PROBLEMS OF YAM CULTIVATION IN BARBADOS

— *by* —
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The yam, *Dioscorea alata,* is the major staple foodstuff grown in Barbados: over 15,000 tons were harvested in 1965/66, valued at about 1.3 million dollars. Yields are, however, not very high, averaging only some 4-5 tons per acre. There are several distinct strains of *Dioscorea alata* in Barbados—clonal propagation is the rule—and of these the White Lisbon (locally called "Crop Libson") is the most extensively grown as it is regarded as having the best flavour and texture as well as being the highest yielder. It has, however a poor shape, the tubers being large and spatulate, with toe-like outgrowths, making them difficult to harvest and not very suitable for packing nor attractive for the growing export market.

Up to about two years ago yams in Barbados had received little systematic study. They are invariably grown on land which has been prepared and ploughed for sugar cane, not especially for yams—they are grown as a true catch crop in the interval between the harvesting of one crop of cane and the planting of the next. We did not know whether the spacing of 5ft. x 5ft. imposed on them by this system was suitable: we knew nothing of any interaction there might be between cultivars and spacing, indeed, we are not always quite certain just what cultivars we are actually dealing with. We did not know whether there was any difference in top or middle or bottom cuttings used for planting material, nor did we know anything about their fertiliser requirements, nor the interactions between rainfall, soil and yield. Further, there have been recent outbreaks of two diseases which have in places been serious — a leaf disease identified as Colletrotrichum and a tuber rotting during storage of the harvested material. Finally we were uncertain as to what causes the aerial parts to die off at about the time of maturity.

With the growing interest about crop diversification that is developing in Barbados and the greater awareness in recent years of the importance both social and economic, of locally grown foodcrops, it is not surprising that the lack of precise knowledge about so important a crop as yams became a matter for concern. Just two years ago, therefore, systematic experiments were started on this commodity, and in this report we shall try to summarise, very briefly, what has been attempted and what has been accomplished. You will appreciate that much more than two years' experimentation is required for many definite conclusions to be drawn, but even in this short time certain trends are so clear that there can be no doubt as to the ultimate answers. However, there are still very large gaps in our knowledge, and these will also be touched upon.

Barbados, in spite of its small size, has a wide range of soil types and well marked rainfall zones. In any programme of field experiments, therefore, it is necessary to lay down a number of experiments in different parts of the island, and this was done in both the 1965 and 1966 series.

(1) *How a yam grows*

As a basis for further understanding growth analysis observations were undertaken on yam plants a large number of measurements being carried out on white lisbon yams in an intermediate rainfall area. The observations included:—

Area of ground covered
Total length of all stems
Number of leaves
Total area of leaves
Leaf area index
Total fresh weight of shoot system
Dry weight of shoot system
*Fresh weight of root system (not including tubers)
*Dry weight of root system (not including tubers)
Fresh weight of tubers
Dry weight of tubers

The progress of growth is shown in Figure 1 and may be summarised in words as follows:—

(1) Both the shoot and the roots system developed very slowly for the first eight weeks but then grew with increasing rapidity to the 30th week after planting, subsequently dying back quite sharply. Secondly spires — i.e. new shoots emerging from below ground—appeared at 10-12 weeks, and this really marked the onset of development of the shoot system. It would seem that previously the plant had been living almost entirely off the old tuber, but the appearance of second spires was the start of an independent plant.

(2) Outgrowths of undifferentiated meristematic tissue appeared at about 10 weeks and from these grew the new shoots that formed the "second spires", and a vigorous root system.

(3) Bulking of the tubers started at about 22 weeks, and was extremely rapid after 26 weeks up to the 36th week, when the yams were harvested.

(4)) The general dying back of the shoot system after 30 weeks already noted in (1), was associated with a cessation in growth of the stems and a reduction in the number of leaves. (It may be noted in passing that the aerial portions of a well grown yam plant are very substantial; at 30 weeks, the average total stem length (i.e) stem and branches) was 220 feet and the number of leaves per plant was approximately 500. One plant was measured with total stem length 410 feet and another with 632 leaves).

(5) The leaf area index (i.e. the area of leaves divided by the area of ground covered) rose rapidly to a figure of 2.7 by the 16th week and then remained very steady until the 26th week, when it fell rapidly, owing to the loss of leaves from the plants. The literature suggests that leaf area indices above

*In practice the adequate removal of the root system was not achieved and these observations were abandoned.

3 may imply excessive mutual shading; there is thus no evidence from the current observations that the yam plant, spaced 5ft. x 5ft. trailing on the ground, is lacking on photosynthetic efficiency. On the other hand, shading may be causing leaf fall from the lower shoots, and it is quite possible that elevating the plant on stakes, as is done in several West Indian Islands (but not in Barbados), may allow the development of many more leaves on the shoot system.

(6) Rainfall throughout the growing period was fairly well distributed and no direct effect on the growth rate could be discerned.

So here we have a picture of the life cycle of the yam plant, albeit it is only for a single cultivar under one set of conditions. Even so, it has given those of us who worked on this crop an understanding that we did not possess before.

In 1966 observations were carried out on the rate of the development of tubers of four cultivars—White Lisbon, Coconut Lisbon, Oriental and Hunt. The growth curves are shown in Figure 2; distinct differences in rates of development are shown the more rapid bulking of Oriental and Coconut Lisbon being clear ; Oriental has long been established as an early variety for harvest in November/ December. There are now indications that Coconut Lisbon can be harvested around the same time. Hunt also seemed to mature fairly early (30-32 weeks from planting), but White Lisbon develops more slowly for a considerably longer period.

(2) *Spacing*

In the 1965 experiments, on five localities, randomized plot layouts were used, the plots being relatively small, 40 x 20 ft. (800 sq. ft.). The actual spacing treatments were as indicated in Table I; yields per acre for the five localities are also shown.

The considerable increase in yield with closer spacing is clear although there were anomalies, mainly due to death of plants and the rather small numbers involved. Closer spacing also led to a reduction in size of the tubers and a larger proportion of better shaped material.

There was no very close correlation between the total rainfall and the ultimate yield; further analysis of the rainfall figures, however, showed that the amount and pattern of rainfall in the first few weeks after planting was extremely important, affecting the establishment of the plants.

Table I. Yams 1965: Spacing Experiments (Cultivar White Lisbon)

Spacing (feet)	Plants per acre	Yield in lb. per acre plantations Nos. (1)					Average of 5 Plantations
		1	2	3	4	5	
2.5 x 2.0	8,700	34,500	24,500	22,600	18,900	16,500	23,580
5.0 x 2.0	4,350	28,500	20,000	15,500	16,300	9,900	17,960
5.0 x 3.0	2,900	19,800	16,600	11,700	13,800	10,800	14,540
5.0 x 4.0	2,200	18,800	16,800	12,800	13,400	11,600	14,680
5.0 x 5.0	1,750	22,300	12,200	7,500	12,900	5,400	12.060
5.0 x 6.0	1,450	16,200	12,800	9,800	11,600	8,500	11,780

Rainfall during the growing season was as follows:

Plantation 1 .... 50.56 inches " 2............. 43.79 "
" 3 .... 36.38 " " 4 .... 51.80 "
" 5 .... 36.22 "

Along with these small scale experiments a single large scale observation was made on one plantation where, in a 5 acre field otherwise planted at the conventional 5ft. x 5ft. an area of 1 acre was planted 5ft. x 2ft. 6 ins. The results were striking (Table II).

Table II

Planting distance	Yield per plant (lb)	Yield per acre (lb)	Value of crop per acre ($) *
5'0" x 5'0"	7.8	13,600	476.00
5'0" x 2'6"	6.9	24,000	720.00

* *Valued at 3.5 cents per lb. for 5'0" spacing and 3.0 cents per lb. for 5'0" x 2'6" spacing because of the higher proportion of small tubers in the latter case.*

In the 1966 experiments all plantings were made on ridges 5 feet apart (as this was the distance between ridges required for sugar cane cultivation), but spacing of 5'0" and 2'6" along the ridge were used. Two cultivars, White Lisbon and Coconut Lisbon, were used in these experiments. Results are summarised in Table III.

On the field scale, then, we have a consistent increase in yield with closer spacing, averaging 3,922 lbs per acre for White Lisbon and 4,238 lbs per acre for Coconut Lisbon. These increases are worth about $157 and $180 respectively at the current price of 4 cents per lb.

All the yields were relatively low; this is attributed to excessive rainfall and periodic waterlogging of the soil.

(3) *Planting Material*

It is customary in Barbados to use slices of tuber as planting material, each weight 4 to 6 ounces. A single tuber will provide 3 to 5 or 6 cuttings. Sometimes, however, small whole yams, also weighing 4 to 6 ounces, (which are virtually unsaleable) are planted. These are known as seed yams. It is frequently stated that the top cuttings grow more quickly and give higher yields than middle or bottom cuttings. Seed yams also are regarded highly by planters.

Table III. Yams 1966: spacing trials

Location	Planting distance	White Lisbon	Coconut Lisbon
		Yield per acre (lb)	Yield per acre (lb)
1	5'0" x 5'0"	18,097	10,433
	5'0" x 2'6"	19,650	17,967
2	5'6" x 5'0"	9,713	9,090
	5'6" x 2'6"	12,583	13,623
3	5' x 5'0"	5,873	3,903
	5'0" x 2'6"	10,937	6,838
4	5'0" x 5'0"	7,340	6,483
	5'0" x 2'6"	10,893	9,660
5	5'0" x 5'0"	8,653	6,113
	5'0" x 2'6"	14,373	9,800
6	5'6" x 5'0"	8,920	7,250
	5'6" x 2'6'	12,387	10,690

Plantation 1 high rainfall area
" 2, 3,4 intermediate rainfall area
" 5, 6 low rainfall area

One experiment has now been done in which top, middle and bottom cuttings, and seed yams were compared. The first observations were on the percentages that sprouted within certain periods (Table IV).

Table IV. Yams 1966 Planting material: rate of development

Period after planting	Percentage sprouted			
	Top Cuttings	Middle Cuttings	Bottom Cuttings	Seed yams
4 weeks	63	49	53	62
10 weeks	98	98	99	92

Thus it appeared that indeed top cuttings and seed yams sprouted rather more rapidly than middle and bottom cuttings, but the others caught up eventually. Final yields are shown in Table V.

Table V. Yams 1966 Planting material and yields

Yields in pounds per acre

Top Cuttings	Middle Cuttings	Bottom Cuttings	Seed yams
10,483	9,475	9,521	8,131

Although it appeared that the top cuttings did give a higher yield, this was not significantly different from the middle and bottom cuttings, the lower yield of the seed yams was clear: the difference was significant at the 20% level compared with that from cut pieces.

(4) *Fertilising*

There have been no systematic experiments in Barbados to ascertain when fertiliser should be applied to yams, though from the growth analysis described above it seemed logical to apply it at "second spires", the time when the main root and shoot system were starting their independent life, and this was done in the experiments of 1965 and 1966.

Experiments on small plots in 1965 showed no discernible responses to fertilizers, but the experimental error with these plots was so great that only very major treament differences could have been detected. In 1966 the experiments were conducted on the field scale, with strips of treated and untreated material alternating, the area of each strip being approximately 1/6 acre; the total area of each experiment containing three replications of the fertiliser treatments was thus 2 acres. This layout not only had the advantage of size and of being directly translatable to commercial conditions, but the alternating strips of control plots showed fertility trends across the fields, which in some cases changed by as much as 100% over a distance of only 25 feet. Further, this layout was easily operated with plantation labour. (The same type of layout was used in the spacing experiments already described). Experiments of this kind were put down on eight widely differing localities. In six out of the eight localities increases in yield followed the application of 2 cwt. of a fertliser of formulation 8:12:25; in the other two instances there were decreases in yield. However, the increases were in some cases substantial, though not statistically significant, amounting to an average of 1,200 lbs. per acre (10%) for all eight localities (Table VI). When the fertiliser was increased to 4 cwt. per acre further increases were shown in only four instances, and there were decreases in four, though the average difference from the unfertilised control was an increase in yield of 900 lbs. per acre (9%).

Previous experiments on fertilising yams in Barbados have also failed to show significant responses, but in view of the current results it would be difficult to say that there was truly no response. With changes of up to 100% in control plots only 25 feet from each other it would require a large response indeed to be statistically significant.

The poor response to 4 cwt. per acre of 8:12:25 is peculiar: this is still a relatively low level of fertilisation. The results may perhaps be associated with the exceptionally wet growing season of 1966: yields were lower than in the dry year of 1965 and may have been limited by periodic waterlogging of the soil, and this also may have affected the response of the plants to fertilisers. Much more research is necessary.

Table VI. Yams 1966—Effect of fertilising.

Location	Treatment	Yield per acre	Increase (lb)	% Increase
1	I	17,980		
	II	22,360	4,380	24
	III	21,933	3,953	22
2	I	10,807		
	II	12,497	1,690	16
	III	13,760	2,953	27
3	I	12,892		
	II	11,827	- 965	-7
	III	13,783	981	8
4	I	12,260		
	II	11,260	-1,000	-8
	III	11,780	- 480	-4
5	I	16,537		
	II	17,633	1,096	7
	III	15,377	-1,160	-7
6	I	11,253		
	II	11,325	72	0.6
	III	12,410	1,159	10
7	I	7,722		
	II	10,207	2,485	32
	III	6,953	- 769	-1
8	I	11,100		
	II	12,967	1,867	17
	III	11,837	737	7

Plantations 1, 5, 6—High rainfall area
2, 3, 7—Intermediate rainfall area
4, 8—Low rainfall area

Treatments: I—No fertilizer
II—2 cwt. per acre 8:12:25
III—4 cwt. per acre 8:12:25

(5) *Rainfall and Soil*

No systematic study has yet been made of the effect of rainfall and yield. It is a matter of common observation that in certain years with very low rainfall the yield of yams has been low, and it may be possible to find statistics which can be analysed. We have no idea at all whether rainfall in the early part of the growing season is more important than in the late, or viceversa, except that, in the 1965-66 experiments, the effect of early rainfall on the establishment of the crop,— both in respect of the number of plants surviving, and of their subsequent development, appeared to be important. We hope that in the course of the next few years information of this kind will be developed.

There is equally little knowledge about the effect of soil type and conditions on the growth of yams. There seems to be no area in the island, where, if rainfall is adequate, yams will not do well; on the otherhand, for no reason so far ascertained, a crop may be poor under conditions which were expected to give a good yield. Further, every plantation manager can point out fields in which he will say that yams never thrive, though there is no clear reason why this should be so.

One observation of interest in this year's experiments, however, is that even with the very high rainfall in all parts of the island, the plantations in the higher rainfall areas gave higher yields than those in the lower rainfall regions. This may perhaps be associated with the freer drainage properties of the soils in the high rainfall areas; waterlogging was experienced on several occasions in the other soils.

(6) *Diseases*

Two, perhaps three, diseases of yams have attracted attention in recent years.

(i) *Leaf and stem necrosis*

This is attributed to a species of Colletortichum and appears as spots on the leaves, immature or mature, and black areas on the young stems. Typically the necrotic areas rapidly enlarge, affecting first the more distal parts of the shoot system, ultimately killing the whole aerial portion of the plant. The necrosis does not appears to penetrate into the tubers and if the onset of the disease is late enough, e.g. November, it may be possible to harvest a modest crop; if the disease strikes earlier, however, the crop from affected plants are recognised early the fungus spreads rapidly, mainly downwind and the whole fields can be virtually wiped out. At present control is by spraying the whole field with copper fungicides as soon as any diseased plants are seen.

A study of this disease is under way both in Barbados and in Trinidad; we hope that information will come forth as to the conditions leading to its occurrence and spread, and to effective means of control. An early report suggests that the disease is most severe in cultivars that mature early.

(ii) *Internal Spotting*

The flesh of the mature tuber, particularly towards the stem end, shows small brownish to black spots, often minute, but sometimes several millimeters across. These spots are nodular and may be cleanly excised from the tissues : they show no obvious connections with the vascular system. Under the microscope they appear to be made up of radiating groups of cells. So far there is no clue to their origin: no pathogenic organisms have been isolated from these areas; viruses or mineral deficiency have been suggested also nutrient imbalance associated with a higher degree of fertility of present-day soils. The Ministry of Agriculture has set up experiments to examine these and other possibilities, and an early observation suggests that the condition is most severe in yams that mature relatively late, e.g. White Lisbon.

(iii)

Possibly associated with the above is a general necrosis of the internal tissues of the tuber of the yam during storage, though it has certainly not been conclusively proven that the black spots develop into the large necrotic areas, nor is it, to the best of our knowledge, absolutely certain that the necrosis has ever appeared in areas completely free from skin lesions. Two years ago this necrosis seriously threatened the export industry, but in 1966 rigorous selection of tubers without skin lesions and from fields relatively free from "internal spotting" led to — or perhaps was merely coincidental with — virtually not problems of this kind.

(7) *Die Back*

In December and January the aerial parts normally die back: this is commonly supposed to be associated with maturing of the tuber. However, this is by no means certain. It may to some extent be associated with or accelerated by the handling the 'vines' receive when the cane is being planted—we do know that even quite young plants can be virtually killed by quite gentle handling. It may be associated with physical damage resulting from the tradewinds which usually re-assert themselves after the rainy season, about mid-December. It may be associated with late development of fungal diseases. No systematic observations have been made as the matter has seemed relatively unimportant, since the yams are to be reaped at about this time in any case. However, a late maturing yam (March or April), might enjoy an advantage on the export market, and an experiment was actually done with yams that had had their sprouting artificially delayed by Maleic hydrazide. These were planted in August; they grew well, but died off only 4 months growth (end of December), and produced only very small tubers.

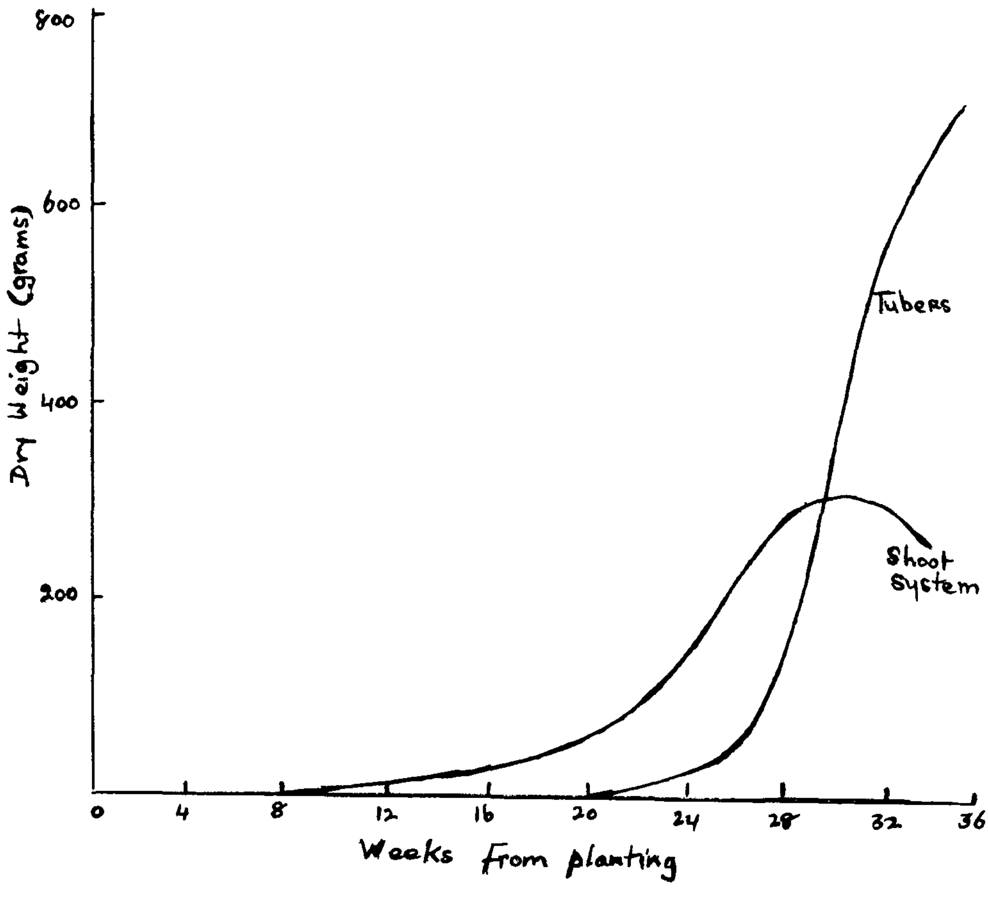
(8) *Deterioration of planting material*

It is commonly said among planters that continuing to plant cuttings from grown yams on the same plantation for several successive years leads to diminution of the crop, and it is normal practice to bring in planting material from some distant plantation every third or fourth year. There is no systematic experimental evidence that this deterioration does in fact take place, though a planter can often point out adjacent fields, one good and one bad, the good one having been planted with "outside" cuttings. Certainly the idea cannot be dismissed out of hand, but the explanation of such a phenomenon, in a small island where disease, for example, can hardly be isolated, is far from clear.

As we said at the start of this paper, little scientific atention has been paid to yams in Barbados until very recently. We have tried to show you some of the more important problems we have recognised—indeed there are many others—and to indicate where there has been progress, what has been done and what is being attempted.

Fig 1. YAMS 1965-66

DEVELOPMENT OF SHOOT SYSTEM AND TUBERS



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DEVELOPMENT OF FOUR CULTIVARS