follows: the tubers or roots are cooked, mashed into a paste and drum-dried. The main problems encountered with yams were high blue-values (200 to 1,200) and difficulty in scraping the product clean off the drum. The high blue-value was an indication of large number of raptured starch cells. This was solved somewhat by passing the cooked yam pieces first through a meat mincer and then mixing to the required consistency using a "K" beater (Hobart). This reduced the amount of free starch from broken cells to an acceptable level. To assist the scraping of the product from the drum dryer 0.1 to 0.5 per cent glyceryl monostearate was added. With these modifications an acceptable product was produced. There was some difficulty with discoloration of the final product. It is known that the stem-end of cooked yam becomes discoloured, varying from light reddish brown to brown, while the rose-end remains white to off-white. However, this problem was overcome by judicious blending of stem and rose ends to give an acceptable off-white product.

Experimental results have shown that pre-cooked yam flakes may be produced with equal facility from a variety of yams such as lisbon, coconut, and oriental (D. alata); protuguese (D. rotundata) cush cush (D. trifida) and chinese (D. esculenta). The flakes produced from the chinese yam had poor texture on reconstitution, and developed a bitter taste after two weeks of storage. The flakes prepared from the other varieties were all acceptable.

It is gratifying to report that from this work a semi-commercial size pilot plant was set up in Barbados to test market "instant yam" made from D. alata. The test proved successful and steps are being taken to set up a commercial-size plant.

Preliminary experiments have indicated that an "instant" sweet-potato, similar to the yam product is possible. Intensive research is continuing in order to work out the various parameters affecting the final product. The results obtained thus far are encouraging.

BREAKFAST FOOD

Because of the North American influence in the West Indies imported convenience breakfast foods are well established among the upper and middle class of our society, and are fast filtering down to the lower level. Most breakfast foods have a carbohydrate base. There is therefore no reason why convenience breakfast foods cannot be made from root-crops. The object of this research is to produce breakfast foods from root-crops or with a root-crop base to replace those imported. Experiments are being carried out on two types of products, the flake type, similar to corn flakes and an instant porridge.

Preliminary work has indicated that both types of products are possible from sweet-potato. The study includes fortifying the products with soya beans and other legumes in order to increase the protein content. Table 7 gives a summary of the formulations and process conditions.

Future research on the processing potention of root-crops will expand on the breakfast foods to include puffed products and milled products. High protein pre-weaning mixes for children using locally produced legumes and root-crops as the carbohydrate base are also being considered. Other root-crops to be included would be dasheen, eddoes, tannia, (aroids).

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TABLE 6. Effect on Baking Properties of Composite Flour (Breadfruit and Wheat Flour) with different Proportions of Breadfruit (Home Baking).

% Breadfruit Flour	0	5	10	15	20
Loaf Volume:					
ml/g bread	3.3	3.3	3.1	3.0	2.5
ml/kg flour	5865	5850	5540	5128	4385
Shape:					
Colour:					
crust	light brown	light brown	light brown	light brown	light brown
crumb	white	white	off-white	off-white	off-white
Texture:					
crust	smooth	smooth	smooth	slightly rough	rough (cracks)
crumb	good(even cells)	good(cells even)	very fair (cells uneven)	fair(cells uneven)	poor
Taste:	good	good	slight off-flavour	off-flavour	off-flavour

TABLE 7. Formulation for Flake type breakfast foods using sweet-potato flour as the bas

Experiment No:	11	12	13	15	16	18	19
Ingredients (% dry weight)							
Sweet-potato flour	94	82	13	50	50	50	50
Rice flour	-	-	-	44	34	22	12
Wheat flour (white)	-	-	-	-	-	20	35
Corn (maize) flour	-	12	-	-	10	-	5
Skim milk powder	4	4	4	4	4	-	-
Salt	2	2	2	2	2	3	3
Soya flour (whole)	-	-	12	-	-	-	-
Water (gms)	40	40	40	40	40	40	40

Processing Conditions	Range
% Dough moisture	32-41%
% Moisture after drying	13-16%
Roller spacing for pressing flakes (cold) (inches)	0.003
Toasting temperature °C	210
Toasting time (Sec)	105-120
Moisture content of finished product(%)	2-4

TABLE 4. Properties of Sweet-Potato Tubers and Flour made from them.

Cultivar	Tuber Shape	Colour: Skin	Colour: Flesh	Moisture: Tuber	Moisture: Flour	Flour Bulk-Density g/ml	Crude Protein %*	Total Sugar %*	Reducing Sugar %*	Fat %*	Fibre %*	Ash %*
A13/56/11	Bulbous	yellow	light orange	68	2.7	0.472	4.1	9.5	3.0	0.56	3.72	1.40
02/62	Cylindrical	reddish	white	70	3.1	0.506	4.1	7.9	2.4	0.16	2.47	1.46
08/589	Bulbous	white	white	71	3.2	0.618	3.8	8.2	1.0	0.60	1.46	2.07
C9/9	Cylindrical	white	white	65	2.8	0.494	3.8	6.1	1.2	0.27	2.39	2.03
02/59	Bulbous	reddish	white	67	2.5	0.542	3.6	7.9	1.2	0.61	2.85	1.62
Austin Canner	Bulbous	yellow	orange	69	3.4	0.508	3.6	8.2	1.5	0.81	3.41	2.19
B13/56/11	Bulbous	yellow	orange	68	2.3	0.442	3.1	12.0	2.0	0.90	4.31	2.07
Centennial	Cylindrical	deep orange	deep orange	72	2.1	0.498	3.3	10.4	1.3	0.39	1.66	2.15
049	Bulbous	reddish	white	70	3.9	0.486	3.0	6.3	3.2	0.41	1.82	1.71
28/59	Bulbous	reddish	white	68	2.2	0.564	3.0	6.9	1.4	0.46	1.04	1.29
A7/63/22	Bulbous	dark red	pale yel.	69	2.3	0.548	2.9	7.9	3.0	0.17	1.64	1.94
A16/15	Bulbous	orange	orange	66	3.2	0.466	2.6	4.7	2.7	0.54	2.32	1.70
I 62	Cylindrical	reddish	white	70	2.3	0.596	2.6	6.5	3.0	0.31	2.26	1.04
03/62	Bulbous	white	white	71	2.5	0.518	2.4	5.6	2.9	0.52	2.35	1.64
Sunny side	Bulbous	orange	pale orange	69	3.4	0.550	2.1	9.1	1.4	0.85	2.45	1.93
C9	Cylindrical	white	white	68	3.2	0.494	2.8	7.1	0.7	0.62	1.62	1.74
A 28/7	Bulbous	reddish	white	66	2.6	0.504	2.6	4.5	1.0	0.53	2.62	1.17

* On dry wt basis

TABLE 5. Effect on Baking Properties of Composite flour with Different Proportion Yam Flour (Baked under 'Home Condition')

	Percentage of Yam Flour in Composite Flour of Yam & Wheat Flour						
	0	5	10	15	20	25	30
Loaf volume:							
ml/g	3.3	3.4	3.5	3.6	3.5	3.3	3.1
ml/kg flour	5860	5940	6160	6380	6165	5850	5500
Shape:	normal	normal	normal	normal	normal	slightly fallen	fallen
Colour:							
crust	light brown	lightbrown	light brown	light brown	light brown	light brown	light brown
crumb	white	white	white	white	white	white	off-white
Texture:							
crust	smooth	smooth	smooth	smooth	smooth	slightly rough	rough (few cracks)
crumb	good(cells even)	good(cells even)	good(cells even)	good(cells even)	good(cells even	very fair (cells uneven)	fair(cells uneven)
Taste:	good	good	good	good	good	good	good

TABLE 3. Comparative Study of Flour Made From Different Sweet-Potato Cultivars for Bread-making

Loaf Properties of Bread from "Composite Flour" with 15 per cent Sweet-Potato Flour and 85 per cent Wheat Flour.

Cultivar	Volume ml/kg Flour	Volume ml/kg Bread	Shape of Loaf	Colour Crust	Colour Crumb	Texture Crust	Texture Crumb	Taste
Wheat flour	5830	3.3	Normal	Brown	White	Smooth	(Even cells)	Good
A 13/56/11	6380	3.6	normal	light brown	yellowish	smooth	good(cells even)	good
02/62	6270	3.5	normal	light brown	off-white	smooth	good(cells even)	good
08/58/9	6160	3.5	normal	brown	white	smooth	very good(cells even)	good
C9/9	6160	3.5	normal	brown	off-white	smooth	good (cells even)	good
02/59	5940	3.4	normal	brown	off-white	smooth	coarse(uneven cells)	good
Austin Canner	5940	3.4	normal	dark brown	light yellow	smooth	good(cells even)	good
B 13/56/11	5885	3.3	normal	golden brown	golden yellow	smooth	coarse	slightly sweetish
Centennial	5830	3.3	normal	dark brown	golden yellow	smooth	coarse(large uneven cells)	slight off flavour
049	5720	3.3	normal	brown	off-white	smooth	good(cells even)	good
28/59	5720	3.3	normal	brown	off-white	smooth	fair(small cells, dense)	slight off flavour
A 7/63/22	5530	3.1	normal	brown	buff	smooth	coarse(few large cells)	good
A 16/15	5520	3.1	normal	brown	golden yellow	smooth	coarse(few large cells)	good slight off flavour
I 62	5500	3.1	normal	brown	off-white	smooth	fair(small cells dense)	good
03/62	5060	3.0	normal	brown	greyish	rough	fair(small cells dense)	off-flavour
Sunny side	5060	3.0	slightly fallen	brown	light yellow	slightly rough	coarse (soggy)	off-flavour (poor mouth feel)
C9	4290	2.4	fallen	brown	light grey	rough (many cracks)	coarse(uneven cells)	off-flavour
A 28/7	3960	2.3	fallen	light brown	off-white	rough (many cracks)	coarse(uneven cells)	off-flavour

TABLE 1. Effect of Different Proportions of Sweet-potato and Wheat Flour on Characteristics of Loaves Baked under "Controlled Conditions".

	Cultivar								
	"049"						"C9"		
Sweet Potato Flour %	0	5	10	15	20	25	5	10	15
Loaf Volume:									
ml/g bread	4.6	4.2	4.3	4.3	3.7	2.8	4.0	3.8	2.7
ml/kg flour	7429	7214	7286	7357	6333	5000	7000	6428	4571
Shape:	stable	stable	stable	stable	slight fall	fallen	stable	slight fall	fallen
Colour:									
crust	pale brn.	pale brn.	brown	brown	brown	brown	pale brn.	brown	brown
crumb	white	l. grey	l. grey	light grey	light grey	light grey	light grey	l. grey	light grey
Texture:									
crust	smooth	smooth	smooth	smooth	rough few cracks	rough many cracks	smooth	rough few cracks	rough many cracks
crumb	cells even (good)	cells even (good)	cells even (good)	cells even (good)	cells un-even (v. fair)	cells un-even (fair)	cells even (good)	cells un-even (v. fair)	cells uneven (fair)
Taste:	good	good	good	good	fair	poor	good	fair	poor

TABLE 2. Effect of "Composite Flour" with Sweet-Potato on Pastry Quality.

Product	%Sweet Potato Flour	Cultivar "049"	Cultivar "C9"
Roti (unleavened Bread)	15	good	poor
Sponge Cake	20	good	poor
Raisin bread	20	good	poor
Pancakes	20	good	poor
Doughnuts	20	good	poor
Sweet cream biscuits	15	poor	poor

Good means acceptable as compared with product made from wheat flour
Poor means unacceptable

EFFECTS OF BANK SIZE AND STAKE HEIGHT ON YELLOW YAM (D. CAYENENSIS) YIELDS ON ST. ANN CLAY LOAM (RED BAUXITE) SOIL

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The traditional method of individual mounds and single poles for yams aggravate soil erosion, since yams are grown on hill-sides. Use of continuous mounds or ridges along the contours, would avoid erosion, but soils may be too shallow to provide a proper depth of ridge. Individual mounds may improve soil drainage however, and continuous ridges may increase shading or result in blowing down of vines and supporting structures. The experiment compared banks (or ridges) 1.5 or 0.9 m apart, with a standard height of 46 cm., in combination with pole heights of 3 or 1.5 m. (above ridge crest) and either one or two plants per pole.

Yields were significantly higher with taller poles, but neither bank spacing nor number of plants per pole affected yields. None of the interactions were significant. Vine exposure, which might be expected to influence yield, probably differed but little between treatments, as vines jumped from pole to pole, so giving a continuous wall of foliage.

EFFECTS OF DIVISION LEVELS OF SEED TUBERS ON YAM (D. alata, D. trifida) GERMINATION AND YIELD

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INTRODUCTION

Yam cultivation rests essentially on tuber cutting for propagation. Only some small tubers bearing species (*Dioscorea esculenta*, *D. trifida*, in the West Indies) are regularly cultivated from whole tubers. Even with these species cutting may be practiced at times.

A number of authors have discussed the effects of cutting (see COURSEY, 1967) We quote here some of them.

As early as 1921, KINMAN showed in the West Indies (Puerto-Rico) the advantage of top setts (cuttings from near the stem) over middle and lower setts of *D. cayenensis* (forma *rotundata*) in yield although middle setts gave more tubers at harvest.

SAWADA (1952) showed with *D. batatas* that germination was polarized according to the tuber-mother structure : first germination point appeared or prevailed on sett part facing the tuber-mother top. He discovered that tuber initiation was exogen in large setts and endogen in small ones. With bulbils he observed that cuttings as small as 0.5 gram could grow.

MIEGE (1957), in Ivory Coast, with *D. alata* and *D. cayenensis*, explored the heterogeneity of tubers. He found a gradient in starch granule distribution, with raphids when present mostly in the top part. Here also top setts were the best in earliness of germination as well in yield, over middle or lower setts, the latter outyielding the middle setts. Level of yield depended also on tuber-mother weight (lighter better than heavier) and some optimum weight existed from each variety.

FERGUSON, HAYNES and SPRINGER (1969) studied cutting of tubers of *D. alata*, *D. esculenta* and *D. trifida* in a study of limiting experimental and random variations in yam growing. Top sett earliness was confirmed, but no yield significative differences existed between level of cutting of setts. In some cases origin of the setts influenced number of stems and tubers. Overall, their studies confirmed the high variance heterogenity in yam propagation material, and thus the inadequacy of simple statistical comparisons in experiments in this crop.

In Guadeloupe, the Plant Breeding Station (INRA) set up several trials in 1965 which established:

- the clear superiority of head and decline in yield toward the tail with *D. alata* cv. Couleuvre;
- the net superiority of head over other parts with *D. alata* cv. Tahiti;
- a variation of head yield when comparing setts from second harvest tuber (usual seed sett) with setts from first harvest tuber (usual market tuber), the last giving higher yield, with *D. cayenensis* cv. IGNAME JAUNE

Recent experiments aim at the following points:

- verifying yield and physiological gradient in tubers of recently released varieties
- studying optimal propagation conditions for these slones
- exploring tuber heterigeneity as a possible source of genetic diversification

The first year of experimentation here reported attempted to verify yield and physiological gradient in some controlled conditions which may justify drastic limitation in sampling, one tuber being taken for each treatment.

MATERIAL AND METHODS

The cvs. were PACALA STATION of D. alata and INRA 25 of D. trifida.

PACALA STATION is a selected clone of a desirable commercial type, with fair tolerance against disease (FOURNET et al., 1974) and good production, cooking and keeping abilities.

INRA 25 is an hybrid clone from a Cush-cush crossing (DEGRAS, ARNOLIN, POITOUT, 1971) of high productivity and good cooking ability.

Four tubers of each varieties were divided into 4, 8, 16 and 32 setts respectively. Their origin are indicated in gigures 1 where levels are I to IV from head (or top) toward growing point when tubers are divided into 4 and setts.

Tubers of PACALA weight about 800 grams each, those of INRA 25, 160 g. These weights are normal commercial tuber weights from each variety. All setts were placed on 5.22.73 in a humid frame in individual pots filled with soild mixed with vegetable mould and regularly watered till germination. They were then planted in the field at a uniform spacing of 0.50 m between setts. These procedured gave the experimental combinations which follow:

SETTS NUMBER/TUBER		4	8	16	32
PACALA	sett weight (g)	200	100	50	25
	field weight/m2 (g)	800	400	200	100
INRA 25	sett weight (g)	40	20	10	5
	field weight/m2 (g)	160	80	40	20

Treatments (16) for PACALA and (4) for INRA are more or less common field densities.

PACALA was harvested on 1. 7. 73, INRA 25 on 2. 18. 73, which represents respectively 228 days and 268 days from planting.

RESULTS

Tables I to IV summarise the results. We have lost 8.3% setts of INRA 25 by decay before germination and 3.1% between germination and harvest. On account of ditribution of these losts, which occur mostly among size 1/16 and size 1/32 upper setts, we think that peduncle fungus diseases related to Penicillin oralicum attacks (RICCI, ARNOLIN, 1973) may be the main factor.

Germination earliness

In tables I and II, setts of both varieties show

- maximum earliness towards head setts,
- maximum earliness with heavier setts.

Seemingly, interactions exist. Their values are difficult to estimate considering FERGUSON's (1969) data. At least the following points are of interest:

- no simple head-tail gradient of germination in PACALA, where IV level and III level are similar
- no simple gradient of germination in relation with INRA 25 setts weight : the 1/32 sett size, on a mean, is not inferior to 1/16 sett size as in PACALA case.

There was wide range of earliness among setts from the same level when cut into 32.

Harvested tuber yield

Table III and IV show

- a clear but slight variation of tuber yield in relation to level
- a clearer and greater variation of tuber yield in relation with the setts weight.

The most striking difference is between 1/4 and 1/8 setts of INRA 25. On the contrary no difference is observed between 1/16 and 1/32 sett type of either cv., nor between 1/4 and 1/8 sett types of PACALA.

It is worth noting the rate of propagation permitted with each sett type of each variety (sett weight in g/m^2 in parenthesis):

Sett type	1/4	1/8	1/16	1/32
PACALA	12 (200)	23 (100)	30 (50)	17 (25)
INRA 25	50 (40)	30 (20)	37 (10)	87 (5)

The greatest efficiency in cumulated harvested weight is obtained in PACALA with 8 setts and in INRA 25 with 32 setts (table III and IV), though absolute yield per m is higher with 4 setts in both varieties.

Origin levels of setts give small differences with a superiority of "tail" over "head", more regular in PACALA than in INRA 25 where maximum yield appears with level II (upper middle level).

Number of tuber harvested

In PACALA in all cases but one (level III, type 1/32, where two tubers was harvested) each sett gave one tuber.

In INRA 25 which normally give several tubers per plant, a clear difference appears both with level of origin of setts and with sett size. Only this latter is considered, the former being in accordance with the harvested tuber weight.

Variation with size of setts results in the following data for harvested tubers:

Number/sett	1/32	1/16	1/8	1/4
Number/mother-tuber	10.3	7.5	11.0	28.2
Tuber mean weight (g)	329.6	120.0	88.0	112.8

DISCUSSION AND CONCLUSIONS

1. Longitudinal heterogeneity of yam tubers in physiology and yield potential is confirmed.

Earliness of germination shows the known gradient from head to tail. though some interaction may be found with size of setts.

Both with PACALA and INRA 25 earliness of germination differences between head and tail are smaller when sett size is smaller; mean earliness is lower also (an exception could be in the case of INRA 25 from 1/16 to 1/32). Two process may account for this:-

- slower initiation of new buds when tissue are less important
- an inhibition correlation stops fewer buds when setts are smaller so that the leading bud is less able to realise its potential.

2. A transverse heterogeneity of yam tubers may account for the wide dispersal of earliness in germination from a particular level (size 1/32), but this may not be entirely random. The regular occurrence of the latest germination at all levels in PACALA 1/32 raises some doubts.

3. Yield results along a head-tail gradient conflict with published results and with our previous observations on the effects of level of setts. FERGUSON, HAYNES and SPRINGER (1969) reported only the better performance of tail sett for number of stems and number of tubers, this last point being in accordance with KINMAN's (1921) observation. We think that the field density could be a cause of interaction, but further observations are needed.

4. As for the sett size effect, interaction with field density precludes any conclusion, but the higher propagation rates found in each variety for a limited size setts remain of interest.

Further experiments will examine the following:

- uniform density and uniform spacing
- 2-3 mother-tubers by treatment
- a more systematic division into setts
- numbering of setts for testing transverse heterogeneity
- dormancy observations after harvest
- a first "vegetative genealogy" for search of "progenies" diversity.

We hope that breaking the bud inhibitions of a wider area of the mother-tube will show possible "somatic" mutations as well as phenotypic "variants" representing different balances of explored in classical breeding needs more attention in the selection of vegetatively reproduced tropical plants.

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YAM FERTILIZER TRIALS ON THE BAUXITE SOILS OF JAMAICA

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Four trials were carried out in 1971-73 on two major yam-producing soils of Jamaica - Chudleigh Clay Loam (#73) and St. Ann Clay Loam (#78).

Yams were grown on continuous mounds with trellis supports. Three trials were 2^3 factorials with rates of 0-90 kg/ha N, 0-90 kg/ha P_2O_5 and 0-240 kg/ha K_2O. Main effects were not significant and in only one instance (on Chudleigh Clay Loam) was an interaction significant (NK). In the fourth trial, on St. Ann Clay Loam, three commercial fertiliser grades - 5:10:10, 6:18:27 and 12:24:12 - were compared, each at 650 kg/ha, with an unfertilised control treatment. Plots were split for time and method of application. Neither differences between fertiliser grades, nor between methods and times of application were significant.

FIELD TRIALS ABOUT YAM ANTHRACNOSIS

by

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INTRODUCTION

In the West Indies, on Dioscorea alata, several leaf spots may be observed, caused by various fungi, the most frequent of which are:

- Rhizoctonia solani , a soil fungus which causes during wet periods or in damp conditions severe leaf die-off. On the rapidly enlarging lesions two sorts of sclerotia may be found. microsclerotia spread by splashing, and macrosclerotia, probably the conservation stage of the fungus.

- Sclerotium rolfsii a soil fungus too, causing large lesions covered by a white, radiating mycelium (rhizomorphs), which often give rise to radish seed-like sclerotia.

- Cercospora carbonacea, the attacks of which are characterized by black, rectangular-shaped spots limited by the veins covered beneath with a thin velvety, grayish layer of sporangiophores and spores.

- Collectotrichum gloeosporioides (probably the f. sp. alatae) causing irregular-shaped spots, very often initiating on veins, and leading to leaf die-off.

On some clones of the "Pacala" type a very severe stem blackening and die-off is often observed, which has long been womewhat puzzling. Very simple trials carried out about two years ago have shown that this symptom is also caused by Collectotrichum gloeosporioides. On the susceptible clones, the symptom occurs about 3 to 4 months before harvest.

In order to determine the importance of losses caused by anthracnosis (which should be done in our opinion, in every case before studying any disease), and to find out efficient field treatments, two trials were simultaneously carried out:

(1) A fungicide trial

(2) A variety trial, in which 16 different clones were compared.

As Bénomyl revealed itself to be the most efficient of the fungicides tested, it was feared that it might be stored in the tubers, and so the Bénomyl content of tubers was analysed.

METHODS

(1) Fungicide trial

Propineb and Mancozeb were combined in a factorial pattern with Bénomyl, in three blocks. Each block contained the following treatments: Control, propineb, Mancozeb, Bénomyl, Bénomyl + Propineb, Bénomyl + Mancozeb. Each plot was split into two clones ([illegible] plants/clone):

- Sainte-Catherine, a "leaf-spot" clone
- Pacala Dominique INRA, a "leaf-spot and stem die-off" clone.

The trial was set up on April 10, 1973.

The inoculation (June 18 and September 10) occurred by hanging short *Solanum torvum* stem segments on which the parasite had been grown *in vitro* (our usual inoculation technique).

Treatments:

Every fortnight from July 23 to December 24 (one treatment omitted on September 3 because of the threat of a hurricane).

Doses : about 750 cm^3/plant of the following suspensions:

Propineb	210g/hl (active material)
Mancozeb	150g/hl (" ")
Bénomyl	50g/hl (" ")
Propineb 210 g/hl + Bénomyl	50g/hl
Mancozeb 150g/hl + Bénomyl	50g/hl

Disease ratings:

Two ratings of stems and leaves symptoms were carried out on October and November 20, according to the following scales:

Stems: (2 ratings/plot)

- 0 = healthy stem
- 1 = some small spots
- 2 = some large spots
- 3 = blackening of some stems
- 4 = general blackening of the stems.

Leaves: (10 ratings/plot)

- 0 = healthy leaf
- 1 = some small spots
- 2 = many small spots or 1-3 large spots
- 3 = 4 and more large spots
- 4 = leaf almost completely necrosed.

Harvest January 16 and February 2 (1974).

(2) **Variety trial**

Sixteen clones from the Plant Breeding Station collection were compared in a split plot 3 blocks design : Punéji bis, Barbados, Pacala Dame-jeanne, V_7 B/2, Oriental, Lupias, Gordito, Pacala commune, Bété-Bété, Bélep, Télémaque, Saint-Vincent Sainte Rose, Goana, Florido, Pacala -station, Pacala 72. Each plot was split into a treated and an untreated part (Propineb 210g/hl weekly, plus Bénomyl 50g/hl every fortnight from July to December 3). Uniform innoculation occurred monthly using the technique described above. Two similar notations were carried out. Harvest occurred on January 21 (1974).

Statistics:

Harvest (in kg) was analysed directly ; but the variance of symptom notes was dependent upon mean value. Therefore the mathematical transformation.

$Y = \log (x + 1)$ was used, where x is the note.

Bénomyl residues in the tubers was investigated only on some Sainte-Catherine tubers from the fungicide trial, using the technique described by NESTER. TOURTE & CAMPO (1971) : Optical density of the purified ethylacetate extract at 282 mm. measured by an U.V. spectrophotometer.

RESULTS

Fungicide trials:

The results are summarised in Table 1.

Leaf spots: analysis of variance shows that Bénomyl, alone or mixed with Propineb or Mancozeb provides a highly significant control of leaf spots in both varieties. The effects of Propineb and Mancozeb are not significant. No interaction may be pointed out.

Stem symptoms: same conclusions, but a highly significant interaction Bénomyl x Variety shows that Bénomyl was more efficient on Sainte-Catherine.

Yields: the results are not quite satisfactory, probably due to the small size of plots (high co-efficient of variation). Nevertheless the effect of Bénomyl on yields, by reducing anthracnosis, is highly significant; yields are increased respectively by 72% and 88% in Sainte-Catherine and Pacala. Figures 1 and 2 show the regression of yields in both varieties, respectively, upon leaf and stem notes. The high values of r (correlation co-efficient between yields and stem notes) show that stem lesions are probably more damaging to yield than leaf lesions, particularly in the case of Pacala, a clone of the "stem-blackening" type.

Variety trial:

Results are given in Table 2 where the varieties are listed according to decreasing leaf susceptibility; it should be noticed that there is an obvious correlation between leaf and stem susceptibility ($r = 0.94$) which can be assumed not to be due to the method of notation. On the contrary, no correlation may be pointed out between potential yields and leaf or stem susceptibility, which means that high yielders may be susceptible (for example Goana or Punéji bis) or resistant (Gordito, Bélep, Pacala-station).

It should be noticed that yields are increased by the treatments mostly in varieties of the "stem-blackening" type or at least in varieties, the stem and leaf notes of which are superior to 2 without treatment.

In susceptible varieties, the mean yield is increased by about 100% by the treatment.

Nevertheless, the rather low accuracy of the trial raises apparent discrepancies: in some varieties (for example Barbados) the yields are significantly increased by the treatment, although there is no significant action upon leaf and stem symptoms. The reverse is true in some slightly susceptible varieties (Florido, Gordito); the latter effect may be to some extent explained by late attacks.

The "Pacala" group shows a very high heterogeneity as to the susceptibility to anthracnosis.

In some clones (Bété-Bété, Pacala commune, Oriental), Bénomyl seems to have a somewhat phytotoxic effect; this point requires further investigation if necessary.

Bénomyl residues:

An analysis carried out on some Sainte-Catherine tubers from the fungicide trial has shown that the B M C residues were quite negligible (0.03 mg/kg tuber, corresponding to 0.045 mg/kg, expressed in Bénomyl), and probably did not even reach the threshold of sensitiveness of the method used. This result agrees with our knowledge of Bénomyl transportation in plants.

DISCUSSION

Yam anthracnosis may be considered a disease to be feared only on certain varieties, i.e. mostly on those which show the "stem blackening" symptom, and those with a very high leaf-susceptibility. In the case of cultivation of such varieties (which should not be recommended, except in certain instances, as stated below), Bénomyl can provide a good control of the disease, even at a fortnightly treatment rate; yiel s may be then raised by over 70% (up to 100%). In moderately susceptible varieties, i.e. in va eties which never show more than a few large, or many small leaf-spots, and some stem-spots, t e disease can be assumed not to be worth any treatment.

At any rate, the possibility of treatments against Yam anthracnosis presents some significance in certain instances:

- Some of the clones studied in the Caribbean for mechanised cultivation because of a favourable tuber shape may be very susceptible to this disease, and may present stem-blackening; it would be difficult to grow them on a large extent, the more so as hybridization and therefore combination of characters is still almost impossible in *Dioscorea alata*.

- Some clones found in collections, which may be interesting to practical or theoretical research purposes may be highly susceptible to anthracnosis, and therefore difficult to keep in good condition.

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TABLE 1. Summarized results of the fungicide trial.

Treatments Disease ratings		No Benomyl			Bénomyl			Co-efficient of variation
		Control	Propineb	Mancozeb	Bénomyl alone	+ Propineb	+ Mancozeb	
Mean rating of a leaf (0-4)	S.C.	2.62 fg	1.98 cdef	1.82 bcdef	.68 a	.92 a	1.02 ab	11,3%
	Pac.	4.00 g	2.57 efg	2.30 defg	1.33 abcd	1.27 abcd	1.02 ab	
Mean rating of a stem (0-4)	S.C.	2.42 bcd	1.83 b	2.17 bc	.50 a	.92 a	.67 a	12,2%
	Pac.	3.83 e	3.67 de	3.00 cde	2.42 bcd	2.33 bc	2.42 bcd	
Mean yield per plot (kg)	S.C.	9.20 b	11.50 b	9.73 b	15.00 a	15.80 a	21.67 a	40,3%
	Pac.	3.47 c	7.75 bc	3.87 c	4.10 bc	7.57 bc	7.03 bc	

(Variance analysis followed by Duncan multiple range test, P = 0,05)

S.C. = Sainte-Catherine - Pac. = Pacala-Dominique INRA

TABLE 2. Summarized results of the variety trial - Varieties listed according to decreasing leaf susceptibility.

Variety	Origin	Tuber shape	Cooking qualities	Mean note of a leaf (0-4)		Mean note of a stem (0-4)		Mean yield per plot (kg)	
				NT	T	NT	T	NT	T
Sainte-Vincent Sainte-Rose	Guadeloupe	short flattened wide	Good	4.00 ≠	1.28	* 4.00 ≠	1.58	6.00 ≠	15.90
Pacala-Dame-jeanne	Guadeloupe	rather short flattened	Good	3.83 ≠	1.36	* 4.0 =	2.08	1.49 ≠	10.17
V_7 B/2	IRAT collection	short cylindrical	Good	3.78 ≠	.78	* 3.83 =	2.00	3.36 =	6.33
Barbados	Trinidad	short cylindrical	Good	2.40 =	1.23	* 3.41 =	1.83	7.43 ≠	13.87
Punéji bis	Oceania	long conical	Rather good	2.00 ≠	.00	* 3.00 ≠	1.00	9.59 ≠	17.23
Florido	Puerto-Rico	short cylindrical	Very good	1.85 ≠	.45	3.16 ≠	.58	9.00 ≠	13.23
Goana	Oceania	long cylindrical	Good	1.71 =	.88	* 3.00 ≠	1.16	13.30 ≠	22.00
Gordito	Puerto-Rico	long irregular	Rather good	1.16 ≠	.00	1.58 ≠	.33	23.10 =	23.63
Bélep	Oceania	rather short conical	Very good	.68 ≠	.25	1.33 =	.75	19.30 =	20.27
Oriental	Trinidad	short cylindrical	Rather good	.45 =	.21	1.50 ≠	.50	19.33 =	15.23
Bété-Bété	Ivory Coast	rather short flattened wide	Good	.40 =	.16	1.33 =	.91	15.63 =	11.63
Lupias	Oceania	short cylindrical	Good	.38 =	.18	2.16 =	1.00	10.93 =	12.33
Pacala 72	IRAT collection	long cylindrical	Very good	.25 =	.10	1.41 =	1.16	13.20 =	13.86
Télémaque	Martinique	long irregular cylindrical	Very good	.25 =	.08	1.50 ≠	.33	7.82 =	7.77
Pacala commune	Guadeloupe	long irregular cylindrical	Good	.13 =	.05	1.50 =	.58	13.73 =	12.50
Pacala station	Guadeloupe	long irregular cylindrical	Very good	.13 =	.03	.75 =	.58	15.77 =	18.93

NT = untreated. T = treated. The symbols ≠ and = are used to indicate respectively significant and non-significant benefit obtained from the treatment. * Stem-blackening and die-off.

NEMATODE PESTS ON YAMS IN JAMAICA

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INTRODUCTION

Yam tubers of cultivated species of the genus Dioscorea are of considerable importance as a food crop in most tropical countries. In Jamaica yam forms one of the staple foods for the population, and many species and varieties of Dioscorea are grown not only for the local market, but also for export purposes.

It has been found that plant parasitic nematodes associated with yams can do much damage to them, and can cause reductions in yield, unattractive appearance of the tubers, and reduction in marketability of the produce (Coursey 1967).

Scutellonema bradys has long been associated with a disease of yams described as "dry rot" (West 1934), and this nematode has since been reportedly found in yam tubers in many tropical countries, including Brazil (Lordello 1959), The Ivory Coast (Smit 1967), Nigeria (Bridge 1972), Puerto Rico (Ayala and Acosta 1971), Jamaica (Steiner 1931, Steiner and Buhrer 1934) and others.

The root knot nematode (Meloidogyne spp.) is also a known pest on yams, and causes galling on the roots and tubers. It has been recorded from Puerto Rico, (Ayala and Acosta 1971), Nigeria (Bridge 1972), the United States of America (Hawley 1956) and Jamaica (Dixon and Latta 1959).

The nematode of the genus Pratylenchus sp. has been reported as a pest on Dioscorea spp. in West Africa (Smit 1967), Jamaica (Hickling 1972) and Puerto Rico (Ayala and Acosta 1971).

In addition, recent studies have shown that stored yam tubers are damaged by plant parasitic nematodes, which cause necrosis and degeneration of the tissues, and result in loss in yields (Thompson, Been and Perkins 1973).

In Jamaica nematodes have long been associated with damage to yam tubers, causing "dry rot" and "burning", as it is called locally, of the tissue. In certain areas of the island Dioscorea trifida is no longer planted as yields are extremely poor. This is almost certainly related to nematode damage. In 1959 Dixon and Latta reported that nematodes might be a major cause of storage decay in D. alata and D. cayenensis.

This paper reports on the results of investigations on the genera of plant parasitic nematodes found on yams in Jamaica, and their damage to tubers related to parasitism of endoparasitic species during storage of the yams.

MATERIALS AND METHODS

Samples of yam tubers, roots and soil surrounding the roots were collected from farms in the main yam growing areas in Jamaica. These are the parishes of St. Ann, St. Elizabeth, Manchester, Trelawny, Clarendon, St. Mary, and Portland. Yam tubers were also collected from markets, buying stations, and field stations all over the island. Tubers of the species

Dioscorea alata, D. trifida and D. cayenensis composed the majority of the yams examined. Fewer D. rotundata tubers were examined. Soil and roots from all four species of Dioscorea were examined.

Tubers were checked for mechanical damage such as bruising, then sectioned, and pieces of tissue of 10-30 gms in weight from different areas of the tuber were cut and placed in petri dishes containing 10 cc of water. They were either examined immediately under the microscope and the nematodes teased out of the tissue with needles, or left for 1-2 hours before being examined. The following parts of the tuber were examined separately:

1. The skin alone
2. Dead necrotic tissue
3. The edges of necrotic tissue
4. The interior starchy flesh of the tuber
5. The skin and underlying 2 or 3 layers of cells of starch
6. Areas of necrotic tissue associated with fungus and/or bacteria.

Some unbruised, nematode infested, tubers were left uncut in open boxes at ambient temperatures for periods varying from 1 week to 3 months and examined at intervals.

Yam roots were washed, broken up finely with water in a homogeniser for one minute, and the nematodes extracted by seiving and decanting. Nematodes were extracted from yam soil by the Whitehead's tray method (Whitehead & Hemming, 1965).

RESULTS

No nematodes were found associated with the interior starchy flesh of yam tubers, within dead and degenerated necrotic tissue, nor within areas of necrosis associated with fungus or bacteria. They were sometimes found at the edges of such necrotic areas, however. In infested tubers, endoparasitic nematodes were observed to be associated mainly with the underlying areas of skin in the outermost epidermal and peridermal parenchymatous tissue penetrating from 1 to 2 cms in the tuber. They were associated with necrotic lesions, mainly light brown in colour, in lightly infested material, and dark brown in colour in heavy infested material. Most nematodes were found at the edges of the lesions where there was less dead necrotic tissue. In apparently 'clean' tubers, i.e. with little or no necrosis present, a few parasitic nematodes were sometimes found in and immediately under the skin. Necrotic lesions associated with parasitic nematodes were generally found in distinct patches on the outer layers of the tuber, or extending most or all of the way around the tuber. Cracks and pitting of the skin was seen in the necrotic areas associated with nematodes when the attack was heavy. The necrotic lesions associated with nematode attack were sharply defined areas and could be distinguished usually from mechanical damage such as bruising. It was found, however, that bruising of tubers often resulted in invasion by pathogens such as fungi, bacteria or nematodes.

Endoparasitic nematodes were found to build up high populations in tubers kept in storage, and areas of necrosis associated with them increased proportionately until the entire tuber was dry and rotten. At advanced stages of rot the shape of the tuber was maintained, but the entire interior was reduced to a dark brown dry powder while the outer skin remained firm but brittle, cracking and flaking off as the rot advanced.

Pratylenchus coffeae, and Scutellonema bradys were the two major endoparasitic nematodes found in Dioscorea tubers. Tubers were found to be infested with either one or the other of these nematodes. Infestation by either nematode caused the development of necrotic lesions in the outer layers of the tuber underneath the skin. "Dry rot" or "burning", i.e. the complete degeneration of tissues took place with the build-up of the nematode population in the tuber during storage, in tubers infested with either nematode. All stages of development of the parasites could be seen in tubers infested by Pratylenchus and Scutellonema, and in tubers exhibiting advanced rotting secondary invasion by the nematodes Aphelenchus sp. and Aphelenchoides spp., saprophytic nematodes, was seen. At this stage few adults of Pratylenchus or Scutellonema were observed, second-stage larvae being more abundant.

Meloidogyne sp. were observed in a few tubers of D. cayenensis collected. (Less than 1% of the total number examined). They cause galling in the outer epidermal layers, but no necrosis or discolouration of the tissues. Meloidogyne spp. were not found in the tubers of any other yam species examined.

Pratylenchus coffeae was found to be parasitic on 80% of the tubers examined. This nematode was found occurring in all varieties of Dioscorea examined. Scutellonema bradys was found on less than 20% of the tubers examined. S. bradys was found only on D. alata, D. rotundata, and D. cayenensis. Dioscorea trifida tubers were found to be parasitised only by Pratylenchus coffeae. S. bradys was never found in tubers of this species.

Helicotylenchus multicinctus, Rotylenchulus reniformis and Meloidogyne sp. were found to be the major parasitic nematodes in the roots of all species of Dioscorea examined. Meloidogyne sp. caused root knots to occur on the roots. All stages in the development of Helicotylenchus were seen in the roots (i.e. 2nd, 3rd, 4th stage larvae and adults) but mainly second stage larvae were found of Rotylenchulus. Pratylenchus coffeae and Scutellonema bradys were also recovered from roots of yams, but in lower numbers than found in the tuber. Table - shows the genera of plant parasitic nematodes recovered from the soil and roots of Dioscorea species examined. In the soil, as in the roots, Helicotylenchus multicinctus and Rotylenchulus reniformis were recovered in higher numbers than other genera.

TABLE I. Plant parasitic nematodes extracted from yam soil and root.

		Soil	Root
1.	Pratylenchus coffeae	x	x
2.	Rotylenchulus reniformis	x	x
3.	Helicotylenchus multicinctus	x	x
4.	Scutellonema bradys	x	x
5.	Meloidogyne sp.	x	x
6.	Xiphinomea sp.	x	
7.	Hoplolaimus sp.	x	
8.	Criconemoides sp.	x	
9.	Trichodorus sp.	x	
10.	Tylenchorynchus sp.	x	
11.	Tylenchus sp.	x	
12.	Ditylenchus sp.	x	
13.	Dipthorophora sp.	x	
14.	Aphelenchus sp.	x	x
15.	Aphelenchoides sp.	x	x
16.	Saprophytes and predaceous nematodes	x	x

DISCUSSION

The economic importance of nematodes as pests on yams can be related to the damage caused to the tubers, where injury to the cells by the nematodes feeding, elicit host responses from the plant which result in the formation of necrotic lesions in the tissue. This damage of the tubers results in a reduction in yield, a reduction in marketability, and a reduction in numbers of seed pieces for planting material.

While Meloidogyne spp. can cause serious damage to tubers, (Ayala and Acosta 1971), in this investigation they were found infrequently, and in too low numbers to cause concern. The major nematode pests on yam tubers in Jamaica are considered to be Pratylenchus coffeae and Scutellonema bradys. Both genera build up high populations in yam tubers causing necrosis and "dry rot". This observation is consistent with earlier reports Steiner, 1937; Thompson, Been and Perkins 1973; Bridge, 1973; Dixon and Latta, 1959. While S. bradys is found more frequently in other countries (Bridge 1972) P. coffeae is found most frequently at this time in Jamaica.

Nematodes found in roots and soil of Dioscorea in this investigation do not appear to cause serious damage to yams. It is thought that they probably contribute to loss of vigour, and reduction in growth of the vine. It is possible, however, that they are damaging in that by wounding the roots they allow secondary pathogens to invade the yam with serious consequences.

The nematode is therefore considered of great importance as a pest of stored yams in Jamaica. The incidence of infested tubers in storage is high, and it can be seen that populations of Pratylenchus coffeae or Scutellonema bradys, while being too small to manifest noticeable external symptoms immediately after harvesting, may increase greatly in storage, producing extensive damage to tubers. In addition, the damage caused to the tubers by nematodes can allow secondary invaders such as bacteria, fungi or insects to enter and further destroy the produce. It is clear, therefore, that preventative measures should be developed and used to combat nematode pests on yams in Jamaica.

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SOME OBSERVATIONS ON INTERNAL BROWN SPOT AND VIRUS-LIKE SYMPTOMS OF YAM (DIOSCOREA SPP.) IN THE COMMONWEALTH CARIBBEAN

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INTRODUCTION

'Internal brown spot' of yam (IBS) has been known to occur in Barbados in *Dioscorea alata* cv. 'White Lisbon' for the last ten years (Jeffers and Headley, 1967; Coursey, 1967). The condition is characterised by the presence of small brown nodules in the flesh of the yam tubers. These nodules are surrounded by normal white or creamy flesh, with no apparent connection with the outside. Spotted tubers are apparently indistinguishable from spot-free tubers unless they are cut open and examined. Internal brown spot of yam does not seem to be associated with pathogenic fungi, bacteria or nematodes (Iton, 1964; Mills, 1965; Edmunds, 1966). Harrison and Roberts (1973) reported that the tubers of yam (*D. alata* cv. White Lisbon) from Barbados affected by internal brown spot foliage showing mosaic/mottle symptoms. These leaves were found to contain two types of virus-like particles. The results also indicated that IBS is probably caused by a virus although the relationship between the virus-like symptoms on the foliage and IBS has not yet been established. The investigations reported here were carried out to determine the possible occurrence of IBS and virus-like symptoms on the leaves of other species of *Dioscorea* in addition to *D. alata* and their presence in other islands in the Commonwealrh Caribbean.

RESULTS AND DISCUSSION

A. Observations on *Dioscorea alata*

(i) Distribution and occurrence of virus-like symptoms of yam foliage and IBS in yam tubers.

Results of a survey of 8 islands in the Commonwealth Caribbean during 1972/73 showed that virus-like symptoms (mosaic/mottle types) occurred on cultivars of *D. alata* in Trinidad, Grenada, Barbados, St. Vincent, St. Lucia, Dominica. Nevis and Jamaica In a subsequent survey IBS was found to be present in all these islands.

(ii) Occurrence of IBS and virus-like symptoms on different cultivars of *D. alata* in Trinidad, Barbados and St. Vincent.

A survey of yam crops was carried out during November and December, 1973, to determine the incidence of virus-like symptoms on yam foliage. Two sampling methods were used. The first, employed in large-scale plantings (ca. 1-5 hectares), consisted of selecting 2-4 rows at random in each planting and recording the presence or absence of virus-like symptoms on every 5th plant along the rows. The second method, used in small plantings (under 1 hectare) consisted of recording presence or absence of symptoms on every plant occurring along the diagonals of each plot. A follow up survey during February, 1974 determined the incidence of IBS in the same plantings. Tubers were selected at random from yam storage piles and carefully sliced. Slices were cut as thin as possible (2-4 mm.) in order that small lesions were not overlooked.

IBS incidence was assessed as a percentage of tubers in the sample with IBS lesions. Size of the sample varied according to the amount of available material. Wherever possible, samples of 15-25 tubers were taken. The results are presented in TABLE 1.

(iii) Reaction of different cultivars of D. Alata to IBS growing under similar conditions in Trinidad and Barbados

During the survey of February 1974, information on the degree of IBS 'infection' of various D. alata cultivars was obtained. At three locations, two in Trinidad (U.W.I. Field Station, Champ Fleurs) and one in Barbados (Friendship Plantation, St. Lucy), D. alata cultivars had been growing in adjacent plots in more or less similar conditions. Samples of 10-20 tubers of each cultivar were selected at random and sliced as described earlier to determine percent IBS 'infection'. An infection index, the Spotting Index (SI), was calculated for each batch of tubers to assess the intensity of IBS 'infection'. SI was computed using the method of McKinney (1923) as follows:

$$SI = \frac{\sum classes}{N} \times \frac{100}{S}$$

where N = Total number of tubers sampled

S = Maximum spotting category

The classes of 'infection' are presented in Table 2 and the results of the survey are summarised in Table 3.

(iv) Occurrence of IBS under field conditions:

Most of the previous workers have recorded the occurrence of IBS in the tubers from yam storage piles. Coursey (1967) reported that during storage of the yam tubers, the spots enlarge and become more numerous. This observation gives the impression that IBS could be a storage disease. Therefore, it was planned to find out the possible occurrence of IBS under field conditions. Yam tubers infected with IBS were planted and 10 weeks before the normal time of harvesting samples of tubers were dug out at fortnightly intervals, sliced and examined. These observations revealed that the IBS becomes evident in the tubers of D. alata at least six weeks before the normal time of harvesting.

Observations on Dioscorea trifida

As Dioscorea trifida is not grown as commonly as D. alata in the Commonwealth Caribbean it was only possible to examine the former species in Trinidad and Grenada. In Trinidad, out of a total of 213 plants examined, 190 showed mosaic/mottle and 64 showed leaf distortion. In Grenada all 75 plants examined showed mosaic/mottle symptoms but no leaf distortion. Fifty tubers from plants showing foliage symptoms were liced but IBS could not be found in any one of them. A more elaborate examination is needed to confirm the absence of IBS in D. trifida.

Observations on Dioscorea esculenta

As Dioscorea esculenta is also grown on a limited scale in the Commonwealth Caribbean, foliage and tubers of D. esculenta were examined in Trinidad and St. Vincent.

In Trinidad, out of a total of 100 plants examined, 95 showed mosaic/mottle symptoms and of these 9 showed leaf distortion. In St. Vincent all 80 plants examined showed mosaic/mottle only. Ten out of the 50 tubers of D. esculenta examined in St. Vincent showed IBS lesions while none were present in 125 D. esculenta tubers sampled in Trinidad.

A preliminary survey of yams carried out by Harrison (1972) in Barbados, St. Vincent and Trinidad indicated that mosaic and mottle symptoms of a virus-like nature occurred on D. alata, D. esculenta and D. trifida and that IBS was present in the tubers of D. alata, especially in the cultivar 'White Lisbon'. The present investigations confirm these observations and indicate that these disease symptoms are more extensively distributed in the Commonwealth Caribbean than was first reported (Jeffers and Headley, 1967). The present findings record the occurrence of IBS in the tubers of D. esculent . Although IBS was observed in the field this, however, does not preclude the possibility of changes in IBS during storage as observed by Coursey (1967). As far as the authors are aware there are no reports of IBS occurring in any other part of the world.

The occurrence of both IBS and virus-like symptoms on species of Dioscorea other than D. alata suggests that a more complex disease situation may exist than was indicated by previous surveys. The various leaf symptoms observed on the three species may be caused by different viruses or alternatively, by strains of one virus. Harrison and Roberts (1973) reported the IBS-affected tubers of D. alata cv. 'White Lisbon', produced foliage with mosiac symptoms; such leaves contained two types of virus-like particles. Therefore, further work is needed to establish the relationship, if any, between different types of virus-like symptoms (Table 1) on D. alata and other species of Dioscorea and the IBS.

The results presented in Table 1 indicate that several cultivars of D. alata are affected by IBS and virus-like symptoms. Levels of 'infection' varied between cultivars of D. alata growing in similar location (Table 3). For instance, cvs. White Lisbon and Oriental were free of IBS in Barbados, even though other cultivars at the same location were affected. In contrast, these two cultivars were affected by the IBS at the Trinidad locations. The level of IBS in the planting material of these two cultivars in the two islands is not known but it is possible that the Barbados planting material was free of IBS. These results indicate the possibility of growing IBS-free tubers under field conditions.

Harrison and Roberts (1973) suggested that the bacilliform particle found in diseased yam plants probably belongs to the same major group of viruses as cacao swollen shoot and mealy bugs deserve attention as possible vectors. The authors have observed heavy infestations of mealy bugs in some storage piles of yam tubers. Further investigations to establish the nature of IBS and other virus-like conditions and their transmission are in progress at the University of the West Indies, St. Augustine, Trinidad.

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TABLE 1. Incidence of virus-like symptoms and Internal brown spot (IBS) in different cultivars of *Dioscorea alata* in Trinidad Barbados and St. Vincent

Island/Location	Cultivar	% tubers with IBS	Mosaic/Mottled symptoms	Other virus-liked symptoms
Trinidad				
U.W.I. Field Station	White Lisbon	70	+	+[abc]
	Seal Top[e]	-	+	+[b]
	Oriental	20	+	-
	Ashmore	44	+	-
	Barbados	63	+	-
Barbados				
Thicket, St. Philip	White Lisbon	85	+	+[b]
Sayes Court, Christ-church	Barbados	21	+	+[a]
Chapel, St. Philip	Coconut Lisbon	90	+	-
Lancaster, St. James	Bottleneck	25	+	+[b]
Graeme Hall, Christ-church	White Lisbon	0	+	+
St. Vincent				
Dauphine	White Lisbon	75	+	+[c]
Campden Park	White Lisbon	35	+	-

* See Gooding (1960)

a Leaf Distortion

b Stunting of whole plant associated with chlorosis

c Vein Clearing

d Presence (+) or absence (-) of symptoms

e IBS not assessed in these plants

TABLE 2. Classes of Internal brown spot (IBS) 'infection' used in calculating the Spotting Index (SI)

Class	No. of Lesions/tuber	Class	No. of Lesions/tuber
0	0	5	21-30
1	1-5	6	31-50
2	6-10	7	51-90
3	11-15	8	91-170
4	16-20	9	> 170

TABLE 3. Internal brown spot (IBS) 'infection' of some *D. alata* cultivars growing under similar field conditions at 3 locations in Trinidad and Barbados

Location	Cultivar*	% of tubers with IBS	S.I.
Trinidad, Site (1)[a]	Ashmore	44	5.6
	Barbados	63	8.3
	Smooth Statia	0	0.0
	White Lisbon	70	8.9
	Oriental	20	2.2
	Harper	44	8.3
	Seal Top	11	1.2
Trinidad, Site (2)[a]	Ashmore	10	1.1
	Bottleneck	30	3.3
	Moonshine	60	8.9
	White Lisbon	60	6.7
	St. Vincent Red	90	36.7
	Harper	100	20.0
Barbados, Friendship, St. Lucy	Coconut Lisbon	70	21.1
	White Lisbon	0	0.0
	Oriental	0	0.0
	Bottleneck	60	14.1

* See Golding (1960)

a University Field Station, Champ Fleurs

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STORAGE DISEASES OF CUSH-CUSH YAMS IN GUADELOUPE

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Cush-cush yam in Guadeloupe (F.W.I.) is consumed mainly at Christmas and not at all after April. The reason is found in the poor keeping qualities of the crop. The loss occurs by drying and by diseases and pests. Among them the most important are ones caused by Penicillium and mealy bugs. This paper presents some possibilities of control we could propose.

1. Importance of Penicillium rot

Fourteen samples of one hundred tubers each were observed during a month in natural conditions (temperature 23°C, relative humidity 60-100%). We noticed 2 to 37% of rotted tubers with an average of 10%.

On 78% of the rotted tubers rots were due to Penicillium oxalicum.

On 6%, rots were due to Fusarium oxysporum and F. solani.

We have isolated in these cases as contaminants, some bacteria and nematodes (genera Aphelenchoides and Aphelenchus).

This is a confirmation of the importance of Penicillium oxalicum as a rot factor in cush-cush storage. There is no significant differences in susceptibility towards P. oxalicum among the main varieties used at the INRA plant breeding station. That is to say: INRA 3, 6, 22, 23, 25, 32, 35, 40, IRAT-22, Indian St. Laurent Yam, Indian Yam, Red cush-cush. It is possible to control the decay with fungicides. TABLE I shows that benomyl less than 0.3g/l AM could protect cush-cush tubers quite well during storage.

2. Importance of Mealy Bugs

During storage the population of Planococcus citri is frequently observed. The first larval stages are difficult to detect, but the presence of adult females (pink-white rounded body, 2-3 mm large) is easily observed in the skin hollows; they multiply rapidly when the tubers germinate. The mealy bugs spread then very quickly from one tuber to the others. Their effect is clearly seen on seed-tubers, which are killed or weakened, and on consumption tubers, the commercial value of which is greatly reduced.

Control could be obtained from using an insecticide (like malathion) or keeping the tubers in a cool dark room (temperature about 18°C). This practice gives good results in reducing

the multiplication of the mealy bugs (Fig. 1)
the germination of the tuber (Fig. 2)
the loss in dry matter (Fig. 3)

In conclusion we could propose:

For seed tuber: 24 or 48 h after harvest, wash the tubers in water and dip them 10 minutes in 0.5g/l malathion and 0.1g/l benomyl.

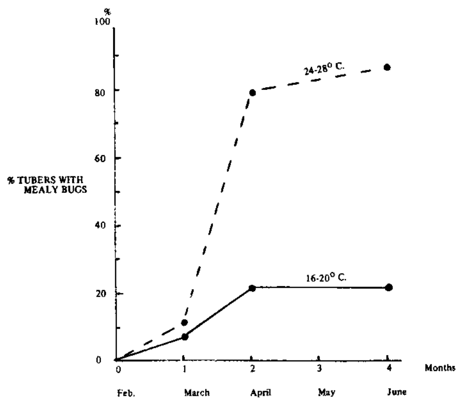

Figure 1 - Effect of storage temperature on the variation of the rate of tubers contaminated by Planococcus citri mealy bugs.

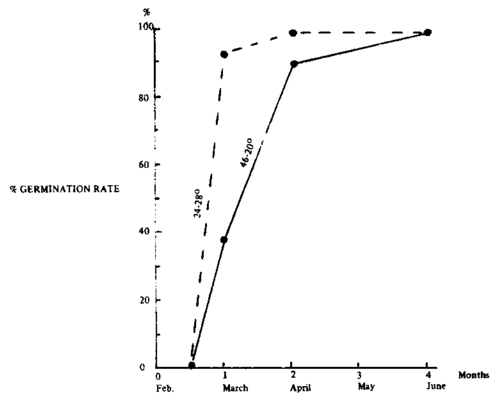

Figure 2 - Effect of storage temperature on the variation of the germination rate.

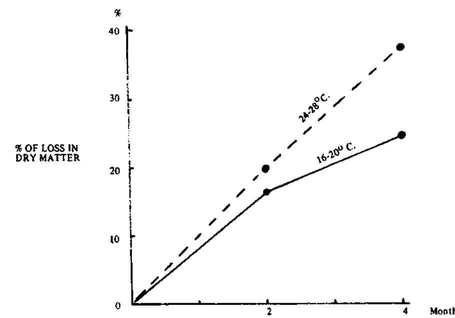

Figure 3 - Effect of storage temperature on the loss in dry matter (in % of the initial weight).

For tubers to be used as food: The day after harvest wash the tuber in water, dip them 10 minutes in 0.25 g/l thiabendazole and store at 18°C (R H : 60-80%).

ACKNOWLEDGMENTS

We thank Dr. Coursey (Tropical Products Institute, London) and Mr. Panis (Station de Soologie et Lutte biologique INRA Antibes) for the specific determination of *Penicillium oxalicum* and *Planococcus citri* respectively.

TABLE 1. Effect of 10 minutes' dipping in fungicides, at different times after innoculation by *P. oxalicum*, on the number of rotted tubers after a month (10 tubers by observation).

fungicide	thiabendazole			benomyl		
concentration (g/l m.a)	0.1	0.3	1	0.1	0.3	1
delay between treatment and innoculation: 1 day	1	0	0	0	0	0
2 days	0	1	0	0	0	0
3 days	4	3	1	0	0	0
4 days	10	9	7	4	5	10
control	10			10		

CONTROL OF IRISH POTATO PESTS

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INTRODUCTION

Irish potato is attacked by many pests at all stages of its growth and during storage. In Jamaica the pests include cutworm caterpillars (Anicta (Lycophotia) infecta, Prodenia ornithogalli and Xylomiges sunia), leaf caterpillars (Trichoplusia ni and Agrotis sp.), aphids (Aphis maidis and Macrosiphum pisi), leaf beetles (Diabrotica balteata and Epilachna sp.), fiddler beetle grubs (Exothalmus vittatus and Pachnaeus citri), white grub (Lachnosterna spp.), leaf hopper (Empoasca fabae), sucking bugs (Nezara viridula, and Leptoglossus sp.), and slugs (Veronicella spp.).

The main spring-planted crop is more prone to damage than the fall crop, and damage varies from negligible to about 60%. Pest control was neglected for a long time but continued losses and the dramatic successes in the control of potato diseases with chemicals led to increased demands for methods of pest control. During the past five years several chemical control trials have been conducted (Antilles 1970, Suah 1972, Suah 1974). At present most of the pests are controllable, but efforts are continuing to improve methods of control, and a close watch is kept for changes in the pest complex and populations and for signs of pesticide resistance. Within the past decade only one new species (D. balteata) was added to the list of pests but there have been reports of suspected resistance to the chlorinated hydrocarbon group of pesticides mainly chlorade and dieldrin.

CROP ROTATION

Several pests may be carried over from a previous crop to damage the planted seed tubers. Chief among these are cutworms and beetle larvae. Cutworms are always present feeding on cultivated crops, grasses and weeds and as Edwards (1936) stated "destruction of crops by this pest is always more severe in plots surrounded by grasslands or in fields brought into cultivation after they have been left to fallow for some time." These are the conditions existing in most of the potato growing areas. White grubs feed mostly on decaying wood in the soild provided by yam stakes and roots of trees and shrubs. Fiddler beetle grubs feed on many tubers but mostly sweet potato, and the roots of plants like avocado, citrus and pimento. Those pests that survive the brief starvation period during land preparation, exposure to the sun, or being eaten by birds or mammals, attack the newly planted crop. Small tubers may be completely destroyed and damage to larger ones provide infection court for disease.

Control is by rotation, with crops such as corn or beans proceeding potato, avoidance of planting potatoes under or near to known hosts of the fiddler beetle, and, where high populations occur, the use of soil applied pesticide such as chlordane, diazinon, dieldrin and heptachlor. These are incorporated in the soil to the planting depth.

SPROUTING STAGE

Newly emerged potato sprouts are damaged by cutworms, crickets and slugs. Where there is only one bud on a tiber and the resulting sprout is chewed off at ground level the plant is lost. If it is cut above a few lateral buds, these may grow to produce the plant. If there is more than one bud, the next in order of apical dominance may sprout and grow, but in both instances later of weak plants are produced.

Proper precautions to control insect pests at the time of planting and the use of a poison bait for the slugs should provide adequate protection at this stage. Where no control measure was adopted at planting, a pesticide soil-drench is recommended for the cutworms and baits for crickets and slugs. Severe damage reduces the size of the plants, the number of tubers set and tuber development. The crop can be easily destroyed at this stage. However the chewing insects are easily controlled added a stomach poison or contact insecticide to the fungicide. Several insecticides are recommended for this treatment including Basudin, Dipterex, Malathion and Sevin. Malathion is most widely used, as apart from its low mammalian toxicity it also controls sucking insects. Rogor 40 and Perfekthion are recommended for sucking insects.

Good weed control and field sanitation will remove the alternate host and harborage of several of the pests. The crop is usually moulded at this stage and if done to cover the tubers to a depth of about three inches this will protect the tubers from cutworms which live and feed near the soil surface.

MATURED TUBER STAGE

Matured tubers are prone to attack by all those pests that will damage the seeds at planting time. If no attempt was made to control beetle larvae earlier, it will be difficult to control them at this stage as they will be feeding on the lower-most tubers. In order to kill them one would have to use a soil drench which could leave harmful residues on the tuber. The cutworms are easier to control because they feed near the surface. If the tubers were not deeply covered by moulding, then the exposed tubers and those near the soil surface will be chewed. To control the pests at this stage it is recommended to cover the tubers with about 2 inches of soil and apply a pesticide as a spray or a bait. In most instances where a pesticide spray is not effective against the caterpillars a bait can give excellent control. If the damaged tubers are not separated and discarded but are stored with the good ones some of the grubs and caterpillars may be carried with them and these will continue to feed and damage more tubers until they pupate. As mentioned before the damaged areas will admit disease pathogens and so encourage tuber rot.

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STORAGE OF FRESH CASSAVA ROOTS IN MOIST COIR DUST

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INTRODUCTION

Fresh cassava roots begin to deteriorate within 3 days after lifting if stored at normal tropical ambient conditions; the primary cause of deterioration being a disorder causing vascular streaking (Montaldo, 1973; Booth, 1973 Booth and Coursey 1974). Vascular streaking usually commence at a site of injury but within a few days spreads longitudinally through the full length of the root making it unacceptable for consumption or industrial use (Booth 1973). Cassava roots have been stored for 8 weeks at tropical ambient conditions by use of a clamp to maintain high humidity and constant temperature (Booth 1973). It has already been indicated (Booth and Coursey, 1974, Booth, personal communication) that storage is also possible in boxes packed with saw dust or similar material and this work was undertaken to develop a packing method suitable for transportation and urban marketing.

METHOD

Cassava roots of 3 varieties, designated 30, 69 and C5 were used. For each storage experiment roots were randomised and weighed within 8 hours of lifting, and packed into fibreboard cartons designed to hold 15kg of produce either without additional packing material (control), or in an unsieved mixture of coir dust and fibre moistened by mixing in an equal weight of water (moist coir). Groups of 3 roots were weighed before and after storage then cut up to assess deterioration. Each root was cut into quarters and vascular streaking assessed on a 0 - 10 scale at each cut surface. Results were expressed both as a percentage of the maximum score obtainable and as the percentage of roots with a score of 2 or more out of 30 (percentage incidence of damage).

In experiment 1, 5 replicates of both packing treatments were stored at ambient temperature (23 - 26°C) and humidity and replicates assessed after, 3, 11, and 28 days. Replicates contained 4 large and 4 small roots of each variety.

In experiment 2 roots were stored at ambient temperature (20 - 25°C), either on a bench top (low humidity) or packed in fibreboard boxes without ventilation holes and wrapped in paper (high humidity). Replicates from both treatments were packed into coir after 0,1,2,4 and 8 days, stored at ambient temperature and assessed 28 days after lifting. Each replicate contained 3 roots of 69 and C5.

In experiment 3, 2 replicates of both packing treatments were stored at ambient temperature (20 - 25°C), at 13°C, and at ambient temperature for 7 days then at 13°C, until assessment. Replicates which contained 4 large and 4 small roots were assessed 14 and 28 days after lifting.

RESULTS

Cassava roots packed in moist coir were in better condition after 28 days storage than roots stored at ambient humidity for 3 days (Table 1). Weight loss in experiment 1 was 3.9% after 3 days and 12.8% after 11 days at ambient humidity against only 1.3% after 28 days in moist coir. Subsequent observations (Table 2 and 3) confirmed that very little damage occurred during 28 days storage in moist coir at ambient temperature. In all experiments rootlets 2 - 8cm long developed during storage in moist coir for 28 days.

In experiment 2, mean weight loss before packing in moist coir was 1.58% per day at low humidity and 66% per day at high humidity. The incidence of vascular streaking after storage increased after 4 days delay at low humidity before packing but not after delays upto 8 days at high humidity. Cassava roots stored at ambient temperature other than those packed in moist coir developed extensive superficial mould in 4 - 8 days.

The incidence and extent of vascular streaking in roots stored at 13°C was much higher than at ambient temperature but this difference was reduced when roots were stored at ambient temperature for 7 days before cooling to 13°C (Table 3). Rootlet formation did not occur in roots stored at 13°C or at ambient temperature for 7 days and then at 13°C for 21 days.

DISCUSSION

Storage in a clamp (Booth, 1973) or packing in moist coir (Table 1) have both provided effective means of storing fresh cassava. Packing in moist coir reduces water loss almost to zero but packing which reduced the rate of water loss by only about 60% also caused a large reduction in the incidence of vascular streaking (Table 2). Rate of water loss appears to be critical to the development of vascular streaking and manipulation of this parameter should provide a means both of investigating the aetiology of this disorder and of controlling it.

After packing in moist coir, changes evidently occurred which protected roots under more adverse conditions at 13°C (Table 3) and Booth (1973) observed that after storage in a clamp roots could be then held at ambient humidity. Vascular streaking is known to be associated with mechanical damage (Booth, 1973) and we have observed wound periderm formation at cut surfaces in stored roots (unpublished data), so this protection against vascular streaking is probably associated with wound healing similar to that which occurs during curing of other starchy roots and tubers. Cold storage of cassava has only been successful at 0 - 5°C and subsequent deterioration at ambient temperature has been very rapid (Ingram & Humphries, 1972, Montaldo, 1973); development of a method of curing may make storage possible over a wide range of temperature.

Acknowledgements:

We thank Mr. D. Reid and Mr. A. Dexter, Ministry of Agriculture for supplying cassava for this work. This paper is published with the permission of the Chief Food Storage Officer, Ministry of Industry, Commerce & Tourism.

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Table 1. Vascular streaking in cassava roots at ambient temperature (Experiment 1).

Packing method		Control	Moist Coir	
Storage period (days)	% Maximum score	% incidence	%Maximum Score	% incidence
3	14	62b	2	21a
11	35	83b	3	25a
28	51	86b	3	13a
Standard error	-	6.3	-	6.3

Figures followed by the same letter were not significantly different.

Table 2. Vascular streaking in cassava roots stored for different periods before packing in moist coir. (Experiment 2)

	Vascular streaking				% weight loss before packing	
	% Maximum score		% incidence			
Humidity before Packing:	High	Low	High	Low	High	Low
Storage period before packing in moist coir (days)						
0	11	11	17ab	17ab	-	-
1	0	0	0a	0a	1.0a	2.2ab
2	0	8	0a	50bc	2.0ab	3.8c
4	0	53	0a	83c	2.3b	7.0e
8	5	90	17ab	100c	5.3d	12.3f
Standard error			9.3			0.29

Table 3. Vascular streaking in cassava roots stored at different temperatures. (Experiment 3).

Packing method	Control		Moist Coir	
Temperature	% maximum score	% incidence	% maximum score	% incidence
Ambient	48	76c	8	21a
13°C	36	83c	22	75c
Ambient (7 days) then 13°C subsequently	14	47b	10	46b
Standard error	-	7.9%	-	7.9%

NUTRITIONAL CONSIDERATIONS REGARDING STAPLES

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Data from food balance sheets show that, for at least four Commonwealth Caribbean countries, cereal products as a whole provide between 30 and 40% of both dietary energy and protein. Imported wheat products are the most important single cereal source. In Jamaica, 95% of cereals are imported. In view of unstable and generally rising prices on the world cereal markets, steps to reduce the dependence on imported wheat in particular seem wise. Locally produced corn and rice can partially replace wheat, but starchy roots and tubers are both expensive to the consumer as energy sources and poor providers of protein. Can plant breeders, agronomists, food processors and nutritionists improve the nutritional value of foods based on tubers and roots and reduce their cost? An expanded version of this paper will appear in "Ecology of Food and Nutrition" (1975) Volume 4.

REVIEW OF RICE PRODUCTION IN JAMAICA

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Rice may have been introduced to Jamaica in the late 17th century. Since then, it has undergone periods of promotion and neglect. The Department of Agriculture imported seed from India in 1890 and with the Jamaica Agricultural Society encouraged farmers to grow it. Production increased during World War I but receded afterwards. World War II again gave an impetus. An FAO expert arrived in 1952-53 and a rice agronomist was appointed in the Department of Agriculture. The Agricultural Development Corporation began rice production in 1953 and opened a mill in 1954. Production continued to fluctuate however. New cultivars and herbicides were tested, and a specialist from CIAT advised on expansion. Currently, there is expansion in St. Elizàbeth and testing of new cultivars, including "floating rice". Japanese experts have assisted with training and advice.

INSECT PESTS OF SWEET POTATO, IPOMOEA BATATAS, AND THEIR NATURAL ENEMIES IN BARBADOS, WEST INDIES

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From the surveys carried out to study the insect pests and their natural enemies on sweet potato in Barbados, it is seen that there are a number of insect pests attacking this crop. Of these the most important are Spodoptera eridania, Sylepta helcitalis, Brachmia emigrans, Agrius cingulata; and Acrocercops sp. nr. tendalli among the Lepidoptera; and Eucepes batatae amongst Coleoptera. Tetranychus tumidus (red spider mite) was important during certain times of the year. Various methods of control are recommended, together with suggestions on the importation of natural enemies in an effort to obtain biological control. The ultimate aim would be to obtain maximum control from natural enemies, rotation of crops, field sanitation and similar measures, using the most suitable when and where necessary. Suitable chemical control measures are those which from experience interfere least with these non-chemical methods. In this manner optimum control will be obtained at least cost and with least danger by way of pollution or toxicity in the crop, since chemical pesticides will only be used sparingly and only when absolutely necessary.

FURTHER WORK ON MECHANICAL PLANTING AND HARVESTING OF ROOT CROPS

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Mechanical harvesting is impracticable unless yams are grown in ridges in pure stand. The smaller tubers formed in 84 cm. ridges are more amenable to mechanical harvesting than those in 168 cm. ridges. A planter, comprising moulding discs, hoppers, a tine to open a furrow, feeder tube and operators seat works well on ridged land. Seed pieces are dropped down the tube and planted about 10-15 cm. below ridge apex. This depth facilitates mechanical harvesting. Percent breakage of yam tubers was greater with hand forking than with a UWI harvester or harvesting aid. The latter loosens and lifts the ridge by undercutting with a heavy share, and may be most useful as a first stage operation before using a digger-elevator which did not handle the large volume of soil successfully when used directly.

The digger-elevator successfully lifted sweet potatoes.

COEFFICIENTS OF VARIATION IN MAIZE EXPERIMENTS AND THEIR USE IN PREDICTING THE EFFICIENCY OF SIMPLE EXPERIMENTAL DESIGNS

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Plot and block size and number of replicates are usually left to the experimenters' judgement. This may result in too small an experiment to detect the effects being investigated. The distribution of coefficients of variation from 118 maize experiments conducted in the Commonwealth Caribbean is considerably skew with a median noticeably lower than the mean. The regression coefficient of mean yield on the standard deviation, calculated from a sub-sample, was significantly greater than zero but significantly less than unity, showing that higher yielding experiments have higher S.E's but means that high yielding experiments have low c. of v.'s. This study enables the number of replicates needed to reduce the S.E. to such a level that an effect of given magnitude is statistically significant, to be estimated.

A survey of c. of v.'s is underway. This could also investigate the effects of varying plant densities, plot and block sizes on variability. A wide range of crops is to be investigated, and a standard form for reporting within the region has been designed. Experimenters with data from statistically designed trials are asked to co-operate by contacting the author.

EFFECTS OF FERTILIZER ON YIELD; SEED QUALITY AND PLANT CHARACTERISTICS OF SOYABEAN (GLYCINE MAX (L.) MERRILL)

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INTRODUCTION

The considerable interest in the development of a successful commercial system of production of soyabeans (*Glycine max* (L.) Merrill) in Trinidad has made necessary the conduct of several agronomic investigations under local field conditions. The only information on soyabean fertilization in Trinidad was reported by RADLEY (1968) from two trials on River Estete Loam soil; only seed yield data without statistical tests of significance were presented. RADLEY reported that phosphate application increased, but nitrogen, especially in the absence of phosphate, decreased soyabean seed yields and that potassium was virtually without effect. He further reported that there was no consistent effect of fertilizer on the seed oil content.

This paper reports data concerning seed yields, seed oil and protein contents and yields and other plant characteristics of soyabean as influenced by fertilizer application on River Estate Loam at the University Field Station, Champs Fleurs, and Cunupia Sandy Clay at the Central Experiment Station (El Carmen), Centeno, in Trinidad.

MATERIALS AND METHODS

Soils

CHENERY (1952) described both River Estate Loam and Cunupia Sandy Clay as deficient in all major nutrients.

of analysis were those of LANG, MOSS and COULTER (1963)

Experimental design and cultural practices

Two experiments were laid down on River Estate Loam and Cunupia Sandy Clay soils. Each consisted of a 3^3 NPK confounded factorial design replicated twice with each replicate in three blocks. The levels of fertilizer application gave 0, 84 and 168 kg/ha of N, P_2O_5 and K_2O from Ammonium sulphate (21-0-0), Triple superphosphate (0-48-0) and Muriate of potash (0-0-50).

Each plot accommodated four rows 6.4 m. long with 53 cm between rows. The fertilisers were broadcast and lightly raked in before planting.

Seeds of the soyabean cultivar Jupiter (F62/3977) were inoculated and sown 4 December 1968 in both experiments. Plants were thinned to seven cm within rows to obtain a population of approximately 235,000 plants per hectare. Experimental sites were irrigated during dry periods and three hand weedings were carried out during each trial. Dipterex SP 80 (Dimethyl 1-hydroxy-2-trichloro-ethyl phosphate) at the rate of 3 g/1 was sprayed weekly against leaf eating pests.

Plants from an area of 4.8 m^2 in each plot were hand harvested and air dried so that seed contained not more than 13 per cent moisture. The dried material was then threshed and winnowed manually, and the cleaned seed, together with samples taken to determine seed moisture contents, weighed as yield.

The seed size (100 seed dry weight), seed number per pod, pod number per plant, plant height (distance from ground level to terminal bud on main stem at maturity) and seed oil and protein contents were determined for each plot in both experiments.

RESULTS

Yield and seed attributes

On River Estate Loam phosphorous significantly increased seed yield, seed oil content, oil yield and protein yield. Neither nitrogen nor potassium affected any of the attributes, except seed oil content which was decreased by nitrogen. The three yield components were unaffected by fertilizer nutrients.

On Cunupia Sandy Clay nitrogen significantly increased seed yield, seed size and seed oil and protein yields. The seed oil content was the only attribute affected by both nitrogen and potassium, where the former nutrient decreased it.

The seed protein content was affected by an interaction of P and K on both soils. Greatest protein contents on River Estate Loam and Cunupia Sandy Clay occurred under treatments P_2K_0 and P_2K_1 respectively.

Plant characteristics

The number of days from planting to flowering and planting to maturity were unaffected by the treatments on both soils. Approximately 50 per cent of the plants in every individual experimental plot flowered and matured about 42 days and 102 days respectively after planting. Treatments neither affected plant height nor resulted in lodging of plants on either of the soils.

DISCUSSION

In a comprehensive review of the literature on mineral nutrition of the soyabean OHLROGGE (1963) concluded that its response to direct fertilization is inconsistent. Evidence of this trend is shown by the present data for increases in yield due to different fertilizer nutrient elements were obtained on the two soils. The seed yields were lower than those RADLEY (1968) due partly to the influence of planting date.

Phosphorus increased not only the seed yield on River Estate Loam, a finding in agreement with RADLEY (1968), but also the oil and protein yields and the seed oil content. The results of seed oil content are in contrast to those of RADLEY. Analysis of variance data for seed size, the only yield component which gave a possible indicated response to fertilizer (F calc. - 3.02: F 5% - 3.40), suggest that phosphorous probably promoted the development of larger seeds thereby increasing seed yields. Contrary to RADLEY'S finding and in agreement with WEBER (1966) nitrogen did not reduce seed yield but did reduce the seed oil content.

The cultivation of soyabean on acidic soils can result in reduced activity of the root nodule bacteria (BRYAN, 1922) and decreased plant vigour and seed yields (CARTTER and HARTWIG, 1963). This is evident from the lower seed yields recorded on Cunupia Sandy Clay than on River Estate Loam. The results from Cunupia Sandy Clay agree with those of several workers quoted by CARTTER and HARTWIG who reported seed yield increased from nitrogen fertlization on some acidic soils. Nitrogen fertilizer increased seed yield through the development of larger seeds, but as on the River Estate Loam these seeds contained less oil. However both oil and protein yields were increased by nitrogen.

On both soils the seed protein content was affected by phosphorous in combination with potassium, but the greatest values were produced by different treatments in each case. No logical trend is discernible from the results.

Fertilizer treatments on the soils affected neither the time of flowering as reported by TEWARI (1965) nor resulted in any lodging of plants as found by MILLER, PESEK, HANWAY and DUMENIL (1965). These findings are important for they suggests that good economic yield responses can be obtained, and easy and successful harvesting conducted, because plants will flower uniformly and display good standing ability under higher fertility levels of the two soils.

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EFFECTS OF FERTILIZER ON LEAF MINERAL CONTENTS OF SOYABEAN (GLYCINE MAX (L.) MERRILL)

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INTRODUCTION

The effects of N, P and K fertilizers on soyabean (*Glycine max* (L.) Merrill) yield, seed quality and plant characteristics on River Estate Loam at the University Field Station, Champs Fleurs, and on Cunupia Sandy Clay at the Central Experiment Station (El Carmen) Centeno, in Trinidad were reported elsewhere in these proceedings (BRATHWAITE, HAMMERTON and TAI, 1974). This paper describes the influence of the same fertilizer applications to the two soils on the leaf mineral contents at different stages of plant growth and their relation to seed yield.

MATERIALS AND METHODS

The methods used in the experiments were described and the seed yields obtained reported previously (BRATHWAITE et al., 1974).

Leaf samples were collected on five occasions. The leaf at the third node from the top of the ten plants, randomly selected in each plot, was sampled and bulked for each site. The first samplings were taken four weeks after planting and subsequently at fortnightly intervals until plants were just beginning to senesce. Each leaf was washed in a weak detergent solution and then rinsed in four successive lots of distilled water. The lamina was then dried at 65° for 24 hours and ground in a stainless steel mill.

The ground material was analysed by the Central Analytical Laboratory of the University of the West Indies, St. Augustine for total nitrogen (by the micro-Kjeldahl procedure), phosphorous (colorimetrically by the Molybdenum blue method), potassium (by flame photometer) and calcium and magnesium (by atomic absorption). Results were expressed as percentages on a oven-dried plant basis.

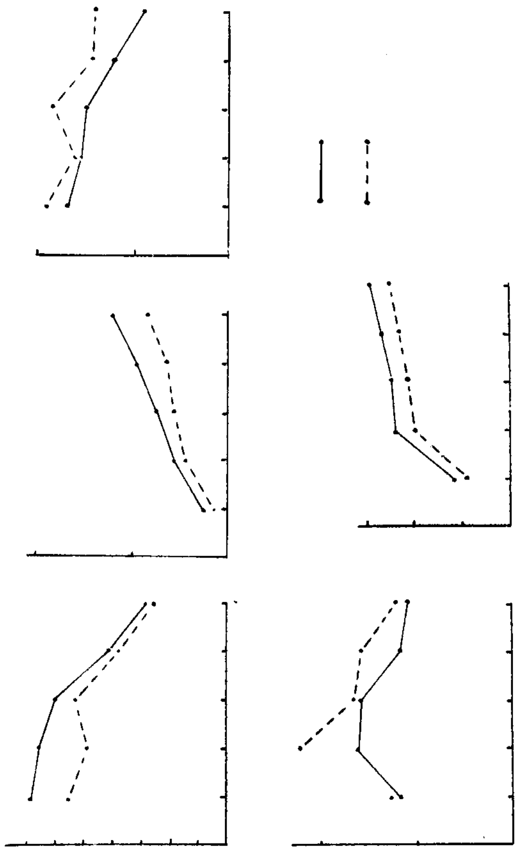
RESULTS

Variation with time

Figure 1 shows the change in nitrogen, phosphorous, potassium, calcium and magnesium leaf content with time on the two soils.

Effect of fertilizer nutrients

Leaf nitrogen content: On River Estate Loam P_{84} fertilizer increased the leaf nitrogen content at flowering, and N_{84} and K_{168} increased it at senescence. The nitrogen content at the first three stages of growth samped was increased by N fertilizers on



Cunupia Sandy Clay. On that soil P_{168} fertilizer decreased the nitrogen content at flowering only and K fertilizer was without effect.

The nitrogen content decreased after flowering on River Estate Loam; N, P and K fertilizers did not alter this general pattern. On Cunupia Sandy Clay, after an increase between flowering and the pod development stage, the nitrogen content decreased with age. However, N fertilizer altered the general pattern. On both soils the nitrogen content at senescence was less than half the value at the pre-flowering stage.

Leaf phosphorous content: N and K fertilizers had no effect on the phosphorous content on River Estate Loam but affected it on Cunupia Sandy Clay. P fertilizer on River Estate Loam increased the phosphorous content all stages, except flowering but had no effect on Cunupia Sandy Clay. On the two soils the phosphorous content decreased as plants aged. On River Estate Loam the phosphorous content at senescence was half that at pre-flowering.

Leaf potassium content: On River Estate Loam K fertilizer increased the potassium content at all five growth stages. N fertilizer affected the potassium content especially after the development of pods. P_{168} increased theepotassium content only during the pre-flowering stage. At flowering and senescence the values for this level were lower than those of the P_0 treatment. At pod development the value was similar to that of the P_0 treatment, and at seed development equal to that produced by P_{84}.

Neither K nor P fertilizer affected the potassium content at any stage of growth on Cunupia Sandy Clay. N fertilizer increased the potassium content at varying growth stages with the exception of the pod development stage.

On both soils potassium content increased from pre-flowering to the flowering stage and then decreased until senescence.

Relation to seed yield

Leaf mineral content data for samplings at the pre-flowering, flowering and pod development stages of growth were used for evaluation of nutrient content as it related to seed yield.

DISCUSSION

In general the leaf nitrogen, phosphorous and potassium contents varied throughout the stages of plant growth and development and with the levels of N, P and K fertilizers applied to River Estate Loam and Cunupia Sandy Clay. Phosphorous contents in the leaf tissue increased with application of P fertilizer on River Estate Loam and showed a positive relationship with seed yield. The application of P fertilizer probably stimulated better vegetative growth and thereby resulted in increased production and accumulation of photosynthetic products and increased yields.

OHLROGGE (1963) considered 5.2 per cent N in soyabean as high, but **the present data show that the leaf nitrogen value was only increased by N_{84}** fertilizer, and only during senescence. The high nitrogen values recorded were neither associated with increased seed yield nor with seed protein conten or yield, and it is concluded that plants exhibited luxury nitrogen consumption, similarly recorded by NORMAN (1943). These data suggest that there was definitely no benefit from N fertilization on River Estate Loam either because the inherent soil nitrogen content and symbiotic activity of the root nodule bacteria provided adequate nitrogen for good yields, or because nitrogen within the plants was restricted by some unidentifiable limiting factor.

Although K fertilizer increased the potassium contents in the leaf, the values never attained critical levels reported by MELSTED, MOTTO and PECK (1969) in the U.S.A. In so far as no deficiency symptoms occurred, it may be concluded that potassium levels were adequate and presumably did not limit the production of seed.

On Cunupia Sandy Clay where a positive seed yield response to nitrogen was reported (BRATHWAITE et al., 1974), N fertilizer also increased the leaf nitrogen content producing high values as on River Estate Loam. Despite the absence of a significant correlation coefficient for nitrogen content x seed yield, it would seem that this nutrient had an important effect on pod retention and possibly pod filling. Both the phosphorous and potassium contents, though unaffected by P and K fertilizers respectively and not considered limiting factors to the attainment of high yields on this soil showed a positive relationship with seed yield.

The loss of nitrogen, phosphorus and potassium from the leaf, indicated by their decrease as the crops aged, presumably reflects their translocation to the seeds. In contrast the leaf calcium and magnesium contents increased. These patterns demonstrat on both soils by the two groups of nutrient elements agree with those reported by HAMMOND, BLACK and NORMAN (1951).

The present data suggest that nutrient uptake was apparently never restricted on either of the soils and the translocation patterns did not appear to limit the capacity of the crops to produce increased yields.

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SOME USES OF THE COMPUTER IN AGRICULTURAL RESEARCH

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Uses of the computer include the following:

(1) Analyses of large bodies of data from single experiments: analyses of variance, correlation and regression coefficients may be required, including non-linear regressions, and one might wish to examine factor or principal components analyses. Such analyses are at least formidable tasks on calculating machines but take only minutes on a computer.

(2) Difficult problems - including curve fitting may involve sophisticated mathematical techniques: the computer is here used not because the amount of data is large, but because the analysis is complex.

(3) Surveys - these often involve a large quantity of data which may need to be classified in numerous ways.

(4) Data storage and retrieval - records of experiments on particular crops, or at a particular station, or of production and marketing can most compactly be stored on magnetic tape and single pieces of information retrieved in minutes.

Computers can save time and effort and reduce risks of error. A Package of computer programs is currently being developed in the Biometrics Unit of U.W.I. at St. Augustine. A package for drawing the commoner types of graph,using the CALCOMP graph plotter is also being prepared.

A FURTHER LOOK AT EXPERIMENTAL DESIGNS UNDER LIMITED RESOURCES

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An experimental design based on a 2^3 factorial with probe points outside the treatment range of the factorial system is described and a blocking system, which partially confounds the third order interaction is given. This three-factor model can be extended to four factors. Treatments are added at the centre and at probe points outside the factorial system. The highest order interaction is again partially confounded in the blocking arrangement. An appropriate analysis of variance has been developed. The basic three-factor model can be repeated to give a 4^3 type experiment: this is essentially two 2^3 factorial configurations with additional probe points. Blocking systems have been worked out and the analysis of variance can be carried out so as to investigate the three factors separately for each 2^3 configuration. This design may be useful when there is little prior knowledge of response to the three factors, but size of the experiment may restrict replication.

EFFECTS OF ORGANIC AND MINERAL AMENDMENTS IN HORTICULTURAL ROTATIONS ON ACID SOIL IN THE WET TROPICS

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Trials were carried out to assess the effect of various forms of organic manures on the yield of vegetable crops in an acid latosol soil which had been exhausted of both mineral and organic constituents by intense cropping in a wet tropical climate.

A rotation of 'Tomatoes and Eggplant', 'French Beans and Sweet Potatoes' was used to assess the effects of Goat Manure, Stylozanthes compost, cane sugar scum, distillery bagasse, calcium carbonate and ground calcareous tufa on the yield and performance of these crops. All plots received an application of mineral fertilizer.

Stylozanthes compost gave best results and it could be of interest to define in greater detail the effects of organic matter and mineral amendments in further rotations.

THE INTRODUCTION OF A BUSH-TYPE BODIE BEAN VARIETY TO THE CARIBBEAN

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Bodie bean (*Vigna ungriculata* Walp.) is eaten as immature pods in Trinidad and Guyana. Of 164 bodie accessions, Los Banos Bush Sitaa No. 1 proved outstanding. It was developed at the University of the Phillipines and released in 1958. It was introduced to Trinidad and Tobago in 1971 and released for popular cultivation in 1973. It can be grown all-year-round, is early-maturing (about 6 weeks to first harvest), high-yielding and a bush-type, so does not need supports. Pods are held above the plant. Yields of over 25,000 kg/ha green pods have been recorded.

Recommendations for its production include close planting (c. 45 x 10 cm) and an application of compound fertiliser at or before planting. Adequate water is essential. Harvesting should start before indentations on the pods become pronounced, and should be done at least twice weekly. Infrequent harvesting reduces marketable yields. In seed production, regular insecticide application is essential to avoid infestation by storage pests. Removal of plants with virus-like symptoms and roguing of off-types is recommended. Pods should be sun-dried, and seeds should be stored in sealed containers after treating with insecticide, preferably at fairly low temperatures.

TRICKLE IRRIGATION

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The benefits of applying water to plants by this method, and the fundamental principles that water should be applied at ground level and at low volume and pressure over an extended period of time, are outlined. The benefits are that soil moisture is kept constant, resulting in an even growth of crops, and economy of water usage, as there is no wind drift, surface flooding or excess loss due to evapotranspiration or leaching to the subsoil. A further advantage is that plant nutrients may be added in solution.

Various systems are described: most of them require an efficient filter system to prevent clogging of the orifices, some require pressure in the lines, some are durable, others are cheap and disposable.

The principles of the Chopin Twin Wall system, Viaflo from Dupont in the U.S.A., Blass System in Israel, and one devised in Australia are outlined, and suggested methods by which the costs of a system may be reduced are given.

A REVIEW OF THE USE OF CONVENTIONAL AND SYSTEMATIC DESIGNS IN SPACING EXPERIMENTS

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Conventional experimental designs, such as randomised blocks or latin squares, may limit the range of spacings that can be studied, bearing in mind the need for guard rows and the desirability of keeping block size as small as possible. The experimenter will also face the question of whether to keep plot size constant and vary plant number, or vary plot size with plant number constant. The systematic designs of J.A. Nelder allow both plant density and arrangement to vary over the "plot". Step-wise progression in plant spacing eliminates the need for guard rows and these designs enable thorough coverage of the spacing response surface, as well as efficient land (and labour) use. When the range of spacings is small, and when interactions with either factors must be investigated, conventional designs are preferable.

PATHOLOGICAL PROBLEMS ASSOCIATED WITH VEGETABLE GROWING AT ORANGE RIVER AGRICULTURAL STATION

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INTRODUCTION

A Vegetable Research Programme was started at Orange River Agricultural Station in Jamaica on 1972 to determine the major pathological problems associated with vegetable growing under the particular climatic and ecological conditions and to find effective control measures. After eighteen months of research work on many different types of vegetables, we have found that some of the major diseases are late blight (<u>Phytophthora infestans</u>) and bacterial wilt (<u>Pseudomonas solanacearum</u>) of tomatoes, downy mildew (<u>Pseudoperonospora cubensis</u>) of cucurbits and black rot (<u>Xanthomonas campestris</u>) of cabbages. Since then we have been testing new varieties of these vegetables for disease resistance and searching for other control methods. This paper attempts to report and assess the results of variety trials carried out on 23 tomato, 9 cucumber and 5 cabbage varieties.

The objects of the exercise were to:

1) test all available varieties of important vegetables
2) observe what diseases occurred and at what time
3) assess their severity and relationship to climatic conditions (where possible), and
4) find effective control measures.

The first four tomato varieties tested were Manalucie, Oxheart, Tropi-Gro and Walter. We found that all four varieties were extremely susceptible to late blight, during the rainy season (October-January), crop loss was sometimes as high as 90% and it was almost impossible to effectively control this disease at this time even though a wide range of fungicides were tested. More than 95% of the Manalucie crop was lost to bacterial wilt when grown in areas where the causal organism was present.

Tests on cucumber varieties Straight Eight, Poinsett and Cherokee Hybrid indicated that the former was susceptible to downy mildew throughout the life of the plant. Over 80% of the Straight Eight crop was lost in the rainy season when plants were left lying on the ground and sprayed with different fungicides. However, good control was obtained by trellising the plants and spraying with Manzate D-Benlate or Daconil-Benlate. On the other hand, Cherokee Hybrid and Poinsett have exhibited resistance to the disease.

In late October of 1973 the following cabbage varieties were treated:- Japanese Succession, K-K, Express Cross 60, K-Y Cross, Hybrid 906, Early Jersey Wakefield, Jet-Pak, N-S Japan, Danish Ballhead and Copenhagen Market. After heavy rains in December (9 inches in 36 hours), black rot symptoms became evident. The disease was most severe in the Early Jersey variety, where 90% of the crop was lost. In all other cabbage varieties there were varying degrees of susceptibility, but all heads reaped were free of the disease.

The economic importance of these vegetable crops, the high losses resulting from the diseases mentioned and the limited success of the combination of good cultural practices and pesticide treatment, all point to a need for more intensive work on obtaining and testing resistant varieties in Jamaica.

MATERIALS AND METHODS

Tomato

Fourteen new varieties of tomato are presently being compared to the standard Manalucie for resistance to late blight. Seeds of 13 varieties were obtained from the Regional Plant Introduction Station at Ames, Iowa, and the other variety from Guadeloupe. For late blight resistance tests, seeds of all the varieties were germinated in peat pots. When the seedlings were four weeks old some were placed in an atmosphere conducive to disease build-up (cool, damp, shady conditions), the others were transplanted to the field for observations. Records are being kept of resistance and yield. Prior to obtaining seeds of these 14 varieties, we had obtained seeds of West Virginia 63, a late blight resistant variety, from the United States. The seeds of this variety and Manalucie were grown in peat pots and transplanted to the field when the seedlings were one month old. Records have been kept of resistance and yield.

Eight new varieties of tomato are being tested at present for resistance to bacterial wilt, together with the standard Manalucie. Two varieties were obtained from the University of North Carolina, five from the University of Hawaii and one from the Petit-Bourg Research Station in Guadeloupe. For bacterial wilt tests, one-month old seedlings of the new varieties and Manalucie were transplanted to the field in two areas:

a) known from previous experiments to be infested with *Pseudomonas solanacearum*,

b) free of this disease organism.

Records are being kept of performance under wilt and wilt-free conditions.

Cucumber

Six new cucumber varieties are now being tested along with three commercial varieties. The new varieties were obtained from the Plant Introduction Station at Ames. Records are being kept of resistance and yield.

Cabbage

Five varieties of cabbage, together with the standard Early Jersey Wakefield, are being field-tested in an area known from a previous experiment to be infested with *Xanthomonas campestris*. Seeds of the new varieties were obtained from the University of Wisconsin's *X. campestris* and *Fusarium* Yellows resistant breeding lines. Records are being kept of resistance and yield.

RESULTS AND DISCUSSION

Tomato-Bacterial Wilt

The results in Table I indicate that Venus and Saturn perform well under bacterial wilt conditions. Although favourable reports have been obtained from tests in Guadeloupe with INRA #74, it does not react favourably under bacterial wilt conditions at Orange River. All plants of the variety Hawaii 7755 reported tolerant in Hawaii were killed by the bacterial disease. BWN4 reported resistant in Hawaii displays some tolerance, all plants wilt but remain alive. Although there is some fruit-set, it is apparent that the maturation and size of the fruits will be affected by the state of the plants. All Manalucie plants except three, were killed by the disease. The yield obtained for this variety came from the three plants which apparently "escaped" infection and from those few where the disease symptoms were not evident until sometime after fruit-set. For the other bacterial wilt resistant variety BW N10 and the two tolerant varieties, Hawaii #7958 and 7845 (all from the University of Hawaii), complete results are not available at this time, however, wilting had just commenced in #7845 and Manalucie when the paper was written.

It should be mentioned that the area where these tomato varieties are grown was treated with Nemagon prior to planting, to prevent any adverse effects of nematodes on the bacterial wilt resistance performance of the varieties. In correspondence with Dr. Gilbert of the University of Hawaii, it was stated that the bacterial wilt resistance of the Hawaiian varieties is less effective under hot tropical conditions. This could possibly explain the disappointing performance of the Hawaiian varieties tested so far. No attempt has yet been made to sort out the strains of P. solanacearum that exist in Jamaica.

In terms of ability to do well as new varieties under Orange River conditions, when the yields of varieties Saturn, Venus and INRA #74 are compared with Manalucie (TABLE II), INRA #74 is almost as good, Venus is quite good and Saturn is fair. The fruit quality of all three varieties is good. We did not determine the yielding ability of Hawaii #7755 and BW.N4 because of the limited supply of seedlings.

Late Blight

Seeds of West Virginia 63 were obtained from the United States as this variety has resistance to late blight. Seedlings of West Virginia 63 and Manalucie were transplanted after about four weeks. Seedlings of both varieties had slight late blight symptoms before transplanting. After transplanting, there were thirteen days of cloudy, rainy weather. All of the Manalucie plants were lost to late blight whereas all of the West Virginia 63 seedlings survived. We had to replant the Manalucie stand. The quantity and quality of the fruits of the West Virginia 63 compare favourably with the Manalucie variety (TABLE III).

One-month old seedlings from seeds of other Late Blight resistant varieties obtained from the Plant Introduction Station all exhibited Late Blight symptoms before either transplanting to the field or transferring to artificial conditions (to induce disease build-up). Severe infection did occur on some of the plants kept under artificial conditions; however, it was difficult to assess resistance even though an attempt was made (TABLE IV). For those transplanted to the field, several days of cloudy, rainy weather resulted in an increase of the disease. Evaluation of varietal differences is also difficult in the field, since the onset of dry, hot weather conditions has stopped the spread of the disease. It seems, however, that those varieties which were less severely infected in the artificial environment have also been less severely infected in the field:- 263716 (Puerto Rico), 114038 (Honduras), 110946 (Colombia), 118790 (Venezuela), 224675 (New York) (TABLE IV). We are evaluating all of the varieties as to fruit quality and quantity. In the rainy season we plan to repeat the blight resistant test when weather conditions will be more uniform and conducive to disease build-up.

From the results in TABLE V of the new cucumber varieties, only #255936 from Holland appears promising when compared with the most resistant variety commercially grown - Poinsett. No data can be given on yields for these varieties in this paper as harvesting was not completed. Poinsett, Ashley and Straight-8 are all high-yielding commercial varieties. However, Poinsett is the only variety commercially grown at the present time, which exhibits very good resistance to downy mildew.

Cabbage - Black Rot

The five new varieties of cabbage are No. 291-296, 284-287, 268-274, 275-281, 250-256. These varieties now in the field with the standard Early Jersey have not yet reached maturity. Little data is available at this time. However, it is of interest to note that 30% of the Early Jersey plants are already exhibiting black rot symptoms.

CONCLUSION

1. The tomato varieties Venus and Saturn exhibit good resistance to bacterial wilt when tested in the field. The performance of INRA #74, Hawaii 7755 and BWN4 was disappointing. The yielding ability of Venus and INRA #74 is comparable with the standard Manalucie. That of Saturn is a bit low.

2. The variety of tomato West Virginia 63 shows resistance to late blight. Thirteen other varieties were being tested for late blight resistance.

3. Of the nine varieties of cucumbers tested for downy mildew resistance, the commercially grown Poinsett exhibits good resistance, a new variety from Holland is promising.

4. Five new varieties of cabbage are being tested for resistance to black rot, no results are available at this time.

TABLE I. Results of Performance of six varieties of tomato grown in soil infested with *P. solanacearum.*

Variety[1]	Avg. No. fruits/plant	Avg. size of fruits (oz.)	Avg. yield/ plant (lb/oz)	% Wilt
Venus	25	3.5	5.5	0
Saturn	15	3.2	2.9	0
Manalucie	3	1.4	0.3	98 (All wilted plants have died).
INRA #74	20	2.5	3.1	30 (All wilted plants have died).
Hawaii #7755	0	0	0	100 (All wilted plants have died)
BWN4	0	0	0	100 (All wilted plants are still alive)

Key

1 Manalucie - grown commercially

Venus, Saturn - seeds obtained from the University of North Carolina

INRA #74 - seeds obtained from Petit Bourg Research Station in Guadeloupe

Hawaii #7755 and BWN4 - seeds obtained from the University of Hawaii.

TABLE II. Results of Yield of four varieties of tomato grown in soil free of *P. solanacearum*.

Variety[1]	Avg. No. of fruits/plant	Avg. size of fruits (ozs)	Avg. yield/plant (lb/oz)
Venus	15	4.8	4.8
Saturn	11	4.2	3.0
INRA #74	16	5.1	5.0
Manalucie	10	9.0	5.10

1 No results are available for Hawaii #7755 and BW M4 because limited seed supply prevented yield studies.

TABLE III. Results of yield performance of West Virginia 63 - a late blight resistant variety of tomato and Manalucie - a commercially grown variety.

Variety	Avg. No. of fruits/plant	Avg. size of fruits (ozs)	Avg. yield/plant (lb/oz)
Manalucie	10	9	5.1
West Virginia 63	17	6	6.6

TABLE IV. Results of Resistance of tomato varieties to *P. infestans* both under artificial conditions and in the field.

Variety	Disease rating[1]	%Survival[2]	Survival Index[2]
91913 - Bulgaria	2	67	2
95584 - Manchuria	3	25	4
108245 - Germany	2	0	5
110946 - Colombia	1	50	3
114038 - Honduras	1	56	2
118790 - Venezuela	1 - 2	50	3
126408 - Panama	2	60	2
126907 - Peru	2	33	3
198674 - Mexico	0 - 1	0	5
204994 - U.S. (W. Va.)	2	0	5
224675 - U.S. (New York)	1 - 2	47	3
263716 - Puerto Rico	1 - 2	50	3
273446 - Philippines	2	25	4
Manalucie	2 - 3	25	4
Pieraline INRA 1970 Guadeloupe	Too young	-	-

1 Infection in the field

Disease Index

1 - slight
2 - moderate
3 - severe

2 Index of survival of seedlings in peat pots

1 - 76-100%
2 - 51-75%
3 - 26-50%
4 - 1-25%
5 - dead due to disease

TABLE V. Results of resistance, fruit size, colour and eating quality of six new cucumber varieties compared with commercial varieties.

Variety	Disease[1] rating	Size of fruits (cm length)	Diam.	Colour and eating quality
# 173889 (India)	3	8.3	4.3	Yellow, bitter
# 197087 (India)	2 - 3	fruits not mature enough for any assessment		
# 175120 (India)	4	9.6	4.3	Green, good
# 234517 (U.S.)	3	fruits not mature enough for any assessment		
# 255936 (Holland)	1	15	5	Green, good
# 227208 (Japan)	1 - 2	29.3	4.5	Green, good
Straight-8 (commercially grown)	2 - 3	20	5	Green, good
Ashley (commercially grown)	2 - 3	18.75	5	Green, good
Poinsett (commercially grown)	0 - 1	21.25	6.25	Green, good

[1] Key

1 - slight
2 - moderate
3 - fairly heavy
4 - severe
5 - dead

A STUDY OF 100 TOMATO VARIETIES IN RELATION WITH CLIMATIC ADAPTATION AND RESISTANCE TO 7 PREVALENT DISEASES IN THE WEST INDIES

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* CRAAG - Petit Bourg - Guadeloupe

** CRA - Montfavet - France

INTRODUCTION

A description of all the varieties available in the commercial catalogues would be long and possibly not useful. We limited our study to 100 varieties currently grown, and to those which could present in the future an interest in this area. We did not describe any commercial F_1 hybrid. We know that many of them present a real interest, but commercial names are excessively numerous and changing, so any description would rapidly become obsolete.

The varieties are listed in three classes of adaptation to Caribbean conditions:

1) Good varieties
2) Not well adapted but outstanding for some particular characters
3) Not satisfactory, to be replaced

Reactions to Cladosporium fulvum (Leaf mold, Fusarium oxysporum lycopersici races 1 and 2 (Fusarium wilt), Meloidogyne sp (gall nematodes), Phytophtora infestans (late blight), Pseudomonas solanacearum (Bacterial wilt, Stemphylium solani (gray leaf spot) and Verticillium dahliae (Verticillum wilt) are given. A brief description of each variety is added.

These data were collected from author (s) description, commercial catalogues, and from the results of our trials in Guadeloupe and at Avignon (Southern France).

And estimation of the value of the different varieties for the producers is difficult to establish. However, a synthesis of the appreciation of the economic characters was made for the West Indian conditions using three lists of varieties.

RESULTS

LIST 1 - Varieties considered the best.

They were tried and confirmed as good varieties in Guadeloupe except those marked by an asterisk which are : 1/ very similar to confirmed good varieties
or 2/ bred or confirmed in neighbouring climatic areas.

ANAHU
ARC (*)
ATKINSON
CAMPBELL 17
CAMPBELL 28
CAMPBELL 1327
CHEF (*)
CHICO
CHICO GRANDE
CHICO REX (*)
CHICO III (*)
CLAIRVIL (*)
COLDSET
CRA 74
EASTERN STATES 24
EASTERN STATES 58
ECLAIREUR
EL MONTE (*)
FIREBALL
FLORADEL
FLORALOU
FLORIDA MH 1
GULFSTATE MARKET
HEINZ 1370
HEINZ 1409
HEINZ 1438
HEINZ 1548
HOMESTEAD ELITE
HOMESTEAD 24
HOMESTEAD 61
HOMESTEAD 500
HOTSET
IMMOKALEE
INDIAN RIVER
KOLEA C
LA BONITA (*)
LA FAYETTE
LA PINTA (*)
MANALUCIE
MANAPAL
MARION
MARS (*)
MONEYMAKER
MONITA (*)
MONTE GRANDE (*)
NAPOLI
NEMATEX
PELICAN
PINKDEAL
POTOMAC
RED ROCK
ROMA
ROMA VF (*)
RONITA
ROSSOL
SAMARZANO
SAMARZANO VR
SUMMERTIME
TROPIC
TROPIGRO
TROPIRED
VENDOR
VENTURA (*)
VENUS
WALTER

LIST 2 - Varieties not very well adapted to West Indian conditions.

These varieties are outstanding for particular characters and could be recommended where these qualities are most needed.

Varieties	Particular qualities
BUSH VFN	Multiple disease resistant, large fruit
CAMPBELL 19	Excellent in Eastern USA
HEINZ 1350	Early type for canning
MARSOL	Multiple diseases resistance early
PIERALINE	Large fruit, late blight resistant
PIERNITA	Large fruit, nematode resistant
PIERSOL	Large fruit, multiple disease resistant
PIERVIL	Large fruit, Fusarium resistant
RAF	Early, Fusarium resistant
SATURN	Bacterial wilt resistant, larger than VENUS and CRA 74
STAKELESS	Excellent for family gardens
VF 145	Regular production, Mechanical harvest type
VFN 8	cf BUSH VFN
WEST VIRGINIA' 63	Late blight resistant

LIST 3 - Generally not as satisfactory as the preceding varieties.

These varieties are often cited because extensive acreages are grown in the West Indies. We advise the growers to replace these varieties by better adapted ones provided these new introductions meet the market needs.

ACE	CASAQUE ROUGE	MARMANDE VR	PRIMABEL	RED JACKET VR
ACE VR	KAKI	MERIT	PRITCHARD	ROYAL ACE VF
ACE VF	MARGLOBE	OXHEART	PRITCHARD VF	RUTGERS
CALACE	MARMANDE	PIERALBO	RED JACKET	SAINT PIERRE

DISEASE RESISTANCE

They are included in the detailed variety description. In many cases, we did not try the resistance described by the Authors; in such occurrence, we mention "r" in other cases we could try resistance in Guadeloupe for leaf mold (*Cladosporiun Fulvum*) bacterial wilt *Pseudomonas solanaceorum*) and gray leaf spot (*Stemphylium solani*) under natural infestation conditions. Resistance to Fusarium race 1 and 2, to gall nematodes (*Meloidogyne* sp) and late blight (*Phythopthora infestans*) was appreciated under artificial inoculation conditions at Avignon. When varities were found resistant by ourselves they are mentioned "R" when heterogeneous "Het". In rare cases the resistance described by the authors was not confirmed, the varieties are mentioned "S" for susceptibility.

1/Cladosporiun fulvum (Leaf mold)

Resistance when observed is complete. As new psyciologic races occured causing hertofore resistant varieties to become diseased in temperate greenhouses, a study was begun in Guadeloupe to determine the race situation. Our first results indicate that the race 0,1,3,1-3 (as defined by HUBBELING in the Netherlands) could be present. The same race situation was found by BLISS and ARNY in West Africa (Nigeria). If new races occur, the resistances noted in Guadeloupe and probably conferred by genes cf 2 and/or cf 4 (as defined in the Netherlands) will become inefficient. "Florida MH1" was found resistant to some races in Florida but is susceptible to the race (s) of Guadeloupe.

2/ Fusarium oxysporum (Fusarium wilt)

When indicated, resistance to race 1 (due to gene I) should be practically complete. However some varieties and particularly "Marglobe" manifest an intermediate resistance level in our trials. "Pinkdeal" and "West Virginia 63" are described resistance by the authors and found susceptible in our tests, which were possibly very severe and could not determine relatively low resistance levels. In intensive Tomato production areas, Fusarium race 2 c uld appear on varieties bearing I gene. This new race is compeletely controlled by another gene of resistance in "Florida MH1" and "Walter". We found a very high but not complete resistance to race 2 in "CRA 74" "Saturn", "Venus".

3/ Meloidogyne sp (Gall or root-knot nematodes)

Above Circa 30°C soil temperature, the resistance conferred by Mi gene to some varieties ceases to be really effective. This increase in susceptibility at highest temperature is particularly drastic in Mi/+ heterozygous combinations which are often presented as commercial hybrids "resistant to nematodes". Rare cases of appearance of Meloidogyne races able to attack varieties homozygous for Mi in artificial contamination tests and at normal temperature were described.

4/ Phytophthora infestans (Late blight)

Thise disease is generally not observed or not important in our warm conditions. In cooler elevation areas (Domincan Republic, Jamaica) or in the vicinity of continental cold air (Cuba, Habana zone in Winter) its occurrence is frequent; "Pieraline" and "West Virginia 63" show an incomplete but effective resistance in our tests.

5/ Pseudomonas solancearun (Bacterial wilt)

Susceptibility to this destructive soil transmitted disease is very high in all the varieties mentioned except "CRA 74", "Saturn and Venus" which were bred for resistance. However, some plants of these varieties could be severely diseases in difficult conditions. Moreover the resistance in only effective in mature plant, so seedling should be grown in Pseudomonas free soil before planting.

6/ Stemphylium solani (gray leaf spot)

It is often very destructive in West Indian conditions, many varieties carry the Sm gene conferring a good resistance. Epidemics are relatively are around many plant breeding stations, and artificial inoculation is very difficult, so many varieties generally not cited as resistant carry a resistance which was manifest in our trials in Guadeloupe. Conversely, where gray leaf spot is dangerous, it is sometimes necessary to verify the resistance of commercial seed which is not always very carefully bred for reaction to gray leaf spot an unimportant disease in many countries.

7/ Verticillium dahliae (Verticillium wilt)

It is an important disease in Mediterranean and subtropical countries. Its occurence in tropical areas is not frequent but possible in cool soils. Resistance conferred by Ve gene is fully effective except in rare cases where new races of this pathogen appeared.

The authors of "Florida MH1" primitively found that it was bearing Ve gene, but afterwards they discovered it had only an intermediate level of resistance in their tests. We found this variety susceptible in artificial inoculation tests.

TABLE 1 - DETAILED VARIETY, DESCRIPTION

VARIETIES	Origin	List	Climatic Adaptation	Fruit Size	Fruit Shape	Shoulder Color	Plant	Foliage Cover	Growth D=Determinate I=Indeterminate
ACE	U.S.A.	3	Dry	Large	Deep oblate	Uniform	Large	Good	D
ACE VR	Canada	3	Dry	Large	Deep oblate	Uniform	Large	Good	D
ACE VF	U.S.A.	3	Dry	Large	Deep oblate	Uniform	Large	Good	D
ANAHU	Hawaii	1	Warm humid	Medium	Deep oblate	Uniform	Medium	Medium	D
ARC	U.S.A.	1	General	—	Globe	Uniform	—	—	D
ATKINSON	Alabama	1	Warm humid	Large	Globe	Green	Large	Good	I
BUSH VFN	California	2	Dry	Large	Deep oblate	Green	Compact	Good	D
CALACE	California	3	Dry	Large	Deep oblate	Uniform	Large	Good	
CAMPBELL 17	New Jersey	1	General	Medium	Deep oblate	Apple green uniform	Medium large	Good	D
CAMPBELL 19	New Jersey	2	Cool	Medium	Oblate	Apple green uniform	Medium large	Good	D
CAMPBELL 28	New Jersey	1	General	Medium small	Oblate rough	Uniform	Compact	Excellent	D
CAMPBELL 1327	New Jersey	1	General	Medium large	Oblate	Apple green uniform	Large	Good	D
CASAQUE ROUGE	New York	3	Cool	Large	Deep oblate	Uniform	Medium	Medium	I
CHEF	U.S.A.	1	General	—	Globe	Uniform	—	—	D
CHICO	Texas	1	Warm humid	Small	Pear	Uniform	Medium small	Good	D
CHICO III	Texas	1	Warm humid	Small	Pear	Uniform	Small	Poor	D
CHICO GRANDE	Texas	1	Warm humid	Small, larger than Chico	Pear	Uniform	Medium small	Good	D
CHICO REX	Texas	1	Warm humid	-do-	Pear	Uniform	Medium small	Good	D
CLAIRVIL	France	1	General		Globe	Uniform	Large	Good	I
COLDSET	Ontario	1	General	Small	Deep oblate	Uniform	Medium small	Good	D
CRA 74	Guadeloupe	1	Warm humid	Medium	Deep oblate	Green	Large	Good	I
EASTERN STATES 24	Eastern USA	1	General	Medium small	Deep oblate	Uniform	Medium	—	D
EASTERN STATES 58	Eastern USA	1	General	Medium	Deep oblate	Uniform	Medium	Good	D
ECLAIREUR	France	1	General	Small	Globe	Uniform	Large	Good	I
EL MONTE	Texas	1	Warm humid	Medium	Deep oblate	Green	Medium	Good	D
FIREBALL	Eastern USA	1	General	Small	Globe	Green	Medium	Good	D
FLORADEL	Florida	1	Warm humid	Large	Deep oblate	Green	Large	Good	I
FLORALOU	Florida	1	Warm humid	Medium large	Deep oblate	Green	Large	Good	I
FLORIDA MH 1	Florida	1	Warm humid	Medium large	Deep oblate	Uniform	Compact	Good	D
GULF STATE MARKET	Southern US	1	Warm humid	Medium large	Deep oblate	Uniform	Compact	Good	I
HEINZ 1350	Ohio	2	Cool	Medium	Deep oblate	Uniform	Short	Medium	D
HEINZ 1370	Ohio	1	General	Medium small	Globe	Uniform	Medium	Good	D
HEINZ 1409	Ohio	1	General	Medium	Deep oblate	Uniform	Medium	Good	D
HENIZ 1439	Ohio	1	General	Medium	Deep oblate	Uniform	Medium	Good	D
HENIZ 1548	Ohio	1	General	Medium	Deep oblate	Uniform	Medium	Medium	D
HOMESTEAD 24	S. Carolina	1	Warm humid	Largest H in Guadeloupe	Deep oblate	Green	Medium	Good	D
HOMESTEAD 61	S. Carolina	1	Warm humid	Medium large	Deep oblate	Green	Medium	Good	D
HOMESTEAD 500	S. Carolina	1	Warm humid	Medium large	Deep oblate	Green	Medium	Good	D
HOMESTEAD ELITE	S. Carolina	1	Warm humid	Medium large	Deep oblate	Green	Medium	Good	D
HOTSET	Texas	1	Hot	Small	Globe	Green	Large	—	I
IMMOKALEE	Florida	1	Warm humid	Medium large	Globe	Green	Medium	Good	D
INDIANRIVER	Florida	1	Warm humid	Medium large	Globe	Green	Large	Good	I
KAKI	France	3	Dry	Large	Globe	Green	Large	Good	I
KOLEA/C	Hawaii	1	Warm humid	Medium	Deep globe	Uniform	Medium	Medium	D
LA BONITA	Texas	1	Warm humid	Small	Plum	Uniform	Compact	Good	D
LAFAYETTE	Indiana	1	General	Small	Plum	Uniform	Compact	Excellent	D
LA PINTA	Texas	1	Warm	Medium	Globe	Uniform	—	—	D
MANALUCIE	Florida	1	Warm humid	Large	Deep globe	Green	Large	Good	I
MANAPAL	Florida	1	Warm humid	Medium large	Globe	Green	Large	Good	I
MARGLOBE	U.S.A.	3	—	Medium large	Globe	Green	Large	Fair	I
MARION	S. Carolina	1	Warm humid	Medium	Deep oblate	Green	Large	Good	I
MARMANDE	France	3	Cool	Medium small	Oblate rough	Green	Medium	Fair	I
MARMANDE VR	Canada	3	Cool	Medium small	Oblate rough	Green	Medium	Fair	I
MARS	New Jersey	1	General	Small	Globe	Green	Small compact	Reduced	D
MARSOL	France	2	Cool	Medium small	Oblate rough	Green	Medium	Fair	I
MERIT	Maryland	3	General	Small	Globe	Uniform	Small	Poor	D
MONEYMAKER	England	1	General	Small	Globe	Uniform	Large	Good	I
MONITA	France	1	General	Small	Globe	Uniform	Large	Good	I
MONTE GRANDE	Texas	1	Warm humid	Medium large	Deep oblate	Green	Medium	Good	D
NAPOLI	U.S.A.	1	General	Small	Pear	Uniform	Medium	Good	D

TABLE 1 (contd)

VARIETIES	Origin	List	Climatic Adaptation	Fruit Size	Fruit Shape	Shoulder Color	Plant	Foliage Cover	Growth D=Determinate I=Indeterminate
NEMATEX	Texas	1	Warm humid	Medium small	Deep oblate	Green	Compact	Excellent	D
OXHEART	Texas	3		Large	Heart	Green	Large	Good	I
PELICAN	Louisiana	1	Warm humid	Large	Deep oblate	Green	Large	Good	I
PIERALBO	France	3	Dry	Large	Globe	Green	Large	Good	I
PIERALINE	France	2		Large	Globe	Green	Large	Good	I
PIERNITA	France	2	Dry	Large	Globe	Green	Large	Good	I
PIERSOL	France	2	Dry	Large	Globe	Green	Large	Good	I
PIERVIL	France	2	Dry	Large	Globe	Green	Large	Good	I
PINKDEAL	Texas	1	Warm humid	Medium	Globe	Uniform	Medium	Good	D
POTOMAC	Maryland	1	Warm humid	Small	Long	Uniform	Small	Reduced	D
PRIMABEL	France	3	Cool	Small	Globe	Uniform	Small	Reduced	D
PRITCHARD	U.S.A.	3		Medium large	Globe	Green	Large	Good	D
PRITCHARD VF	U.S.A.	3		Medium large	Globe	Green	Large	Good	D
RAF	France	2	Cool	Medium small	Oblate rough	Green	Medium	Fair	D
RED JACKET	New York	3	Cool	Large	Deep oblate	Uniform	Medium	Medium	I
RED JACKET VR	Canada	3	Cool	Large	Deep oblate	Uniform	Medium	Medium	I
RED ROCK	Maryland	1	Warm humid	Medium small	Deep globe	Uniform	Small	Intermediate	D
ROMA	Maryland	1	General	Small	Pear	Uniform	Large	Good	D
ROMA VF	California	1	General	Small	Pear	Uniform	Large	Good	D
RONITA		1	General	Small	Pear	Uniform	Large	Good	D
ROSSOL	France	1	General	Small	Pear	Uniform	Large	Good	D
ROYALACE VF	California	3	Dry	Large	Deep oblate	Uniform	Large	Good	D
RUTGERS	New Jersey	3		Large	Globe	Green	Large	Good	I
SAINT PIERRE	France	3	Dry	Large	Globe	Green	Large	Good	I
SAN MARZANO	Italy	1	General	Small	Long	Green	Medium	Good	I
SAN MARZANO VR		1	General	Small	Long	Green	Medium	Good	I
SATURN	N. Carolina	2	Warm humid	Medium large	Deep oblate	Green	Large	Good	I
STAKELESS	Delaware	2	General	Medium large	Deep oblate	Uniform	Dwarf	Excellent	D
SUMMERTIME	Texas	1	Warm humid	Small	Oblate	Green	Compact	Good	D
TROPIC	Florida	1	Warm humid	V. large	Globe	Green	Large	Good	I
TROPIGRO	Florida	1	Warm humid	Medium large	Deep oblate	Green	Medium	Good	D
TROPIRED	Florida	1	Warm humid	Medium	Deep oblate	Green	Medium	Good	D
VENDOR	Ontario	1	General	Medium	Deep oblate	Uniform	Large	Good	I
VENTURA		1	General	Small	Pear	Uniform	Compact	Fair	D
VENUS	N. Carolina	1	Warm humid	Medium large	Deep oblate	Green	Large	Good	I
VF145 (Many lines)	California	2	Dry	Medium small	Globe	Green or uniform	Medium to small	Rolled	D
VFN 8	California	2	Dry	Medium large	Deep oblate	Uniform	Short	Medium	D
VFN BUSH	California	2	Dry	Large	Deep oblate	Green	Compact	Good	D
WALTER	Florida	1	Warm humid	Large	Deep oblate	Green	Compact	Good	D
WEST VIRGINIA 63	W. Virginia	2	Humid	Medium large	Deep oblate	Uniform	Large	Good	I

TABLE 2 - VARIETAL REACTION TO DISEASES

R=Resistance observed by authors
r=Resistance reported by others

VARIETIES	Cladosporium L.M.	Fusarium race 1 F.W.1	Fusarium race 2 F.W.2	Meloidogyne Nem.	Phythophthora L.B.	Pseudomonas B.W.	Stemphylium G.L.S.	Verticillium V.W.	Remarks
ACE									Used for canning (juice)
ACE VR								r R	Ace type added resistance
ACE VF		r R						r R	Ace type added resistance
ANAHU		r R		r R			r R		Very susceptible to leaf mold
ARC		r					r	r	Mechanical harvest type
ATKINSON		r		r			r R		Rutgers type disease resistant
BUSH VFN		r		r				r	Multiple disease resistance
CALACE		r						r	Ace type added resistance
CAMPBELL 17		r						r	Crack resistant
CAMPBELL 19		r						r	Not so productive in Guadeloupe
CAMPBELL 28		r					R		Crack resistant
CAMPBELL 1327		r R						r R	Crack resistant
CASAQUE ROUGE									Potato leaf
CHEF		r					r	r	Jointless mechanical harvestable
CHICO		r					r		Irregular fruits more disease resistance than Roma
CHICO III		r					r R		Chico type. Machine harvestable
CHICO GRANDE		r					r		Chico type larger
CHICO REX		r					r		Chico type larger
CLAIRVIL							r R		Eclaireur type more disease resistant
COLDSET							r R		Sets well under extreme temperature
CRA 74		r R	r R			r R	r R		Productive in Guadeloupe
EASTERN STATES 24		r					R		Firm
EASTERN STATES 58		r					r R		Firm
ECLAIREUR									Crack resistant
EL MONTE		r					r		Homestead type added resistance
FIREBALL									Early
FLORADEL	r R	r R					r R		Very popular variety in W.I.
FLORALOU	r R	r R					r R		Smaller than Floradel
FLORIDA MH 1	(r) S	r R	r R				r R	(r) S	Jointless, machine harvest fresh market
GULF STATE MARKET									Mature fruit pink
HEINZ 1350		r R						r R	
HEINZ 1370		r R					r R		Firm, crack resistant
HEINZ 1409		r					r R		Firm, crack resistant
HENIZ 1439		r					R	r	Firm, crack resistant
HEINZ 1546		r					Het		Firm, crack resistant
HOMESTEAD 24		r							Fresh market for ground culture
HOMESTEAD 61		r							Fresh market for ground culture
HOMESTEAD 500		r							Possibly more productive than regular Homestead
HOMESTEAD ELITE		r							Fresh market for ground culture
HOTSET		r R							Old variety
IMMOKALEE		r					r		Shorter than Homestead more disease resistent
INDIAN RIVER	r R	r					r R		Smaller than Floradel
KAKI									Saint Pierre type
KOLEA C		r		r R			r		Disease resistant
LA BONITA		r					r		Machine harvestable
LA FAYETTE		r						r	Machine harvestable, crack resistant
LA PINTA		r					r		Mature fruits pink
MANALUCIE	r R	r R					r R		Late
MANAPAL	r R	r R					r R		Late, productive
MARGLOBE									Late
MARION		r R					r R		Resist to early blight in S. Carolina
MARMANDE									Extra early, good shipper
MARMANDE VR								r R	Marmande type, more disease resistant
MARS		r					r	r	Mechanical harvest type
MARSOL		r R		r R				r R	Marmande type disease resistant
MERIT		r						r	Very firm, jointless mechanical harvest poor yield
MONEYMAKER									Old variety
MONITA				r R					Moneymaker type
MONTE GRANDE		r					r		Similar to El Monte. Larger than Roma
NAPOLI		r						r	Roma type

TABLE 2 (contd)

VARIETIES	Cladosporium L.M.	Fusarium race 1 F.W.1	Fusarium race 2 F.W.2	Meloidogyne Nem	Phythophthora L.B.	Pseudomonas B.W.	Stemphylium G.L.S.	Verticillium V.W.	Remarks
NEMATEX		r		r			r R		Soft, productive
OXHEART									Old variety
PELICAN		r		r			R		Crack and disease resistant
PIERALBO								r R	S. Pierre type added resistant
PIERALINE					r R			r R	S. Pierre type added resistance
PIERNITA				r R					S. Pierre type added resistance
PIERSOL		r R		r R				r R	S. Pierre type added resistance
PIERVIL		r R							S. Pierre type added resistance
PINKDEAL		(r) S							Very crack resistant
POTOMAC		r					r R	r	Mechanical harvest type poor color
PRIMABEL									Early
PRITCHARD									Old variety
PRITCHARD VF		r						r	Disease resistant, Pritchard type
RAF		r							Marmande type, disease resistant
RED JACKET									Potato leaf
RED JACKET VR								r	Red jacket type
RED ROCK		r					r R	r	Jointless, crack resistant. Mechanical harvest
ROMA		r R							Blossom end, root susceptible
ROMA VF		r R					r R		Roma type, added resistance
RONITA		r R		r R					Roma type, added resistance
ROSSOL		r R		r R				r R	Roma type, disease resistant
ROYAL ACE VF		r						r	Ace type disease resistant
RUTGERS		r							Late old varieties
SAINT PIERRE									Late old varieties
SAN MARZANO									Not for fresh market, paste type
SAN MARZANO VR									San Marzano type, added resistance
SATURN		r R	R			r R	R		Less productive, larger than Venus
STAKELESS		r							Potato leaf type
SUMMERTIME							R		Sets well at high temperature
TROPIC		r					r R	r	Excellent quality
TROPIGRO		r					r R	r	Comparable to Homestead, more disease resistant
TROPIRED		r					r R	r	More productive and disease resistant than Homestead in Guadeloupe
VENDOR	r								
VENTURA		r							Early machine harvest type
VENUS		r R	R			r R	R		Poor set under adverse conditions butdisease resistant
VF 145		r						r	Mechanical harvest type for peeled tomatoes, regular producer
VFN 8		r R		r R			Het	r R	Very susceptible to leaf mold resistant to 3 diseases
VFN BUSH		r		r				r	Multiple disease resistance
WALTER		r R	r R				r		Multiple disease resistance comparable to Homestead
WEST VIRGINIA 63		(r) S			r R			r R	Disease resistant.

FUNGI ASSOCIATED WITH DETERIORATION OF ACKEE (*Blighia sapida* L.) IN JAMAICA

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INTRODUCTION

The ackee, (*Blighia sapida*), besides being the national fruit of Jamaica, is a major component of one of Jamaica's favourite dishes. Because of seasonality of production and a high demand both locally and by Jamaicans abroad, the food processing industry has developed methods for canning the ackee.

The edible portion of the ackee fruit is botanically known as the aril - a cream-coloured mass of succulent tissue that is attached to the seed.

For marketing as a fresh vegetable, the ackee pods are allowed to open on the tree and the opened pods are harvested individually. For the processing industry, however, because of the large quantity required at any one time and the extreme susceptibility of the aril to deterioration the harvesting procedure has been modified. Fruits for processing are harvested by vigorously shaking the branches of laden trees to dislodge the fruits. The fallen fruits are then collected and delivered to the processing plant some 24 to 48 hours after harvest. By this method, fruits in various stages of maturity are harvested and, in addition the pods generally are badly bruised.

In the processing plant, unopened fruits are placed on racks to allow the maturation process to continue and from these, fruits are collected for processing when they open.

With this procedure, it is estimated that losses of about 40-60% occur. These losses are due either to the failure of the pods to open owing to immaturity or excessive dehydration, and to rots caused by pathogenic micro-organisms.

The primary objectives of this study were to identify the micro-organisms associated with deterioration of the ackee fruits and to extend the shelf-life of the fruits by suppressing the development of micro-organisms and reducing the rate of dehydration of the pods.

MATERIALS AND METHODS

Most of the ackee fruits used in this study were obtained from the processing plant, Frozen Foods (Jamaica) Ltd. However, the fruits used in pathogenicity tests were carefully harvested individually from trees on the University Campus.

Fruits obtained from the processing plant on different occasions were examined individually and classified into the following groups on the basis of symptoms - healthy, soft white rots, soft brown rots and other lesions.

Several specimens were selected from each of these groups and repeated isolations were made both from the pods and decaying arils. Isolations were made both from pods and decaying arils. Isolations were made on potato dextrose agar (PDA) mainly, with or without lactic acid, in an effort to selectively isolate fungi and bacteria. Some isolations for bacteria also were made on nutrient agar. Pathogenicity tests were carried out with all the isolated micro-organisms on individual pods and arils that were either wounded with a sterile needle or undamaged. Inoculated pods were enclosed in polyethylene bags for 48 hours after which they were left on the laboratory bench for a further period of 1-4 days before being assessed.

Rate of maceration of arils by fungi: Mature, unopened ackees were carefully harvested from a single tree, surface disinfested with sodium hypochlorite or 70% ethanol and the arils plus seeds removed under asceptic conditions. Arils were dipped either in sterile distilled water or a standardised spore suspension obtained from a particular fungus and then placed in sterile wide-mouthed flasks. Each treatment contained three arils and there were two replicates. Data on the extent of maceration were obtained at 24, 48, 72 and 96 hr. after inoculation. After removing the seeds, the arils were weighed, washed to remove macerated tissue, blot-dried and again weighed.

Fungicide treatments: The fungicides used were benomyl (methyl 1-butyl carbamoyl)-2-benzimidazole carbamate, thiabendazole (2-(4-thiazolyl) benzimidazole), dicloran (2,6 dichloro nitrol aniline) and sodium hypochlorite. Pods (10 or 25 per treatment) were dipped in each fungicide suspension or hot water for a particular period. Observations were made on the incidence of pod rot and opening of pods at various times.

RESULTS

Frequency of occurrence of various symptoms: From one sample of 365 fruits randomly selected from a batch of fruits obtained from the processing plant, 51% showed brown, soft rot symptoms attributable to *Botryodiplodia theobromae*, 4% showed other brown lesions and 41% apparently were healthy.

Isolations from diseased pods and arils: Repeated isolations from the soft, decaying arils revealed the presence of two unidentified bacteria. One isolate produced whitish colonies whereas the other produced yellow colonies on potato dextrose agar.

A number of fungi were isolated from decaying arils and pods from miscellaneous brown lesions on the pods. *R. nigricans* was repeatedly isolated from pods which showed symptoms of white soft rot, and *B. theobromae* similarly was obtained from pods which showed symptoms of brown soft rot. Other fungi, which were associated with miscellaneous brown lesions included Gloeosporium sp., Pestallotia sp., Phomopsis sp. and Fusarium spp. B. theobromae and R. nigricans also were isolated from decaying arils.

Pathogenicity tests and symptom development: Pathogenicity tests on healthy wounded arils indicated that neither bacterial isolate was pathogenic. However, all the fungi isolated were able to infect both wounded pods and arils but the rate of infection varied appreciably. The Fusarium species, Phomopsis, Gloeosporium, and Pestallotia all caused firm dark brown lesions which developed slowly on the pods. The lesions produced by these fungi were indistinguishable except in the case of Pestallotia which produced lesions that were noticeably sunken. In contrast, B. theobromae produced a rapidly spreading brown lesion which was fairly soft and R. nigricans produced a soft white rot which spread with extreme rapidity.

When unwounded pods were inoculated with spore suspension of the different fungi, only B. theobromae caused infection. Within five days all of 10 inoculated pods were infected and had an average of 55% of the pod surface rotten. All arils were partially macerated. Some 59% of the lesions originated from the attached end of the pod, 29% from the stylar end and 12% from other areas of the pods.

Aril maceration by fungi: All seven isolated fungi were shown to macerate the ackee arils converting them into soft, mushy masses of tissue. R. nigricans was the most prolific. Within 24 hr. after inoculation it had macerated 19% of the aril tissue compared to 0-4% by the other fungi, and by 48 hr. maceration had increased to 92% compared to 5 - 15% by the other fungi. B. theobromae was nearly as prolific except for a slower start and between 48 and 72 hr. after inoculation maceration by this fungus had accelerated from 15 to 82%. The other fungi were somewhat slower and after 96 hr. 81, 79, 72, 61 and 52% of the tissues were macerated by Fusarium (salmon), Gloeosporium, Phomopsis, Pestallotia and Fusarium (red), respectively. The controls remained virtually unaltered during the test.

Effect of fungicides and other treatments on pod rot and pod opening: The results of these treatments are summarised in Tables 1, 2 and 3. In Table 1, all treatments except thiabendazole and cold water were better in suppressing pod rots within four days but by seven days only the hot water treatment was markedly different. Although effective in suppressing pod rot the hot water treatment caused a brown scorch of the pods.

In Table 2, dicloran, benomyl and sodium hypochlorite significantly reduced pod rot at both 4 and 7 days in one lot of pods but in a second lot, neither sodium hypochlorite nor a benomyl plus dicloran mixture was effective. In addition, the ability of the fungicides to suppress pod rot was greatly reduced when treated pods were kept in sealed polyethylene bags. Pods that were enclosed in polyethylene bags were quite fresh after 7 days whereas those kept on open trays were fairly dehydrated and shrivelled. But enclosure in polyethylene bad greatly suppressed pod opening.

This feature again is evident in Table 3 in which 30% of the pods opened after 7 days when kept in sealed polyethylene bags as compared to 80, 80 and 95% when they were kept in open trays with or without periodic spraying with water, or in perforated polyethylene bags, respectively.

In one trial in which carefully harvested undamaged pods were kept in the laboratory for 10 days, rots developed on only 4% of the pods and all pods were either fully or partially opened within this period. The pods, however, were fairly well dehydrated and it is likely that this prevented them from opening fully.

TABLE 1. Influence of various fungicides on percentage pod rot (A) and percentage of open ackee pods (B) after 4 or 7 days when kept on open trays in the laboratory (Av. of two reps.)

TREATMENT	% POD ROT AND OPEN PODS			
	4 days		7 days	
	A	B	A	B
1. Hot water (56°C/10 min.)	0	18	18	52
2. Benomyl (500 ppm/3 min.)	2	32	56	46
3. Thiabenazole (500 ppm/3 min.)	8	46	56	74
4. Dicloran (1000 ppm/1 min.)	0	24	50	58
5. 2 plus 4 (3 min.)	4	26	50	56
6. 3 plus 4 (3 min.)	2	28	40	68
7. Sodium hypochlorite (0.26% 10 min.)	4	52	36	70
8. Tap water (5 min.)	16	28	56	32
9. Control (no treatment)	8	12	64	12

TABLE 2. Influence of various fungicides on percentage pod rot (A) and percentage of open ackee pods (b) after 4 or 7 days when kept either on open trays or enclosed in polyethelene bags in the laboratory (Av. of two reps.)

TREATMENTS	% POD ROT AND OPEN PODS							
	OPEN TRAY				SEALED BAGS			
	4 days		7 days		4 days		7 days	
	A	B	A	B	A	B	A	B
(i) Dicloran	8	96	8	98	8	30	78	42
Benomyl	8	92	10	98	8	18	92	30
Sodium hypochlorite	4	98	4	100	2	4	80	8
Control	20	92	22	98	20	44	64	60
(ii)Sodium hypochlorite	35	55	75	100	30	30	85	30
Benomyl + Dicloran	15	25	70	100	10	10	75	10
Control	25	45	65	100	0	0	50	0

(i) and (ii) represent lots of fruits received on two different days. Rate and duration of treatments as shown in Table I.

TABLE 3. Influence of benomyl and various subsequent treatments on percentage of open ackee pods (B).

TREATMENTS (i)	% POD ROT AND OPEN PODS				
	4 days		7 days		
	A	B	A	B	B
Open tray	10	60	20	80	
Open tray + water spray (ii)	10	70	10	80	
Enclosed in perforated plastic bags	15	80	15	95	
Enclosed in sealed plastic bags	10	20	50	30	

(i) All treatments previously dipped in benomyl at rate and duration as in Table I; (ii) water was sprayed twice daily.

DISCUSSION

It is clear that fungi are the main micro-organisms responsible for the deterioration of ackees. Isolated bacteria were non-pathogenic whereas all fungi isolated were able to infect wounded ackee pods and macerate the arils. *B. theobromae* was the fungus of most importance owing to the frequency of its occurrence, its ability to infect unwounded pods and the rapidity with which infection progressed. Another fungus of major importance was *R. nigricans* again because of its rapid infection rate and its ability to sporulate quickly and profusely. This fungus apparently is unable to infect undamaged pods but because of the method of harvesting, numerous wounds generally are produced on the fruits and these provide ready avenues of ingress for the pathogenic micro-organisms.

The inconsistency in the performance of the fungicide treatments may be largely attributable to variability in the stages of infection at time of treatment. It appears, therefore, that for effective control of pod rots a harvesting method which would greatly reduce pod damage would have to be developed. This, either alone or in association with a fungicide dip (sodium hypochlorite or benomyl) applied immediately after harvest, should result in effective control. In addition, it seems that measures to reduce the rate of dehydration of the pods, possibly by periodic misting, also would be beneficial but since high humidity would favour the development of micro-organisms a carefully balanced system would have to be worked out.

The suppression of pod opening by complete enclosure in polyethylene bags is noteworthy. This may be due to a build-up of carbon dioxide or some other volatile chemical in the immediate environment of the pods and suggests that complete enclosure should be avoided.

Acknowledgements. The writer wishes to thank Technical Assistant Miss L. Murray and other members of staff for assistance with this project. This study was undertaken at the request Of Jamaica Frozen Foods Ltd. who supplied most of the ackee used in the experiments.

PROLONGATION OF THE STORAGE LIFE OF BREADFRUITS

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INTRODUCTION

Breadfruit (Atrocarpus communis, also A. altilis) is widely grown in the tropics as a source of carbohydrate. It has an extremely short storage life and is considered unpalatable as soon as it begins to get soft and sweet. This creates problems in marketing locally and makes exportation even by air unprofitable.

Reported methods of preservation of the fruit are by fermentation (Barrau 1957) and drying (Peters and Wills 1956, and Barrau 1956) but information on the storage of the fresh whole fruit is non-existent. The fruit has a high respiratory rate reaching a climacteric peak of above 3ml CO_2 per kg/h at 20°C 5 days after harvest (Biale and Barcus 1970). The problem therefore is to prolong the post-harvest pre-climacteric stage and delay the onset of the cliacteric stage and its associated accumulation of soluble solids and softening, yet maintain the fruit in its fresh, firm and green state.

This paper describes experiments which were carried out in order to determine the length of the storage life of the fruit and the effects of treatments which have been shown to extend the pre-climacteric of other climacteric fruits.

MATERIALS AND METHODS

Fruits used in these experiments were, except in one case, harvested by a climber who used a forked stick to break their stalks causing them to fall. They were not allowed to fall to the ground but were caught and placed in cartons which had 9 cubicles formed by cardboard separators. The fruits were next packed around with newspaper to prevent bruising during transportation.

Except where stated all the fruits used were mature. A mature breadfruit (cooked by roasting) as compared with a younger one (cooked by boiling) is darker green in skin colour, with a light browning and a lack of lustre. It is generally larger in size. The two most common varieties, Yellowheart and Whiteheart fruits, were used.

Experiment 1.

Ten mature and ten younger fruits were stored under one of the following conditions:-

1) 27.7°C and 85 - 94% RH.
2) 12.0°C and 61 - 75% RH.
3) 7.0°C and 61 - 75% RH.

The weight-loss of 5 fruits from each stage was also determined.

Experiment 2.

One of 6 groups each consisting of 10 Yellowheart fruits was allocated to one of the following treatments and then stored at 12.0oC and 91 - 98% RH:-

1) Unwrapped.
2) Wrapped individually in newspaper.
3) Stored individually in 75x46 cm x 150 gauge polyethylene bags which were then tied.
4) Stored individually in polyethylene bags perforated with 16x6mm diameter holes.
5) Stored in moist coir dust.
6) Stored in a 200 L capacity plastic bin of tap water. The fruits were only partially submerged as they floated.

Experiment 3.

Twenty Yellowheart fruits were left unwrapped and another 20 were placed individually in polyethylene bags. Ten from each treatment were stored at 24.5oC and 56 - 80% RH. and the others at 12.5°C and 92 - 98% RH.

Experiment 4.

Twenty Yellowheart fruits were harvested by the method mentioned earlier and then packed in cartons. Another 20 were allowed to fall to the ground and then packed in hessian bags for transportation.

While in storage the general condition of the fruits was observed daily and their firmness assessed by feeling. Frequent recordings of their fresh weight were also made. At the earliest perception of softening the fruits were regarded as being unmarketable and were therefore removed from storage, On removal they were weighed, ph level measured, their firmness and soluble solids content determined by the use of a Magness Taylor penetrometer and a pocket refractometer respectively. In certain cases the CO_2 content of the polyethylene bags was measured with a Daeger Multigas Detector. The experimental designs were factorial or randomized blocks and the data obtained were calculated mainly by the statistical analysis of variance method.

Results.

The results showed that temperature, unperforated polyethylene bags and a combination of both were most significant in prolonging the storage life of the breadfruit.

Temperature

Storage at 24 - 28°C resulted in the complete softening of fruits within 2 - 4 days while at 12.5°C they softened in 8.3 days. At 7°C softening was greatly delayed and when, either because of prolonged storage or transfer to ambient, ripening eventually began it was irregular and abnormal. The skin colour changed from green to dull brown after 2 or 3 days' storage, softening occurred in patches and the pulp was discoloured.

Fruits stored at low temperatures lost less weight than storage at ambient.

At 28.5°C no soluble solids were found during the first 2 - 3 days but after 3 - 4 days when softening started levels up to 15% accumulated. At 12.5°C soluble solids were rapidly accumulated on return to ambient but at 7°C very little soluble solids accumulated even on transfer to ambient conditions.

Packing

Breadfruit wrapped in newspaper as compared to unwrapped fruits showed no significant differences in weightloss or the number of days to softening. Moist coir dust and polyethylene bags whether perforated or whole resulted in very little weight-loss. Whole polyethylene bags significantly extended the storage life at both high and low temperature. At 24.5°C the extension was from 2.8 to 14.1 days and at 12.5°C from 8.3 to a maximum of 21.5 days (Tables 3 & 4). During storage these fruits retained their fresh green appearance and when they eventually ripened they did so normally. Storage in water prolonged the storage life significantly (Table 3) but after approximately a week in storage the fruits had absorbed so much water (0.9% weight gain per day) that they started to split exposing the mesocarp. After splitting that area got very soft and started to disintegrate.

Maturity

The number of days to softening of the two maturities used did not vary significantly even at different temperatures (Table 1). However, the dry matter contents were significantly different (Table 2).

Fruits which were caught did not prove to have a longer storage life than those which were allowed to fall to the ground.

Microbial Infections

Fungal and bacterial infection were very rare and when seen were limited to very ripe fruits where the tissue structure had broken down.

DISCUSSION

Softening of the breadfruit appears to be associated with the accumulation of soluble solids, a process which normally accompanies the ripening of climacteric fruits eg. bananas (Barnell 1941). Unlike all other fruits breadfruits are utilized as a starchy food and are therefore only marketable during the short period between maturity and the onset of the starch to sugar conversion and softening.

Although the data showed that there are no significant differences in the number of days to softening between the two maturities, other unpublished data showed that there is a difference in the soluble solids content of both (mature 15 - 23% and young 9 - 12.5%) and that an intermediate stage was capable of storage for 12 - 13 days at 20 - 22°C. This data also confirmed the fact that the 2 stages above had approximately the same shelf-life.

Reduced temperatures slowed respiration and the ripening processes as in other fruits and like many other tropical fruits (Biale and Young 1962) breadfruits stored below 12.5°C showed physiological and anatomical abnormalities which are associated with chilling injuries.

Polyethylene bags caused a delay in the onset of softening and a reduction in weight-loss which are understandable. These bags are semi-permeable to O_2 and CO_2. During storage the proportion of each gas changes because of respiration and diffusion resulting in a CO_2 rich environment which slows down respiration and leads to a longer storage life. Thompson et al, 1973, noted that plantains ripened much slower at high humidities than low humidities. The humidities in polyethylene bags containing breadfruits quickly rose to 100%.

The prolongation obtained by storage in water may also be due to inhibition of gas exchange and of water loss.

Harvesting by the traditional method of allowing fruits to drop to the ground had no detectable effect on the length of storage life. This seems surprising as the height of fall was in excess of 6m but is encouraging as other methods would prove to be practically difficult as trees are commonly 15 to 20m tall.

It was surprising that no significant differences was observed in the storage life of young and mature breadfruits (Table 1). Unpublished observation indicate that fruits intermediate in development between these 2 gnades have a longer storage life than either. If, therefore, this stage of development can be identified it is possible that the storage life of breadfruit can be further extended.

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TABLE 1. Effects of temperature and stage of maturity on the number of days for breadfruit to soften after harvest.

Temperature	Mature	Young	Mean	C.V.%
28	3.3	3.4	3.4C	
12	5.2	5.6	5.4B	
7	8.4	9.2	8.8A	
Mean	5.6A	6.1A		5.9

Figures followed by the same letter were not significantly different (P=0.05) and are read separately for each mean.

TABLE 2. Effects of storage conditions and stage of maturity on the mean of dry matter content of breadfruits.

Days in storage	Temperature °C	Mature	Young	Mean	C.V.%
0		32.6A	31.7A	-	3.7
4	28	34.1	32.1	33.1B	
8	12	33.0	31.5	32.3B	
10	7	36.0	32.0	34.0A	
Mean		34.4A	31.9B		2.2

Figures followed by the same letter were not significantly different (P=0.05) and are read separately for each mean.

TABLE 3. Effects of packing treatment on the length of storage life and other parameters.

Treatment	Soluble solids %	Firmness (kg./cm²) skin	flesh	Dry matter %	Days to softening (mean)
Unwrapped	18.8A	61AB	5.6AB	31.4A	10.4BC
Newspaper	17.4A	62AB	4.3AB	27.5A	8.5C
*Polyethylene	17.1A	78A	8.6A	28.2A	17.7A
Perforated polyethylene	16.1A	64AB	2.8C	28.5A	9.1C
Coir dust	19.0A	77A	4.2BC	27.3A	11.8B
*Water	7.0B	48B	8.9A	23.1B	16.7A
C.V.%	12.0	8.6	30.8	2.9	18.8

*Polyethylene and water treatments were analysed after 19 days storage. Other treatments after 15 days.

Figures followed by the same letter were not significantly different (P=0.05) and are read vertically.

TABLE 4. Effects of packing treatment and temperature on the no. of days to softening.

Storage temperature	Packing treatment	Mean no. of days to softening
24.5°C	Unwrapped	2.8
	Polyethylene	14.1
Mean		8.5*
13.0°C	Unwrapped	8.3
	Polyethylene	21.5
Mean		14.9

*Effect of temperature significant at P=0.001 level

Effect of polyethylene significant at P=0.05 level.

TABLE 5. Effects of packing and temperature on the mean % weight-loss during storage.

Days from harvest	Storage temp. °C	Unwrapped	Polyethylene bags	Mean
3	24.5	3.9	0.2	2.0
	13.0	1.1	0.1	0.6
	Mean	2.5	0.2	
7	24.5	12.6	1.9	7.3
	13.0	3.9	0.3	2.1
	Mean	8.2	1.1	
12	24.5	-	3.2	-
	13.0	7.9	0.8	4.3
	Mean	-	2.0	
16	24.5	-	4.7	-
	13.0	-	1.3	-
		-	3.0	-

TABLE 6. Effects of harvesting and transportation methods on weight-loss and softening.

Treatment	% weight-loss (day 13)	% of soft fruits (day 9)
caught	10.9	86
dropped	10.6	93

SOME NUTRITIONAL ASPECTS OF BUNCHY TOP DISEASE OF PAPAYA (CARICA PAPAYA)

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INTRODUCTION

Bunchy top disease of papaya is widespread in the Caribbean and is an important limiting factor in the commercial production of papaya in many islands. It has been recorded in Trinidad and Tobago, Grenada, St. Vincent, Antigua, Montserrat, and St. Kitts (Phelps and Haque, 1968) and Cuba (Acuna and De Zayas, 1946) and in Jamaica and Haiti (Martorell and Adsuar, 1952).

Originally described as a virus disease (Bird and Adsuar, 1952) it is now thought to be caused by a mycoplasmal agent. Storey and Halliwell (1969) reported the presence of allipsoidal mycoplasma-like bodies 700 - 800 mu long in phloem parenchyma tissue of infected plants in Dominican Republic. Mycoplasmal-like bodies have also been observed in infected tissue from Trinidad (Kenten and Haque, 1973). In common with many mycoplasmal type diseases transmission has been found to occur via leaf hoppers. Sein and Adsuar identified Empoasca papayae as the vector in Puerto Rico (Sein and Adsuar, 1947). More recently Empoasca stevensii has been identified as a vector in Trinidad (Haque and Parasram, 1973). Direct mechanical transmission appears successful and the disease is probably not seed borne.

The earliest symptom of infection is the appearance of 'oil spots' on the stem and petioles. These spots, of variable shape and size, appear to be caused by water soaked tissue, and have so far always been found where bunchy top infection is present solo papaya and in many local Trinidad types. They are no proof of bunchy top infection however, since such areas can arise from other causes. Leaf symptoms then appear, the younger immature leaves of the crown becoming membranous in places at their margins and chlorotic in patches throughout the lamina. Recently matured leaves are also affected, not expanding normally and becoming curled and brittle and giving, together with the shortening of the internodes close to the apex and the drooping of the petioles, the bunchy topped' appearance characteristic of infected plants. These older leaves also loose chlorophyll in irregular patches giving rise to blotchy yellow green patches, between dark green areas. Eventually the main growing point dies completely and the tree may send out new lateral shoots from lower down the trunk. These too often become infected. The rate of movement of the disease down the stem is apparently quite slow (Bird and Adsuar, 1952). Quite frequently, bunchy top infected plants become infected with virus diseases, such as mosaic, making identification more complicated.

Apart from the visual effects described above, physiological effects have also been described. Storey et al (1968) reported higher concentrations of several micronutrients in the tissues of infected plants, and the association of above - normal calcium levels in infected tissue reduced expression of the disease. Plants growing in high coraline soils were apparently less likely to suffer from the disease than those in soild low in coral material.

Storey and Halliwell also reported that soil drenches and root dipping of transplants with either acromycin or aureomycin produced complete remission of symptoms, and suggested this as a possible control measure. In general control measures have been directed at the insect vector and have been costly and only partially successful in many areas. Some selection and breading work has been done, notably in Puerto Rico (Singh-Dhaliwal, 1966) to develop types with improved resistance.

The present study was conducted in an effort to discover something of the psyiological effects associated with bunchy top disease. The similarity of some of its symptoms to nutrient imbalances and the present lack of general information on the physiological effects of mycoplasma caused plant disease (Hull (1971) suggested that this might be worth while.

MATERIALS AND METHODS

Five paired samples of one apparently healthy and one visibly diseased tree were selected from a 2.5 month old planting of Solo-sunrise papaya at the Univeristy of the West Indies Field Station. Paired trees were this growing under very similar environmental conditions and were of similar size. Trees were removed from the field for sampling of leaf, petiole and stem.tissue. Leaf and petiole sampling was commenced at the youngest node bearing a lead longer than 15 cms. and continued downwards for a 15 nodes.

The following data were obtained at sampling:

Length of leaf measure from the tip of the central longest lobe to insertion of the petiole.

Length of petiole.

Appearance of leaf and petiole.

Fresh and dry weights of leaf and petiole tissue were obtained subsequently. After grinding of dried samples, they were analysed for N, P, K, Ca and Mg according to the routine procedures of the U.W.I. Central Analytical Laboratory, St. Augustine. Only data for the N and Ca analyses will be reported in this paper.

RESULTS AND DISCUSSION

Leaf and Petiole Characteristics

It can be seen from Figure 1 that leaf length steadily increased in healthy plants up to node 5, thereafter leaf length remained more or less constant. The diseased leaves showed a reduced increase and considerably more irregularity in their length. Maximum stunting effect on expansion was evident for recently matured leaves.

Petiole elongation apparently continued longer than leaf expansion as can be seen from Fig. 2. where petiole lengths are plotted against node number. Healthy petioles increased in legth up to node 11 and after that decreased again, possibly also due to juvenile character still present in the trees at that stage. Diseased

Fig. 1

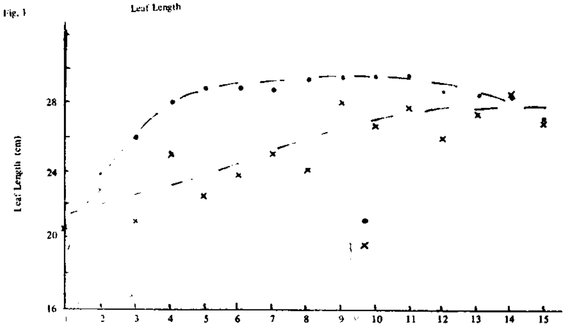


Fig. 3a

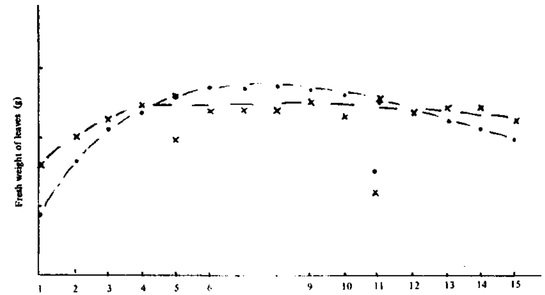


Fig. 2

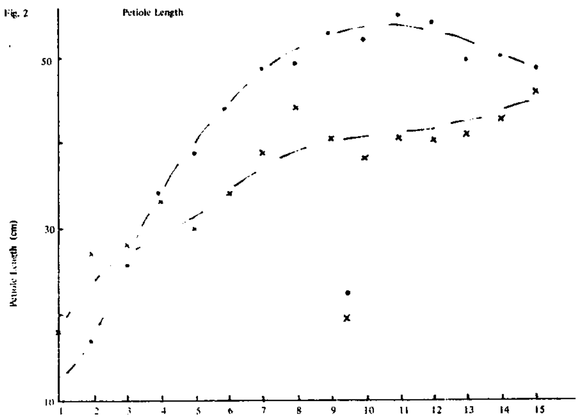
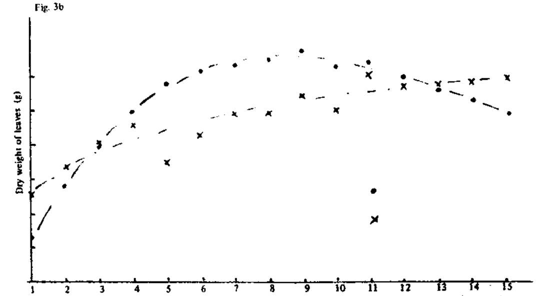


Fig. 3b



petioles also increased in length but showed a more erratic relationship to node number. Maximum effect of the disease appeared to occur at higher node number than with leaves.

Nutrient Data.

N contents of leaves and petioles are shown in Tables 1 and 2. N content in both healthy and diseased leaves decreased with age. A similar trend was evident in petioles, where N concentrations were less than half those found in the leaves. Mean N concentrations for healthy and diseased leaves were 5.23% and 4.88% respectively. The mean difference of 0.342% was not significantly different from zero at the 5% level. In petioles, N concentrations were higher in the diseased tissue by a mean differences of 1.09% which was significantly greater than zero at the 5% level.

The Ca data obtained can be seen in Tables 3 and 4. Ca content increased with age of both healthy and diseased leaves and petioles. Mean Ca levels were higher in diseased leaves and petioles but differences were not significant at the 5% level from healthy tissues.

The N levels from healthy tissue reported here show similar trends with age to those reported by Awada and Long (1969), but their N concentrations were generally lower in both petioles and leaves. Storey et all(1969) reported finding higher concentrations of N in diseased leaves of Solo papaya growing on coraline soil and the opposite relationship on non-coraline soild but did not indicate whether such differences were statistically significant. Increased N in the petioles and decreased levels in the leaves would be consistent with a disease induced blockage of N transport into the leaf. Failure of the removal of starch from diseased leaves could also suggest interference with normal transport processes, but other explanations are also possible.

The Ca data reported on here suggest, but do not prove higher Ca level in diseased tissue. The data of Storey et al (1968) indicate higher Ca in diseased tissue even though the generally higher Ca levels occurring in plants grown on coraline soils were linked with an apparent supression of symptoms in these plants. Storey et al suggest that the higher Ca levels may exert some protective action against the high Cu levels they observed in diseased tissue. Evidently more work is needed to unravel the interactions of Ca with the disease. The levels of Cu, Zn and Fe found in their healthy tissue were similar to those reported by Gonzalez et al (1972) for *Carica candamarcensis* L.

CONCLUSIONS

The results reported on here, and those of other workers point to a severe physiological disruption resulting from infection by the bunchy top mycoplasma. The disturbance of normal patterm of leaf and petiole expansion and of leaf fresh and dry weights has been observed. There are also concomitant disturbances in leaf and petiole nutrient levels. The present work can be considered only as a preliminary investigation but does suggest several aspects of the problem that might bear further investigation. Th e possible role of Ca in mitigating the expression of the disease would appear to be the most interesting.

TABLE 1. Nitrogen Content Of Leaves And Petioles As Function Of Node Number (% O.D.M.)*

NODE No.	LEAVES		PETIOLES	
	HEALTHY	DISEASED	HEALTHY	DISEASED
1	7.08	6.94	3.64	4.89
2	6.40	6.47	3.33	3.91
3	5.87	6.04	3.29	3.34
4	5.68	6.08	2.41	3.72
5	5.68	5.25	2.21	3.92
6	5.37	4.52	2.06	3.01
7	5.17	4.50	1.91	2.83
8	4.97	5.13	1.72	2.68
9	5.12	4.67	1.65	2.76
10	4.85	4.08	1.51	2.51
11	4.73	3.95	1.50	2.55
12	4.44	4.07	1.49	2.40
13	4.40	3.98	1.36	2.43
14	4.30	4.03	1.27	2.20
15	4.08	3.75	1.31	2.30

(*Means of 5 plants)

TABLE 2. Comparison Of Diseased/Healthy Pairs

PAIR No.	NITROGEN % O.D.M.					
	LEAVES			PETIOLES		
	1 HEALTHY*	2 DISEASED*	3 DIFFERENCE (1 - 2)	1 HEALTHY*	2 DISEASED*	3 DIFFERENCE (1 - 2)
1	4.950	4.917	+ .033	1.799	1.807	-0.008
2	5.324	4.534	+ .790	2.135	3.131	-0.996
3	5.435	5.507	+ .928	2.159	3.506	-1.347
4	5.216	5.821	- .605	2.007	2.952	-0.995
5	5.204	4.641	- .563	1.797	3.952	-2.155
Mean	5.226	4.884	+0.342+	1.979	3.070	-1.091+

+Not significant at 5% level

+Significant at the 5% level

(* Means of all nodes)

Table 3. Calcium Content of Leaves and Petioles as Function of Node Number (% ODM)

NODE No.	LEAVES HEALTHY*	LEAVES DISEASED*	PETIOLES HEALTHY*	PETIOLES DISEASED*
1	0.65	0.83	0.53	0.72
2	1.13	1.01	0.79	0.95
3	0.99	1.15	0.60	1.12
4	1.21	1.28	1.14	1.21
5	1.35	1.47	1.14	1.36
6	1.66	1.77	1.23	1.65
7	1.71	1.85	1.39	1.61
8	1.86	1.73	1.32	1.65
9	1.90	1.94	1.50	1.76
10	1.93	2.17	1.49	1.86
11	1.93	2.18	1.48	1.67
12	2.00	1.91	1.82	1.79
13	2.02	1.97	1.57	1.83
14	2.00	1.05	1.67	1.61
15	1.88	2.29	1.67	1.80

(* Means of 5 plants)

Table 4. Comparison of Diseased/Healthy Pairs

PAIR No.	CALCIUM % O.D.M. LEAVES 1 HEALTHY*	LEAVES 2 DISEASED*	LEAVES 3 DIFFERENCE (1 - 2)	PETIOLES 1 HEALTHY*	PETIOLES 2 DISEASED*	PETIOLES 3 DIFFERENCE (1 - 2)
1	1.175	2.073	-0.898	1.317	1.885	-0.557
2	1.489	1.395	+0.094	1.158	1.166	-0.008
3	1.576	1.629	-0.053	1.611	1.870	-0.259
4	2.349	1.751	+0.598	1.285	1.433	-0.149
5	1.407	1.464	-0.057	1.324	1.391	-0.067
Mean	1.599	1.662	-0.063+	1.341	1.549	-0.208+

+ Not significant at 5% level   + Not significant at 5% level

(* Means of all nodes)

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A PRELIMINARY REPORT ON OXAMYL FOR NEMATODE CONTROL IN TOMATO

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ABSTRACT

In a field experiment, the effect of Oxamyl (methyl N', N' - dimethyl - N - [(methyl - carbamoyl) oxy] - 1 - thiooxamimidate) for the control of four plant parasitic nematodes in tomato (Lycopersicorn esculentum Mill. "Floradel") was studied. Oxamyl at concentrations of 0, 1250, 2500, 5000 ppm active ingredients was first applied as a bare-root dip to four-week old seedlings and subsequently as a foliar spray at 10, 25 and 35 days after transplanting. Soil and root samples were taken for each experimental plot at one and two-months after transplanting. Helicotylenchus dihystera and Rotylenchulus reniformis were considerably reduced with 5000 ppm Oxamyl at one- and two-month soil sampling, whereas the 2500 and 5000 ppm rates were found to be effective in controlling Meloidogyne incognita only at the one-month sampling. Root sampling at one and two-month showed 2500 and 5000 ppm Oxamyl were more effective in controlling Pratylenchus zeae but only 5000 ppm level controlled Meloidogyne incognita. On the other hand, Helicotylenchus dihystera and Rotylenchulus reniformis were reduced at the 1250, 2500 and 5000 ppm levels.

STUDIES ON THE INTERCROPPING OF CORN AND SWEET POTATO

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Corn and sweet potato are often grown together in the Caribbean. Two experiments compared corn and sweet potato alone or in three combinations differing in spacing. Row distance was constant at 90 cm. and both crops were planted on ridges.

In a wet season trial, planted 25 May, intercropping with sweet potato reduced corn yields. This was due to both fewer and smaller cobs. Sweet potato yields were poor, and were reduced by the presence of corn. Tuber size decreased with increase in corn plant number. Corn alone had the highest gross value. In a dry season trial planted 15th November, yields were relatively low. Intercropping did not reduce corn yields but did reduce sweet potato yields. Gross value was again greatest for corn alone.

It is suggested that the sweet potato cv (049) is not suitable for intercropping and other cvs should be tested for this purpose.

Comparative Effects of Soluble and Controlled Release (Sulphur-Coated Urea) Nitrogen on Phosphorous, Potassium, Calcium and Magnesium uptake by Corn (Zea mays)

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INTRODUCTION

In a previous investigation on the efficiency of the soluble N sources (ammonium sulphate (AS), area ammonium phosphate (UAP) and urea) and controlled release N sources, sulphur-coated urea (SCU-18, SCU-102 and SCU-183) of differing N release rates applied at 50, 100, and 200 kg/ha of N to an acidic soil, it was shown that N uptake, grain yield and apparent N recovery by corn were increased in the order: SCU-183 - SCU-102 - SCU-18 = Urea - UAP = AS. This order of N efficiency was found to be generally opposite to the nitrification rates, that is, the N fertilizers with slower nitrification rates were more efficient sources of N except that the performance of urea was better than other soluble N sources primarily because it has a smaller effect on soul pH and exchangeable Al (Dalal, 1974).

In this paper, the effects of soluble and controlled release N sources on phosphorous, potassium, calcium and magnesium uptake by corn (*Zea mays*) are reported.

MATERIALS AND METHODS

Fertilizers: Sulphur -coated urea fertilizers were supplied by Dr. G.L. Terman of T.V.A., Alabama. SCU-18, SCU-102 and SCU-183 contained 25.0, 30.3 and 30.4 per cent N respectively and all three had 30 per cent sulphur-coating with 5, 3 and 3 per cent wax, respectively. SCU-18 and SCU-183 did not contain microbicide; SCU-102 had 0.5% microbicide as coal tar. Conditioner (1.5%) was added to the sulphur coatings of SCU-102 and SCU-183. The dissolution rates of SCU-18, SCU 102 and SCU-183 were 8.9, 1.1 and 0.9 per cent, respectively, in first 24 hours. AS, UAP and urea contained 20.5, 33.8 and 45.5 per cent N and were soluble sources of N. The nitrification rates, evaluated by incubation studies (Dalal, 1974) were in the order: AS = Urea - UAP - SCU-18 - SCU-102 = SCU-183.

Soil: The soil, Fluventic Eutropept, had the following physico-chemical properties: pH, 5.1; clay content, 16%; organic C, 0.90%; total N, 0.13%, CEC, 6.8 meq/100g.

Field experiment: The field experiment was conducted on River Estate loam at the University Field Station, St. Augustine, Trinidad. Corn (cv. X-306) was planted on 11 Sept. 1972 at a plant density of 49,380 plants/ha (45 cm x 45 cm) in six rows, 5.5 m long. N fertilizers at the rate of 0, 50, 100 and 200 kg/ha of N and basal doses of P (50 kg/ha) as triple super-phosphate and K (100 kg/ha) as muriate of potash were placed, in a band furrow, 5 cm deep and 5 cm away from the seed on one side of the rows on 11 Sept. 1972. N treatments were replicated 4 times in a randomized complete block design. The crop was harvested on 14 Dec. 1972. The corn ears of the four inside rows were harvested for the grain yield and then 10 plants per plot were randomly selected, harvested and grouped. The plant and grain samples from each plot were dried at 80°C for 24 hours, weighed and analyzed for P, K, Ca and Mg. Apparent P and K recoveries were calculated by the differences in P and K uptake from the N treated plots as compared to that from the plots where no N was added.

The field was well provided with drains to prevent waterlogging. In addition, each plot was isolated from others by drains 30 cm wide and 10 cm deep. The insect pests and weeds were controlled by insecticide spray and hand weeding.

RESULTS AND DISCUSSION

In general, P, K, Ca and Mg uptake was increased by increasing the N rate; maximum increases in the uptake of nutrients by corn were obtained by SCU-102 and SCU-183 treatments. That is, the slower release rates of N from the N fertilizers (SCU-102 and SCU-183) resulted in not only greater N uptake (Dalal, 1974) but also greater absorption of other nutrients (P, K, Ca and Mg). However, AS and UAP applied at 200 kg/ha of N depressed the uptake of P, K, Ca and Mg, and Ca and Mg respectively. This was probably due partly to higher NH_4^+-N/NO_3^--N ratios in the soil in the early stages if corn growth and hence adversely affecting the uptake of other nutrients (Hansen, 1972; Cox and Reisenauer, 1973) and partly to greater increases in acidity and exchangeable Al as compared to slow release fertilizer (Dalal, 1974). The better performance of urea as compared to AS and UAP was primarily due to its insignificant effect on soild pH and exchangeable Al (Dalal, 1974).

Maximum P and K were recovered in SCU-102 and SCU-183 treatments. The maximum recoveries of P and K were 18.6 and 24.0 per cent, respectively, in SCU-183 treatment when it was applied at 200 kg/ha of N.

The decrease in exchangeable K, Ca and Mg due to cropping were found to be closely associated with K, Ca and Mg uptake respectively. The regression equations were:

$$\text{K uptake (kg/ha)} = 26.9 + 438.6\Delta \text{exch. K (me/100g)}$$
$$r = 0.7566 \quad P \angle 0.001$$
$$\text{Ca uptake (kg/ha)} = 8.2 + 36.7\Delta \text{exch. Ca(me/100g)}$$
$$r = 0.8387 \quad P \quad 0.001$$
$$\text{Mg uptake (kg/ha)} = 8.7 + 66.1\Delta \text{exch. Mg(me/100g)}$$
$$r = 0.6626 \quad P \angle 0.01$$

Thus high NH_4^+-N/NO_3^+-N ratios would affect not only the absorption of K, Ca and Mg but also their release from exchangeable positions on the soil colloids to soil solution.

It appears that the controlled release of N from SCU-102 and SCU-183 considerably increases the uptake of P, K, Ca and Mg by corn as compared to the soluble N sources. The factors responsible for this effect on the acidic soil are small pH changes, less exchangeable Al, low NH_4^+-N/NO_3^--N ratios and slower release of N over longer periods.

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INFLUENCE OF THE PART OF THE LEAF AND LEAF RANK OF PLANTAINS ON ITS NUTRIENT CONTENT

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INTRODUCTION

Fertilizer ranks as one of the largest direct cost a farmer has in growing high yielding crops. The correct recommendations of fertilizer for a given crop in a given soil can mean increased yields with no excessive fertilizer costs. The problem is one of determining a practical method of evaluating the fertilizer needs of the crop in the soils where it is growing.

Soil and plant analyses are used to evaluate the fertilizer requirements of the soil and its crop. Foliar analyses has become a valuable guide in this work, especially because of its value for nitrogen recommendations and its sensitivity to variables which effect the growth of the crop. Foliar diagnosis is being used as a practical guide to fertilizer usage for sugarcane (Samuels, 1969) and pineapples (Sanford, 1962).

Little information is available as to use of foliar analysis as a guide for fertilizing plantains (Musa paradisiaca) an important food crop in Puerto Rico. Research work has been initiated at the Agronomy and Soils Department, Agricultural Experiment Station to determine the fertilizer requirements of plantains and how best to evaluate these needs. This paper deals with the findings in the leaf tissue and its possible role in foliar diagnosis for plantains.

MATERIALS AND METHODS

A fertilizer experiment with plantains on a Corozal clay, a Ultisol, pH 5.2, in the humid mountain regions of Puerto Rico was utilized as a source for material in this work, and consisted of N and K_2O at 4 levels: 101, 202, 403, and 605 Kg/ha (90, 180, 360, and 540 lbs/A) and P_2O_5 at 2 levels: 0 and 112 kg/ha (100 lbs/A). When one element was varied, the other two fertilizer elements were held at constant level of N at 202 Kg/ha, P_2O_5 at 112 Kg/ha and K_2O at 404 Kg/ha. All treatments received 202 Kg/ha of MgO (180 lbs/A), and total fertilizer was applied in 3 applications: 1, 3, and 10 months after planting on June 6, 1973.

The experiment was replicated 6 times in rectangular-lattice design. The plot consisted of 9 trees total planted 1.82 m x 1.82 m in 3 rows with a 2.13 m space between plots. Leaf samples were taken at 4, 6, and 9 months after planting. Leaf No. 1 was designated as the first fully-opened leaf counting from the top.

RESULTS AND DISCUSSION

Part of Leaf

In very few cases is the entire plantain leaf taken at sampling used for chemical analyses. To save space and time in drying the leaf materials, and in grinding, only a portion of the plantain leaf is used. If the plaintain leaf were rather uniform in its nutrient composition along its long axis, there would be no particular concern about a little variation as to what part of the leaf was used. However, this is not so, for there is quite a large variation in nutrient composition for various sections of the leaf as shown in Table 1.

Both in leaf blade and midrib, the N and Ca content increased from base to tip of the leaf. Leaf K, however, decreased from base to leaf tip for both blade and midrib. Leaf P changed little from base to tip with a trend to increase for midrib-P only. There was no definite trend for change in leaf-Mg from base to tip. The variations found in leaf blade N P K and Mg for plantains were similar to those obtained by Twyford and Coulter (1964) for bananas in the Windward Islands; however, they found that leaf-blade Ca decreased from base to tip. The variation in leaf N P K composition in leaf lamina and midrib for plaintains was also similar to those for sugarcane (Samuels 1967).

The data indicates that plantain leaf does not have a uniform nutrient composition along its long axis. Therefore, to insure accuracy in foliar-diagnosis work it is necessary that the leaf sample be taken from the sameportion of the leaf each time. The use of visual estimates of the leaf center is not sufficiently accurate to ensure consistent and uniform sampling if a portion of the leaf is to be used. A simple measurement of folding the leaf in half is a rapid means of finding the center of the long axis of the leaf. A ruler or mark on the cutting table or board will ensure that the same length of section is taken from the leaf each time for analyses.

Aside from variations in nutrient composition along the long axis of the leaf, there is a difference in nutrient, composition between - leaf blade or lamina and the midrib. The differences are showing in table 2 under averages. The leaf blade has a higher N and P and lower K content than the midrib. The Ca and Mg content is rather similar in both leaf blade and midrib. The higher N and P in the leaf blade or lamina as compared to the midrib has also been found in the sugarcane leaf (Samuels 1967).

Leaf Rank

The influence of the leaf rank or number on the nutrient content of the plaintain leaf is shown in table 2. The leaf blade and midrib N and Ca increased from second to fifth leaf with the increase being more than double for Ca, but only about 12% for N. The variation in leaf K differed between blade and midrib with a decrease in K from second to fifth leaf in the blade and an increase in the midrib.

There was no appreciable change in leaf P for blade or midrib for leaves nos. 2 to 5. The same was true for leaf-blade Mg with a slight trend to increase in midrib Mg from second to fifth leaf.

Murray (1960) working in sand culture, found that the banana leaf-blade N increased from first to fourth leaf then a progressive fall with increasing age or leaf number. Leaf-blade P and Mg was rather constant for all leaf number, and leaf-blade K had only a little fall with increasing leaf number. Leaf blade-Ca increased rapidly from first to fifth leaf. These findings were quite similar to those found for the plantain leaf.

The leaf number containing the highest amount of the nutrient element being studied does not necessarily serve as the best criteria for foliar-diagnosis recommendations. The leaf rank or number most sensitive to changes in available nutrient level to the plantain will give a better picture of the fertilizer needs of the plant. Using the fertilizer treatments with low and high level of N P K as a guide, table 3 shows the differences in uptake of the nutrient in the leaf blade by leaf number.

For N, the largest differences between N fertilizer application was detected in leaf No. 2, and differences decreased thereafter to leaf No. 5. Differences in phosphate application was hardly detected, with only leaf No. 4 showing a slight difference in leaf P. Leaf No. 4 gave the greatest difference in leaf K with differential potash application to the soil.

Hewitt (1955) in his work with bananas in Jamaica suggested leaf No. 3 for the most general indication of the nutrition of the tree. However, his decision was based moreso on the fact that the third leaf had the highest N level and next to highest P and K levels as compared to leaves Nos. 1, 5, and 7. Table 2 indicates that for the leaf blade of plantains, using a criteria of highest level of the nutrient, the second leaf is best for N and Ca while any leaf from second to fifth was suitable for P and Mg. Yet, if we use the criteria of the leaf number showing greates sensitivity to differences in fertilizer levels (table 3), we obtain an entirely different picture with the second leaf best for N and the fifth for K.

CONCLUSIONS

For foliar diagnosis with plantains this study suggests that the third or fourth leaf gives the most general indication for N P K. The leaf blade or lamina is suggested as the most general indicator for N P K as compared to the leaf midrib. The use of a constant section near the center of the leaf is indicated to avoid variation in sampling along the long axis of the leaf. The preliminary findings of this study with plantains does not differ greatly with those obtained for bananas in choice of leaf-analysis tissue.

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Table 1. - The Distribution of Nutrient Elements in the Plaintain Leaf*

Element Determined	Distribution of element in leaf				% dry-weight basis			
	0- " Base	-12",	12-18",	18-24",	24-30",	30-36"	36-42"	42-48" Tip
				Leaf blade				
N	4.27	4.47	4.67	4.82	5.07	4.96	4.82	4.81
P	.32	.28	.27	.26	.25	.27	.26	.27
K	7.06	6.71	6.36	6.09	5.93	5.79	5.70	5.49
Ca	.64	.72	.81	.77	.89	.89	.84	.66
Mg	.28	.33	.28	.29	.24	.27	.28	.33
				Midrib				
N	1.33	1.35	1.39	1.53	1.66	1.75	1.95	2.03
P	.12	.12	.12	.11	.13	.15	.15	.1
K	12.96	13.09	12.23	12.33	11.79	11.68	11.66	-
Ca	.55	.68	. 7	72	.80	.81	.86	-
Mg	.18	.14	.13	.14	.15	.15	.16	-

Table 2. - The Influence of Leaf Rank or Number on the Distribution of Nutrient. Element in the Plaintain Leaf *

Leaf Number	Leaf nutrient content on a % dry-weight basis				
	N	P	K	Ca	Mg
			Blade		
2	4.33	0.27	5.72	0.39	0.31
3	4.57	.28	5.31	.58	.31
4	4.66	.27	5.00	.75	.31
5	4.76	.27	4.88	.84	.30
Average	4.58	.27	5.18	.64	.31
			Midrib		
2	1.25	0.12	9.34	0.35	0.29
3	1.31	.12	9.90	.49	.31
4	1.32	.13	9.93	.58	.32
5	1.42	.12	10.40	.84	.34
	1.33	.12	9.89	.75	.32

* Average of 3 samplings at 5, 6, and 8 months of age.

Table 3. - The Difference in Nutrient Uptake by Plaintain Leaves by Leaf Rank *

Fertilizer		Nutrient content, % dry-weight, for leaves blade No.			
Element	Lbs./acre	2	3	4	5
			Nitrogen (N)		
N	404	4.37	4.63	4.75	4.83
	101	3.91	4.33	4.58	4.68
Difference		.46	.30	.17	.16
			Phosphorous (P)		
P_2O_5	112	0.29	0.27	0.27	0.26
	0	.29	.27	.26	.26
Difference		0	0	.01	0
			Potassium (K)		
K_2O	404	6.68	6.20	5.96	5.92
	101	6.62	6.03	5.51	5.52
Difference		.06	.17	.45	.37

* Mean of leaf samplings at 6 and 9 months.

MINERAL NUTRITION OF TWO PLANTAIN (MUSA, AAB GROUP) CULTIVARS OF THE FRENCH AND HORN TYPE

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INTRODUCTION

Although plantains provide an important source of starches in the Caribbean, in most parts of the region they are not grown intensively on a plantation scale. Also, most of the crop is consumed locally and any export trade is for the most part between the various territories of the Caribbean. Maybe because of this, in the past there has been little systematic research on the cultivation practices required for efficient production. This is in marked contrast to the large volume of work on other types of banana produced for the export market.

Most of the published work in the Caribbean area has been conducted in Puerto Rico where a sizeable industry in processed plantain products has been developed. Investigations into plantain production there have often been concerned with the effect of agronomic practices on characteristics which are important in processing (SANCHEZ NIEVA et al, 1971) but others on plant density (VINCENTE-CHANDLER and FIGALLA, 1962; CARO-COSTAS, 1968), and mineral nutrient requirements (CARO-COSTAS et al, 1964; HERNANDEZ MEDINA and LUGO LOPEZ, 1969; SAMUELS et al, 1973) have been carried out. These latter have shown the need for both magnesium and micronutrients (especially iron and zinc) for maximum yield on some of the soils in Puerto Rico.

In other parts of the West Indies few field fertilizer trials have been carried out, and it is usually assumed when giving fertilizer recommendations that the requirements for plantain would be the same as other banana cultivars.

In any case, fertilizer trials as normally designed do not give all the information needed for a crop like banana where requirements for the plant crop are different from those for ratoon crops (TWYFORD and WALSLEY, 1973). Taking into account these circumstances it should be possible to obtain the mineral needs of a plantain crop, at least to a good approximation, from total plant analysis. Therefore, the object of the present study was to determine the total uptake of the major nutrient elements into two cultivars of plantain commonly grown in Trinidad at various stages throughout their life cycle in order to get an estimate of the total nutrient requirements on a field basis.

EXPERIMENTAL

Cultivars: Two cultivars of the plantain sub-group of the Musa, AAB Group (see SIMMONDS, 1966) were used, one of the French type (called locally Green French plantain, Banane creole, Platano congo etc.) and one of the Horn type (Horse, Banane corne, Platano comun etc.).

Site: The plants for the experiment were grown on the University Field Station, Trinidad, where the soil is of the River Estate series described by CHENERY (1952) and BROWN and BALLY (1970).

Although the surface soil is loam there is a silty clay subsoil of poor drainage. The clay content of the surface soil is low and so therefore is the cation exchange capacity. The soil is acid with pH 5-6, calcium and magnesium are usually in adequate supply and although potassium tends to be low, cations are released from weathering silt in the soil. Organic matter is very low and crop responses to phosphorus have been recorded.

Rainfall at the site between planting in Oct/Nov 1971 and harvesting in Nov 1972 was 1350 mm, the months of February, March, April and August having less than 10 mm.

Field techniques: Two stands of about one fifth of a hectare of each cultivar were established on adjacent areas. Planting was on cambered beds at 1.8 m x 1.8 m i.e. a density of 3000 plants per ha.

Planting material was selected from known 'pure' stands of the two cultivars. 'Sword' suckers of as uniform a size as possible were first pared to remove any rotted or discoloured superficial corm material (due to damage by borers, *Cosmopolites sordidus* or nematodes) and then dipped in a solution of Nemagon (6 g per l.) and Aldrin (10 g per l. of 25 per cent), for borer and nematode control.

Planting holes (60 cm x 60 cm x 60 cm) were treated with 50g of 2 per cent Aldrin dust per hole. Soil was replaced in the holes and the suckers planted about 15cm below the surface.

Weeds in the early stages were controlled as necessary by hand cutting or paragnat sprays. Fertilizers applied were 200kg N per ha per year as ammonium sulphate, 120 kg P as triple super phosphate and 750 kg K as muriate of potash, given in four applications.

Sampling techniques: Samples were taken of the planting material from each cultivar. Subsequently, 10 plants of each cultivar were dug up at the following stages of growth:-

1) 'Young' plants with two broad leaves - about two months from planting
2) 'Small' plants with six broad leaves - about four months from planting
3) 'Large' plants with 15-20 broad leaves - about six months from planting
4) 'Shooting' plants - at the first appearance of the flower
5) 'Shot' plants - with immature fruits about half way to harvest (1.5 months old)
6) 'Harvest' - plants at the time of reaping the bunch. At each stage the plants were dissected into their organs; roots were neglected. These organs were,

    a) In the vegetative phase; unemerged leaf (i.e. developing leaf tissue inside the pseudostem), leaf lamina, leaf midrib, petioles, pseudostem, meristem and corm. In the early stages meristematic tissue was included with the corm.

    b) Shooting plants: leaf lamina and midrib, petioles, pseudostem, corm, internal fruit stalk and the inflorescence.

    c) Shot and harvest plants, leaf lamina and midrib, petioles, pseudostem, corm internal fruit stalk, external fruit stalk, fruits and inflorescence. Where the remnants of the inflorescence were very small this material was included with with the external stalk.

Each part was weighed fresh and a representative sample taken (cf TWYFORD and WALMSLEY, 1968). The samples were weighed fresh, then dried in the oven at 80°C re-weighed and the percentage oven dry matter and the total dry weight of the whole part calculated.

After grinding, each sample was analysed separately for N, P and K.

RESULTS AND DISCUSSION

Dry matter production

For both cultivars there was only small production of dry matter until about few months from planting at which age the plants had six unfurled leaves. By the next sampling date in the late vegetative phase the French plants had increased considerably and this rate of increase continued to the shooting stage. After shooting further dry matter was produced right up to harvest.

The Horn type plants began their period of rapid growth later than the French at about five and a half months when they had about 12 broad leaves; only a small amount of dry matter being produced between the six and 12 leaf stages. However, after that stage, growth increased at a more rapid rate than for the French plants and by shooting they had produced more dry matter than the French. Although this rate of increase diminished somewhat up to the shot stage, subsequent increases ensured that they contained about 35 per cent more dry matter at harvest than the French.

Distribution of dry matter within the plant

At harvest for both types, the fruits had more dry matter than any other part, with pseudostem and leaves making up the bulk of the rest of the material, Much of the difference in the total plant dry weights for the cultivars was due to the amounts assimilated in the leaves and pseudostem although generally all vegetative parts of the French contained less dry matter than the counterparts of the Horn type.

It is interesting to note that although the Horse plants accumulated more total dry matter the amount in the fruits was almost the same for both cultivars. The mean fresh weights of fruits produced from these plants were 12.1 kg for Horn and 13.5 kg for French i.e. the fruits produced by the French were heavier only because they have a higher percentage of water.

Concentration of mineral nutrients

In the vegetative stages of growth nitrogen and phosphorus were most concentrated in the actively differentiating tissues, the unemerged leaf and meristem. Nitrogen concentrations were also high in the leaf lamina during this phase. Potassium was concentrated in the young leaf tissue but in the earlier stages, the conducting organs, midribs, petioles and pseudostem were also rich in potassium. In the later stages of vegetative growth potassium concentrations in these latter tissues decreased considerably probably due to a dilution effect as the tissues had by then increased greatly in bulk. This effect was particularly noticeable in the French type.

In the fruiting phase nitrogen and phosphorus were still concentrated in leaf lamina, and also in the inflorescence, and fruit stalk. The tissues where potassium was most concentrated in this phase were inflorescence and fruit stalk. Thus here again the nutrients tended to be concentrated in the new tissues which were rapidly developing during this time except that the fruits themselves had only low concentrations. This may be due to the fact that it is material in the 'skins' which is actively concerned with producing new tissue and not the pulp. Since these were not analysed separately this effect could not be demonstrated in these studies.

Nitrogen

Both cultivars showed a similar pattern of distribution amongst the organs. In the vegetative phase nitrogen taken up appeared mainly in the leaf lamina; pseudostem and corm having the next highest amounts.

In the fruiting phase, whilst the leaves continued to be a major depository, a high proportion of the nitrogen in the plant was to be found in the fruits at harvest.

The total plant uptake increased slowly up to the six leaf stage but the French plants took in more nitrogen than the Horn during this period. For the French plants there was then a very rapid increase in uptake up to the sampling time at the late vegetative or 'large' stage and the nitrogen content increased eight-fold over this period. There was a dimunition in uptake rate from then up to the shooting stage and from shooting to harvest no further nitrogen was taken into the plant; at the shot stage there was an apparent decrease from the shooting stage. Since any dead leaves were retained as far as possible in the experiment it may be assumed that this was due to losses from flowers, bracts and other parts of the inflorescence which fell off but were not collected for analysis.

The Horn type showed a much less rapid uptake between the six-leaf and late vegetative stage than the French but between the latter stage and shooting uptake had increased to such an extent that the content of nitrogen was somewhat higher in the Horn plants. In this sense nitrogen uptake followed the dry matter production pattern. At harvest the Horn plants had accumulated more nitrogen than at the shooting stage, but again these plants showed an apparent loss at the shot stage compared with shooting, probably for the reasons stated above, the greater loss being due to much more of the inflorescence being shed in this type of plantain.

In the French plants no further net nitrogen was taken into the plant after shooting and nitrogen used in the development of the fruiting parts came mainly from the leaves.

In the Horn type some net nitrogen uptake was recorded after shooting but this was insufficient for the development of the fruiting parts. Small losses to make up this deficiency were recorded from other parts of the plant mainly leaves and corm.

Phosphorus

The distribution pattern of phosphorus amongst the organs was similar for both cultivars. As for nitrogen, in the vegetative phase, most of the plant's phosphorus was contained in the leaves, pseudostem and corm. By shooting leaves still contained the most phosphorus followed by pseudostem. At this stage the French inflorescence contained more phosphorus than the corm but in the Horn plants, the corms had twice as much phosphorus as the inflorescence. At harvest the fruits had much more phosphorus than any other part of the plant.

Total phosphorus uptake into the plant followed the nitrogen pattern during the vegetative phase with a more rapid uptake by the French plants in the earlier stages and with an accelerated increase in the Horn plants in the late vegetative phase so that by shooting the Horn plants contained more phosphorus than the French. There was only a small uptake between shooting and harvest for both cultivars. This was insufficient to supply the amount needed for fruit development. The deficit was made up by redistribution from other parts of the plant, mainly the leaves and pseudostem; the corm also supplied a substantial amount in the Horn plants only.

Potassium

In the very early vegetative phase the corms contained more potassium than other organs but this pattern changed as growth continued so that in the late vegetative stages pseudostem was the biggest repository, leaves the next, with corm in third place. This pattern was the same at shooting.

At harvest the fruits had by far the greatest amount of potassium. In the Horn plants, pseudostem and leaves still contained substantial amounts but in the French these organs had been considerably depleted.

The pattern of total uptake for the two cultivars differed markedly. Up to the six leaf stage the Horn plants appeared to have taken in no potassium at all from the soil. On the other hand the French cultivar showed a steady intake with a very rapid increase from the six leaf stage up to shooting. The Horn plants increased their potassium content relatively more slowly from the six leaf stage but then there was a very rapid uptake between the 'large' stage (12 broad leaves) up to shooting.

As was observed for nitrogen uptake from shooting to shot there was an apparent decrease in total potassium which was assumed to be due to loss of flower bracts. Further uptake was recorded from shot to harvest resulting in a net uptake from shooting for both cultivars, the Horn type having the greater total uptake.

For both cultivars the net uptake from the soil after shooting was not sufficient to supply the potassium needed for fruit formation. In the French plants losses were recorded from vegetative parts of the plant mainly the pseudostem and leaves. In contrast, in the Horn plants little redistribution took place from the leaves and pseudostem; corm supplied the largest amounts of potassium for this purpose.

Nutrients in Fruits

The fruits of the French plants contained 60 per cent of the total potassium in the plant, compared to 35 per cent for the Horn.

Comparable figures for nitrogen are 39 and 22 per cent and for phosphorus 47 and 36 per cent. Thus although the Horn plants take in more total nutrients, the proportion used in fruit production is much lower than for the French cultivar. In this sense the French is more efficient than the Horn.

NPK requirements

a) First year

If we consider the development of a newly planted field of plantains at a density of 3000 plants per ha and assume that all plants have been harvested within the first year then the field would produce about 40 tonnes of fruit for the French plants but only about 30 tonnes for the Horn type. In the experiment the mean weight of fruits per plant was 13.5 kg for French and 12.1 kg for Horn but from a larger sample from the same area taking the mean of 100 bunches mean weight of fruits produced was 13.7 and 10.0 kg respectively.

Thus basing the fertilizer requirement on the higher producing French cultivar assuming that during the first year enough should be supplied for 3000 plants up to harvest, 3000 ratoon plants which at the end of the first year may be taken to be at the 'large' or late vegetative stage and 300 suckers (which would eventually form the second ratoon) at the 2 leaf stage, it can be calculated that 286.5 kg of N, 79.6 kg of P and 724.6 kg of K would be needed. In this calculation the nutrients in the planting material are ignored. If supplies from the soil are also assumed to be negligible which of course would not always be the case then net uptake can be computed in terms of fertilizer. This would give a fertilizer ratio of 1:0.3:2.5. The quantity of NPK fertilizer required on this basis assuming no losses, would be approximately 3000 kg of 10:3:25 or 1 kg of this grade fertilizer per stool. There would be losses due to fixation and leaching. To allow for phosphate fixation the fertilizer grade could be changed to 10:10:25. To compensate for nitrogen and potassium losses the dose per stool could be increased somewhat.

b) Ratoon years

In the second year the situation is somewhat different as residues from the previous crop contribute to the nutrition of the ratoon. After the bunch is cut the plant has completed its life and its nutrients are released.

The pseudostem is usually cut at about 1.5 meters from the soil surface and 'crown' (upper pseudostem, leaves petioles and part of the external fruit stalk) begins to rot on the soil surface. Nutrients from the rotting plant can then be used by the roots of the developing ratoon plants. Nutrients from the other parts of the harvested plants i.e. the standing pseudostem with the internal fruit stalk, can pass directly into the developing ratoon (WALMSLEY and TWYFORD, 1963) or become available after rooting.

Thus the ratoon crop receives a substantial quantity of nutrients from plant crop residues, only those in the bunch being removed from the field. Also by the end of the first year the root system is well developed and more efficient is absorbing nutrients and we can therefore assume that losses by leaching and fixation would be smaller.

Fertilizer to be applied in the second and subsequent years can therefore be based on the amount of nutrients removed in the bunches. For the French cultivar the nutrients exported are 66 kg N, 24 kg P and 323 kg K. A suitable NPK fertilizer ratio to replace these nutrients would be 1:0.4:3.9. This has about twice as much potashas that required for establishment of the field so either a different compound fertilizer would be needed or the same one could be used and supplementary muriate of potash given. To supply N and P about 700 kg per ha of the 10:10:25 would be needed or say 230 g per stool. In addition about 250 kg per ha of muriate of potash would be needed.

Thus it can be seen that although heavy dressings of fertilizer are needed for the establishment of the field in the ratoon years the requirements are markedly reduced and over a period of three or more years no more total fertilizer would be required than is normally recommended. Therefore a higher expenditure on fertilizers is not involved only a re-arrangement with time.

It is possible that with more fertilizer than that suggested here, higher yields than 40 tonnes per ha would be obtained.

CONCLUSIONS

1) The fruits of the French type contain a higher percentage of mineral nutrients, especially potassium, than the Horn plantains.

2) A higher percentage of the total nutrients taken into the plants is used in fruit production in the French type than the Horn.

3) From total plant analysis, fertilizer rates for a soil of low nutrient status should be high in the first year when the field is being established. Rates in subsequent years can be reduced considerably since plant residues contribute substantially to the nutrition of ratoon crops.

   a) For the French cultivar, calculations show that a hectare with 3000 plants would require of the order of three tonnes of 10:10:25 fertilizer (1 kg per stool) in the first year.

   b) In the second and subsequent years this could be reduced to about 700 kg per ha (230 g per stool) but supplementary potash would be needed (250 kg KCl per ha) since proportionally more potassium than either nitrogen or phosphorus is removed in the bunches exported from the field.

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PRIMARY SCREENING OF NEW UNREGISTERED PREEMERGE VEGETABLE HERBICIDES II

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INTRODUCTION

New herbicides and improved registered materials are becoming available with increasing frequency for the tropical weed researcher. In order to evaluate the weed control activity, the necessity arises for a simultaneous screening of a number of candidates on a wide spectrum of vegetable crops in the shortest time possible. The method described by Furtick and Romanowski (1967) has been used successfully by Jackson and Sierra (1973). It consists of planting on the flat, one row each of the crop to be tested, and then applying the herbicides at right angles over the crop. Herbicides are applied at the recommended concentration, and may or may not be replicated with the inclusion of as many check plots as considered necessary. Such an experiment was established at the Fortuna Sub-station, Juana Diaz, Puerto Rico on March 19, 1974, evaluating twelve candidate chemicals at three levels on twenty-eight crop species. Only the level recommended by the manufacturer is reported in this paper.

MATERIALS AND METHODS

The planting was made on a well prepared field of Paso Seco Sandy Loam (Sand 41.2%, Loam 30.0% and Clay 28.8%). Soil pH was 7.12, with 2.57% organic matter and a base exchange capacity of 25.3 meq. per 100 grams.

Seeding was done with a Stanhay Mk II precision seed spacing drill, using the correct size belt for each crop planted and depth depending on the species. Seeding was extra heavy to assure a good stand of crop, with an inter-row spacing of 0.45m. (1.5 ft.).

One row each of the following crops was included in the test: C-17 sorghum, Hawaii-68 sweet corn, Sinaloa rice, Texas Grano 502 onion, Winter Bloomsdale spinach, Georgia collard, Market Prize cabbage, Waltham 29 broccoli, Purpletop White Globe turnip, Milichihi Chinese cabbage, Cherry Belle radish, Romano bush bean, Kanrich soybean, Kaki pigeon pea, Dwarf Long Green Pod okra, Line 8-65 papaya, Scarlet Nantes carrot, Florida Market eggplant, Walter tomato, Yolo Wonder Y Sweet pepper, Boriquen pumpkin, Charleston Gray watermelon, Gemini 7 Hybrid cucumber, Perlita cantaloupe, Curly Leaved Batavian endive, Great Lakes 659 head lettuce, Black Seeded Simpson Leaf lettuce and Mammoth Grey Stripe sunflower.

All herbicides were tested for preemerge activity at manufacturers' recommended rate. Materials are expressed as active ingredient per acre, and the rates were: Tolban (CGA-10832) at 0.45 kg. (1.0 lb.), Furloe-124 (Chloropropham plus PPG-124) at 1.81 kg. (4.0 lbs.), Destun (MBR-8251) at 1.36 kg. (3.0 lbs.), Dioxane (NIA-25213) at 0.91 kg. (2.0 lbs.), HCS-3438 75WP at 0.45 kg. (1.0 lb.), RH-2512 at 0.34 kg. (0.75 lb.), RH-2915 at 0.11 kg. (0.25 lb.), RP-15018 at 1.81 kg. (4.0 lbs.), RP-20810 at 0.23 kg. (0.50 lb.), S-6851 at 1.36 kg. (3.0 lbs.), U-27267 at 0.45 kg. (1.0 lb.) and UNI-N-252 at 0.45 kg. (1.0 lb.).

Materials were applied using a Chem-Farm Sprayer with PTO pump powered and transported by a Ford 3000 tractor. Four NW-5 nozzles adjusted to spray a band 1.8 m. (6 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 forward speed of 2.4 km/hr (1.5 mi/hr). Plots were sprayed at right angles to crop rows. Each plot was 17.2 x 1.8 metres (57 x 6 ft.). The sprayer was washed out thoroughly between applications using a water-ammonia-detergent solution.

The day was clear with wind east south east at 4.9 km/hr. (3.0 mi/h.). Air temperature 30.6°C. (87°F.). Relative humidity 45%, soil temperature at 5.1 cm (2 in.) 32.2°C. (90°F.).

All irrigation was applied overhead. First irrigation was sufficient to saturate field to puddling and then turned off. All irrigations were applied as required but to the point of run-off only. Total rainfall for the four weeks duration of the experiment was 0.23 mm. (0.91 in.), highest temperature 31.7°C. (89°F.) and lowest being 12.8°C. (55°F.).

The crop and weed responses to the candidate herbicides were evaluated using the following subjective rating system:

Crop Tolerance Rating	Weed Control Rating
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 made to measure degree of weed control activity.

RESULTS

Results obtained were encouraging for the performance of some of the candidate materials tested with most vegetables. The trial clearly indicated that many of the herbicides were phytotoxic under the test conditions. Table I summarises the crop test results. Weed control rating was largely to compare the herbicide treatments when considering crop tolerance and to compare with the control when interpreting weed response. Data presented in Table 2 indicates weed response to the candidate herbicides. Due to the variation in common plant names throughout the Caribbean, Latin names are used for the weed species encountered. For English or Spanish description of species recorded, common names and illustrations, the reader is referred to Adams, et al (1968) and Cardenas, et al (1972).

RECOMMENDATIONS

Jackson, et al (1972) have tested registered preemerge herbicides for use on thirteen vegetable crops grown in Puerto Rico. Further experimental activity is recommended for the selected candidate herbicides to be tested in secondary formal replicated trials, utilizing the presently recommended registered herbicides as control or check for that specific crop. Reference is made to Table 3.

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TABLE I. Effect of Chemical on Crop Germination and Early Growth

Crop \ Chemical	CGA-10832 (Tolban)	Chloropropham Plus PPG-124 Furloe-124	HCS-3438	MBR-8251 (Destun)	NIA-25213 (Cioxane)	RH-2512	RH-2915	RP-15018	RP-20810	S-6851	U-27267	UNI-N-252
Sorghum	1*	3	2	5	4	4	4	5	4	3	2	2
Sweet Corn	1	1	1	3	4	4	2	3	4	3	1	2
Rice	1	2	5	5	4	3	2	1	2	4	3	3
Onion	1	2	3	5	1	5	5	3	5	5	1	1
Spinach	1	1	5	5	4	5	5	5	5	2	1	3
Collard	1	1	5	5	4	5	5	5	5	5	2	5
Cabbage	1	3	5	5	4	5	5	5	5	5	2	3
Broccoli	1	2	5	5	4	3	5	3	5	5	2	5
Turnip	1	2	5	5	4	3	5	3	4	5	1	5
Chinese Cabbage	1	2	5	5	4	3	5	4	4	5	1	5
Radish	1	1	5	3	3	3	5	3	4	1	1	5
Bush Bean	2	2	5	3	1	4	4	5	3	1	1	2
Soya	1	1	5	1	2	4	3	1	1	1	1	2
Pigeon Pea	1	1	1	5	3	5	3	1	2	1	1	1
Okra	1	2	5	3	2	4	5	5	5	1	1	2
Papaya	1	5	2	5	5	5	5	5	5	1	5	5
Carrot	1	3	5	5	5	1	2	1	2	1	5	1
Egg Plant	1	4	5	5	2	5	5	4	5	3	1	4
Tomato	2	4	5	5	1	5	5	4	5	5	1	2
Sweet Pepper	1	2	1	2	1	3	4	4	5	2	1	1
Pumpkin	1	1	4	3	2	3	2	4	3	1	1	3
Watermelon	2	4	4	3	3	4	3	5	5	2	2	3
Cucumber	1	4	5	3	3	4	5	5	4	1	2	3
Cantaloupe	1	3	5	2	2	5	5	5	5	1	2	3
Endive	1	2	5	5	4	5	5	5	5	5	3	3
Head Lettuce	2	2	5	5	5	5	5	5	5	5	4	3
Leaf Lettuce	2	2	5	5	5	5	5	4	5	5	1	3
Sun Flower	1	1	4	4	1	1	3	2	1	[illegible]	1	2

* Crop Rating: 1 = No injury
2 = Slight injury
3 = Moderate injury
4 = Severe injury
5 = Dead.

TABLE 2. Control of Prevalent Weed Species Encountered.

Weed Species \ Chemical	Tolban	Furloe-124	Furloe -124	Destun	Dioxane	RH-2512	RH-2915	RP-15018	RP-20810	S-6851	U-27267	UNI-N-252
Digitaria sanguin												
<u>Digitaria</u> <u>sanguinalis</u>	T*	I	T	S	S	S	S	S	S	S	I	I
<u>Echinochloa</u> <u>colonum</u>	T	T	T	S	S	S	S	I	S	S	T	T
<u>Eleusine</u> <u>indica</u>	I	I	S	S	S	S	S	S	I	S	T	I
<u>Trianthema</u> <u>portulacastrum</u>	I	T	I	S	S	S	S	T	I	S	I	S
<u>Amaranthus</u> <u>dubius</u>	T	T	S	I	S	S	S	S	S	S	T	I
<u>Cleome</u> <u>spinosa</u>	T	S	S	S	S	S	I	S	S	S	T	S
<u>Ipomoea</u> <u>tiliacea</u>	I	I	S	S	T	I	S	S	I	S	S	I
<u>Phyllanthus</u> <u>niruri</u>	T	S	I	S	S	I	S	S	S	S	T	S
<u>Sida</u> <u>rhombifolia</u>	I	S	T	S	I	I	I	S	I	I	S	S
<u>Boerhaavia</u> <u>decumbens</u>	S	S	I	S	S	I	T	I	S	S	I	S
<u>Argemone</u> <u>mexicana</u>	S	S	S	I	T	I	S	S	S	I	I	I
<u>Portulaca</u> <u>oleracea</u>	I	T	S	I	S	S	S	S	S	S	S	S
<u>Datura</u> <u>stramonium</u>	I	S	S	S	S	T	I	S	I	S	S	I
<u>Kallstromia</u> <u>maxima</u>	I	I	S	S	I	S	S	I	S	S	T	S

*** Weed tolerance: T - Tolerant to the herbicides**
I - Intermediate
S - Susceptible

TABLE 3. Suggested Recommendations for Selected Crops.

CROP	HERBICIDE lb a.i./ac		Tolban*	U-27267*	S-6851*	Dioxane*	Furloe*	HCS-3438*	UNI-N-252*	RP-15018*
Sweet Corn	Propachlor	6.0	1.0	1.0			4.0	1.0		
Onion	Chlorthal-dimethyl	10.5	1.0	1.0		2.0			1.0	
Cabbage	Chlorthal-dimethyl	10.5	1.0							
Bush Bean	Chlorthal-dimethyl	10.5		1.0	3.0	2.0				
Pigeon Pea	Chloramben*	4.0	1.0	1.0	3.0		4.0	1.0	1.0	4.0
Okra	Trifluralin	1.0	1.0	1.0	3.0					
Eggplant	Chlorthal-dimethyl	10.5	1.0	1.0						
Tomato	Diphenamid	6.0		1.0		2.0				
Sweet Pepper	Diphenamid	5.0	1.0	1.0		2.0		1.0	1.0	
Pumpkin	Chloramben	4.0	1.0	1.0	3.0		4.0			
Cucumber	Naptalam	6.0	1.0		3.0					
Cantaloupe	Naptalam	8.0	1.0							
Leaf Lettuce	Pronamide*	4.0		1.0						

Note: Materials marked (*) are not registered for commercial use on crops indicated. Produce must be destroyed, and cannot be used for human or animal consumption: this includes, seed, foliage, fruits, roots or other parts. Keep materials out of reach of children. Do not store with feed or food stuffs. Consider materials lethal to all wild life, do not contaminate streams, lakes or potable water sources. These suggested experimental recommendations are for use of authorized and qualified research stations only. This is not a commercial recommendation.

All materials are expressed as lb. ai/ac., to convert kg multiply by 0.4536.

MATERIAL SOURCES

CGA-10832 (Tolban): CIBA-Geigy Corp., Suite 307, 500 East Morhead Street, Charlotte, NC 28202, U.S.A. Attn: Dr. T.R. Dill

Furloe-124: PPG Industries Inc., One Gateway Center, Pittsburgh, PA 15222, USA: Attn: Dr. Warren H. Zick

HCS-3438: Velsicol Chemical Corporation, 341 East Ohio St. Chicago, IL 60611 USA. Attn: Mr. Bert Eddins.

MBR-8251: (Destun): Three M. Company, 3M Center, Saint Paul, MN 55101 USA. Attn: Dr. Eldon S. Radcliffe

NIA-25213 (Dioxane): FMC Corp., Apartado 2847, San Jose, Costa Rica. Attn: W.S. Nakayama

RH-2512 and RH-2915: Rohm & Hass Co., Box 2019, San Juan, P.R. 00919, USA. Attn: Mr. Eduardo G. Kimenez

RP-15018 and RP-20810: Rhodia Inc., Chipman Division, 120 Jersey Ave., New Brunswick, NJ 08903 USA. Attn: Mr. J.R. Bone

S-6851: Gulf Oil Chemicals Co., Industrial & Speciality Chemicals Div., Research & Development Dept., 9009 West 67th Marriam, KS 66202 USA. Attn: Dr. R.A. Schwartzbeck

U-27267: Upjohn International Inc., Research & Development Dept., 320 Portage St. Kalamazoo, MI 49001 USA. Attn: Dr. George Swank.

UNI-N-252: Uniroyal Chemical Div., of Uniroyal Inc., Research & Development Dept., Bethany, Ct 06525 USA. Attn: Dr. Allyn R. Bell.

PRELIMINARY STUDIES ON POD SETTING AND POD DEVELOPMENT IN PIGEON PEA (CAJANUS CAJAN)

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Flower-tagging of four cvs of pigeon pea showed pod sets of 2 to 63%. There were no consistent trends in pod set with time. The act of tagging, using 14 cm length of 4-ply nylon knitting yawn, did not affect per cent pod set, but enclosing flowering branches in nylon tulle bags for selfing did reduce pod set. Pod samples taken at different times varied considerably in mean weights per pod, in weight of seed per pod, number of seeds per pod and mean weight per seed. Rates of pod and seed development were also found to vary: the time to reach the mature green pod stage varied by 12 days. More detailed work is needed to understand the causes of variation in pod set and in the development rate of pods and seeds. Such information could enable some control of this variation to be exercised and could guide the breeder on plant types needed for consistent high yields.

AN EVALUATION OF A NEW SYSTEM OF PIGEON PEA PRODUCTION IN TRINIDAD & TOBAGO

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SUMMARY

Trinidad and Tobago currently imports much of its grain legumes. Pigeon peas are the most commonly grown grain legume. Considerable work has gone into the development of dwarf determinate cultivars of pigeon peas in the Regional Research Centre of the University of the West Indies. A new system of production has evolved based on high density plantings of these cultivars in December of January, so that they come to bearing within 110 days, and give high yields of green pods from a single harvesting. With a yield of 4000 lb/ac., a gross income of $680/ac could be achieved, but hand-harvesting costs could be high. Work is in progress on a mechanical harvester. This system of production should ensure increased supplies of fresh peas for processors, lead to intensified land use (since the crop occupies the land far less time than traditional pigeon pea crops), and could lead to savings in imports and export earnings.

MINERAL NUTRITION REQUIREMENTS OF PIGEON PEA (CAJANUS CAJAN) IN RIVER ESTATE LOAM, ST. AUGUSTINE, TRINIDAD

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INTRODUCTION

Assessments of mineral nutrition requirements of pigeon pea (*Cajanus cajan*) have assumed greater significance by placing special emphasis on this crop in the Grain Legume Programme in the Caribbean. To identify the nutrient needs of pigeon pea, a preliminary experiment was conducted wherein the effects of small amounts of several macro- and micro- elements on dry matter production and nitrogen uptake by pigeon pea were investigated.

MATERIALS AND METHODS

The surface soil (0-20 cm) was collected from University Field Station, St. Augustine, Trinidad. It was air-dried and ground to pass through 5 mm sieve. The physico-chemical characteristics of the soil are given in TABLE 1.

One kg soil was added to each pot. The treatments, in triplicate, were: N, P, K, Ca, Mg, Fe, Mn, Cu, Zn, B, Ni, Co, Cr, Bi, Mo, all added together and none (control). All except Ni, Co, Cr and Bi are essential nutrients for plant growth. Co has been shown to be essential to soybeans (Ahmed and Evans, 1960). Ni, Cr and Bi were investigated for their possible roles in affecting yield and N uptake. The rate and source of macro- and micro- elements added to the soil are shown in TABLE 1. The nutrient solutions, containing required rate (TABLE 1) per pot per 10 ml, were sprayed uniformly over the surface after the soil was moistened to 50 per cent WHC (water holding capacity) with deionised water. After 24 hours, the pots were planted with pigeon pea (cv. G127/4A) and were thinned to two plants per pot a week after germination. The pots were frequently watered with deionised water to maintain the soil moisture at 50 per cent WHC.

After 35 days, the plants were harvested, dried for 72 hours at 80°C, weighed and analysed for N (Linder, 1944).

The experiment was conducted in the greenhouse at 27±5°C.

TABLE 1. Physico-chemical properties of the River Estate Loam Soil used for the experiment.

pH (1:2.5 soil:water)	5.2
Clay content (%)	15
CEC (me/100g soil)	7.50
Exch. Ca (me/100g soil)	2.50
Exch. Mg (me/100g soil)	0.79
Exch. K (me/100g soil)	0.09
Exch. Na (me/100g soil)	0.05
Org. C (%)	0.94
Total N (%)	0.104
Available (Troug) P (ppm)	10

TABLE 2. Rate and source of macro- and micro- elements added.

Macro- and micro- element	Rate (ppm)	Source
N	10	$(NH_4)_2SO_4$
P	10	$NaH_2PO_4.7H_2O$
K	10	K_2SO_4
Ca	10	$CaCl_2.10H_2O$
Mg	10	$MgSO_4.7H_2O$
Fe	1	$FeSO_4.7H_2O$
Mn	1	$MnSO_4.4H_2O$
Cu	0.1	$CuSO_4.5H_2O$
Zn	0.1	$ZnSO_4.7H_2O$
B	0.1	$Na_2B_4O_7.10H_2O$
Ni	0.1	$NiCl_2.6H_2O$
Co	0.1	$CoCl_2.6H_2O$
Cr	0.1	$Na_2Cr_2O_7.2H_2O$
Bi	0.1	$BiCl_3$
Mo	0.01	$Na_2MoO_4.2H_2O$

RESULTS AND DISCUSSION

Dry matter yield was significantly increased by the application of P, Mn, Cu, Zn, Ni and Mo; maximum increase in yield was obtained by the addition of P. But when all the macro- and micro-elements were added together, no response was obtained, possibly because of the toxicity by Cr. Application of Cr depressed the dry matter yield of pigeon pea.

Nitrogen uptake was significantly increased by the application of P, Fe, Mn, Cu, Zn, Ni and Mo; again, maximum increase in N uptake was obtained by the addition of P. Application of Fe significantly increased N uptake but did not increase dry matter yield significantly, possible because additional Fe was required by the *rhyzobium* in the root nodules to fix atmospheric N and that for plant growth probably sufficient Fe was present in the soil. When all the macro and micro-emelents were added together, N uptake was significantly increased although there was no effect on dry matter yield of pigeon pea, as stated earlier. It indicated that Cr and possibly Bi alone may have little or even toxic effect on plant growth and N uptake. Even in combination with other nutrient elements, Cr and Bi countered the beneficial effect of the addition of other elements on plant growth but these elements, Cr and Bi, had little effect on suppressing the beneficial effects of other nutrient elements in N fixation by *rhyzobium* when these elements are added together.

Therefore, it is suggested that the effects of different rates of P, Mn, Cu, Zn, Ni and Mo on the yield of pigeon pea should be evaluated in the field on River Estate loam. The role of P, Mn, Cu, Zn, and Mo in the mineral nutrition of legumes is well known (E.J. Hewitt, 1958) but Ni has not been shown to be essential for plant growth (Tiffin, 1972) although increases in pea yields on leached chernozem by the application of Ni at the rate of 2 mg/kg soil have been reported (Orlova, 1965).

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SOME OBSERVATIONS ON THE INTERCROPPING OF PIGEON PEA (CAJANUS CAJAN) AND CORN (ZEA MAYS) IN TRINIDAD

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INTRODUCTION

Intercropping is widely practised by peasant farmers in Trinidad and Tobago and HENDERSON (1965) reported that pigeon pea and corn were the commonest components. Despite the prevalence of the practice it has been the subject of little research (HENDERSON, 1965; BAYNES, 1971), and FERGUSON (1972) reported that the full benefit of the practice is not derived by farmers. Some observations made in an experiment conducted to provide information on the reactions of pigeon pea and corn under different systems of intercropping are presented in this paper.

MATERIALS AND METHODS

The study was conducted on a Streatham Loam located at the Texaco Food Crops Demonstration Farm, St. Joseph, Trinidad. The soil, pH 4.0, is low in plant nutrients and exhibits imperfect drainage. There were six treatments (Table 1) replicated four times in a randomised block design. U.W.I. GI 27/4A pigeon pea and high-lysine white translucent corn were sown thickly by hand at a depth of about 5 cm. in hills on 11 and 12 January, 1973 and were thinned to one plant per hole within three weeks. Each plot was 11.25 m. long and 6 m. wide. Plant populations are shown in Table 1.

No fertilizer was applied to pigeon pea. Corn was fertilized with 628 kg/ha of a 22:11:11 compound commercial fertiliser; two-thirds of this amount applied at planting and the remainder at the onset of flowering. Weeds were controlled by prometryne (2.24 kg/ha) at planting, three hand weedings and two sprays of paraquat (0.54 kg/ha) during the growth of the crops. Pigeon pea pod borer was controlled by spraying Gardona 25 EC (1.68 kg/ha) and corn army worm with Dipterex SP80 (1.68 kg/ha).

The durations from planting to flowering, podding and harvest in pigeon pea, and from planting to silking, tasselling and harvest in corn were recorded. Plant height measurements were made at three-week intervals from the fifth to the fourteenth week after planting.

The crops were harvested at the mature green stage. The harvested areas varied with treatments and ranged from 59.5 m^2 to 60.4 m^2. Corn was sun-dried to about 14 per cent moisture content and the green pea pod weights were converted to dry weight by the ratio 3.35:1 suggested by HENDERSON (1965). The dry weight per plant, seed yield components and seed protein contents were determined and total dry matter yields and total seed protein yields were computed.

The seed yield of corn in every replicate of the mixed stand treatments was converted to seed yield in kilogrammes per hectare and the seed yield of pigeon pea, which could occupy the remaining portion of the area based on the seed yield per hectare of pure stand corn was calculated, using the following formula:-

$yp = (1 - \frac{xc}{X}) Y$ (SPRINGER, personal communication, 1973) where

xc is seed yield (kg/ha) of corn in mixed stand

yp is seed yield (kg/ha) of pigeon pea in mixed stand

X is seed yield (kg/ha) of corn in pure stand

Y is seed yield (kg/ha) of pigeon pea in pure stand.

RESULTS

Seed yield and components of yield

The effects of different systems of intercropping on the actually observed seed yields of pigeon pea and corn both in pure and mixed stands as compared to the computed combined seed yields (using the above formula) are shown in Table 2. The real advantage of mixing the two crops was shown by the seed yield of all mixed treatments except Treatment 4 (one row of pigeon pea for every two rows of corn), where the actual seed yield was less than the computed seed yield.

Data on the yield components of the crops are presented in Table 3. There was no significant difference between the treatment effects on pigeon pea seed number per pod or pod number per plant. Pure corn produced significantly less seeds per ear and less ears per plant than the other treatments.

Seed attributes

Neither the seed protein content of pigeon pea nor that of corn was affected by the different systems of intercropping (Table 4). The highest protein yield (Table 4) was produced by Treatment 1 (pure pigeon pea) and the lowest by Treatment 2 (pure corn).

Plant characteristics

Treatments affected neither the dates of flowering and podding in pigeon pea nor the dates of silking and tasselling in corn. Pigeon pea flowered and podded in 80 and 88 days respectively after planting, and harvesting was done 118, 131 and 148 days after planting. Corn plants tasselled and silked in 53 and 63 days respectively after planting and were harvested at 118 days.

Table 5 presents the observed effects of different systems of intercropping on the height of pigeon pea and corn 11 weeks after planting. The various treatments had no effect on the height of corn. However, differences in pigeon pea plant heights were observed at 11 and 14 weeks after planting. Treatment 1 (pure pigeon pea) produced the tallest plants at both sampling dates.

The total dry matter per plant of the two crops was unaffected by the treatments (Table 6). on the other hand, Treatment 1 produced lower dry matter yields than the other treatments.

DISCUSSION

The seed yield data are, in general, consistent with the findings of EVANS (1960), DONALD (1963) and WILLEY and OSIRU (1972) who reported that higher seed yields were obtained from mixtures than from pure stands of the component crops. The fact that corn appeared to benefit more than pigeon pea from the association confirmed the general statements of OLSON and TIHARUHONDI (1972) for grass-legume mixtures. In agreement with HUSSEL (1961) for a legume/non-legume association, corn plants in mixed stands probably had more available nitrogen since pigeon pea nodules could have fixed sufficient nitrogen for use by both crops. The competition stress for soil nitrogen and light which apparently occurred in pure corn stands might have reduced ear and seed numbers as previously reported by DONALD (1963), but was not statistically significant enough to affect the dry matter per plant and seed protein content of corn. However the dry matter and protein yields might have been affected.

Initially, the pigeon pea plants in mixed stands were apparently poor competitors since corn exhibited a greater visible top growth and appeared to have well established root systems. At later stages the corn plants had a height advantage over the pigeon pea plants. This height advantage may have caused shading of pigeon pea plants possibly resulting in reduced vegetative growth.

The present findings are different from those of EVANS (1960) and HUSSEL (1961) in that, while for pigeon pea the dry matter yield in mixed stands was higher than that of the pure stand, the converse was true for corn. It would seem that the yields were generally influenced by the plant population density and particularly by the relative proximity of the component plants in mixed populations.

THOMPSON (1957) and HUSSEL (1961) reported a higher protein yield from mixtures than from either component crop grown alone. The present findings differ in that protein yields from mixtures of corn and pigeon pea were no better than those from either of the pure stands.

It would appear that plants in mixtures are able to utilise environmental resources more efficiently than those in pure stand. Moreover, it is evident from Table 2 that alternate row planting of pigeon pea and corn produced the highest total yield. In this system of intercropping the proximity of pigeon pea plants to each other and to the neighbouring corn plants is greatest. This is presumably the cause of the outstanding performance obtained. Studies with higher plant population densities and more systematised pigeon pea and corn ration should be conducted to investigate further the validity of this inference under similar local conditions and to provide essential data on net economic returns.

ACKNOWLEDGMENTS

The authors thank Professor E.A. Tai for helpful suggestions. Thanks are also due to the Management Committee of the Texaco Food Crops Demonstration Farm for use of facilities at the Farm, and to the Central Analytical Laboratory, of the University of the West Indies, Trinidad for the seed protein analyses.

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TABLE 1. The intended plant population (plants per hectare) for pigeon pea and corn in pure and mixed stands.

Treatments	Plant populations	
	Pigeon Pea	Corn
1. Pure pigeon pea	44,444	-
2. Pure corn	-	53,333
3. Alternate row planting	22,222	26,667
4. One row of pigeon pea for every two rows of corn	14,815	35,555
5. Alternate planting within the row	22,222	22,222
6. One plant of pigeon pea for every two plants of corn within the row	14,815	29,629

TABLE 2. Effect of different systems of intercropping on the seed yields (kg/ha) of pigeon pea and corn.

Treatments		Actual observed seed yield	Seed yield computed with formula
1. Pure pigeon pea		6,960	6,960
2. Pure corn		5,939	5,939
3. Alternate row planting	Pigeon pea	4,056	2,627
	Corn	3,659	3,659
4. One row of pigeon pea for every two rows of corn	Pigeon pea	1,281	1,670
	Corn	4,653	4,653
5. Alternate planting within the row	Pigeon pea	3,234	1,775
	Corn	4,427	4,427
6. One plant of pigeon pea for every two plants of corn within the row	Pigeon pea	1,819	1,253
	Corn	4,865	4,865

TABLE 3. Effect of different systems of intercropping on some yield components of pigeon pea and corn.

Treatments	Pigeon pea		Corn	
	Seed number per pod	Pod number per plant	Seed number per ear	Ear number per plant
1. Pure pigeon pea	5.3*a	51.5a	-	-
2. Pure corn	-	-	368.8 b*	1.0 b
3. Alternate row planting	5.5 a	52.3a	455.5 a	1.5 a
4. One row of pigeon pea for every two rows of corn	5.4 a	52.3a	448.8 a	1.3 a
5. Alternate planting within the row	5.4 a	51.8a	474.0 a	2.0 a
6. One plant of pigeon pea for every two plants of corn within the row	5.3 a	51.3a	470.3 a	1.7 a
S.E ±	0.09	1.20	17.41	0.04

* Values in the same vertical column with a common letter do not differ significantly at the 5% probability level based on Duncan's Multiple Range Test, in this and subsequent tables.

TABLE 4. Effect of different systems of intercropping on the seed protein content and protein yield of pigeon pea and corn.

Treatments	Seed protein content (percentage on a moisture-free basis		Protein yield (kg/ha)
	Pigeon pea	Corn	
1. Pure pigeon pea	24.1	-	1673 a
2. Pure corn	-	12.6	746 b
3. Alternate row planting	23.2	13.0	1326 ab
4. One row of pigeon pea for every two rows of corn	22.7	13.0	1025 ab
5. Alternate planting within the row	23.4	12.8	1326 ab
6. One plant of pigeon pea for every two plants of corn within the row	23.5	12.7	1047 ab
S.E ±	0.41	0.51	183.6

TABLE 5. Effect of different systems of intercropping on pigeon pea and corn heights (cm.) at eleven weeks after planting.

Treatments	Plant heights at 11 weeks after planting	
	Pigeon pea	Corn
1. Pure pigeon pea	94.4 a	-
2. Pure corn	-	265.3 a
3. Alternate row planting	92.2 b	263.4 a
4. One row of pigeon pea for every two rows of corn	90.4 b	267.8 a
5. Alternate planting within the row	90.9 b	269.1 a
6. One plant of pigeon pea for every two plants of corn within the row	90.4 b	268.9 a
S.E.±	0.92	2.41

TABLE 6. Effect of different systems of intercropping on the plant dry weight of pigeon pea and corn and dry matter yields.

Treatments	Plant dry weight (g.)		Dry matter yield (kg/ha)
	Pigeon pea	Corn	
1. Pure pigeon pea	335.2	-	14899 b
2. Pure corn	-	416.6	22219 a
3. Alternate row planting	313.1	450.2	18964 a
4. One row of pigeon pea for every two rows of corn	293.3	429.2	17698 a
5. Alternate planting within the row	262.8	452.3	17901 a
6. One plant of pigeon pea for every two plants of corn within the row	267.4	445.2	17154 a
S.E±	43.06	47.76	1277.0

YIELD POTENTIAL AND DISEASE RESISTANCE OF DRY BEAN (*Phaseolus vulgaris*) VARIETIES IN JAMAICA

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INTRODUCTION

Dry bean (*Phaseolus vulgaris*) is one of the most widely utilized grain legumes in Jamaica and it is estimated that some 4,000 to 5,000 tons are utilized annually. Local production has remained more or less static at just over 2,000 tons per annum since 1967 (6), so that reasonably large quantities have been imported every year. In 1972, for example, some 1,615 tons were imported at a value of $479,000 (2). Several factors contribute to this situation. Dry beans are produced almost exclusively by small farmers on small plots (0.1 - 1.0 ac.) in the hilly areas of Jamaica under conditions in which farmers have absolutely no control of water. Since the crop is highly sensitive to excesses and deficiencies in soil moisture during the growing period and in addition the beans rapidly deteriorate under prolonged high humidity during the period of maturation, it is not surprising that farmers consider dry beans a "high risk" crop.

Pierre (3,4,5) has reported that in addition to the limitations associated with moisture, the high incidence of diseases also is a major limiting factor to bean production in Jamaica. Many of the diseases to which the crop is susceptible are seed borne e.g. anthracnose, bacterial blights, bean common mosaic. Unfortunately, no facilities are currently available for the production and distribution of disease-free seeds, with the result that farmers save their own seeds and so perpetuate these diseases.

The main objectives of the University's research programme on dry bean were as follows:

1. Improvement of various agronomic practices including spacing, weed control, fertilizer response
2. Identification of the major diseases and development of measures for their control
3. Evaluation of varieties for yield potential and disease resistance.

As the title of this paper indicates, we are primarily concerned here with yield potential and disease resistance.

METHODS AND RESULTS

Evaluation of varieties for yield potential

In a preliminary trial, 35 varieties were planted during the month of August, 1969 in single row replicated plots. In this trial, 10 varieties yielded in the range 500-1,100 kg/ha and 25 varieties produced less than 500 kg/ha. The better performers included many of the kidney types, e.g. Redkote, Charlevoix, Dark Red Kidney, Light Red Kidney and Diacol Ninia, Pinto UI 114 and two local selections, Miss Kelly and Round Red. Redkote (1037 kg/ha) was the best yielder and the local standard Miss Kelly yielded 663 kg/ha.

In a second preliminary trial, 41 varieties were planted during the month of December 1969, again in single row replicated plots. In this trial, the following varieties yielded over 2,500 kg/ha - Pinto #114, Great Northern #31, Miss Kelly, Pinto 66/9251/1, Great Northern 1140 and Red Mexican #37. Ten varieties, including Portland Red, Small White and a number of black seeded types, yielded between 2,000 and 2,500 kg/ha. Nineteen varieties yielded in the range 1,000 - 2,000 kg/ha and six varieties produced under 1,000 kg/ha. All the kidney types together with the local selections Cockstone and Round Red were in the last two groups.

Two further trials were carried out in December, 1970 and February, 1974, respectively. A randomised block design with three replications was used in each case with four rows 610 x 48 cm. The results are given in TABLES 1 and 2.

RESULTS

In TABLE 1 the best nine varieties were not significantly different from each other and produced yields in the range 1784 (Sutter Pink) to 2351 kg/ha in the local variety Miss Kelly. Within this range also were included the local varieties Portland Red and Round Red, plus Redkote, Diacol Minia and a number of the Red Mexican types. The number of days to harvest ranged from 73 to 86. Round Red produced the lowest number of pods per plant (5.5) compared to Long Red (11.7). The number of seeds per pod also varied in the different varieties and ranged from 2.3 to 3.9.

In TABLE 2, the varieties ICA Guali, Miss Kelly, Diacol Nima and ICA Duva were not significantly different from each other but there was a significant difference between the yield of these varieties in comparison to the other varieties tested. A total of seven varieties yielded over 2,000 kg/ha. The period to maturation ranged from 63 days in most of the kidney types to 83 days in the case of Mexico 235. The number of pods per plant ranged from 5.1 (Redkote) to 12.8 (Santa Anna) and the number of undeveloped pods per plant ranged from 0.33 (ICA Duva) to 3.33 (Santa Anna).

Evaluation of Varieties for disease resistance

The bean diseases which occur in Jamaica have previously been reported (3,4,5). These include anthracnose, bacterial blights, bean common mosaic, bean yellow mosaic, golden mosaic, rust, powdery mildew, angular leafspot, *Rhizoctonia* root rot, *Sclerotium* wilt and root knot. In addition *Rhynchosia* mosaic and bean smut (*Entyloma* sp.) attack beans to some extent. By far the most important diseases are golden mosaic, rust, anthracnose and bacterial blights.

Golden Mosaic:

Golden mosaic is a virus-like disease which is transmitted by a whitefly (*Bemisia tabaci*) which breeds profusely on poinsettia (*Euphorbia pulcherrima*). The main hosts are bean, lima bean (*Phaseolus lunatus*) and an extremely common weed (*Phaseolus lathyroides*). Over 100 varieties have been tested in Jamaica for resistance to this disease without success. Games (1) has evaluated over 4,000 varieties of beans in Costa Rica and failed to find resistance. In Jamaica, some variability in the response of varieties to this disease has been observed but this is attributed to a varietal preference by the whiteflies rather than varietal tolerance of the pathogen. This disease is prevalent in the lowland areas but the incidence is low during the cooler months from November through March (3).

Rust:

This is a cool season disease which unlike golden mosaic is prevalent during the cooler months. Several varieties have been evaluated for resistance to rust and the results of one of the most recent trials are shown in TABLE 3. Although many resistant varieties have been found, most of them are black or brown-seeded types. Among the red-seeded types, the local variety Miss Kelly is outstanding. Other resistant red types include Mexico 235 - a late, low growing semi-trailing variety - and Portugal, a poor yielder. Some of the newer introductions (ICA Guali, ICA Duva, Diacol Nima, Diacol Calima, Pompadour, NEP-2) appear to be "slow rusters".

Anthracnose:

This is another cool season disease which also is seed borne. Trials in Jamaica indicate the presence of several races of this pathogen to which all the local varieties are highly susceptible. Some of the introduced varieties are resistant to some races of this fungus but because of the wide distribution of the different races control through the use of resistant varieties would be of no significance.

Bacterial Blights:

Two types of common bacterial blight occur in Jamaica. The diseases are seed-borne and can be extremely destructive under conditions of high rainfall. Varietal evaluation for resistance to these diseases is being carried out in Puerto Rico. If sources of resistance are found these will be utilized in our breeding programme.

DISCUSSION

Time of planting was the main contributory factor to the difference in the level of yield obtained in the two preliminary trials. In general, beans grow best under relatively cool weather conditions and it is clear from these trials that all varieties performed better when planted during the cool season, except where there was a superimposition of additional limiting factors.

One such additional factor in the cool season planting was the high incidence of bean rust to which the kidney types and several other varieties are highly susceptible. The high incidence of yet another disease, golden mosaic, also contributed to yield reduction in the August planting.

The level of yield obtained in the major trials are quite similar in the standard varieties Miss Kelly, Portland Red and Charlevoix, the exception being the variety Redkote which produced a much lower yield in the second planting. This again is attributable to the high incidence of rust on this variety and Dark Red Kidney.

Several varieties are resistant to rust but these are mostly black and brown-seeded types and since the consumers in Jamaica prefer the red-seeded types, the main value of these would be as sources of resistance in a breeding programme. A few red-seeded types also are rust resistant and among these, Miss Kelly is outstanding both in terms of resistance and yield potential. Portugal, another rust resistant variety, is a poor yielder and Mexico 235 has the disadvantage of having a low, semi-trailing growth habit. The three varieties, ICA Guali, ICA Duva and Diacol Nima produced yields quite similar to Miss Kelly. These varieties are "slow rusters" and have the advantage of being bush types - a feature which would facilitate mechanical harvesting if this is implemented. These varieties will be released shortly.

One other interesting variety is MEP-2 - a white-seeded pea bean of the type used in the pork and beans industry. This variety also is a "slow ruster" and it appears to have a higher yield potential than the other pea beans which have been evaluated. This variety also will be released shortly.

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TABLE 1. Seed yield and other characteristics of dry bean varieties grown at Lawrence Field, St. Catherine, Jamaica in Dec. 1970.

Varieties	Seed Yield (a) (kg/ha 88% DM)	Growth Habit	Seed Characteristics Colour	100 D.Wt.(gm)	Podding Characteristics No/ph	Seeds/pods	No. of Days to Harvest
Miss Kelly (L)	2351 a	Semi-trailing		24.8	9.0	3.9	80
Portland Red (L)	2210 ab	Semi-trailing	Dk. Red	20.5	10.6	3.7	73
Diacol Minia 85/364	2181 abc	Bush	Wh. Str.	48.6	8.0	2.8	86
Redkote	2084 abcd	Bush	Dk. Red	43.7	7.0	2.3	78
Red Mexican #36	1974 abcd	Semi-trailing	Red	28.5	10.5	3.4	86
Red Mexican #34	1959 abcd	Semi-trailing	Red	26.4	9.6	3.6	86
Red Mexican #37	1837 abcd	Semi-trailing	Red	26.6	7.9	3.6	75
Round Red (L.)	1812 abcd	Bush	Red	24.6	5.5	2.9	73
Sutter Pink	1784 abcd	Semi-trailing	Pink	27.9	10.5	3.6	73
Big Bend	1734 bcd	Semi-trailing	Red	23.8	9.3	3.6	86
Dark Red Kidney	1725 bcd	Bush	Dk. Red	33.4	7.5	2.4	73
Red Mexican #35	1705 bcd	Semi-trailing	Red	29.6	7.8	3.1	86
Pinto #114	1652 bcd	Semi-trailing	Brown Str.	31.5	6.1	3.9	75
Long Red (L)	1628 bcd	Bush	Red	22.2	11.7	3.9	75
Great Northern #59	1612 cd	Semi-trailing	White	26.9	7.8	3.2	79
Charlevoix	1502 d	Bush	Red	38.4	5.8	3.2	73

Coef. of Variation 16.2%
(a) Treatments followed by the same letter are not significantly different by Duncan's Multiple Range Test at 5% or less.

TABLE 2. Seed yield and other characteristics of dry bean varieties grown at Lawrence Field, St. Catherine, Jamaica in February, 1974.

Varieties	Seed Yield (a) (kg/ha 88% BM)		Growth Habit	Seed Characteristics Colour	100 Wt(gm)	Podding Characteristics No/plnt	No/undev/pl	Seed/pod	No. of Days to Harvest	Dis. Incidence Rust	G. Mos.
ICA Guali	3068	a	Bush	Dk Red Wh Str	51.5	7.7	0.56	3.5	73	Trace	-
Miss Kelly (L)	2901	a	Semi-trailing	Lt Red Red Str	23.7	9.6	0.56	4.2	71	None	-
Diacol Nima	2705	ab	Bush	Dk Red Wh Str	47.3	8.1	0.36	2.9	73	Trace	0.7
ICA Duva	2536	abc	Bush	Dk Red	44.4	8.6	0.33	2.4	73	Trace	-
Portland Red (L)	2150	-bcd	Semi-trailing	Dk Red	17.5	9.9	0.63	4.1	66	Mod.	0.3
Pompadour	2144	-bcd	Bush	Red Wh Str	31.9	5.7	1.06	3.1	71	Light	-
Mexico 235	2032	--cde	Semi-trailing	Red	28.1	8.2	1.40	3.2	83	None	-
Diacol Calima	1757	---def	Bush	Dk Red Wh Str	39.4	8.0	0.50	3.1	71	Trace	-
Charlevoix	1618	---defg	Bush	Dk Red	35.8	6.5	1.83	2.5	63	Mod.	-
27-R	1545	----efgh	Bush	Lt Red	35.1	5.7	1.26	3.8	66	Mod.	-
NEP-2	1465	----efgh	Bush (tall)	White	10.2	12.7	0.66	5.3	78	Trace	-
Santa Anna	1432	-----fgh	Semi-trailing	Red	28.3	12.8	3.33	2.2	66	Light	-
Dark Red Kidney	1176	-----fgh	Bush	Dk Red	35.6	5.8	1.53	2.4	63	Severe	0.3
Redkote	1117	------gh	Bush	Dk Red	33.9	5.1	1.56	3.1	63	Severe	-
Portugal	950	-------h	Semi-trailing	Red	30.4	6.1	2.03	3.4	78	None	-

Coef. of Variation 16.6%
(a) Treatments followed by the same letter are not significantly different from each other by Duncan's Multiple Range Test at 5% or less.

TABLE 3. Response of selected bean varieties to rust.

Code	Variety	Seed Colour	Rust Reaction (a) Jamaica	Puerto Rico
71	PRS70/15R42/1BK	Black	2	0
72	PRS70/15R42/52BK	Black	2	0
73	PRS70/15R42/55BK	Black	2	3
74	PRS70/15R42/57BK	Black	2	4
75	PRS70/15R42/87BK	Black	2	0
76	PRS70/15R42/148BK	Red	2	0
77	PRS70/15R42/167/4BK	Buff	2	0
78	PRS70/15R42/180BK	Brown	2	0
79	PRS70/15R42/189/1BK	Brown	2	3
80	PRS70/15R42/193/1BK	Brown	2	0
81	PRS70/15R194/2BK	Brown	2	0
82	PRS70/15R277BK	Red	5	3
83	PRS70/15R287/1BK	Buff	3	0
84	PRS70/15R292BK	Buff	2	0
85	PRS70/15R210BK	Brown	5	3
86	PRS70/15R66/1BK	Black	3	3
87	PR h71/1R 63	Black	2	0
88	PR H71/1R 69	Black	3	0
89	PR H71/1R101	Black	2	2
90	PR H71/1R103	Black	2	0
91	PR H71/1R113	Black	2	0
92	PR H71/1R136	Black	2	0
6	Charlevoix	Dk Red	5	
13	Redkote	Dk Red	5	
14	Portugal	Red	2	
58	ICA Duva	Dk Red Wh Str	5	
59	ICA Guali	Dk Red Wh Str	5	
60	Diacol Calima	Dk Red Wh Str	5	
61	Diacol Nima	Dk Red Wh Str	5	
63	Mexico 235	Red	2	
93	27-R	Lt Red	5	
94	NEP-2	White	2	
95	Pompadour	Red, Wh Str	5	
	Miss Kelly (L)	Lt Red, dk red str	2	
	Portland Red (L)	Dk Red	5	
	Long Red (L)	Red	5	

(a) Jamaica reaction grades based Davison's 1-5 scale ( ) in which 1 = immune; no necrosis or other evidence of infection; 2= hypersensitive necrosis; 3 = pustules under 300/μ dia.; 4 = pustules 301-499/μ; 5 = pustules over 500/μ. In the Puerto reaction grades 0 = no infection.

EVALUATION OF CRISP-HEAD LETTUCE CULTIVARS

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INTRODUCTION

Lettuce imports for Puerto Rico in 1972-73 amounted to 9023 metric tons valued at 2.5 million US dollars.

Sixteen crisp-head lettuce cultivars were tested in this 1973-74 trial. All were evaluated for winter production. Of prime importance were yield, head weight and uniformity. These are the most important characters with or without mechanization.

All cultivars were direct seeded in the field at the Fortuna substation on November 28, December 20, January 10 and January 31. Five replications each in two rows 0.9 m (3 ft.) apart and 4.6 m (15 ft.) long with plants spaced at 0.3 m (12 in.) in the row. No fertilizer was used. Pronamide (Kerb 50 w) at 1.8 kg (4 lbs) active ingredient per 0.4 ha (1 ac.) was applied as preemerge herbicide. The plots were irrigated six times and received 2.5 cm (1 in.) of water at each irrigation. The harvest dates were February 15, March 13, March 21 and April 10, making cycles of 78, 83, 70 and 69 days per crop for each planting respectively.

Weather data for the period from November 28 through April 12 was: Max temp 31.7°C (89°F), mean min temp 15.6°C (60°F) and a mean temp of 22.8°C (73.6°F). Total precipitation was 65.4 mm (2.97 in.) with the greatest in 24 hours 14.5 mm (0.57 in.). The elevation of the substation is 21 m (67.9 ft).

TABLE 1 summarises the combined data of the four plantings of this trial. Individual comments are listed.

Disease is considered the greatest limiting factor effecting yield, principally, bacterial soft rot (*Erwinia carotovora*). Other problems, but minor factors, were leaf spot (*Cercospora longissima*), and tip burn, a physiological disorder. Cultivar Empire appeared more susceptible to root knot nematode than others. Split heads are also considered important in yield production but this is physiological and may be related to high daytime temperatures.

Cultivars Great Lakes R-200-95 (K), Great Lakes 659 (N), Great Lakes 118 (N), Great Lakes Mesa 659 (N), Great Lakes Picoverde (K) and Oswego (D) are considered worthy of further evaluation.

NOTE: The use of cultivar names and names of companies in this paper is for convenience and does not imply endorsement of these cultivars or the companies by the Agricultural Experiment Station of the University of Puerto Rico.

TABLE 1. Evaluation of Crisp-Head Lettuce Cultivars, Fortuna Substation, P.R.

Cultivar and seed source [1]	Yield cases/ha [2]	Metric tons/ha	Head wt. (kg)	% marketable heads	% diseased heads	% split heads	% blooming and no heads
Great Lakes R-200-95 (K)	534.7 a[3]	8.8	0.51	36	35	22	7
Great Lakes 659 (N)	442.4 ab	6.5	0.54	28	48	21	3
Great Lakes 118 (N)	422.9 abc	6.0	0.54	28	41	24	7
Great Lakes Mesa 659 (N)	418.9 abcd	5.8	0.54	27	43	21	9
Mesa 659 (A)	388.7 abcde	5.5	0.51	28	35	33	4
Great Lakes Picoverde (K)	357.9 abcde	5.6	0.63	36	29	27	8
Great Lakes 659 (A)	328.5 abcde	4.5	0.58	39	45	9	6
Oswego (D)	313.2 abcde	4.2	0.58	35	29	24	12
Great Lakes 66 (D)	308.5 bcde	4.7	0.61	28	36	30	6
Great Lakes 659 (D)	291.9 bcde	4.0	0.50	26	36	20	18
Empire (N)	280.2 bcdef	4.3	0.56	22	42	19	17
Picoverde (K)	237.1 bcdefg	3.3	0.63	15	38	40	7
Great Lakes 118 (A)	183.2 efg	2.4	0.58	17	54	23	6
Great Lakes Bellaverde (K)	156.7 fg	2.2	0.56	16	45	27	12
Empire (A)	142.8 fg	2.1	0.63	16	51	26	7
Vanguard (D)	16.1	0.2	0.07	3	21	12	63

1 Seed source: A = Asgrow, D = Dessert, K = Keystone and N = Niagara
2 One case has 24 heads
3 Means followed by the same letter are not significant at the 1% level