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A SYSTEMATIC APPROACH TO IMPROVED YAM
PRODUCTION METHODS IN BARBADOS

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INTRODUCTION

Yams are plants belonging to the botanical genus Dioscorea, tubers of which are used either as a source of carbohydrate food or as a source of medicinal compound (i.e. steriods). Yam is traditionally grown by small farmers in all the islands of the Commonwealth Caribbean. In Barbados, it is also grown on sugarcane plantations. Dioscorea alata var. White Lisbon is widely grown in the Eastern Caribbean and Barbados. This variety has also featured prominently in the export trade of yam from Barbados, although its full potential has not yet been realized. Various aspects of the development of White Lisbon yam as a national enterprise in Barbados are presented and discussed in this paper.

HISTORICAL BACKGROUND

Yams are traditionally grown in the Caribbean by small farmers under rainfed subsistence conditions characterized by lack of fertilizer and pesticide application, with the majority of operations being done manually. This system involves limited investment, low risk, low productivity and low farm level income. Nevertheless yam continues to be an important part of the diet of rural communities.

By a twist of fate in 1942, yam landed in the laps of sophisticated sugarcane farmers in Barbados. Being part of the food production effort during World War II, the

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Institution of the Local Food Production Order made it obligatory on all sugarcane plantations to devote 35% of their arable lands to food crops. After the war, this was reduced to 12% and later to 5%. As a result, the production of yam extended to large estates. However, the cultivation of this crop was carried on more from a standpoint of respect for the Order than from one of maximizing yields and incomes from the crop enterprise. The yam crop became stabilized at the large sugarcane plantations under subsistence conditions. The difference from the small farmer situation was that the land was prepared by machine. Yams were grown as a catch crop on lands prepared for sugarcane, without sacrificing the interest of the main sugarcane crop. There was generally no application of fertilizers and pesticides and the crop was rain-fed. Harvesting was done manually by digging with a fork. A large proportion of the harvest was sold in the field to hawkers who "contracted" rows of the crop, dug it and transported it themselves. The acreage of yam on plantations for a nine year period from 1954 to 1963 remained fairly stable and ranged between 1955 to 2,693 acres (Bishop 1963). During the same period the acreage of yam on small holdings was estimated to be 25% of the plantation acreage.

Yam did not attract the attention or interest of the Caribbean scientists and technocrats until the 1960's, and prior to this, any improvement in the method of cultivation, however small, was left to the innovative urge of individual farmers. The mid sixties can be justifiably regarded as a turning point in the Caribbean history of yams. This time, it was not the "Local Food Production Order" but a disease.

This disease known as Internal Brown Spot (IBS) of yam tubers was discovered in Barbados and was found to adversely effect the quality and hence eventual marketability of the tubers. This caused serious concern - the export market of yam was at stake. Scientists from the Caribbean and the U.K. converged to Barbados. Local scientists started looking at yam. Gooding and Hoad pioneered the description of varieties and large scale fertilizer and spacing trials using innovative methods. Studies by Haynes and Ferguson of the University of the West Indies to establish agronomic parameters were noteworthy.

During the seventies, a number of things, both good and bad, happened to yam in Barbados. The situation in the early seventies was critically examined by Clarke (1975). According to him, the acreage under yam on plantations dropped sharply

from 2,686 in 1969-70 to 1,229 in 1973-74. Similarly, the export of yam fell sharply from a peak of 3,887,392 lbs. in 1970 to 818,288 lbs. in 1973, a decrease of some 78.9 per cent. During the same period, the import of white potatoes, obviously from extra-regional sources, rose from 12 million pounds in 1970 to 17 million pounds in 1973.

The loss in yam acreage and export earnings from the crop could be assigned to the combined effect of:

1. Impairment of the quality of yam tubers (due to Internal Brown Spotting) affecting its export worthiness.
2. Relative drought conditions during the early seventies.
3. Increasing cost of labour for harvesting.
4. Poor availability of labour as a result of a clash between the demand for harvesting of sugarcane and harvesting of yams.
5. Good price of sugar on the international market although only for a relatively short period.
6. Change in the mandatory requirement of 12 per cent under food crops to 5 per cent of the arable lands of the plantation.
7. The tendency of a number of large plantations to replace the growing of root crops with commercial mechanized production of the finer vegetable crops.

The foregoing events saw the beginning of significant developments. Investigations on the Internal Brown Spot and virus diseases of yam were started by the Regional Research Centre of the University of the West Indies in 1973 and were continued later by the Caribbean Agricultural Research and Development Institute. This programme, endowed with funding support from the British Government and the European Development Fund, started with research efforts and continued in the development phase up to the present time. Considerable useful information including a scientific breakthrough of significance emerged out of the efforts of Mantell and his colleagues, particularly Haque and Mohamed (Mohamed and Mantell, 1976; Mohamed, 1976; Mantell, Haque and Whitehall, 1978; Mantell, Haque and Whitehall, 1979; Mantell, Haque and Whitehall, 1980).

The highlights of the findings which were particularly significant to the development of yam production in Barbados and the Eastern Caribbean are summarized below:

1. Contrary to popular belief, IBS was not a storage disease. It was discernible in young growing tubers as early as 20 weeks after planting of yams.
2. There was no increase in the number of IBS during storage although the spots became more prominent under storage conditions involving high humidity.
3. Infected tubers were the major if not exclusive source of the carry over of the disease from one season to another.
4. All tubers produced by an infected mother tuber may not show IBS.
5. Using infected planting material, IBS could be reproduced even under conditions of sterilized sand culture and complete nutrient solution.
6. There was no distinguishable differences between healthy and diseased tubers from outside and the only way to locate IBS was to cut the tuber open and slice it.
7. The IBS, a brown, corny spot is surrounded by healthy flesh with no apparent connection to the outer surface of the tuber.
8. The IBS could be reproduced in the plants raised from nodal cuttings of the vines of infected plants grown under sterile conditions.
9. Contrary to popular belief, IBS lesions were most common in the middle region of the tuber (longitudinally) and in the peripheral region of the tuber slices (laterally).
10. In spite of extensive investigations, IBS has been found only in Dioscorea alata. Other species of Dioscorea examined included D. trifida, D. rotundata, D. cayenensis, D. esculenta and D. bulbifera.
11. All of the eleven cultivars of D. alata (namely

Ashmore, Barbados, Bottleneck, Coconut Lisbon, Harper, Moonshine, Oriental, St. Vincent Red, Seal Top, Smooth Statia and White Lisbon) examined were found susceptible to IBS.

12. Three different types of virus particles (a flexuous-rod, a bacilliform type and polyhedral virus particle) were found on yams.
13. Circumstantial evidence suggested the association of polyhedral virus with the IBS disease.
14. All three viruses are transmissible through infected tubers, but other modes of transmission are unknown.
15. Transmission tests including three species of aphids, mealy bugs and scale insects gave negative results.

The major breakthrough of the investigations on IBS was the development of heat therapy and tissue culture techniques for freeing infected White Lisbon stock of three viruses and the IBS symptoms (Mantell, Haque and Whitehall, 1980). A micropropagation technique for rapidly multiplying the virus-tested plantlets was also developed. Finally, full-sized tubers were produced from plantlets. The virus tested yam gave an average yield increase of about 35 per cent over the diseased ones, under conditions of high technology (Mantell and Haque 1979).

The beginning of the 1970's also saw the start of efforts for the mechanization of yam planting and harvesting. The contributions of Jeffers, Chandler and Harvey in constructing local aids are particularly noteworthy. Chandler (1973) reported the results of his efforts and catalogued major pre-requisites for successful mechanical planting and harvesting. The lack of successful resolution of these pre-requisites functioned as impediments to the further development of the mechanization of yams.

CURRENT EFFORTS AND POSSIBILITIES

Yams in Barbados entered the decade of the 80's with a gloomy picture composed of low acreage under the crop, low production and meagre exports.

The developmental phase of CARDI's Yam Project was mounted in 1980, with the major aim of producing large quantities of virus-tested White Lisbon planting material for the yam farmers of Barbados and the Eastern Caribbean. However, it was realized that the production of high yielding virus-tested planting material alone could not improve the production and export of yam. The project therefore functioned as a catalyst to address some of the other problems of the yam industry.

Although the reasons for the decline of the yam industry and feasible approaches to alleviate these have been pointed out by several authors (Clarke, 1975; Garvey and Hoad, 1975), it is regarded pertinent to reiterate and update them here. Progress in the various areas is also reported.

Production of Virus-tested Planting Material

The variety White Lisbon was selected for this purpose since this is the most predominant and popular variety of Dioscorea alata L. in Barbados and the Eastern Caribbean. Many workers have ascribed its flesh colour, flavour and texture as the major reasons for its popularity. We regard its high yield potential as another important trait. Mantell and Haque (1979) reported an average yield of virus-tested stock of 23.78 tonnes per hectare against 15.60 for the diseased stock, based on 5 trials over a 3 year period. George and Pilgrim (1982) demonstrated that virus-tested White Lisbon yam out yielded the farmer's local variety by an average of over 90 per cent under conditions of low inputs and technology. The value of the virus-tested stock was very well demonstrated through these trials.

Production of Virus-tested Stock of var. White Lisbon and its Maintenance

Because of the lack of information on the genetic integrity of yam plantlets grown in vitro, these are not released for direct use at the moment. A scheme for the production of tubers with proven yield records was therefore instituted. The plantlets are first grown in sterilized potting mixture inside insect protected greenhouses. After one season's growth, these plants normally produce tubers of an average weight of 100 gm. a size almost ideal to be used for planting as a whole tuber. In the second year, these tubers are grown in the field under insect-protected conditions inside a gauze-house. To take further precautions against possible field infection, the gauze-houses are located on the

eastern coast of the island with no yam crop to the windward side. The harvest from the crop produces normal sized tubers of around 1,600 gm. Selection criteria are applied at this stage, before releasing the tubers for multiplication by 6 Registered Growers who are all plantation yam growers. Agreement is made with these growers to grow the crop under specific conditions. Although the multiplication plots are relatively isolated from other yam crops and roguing of suspected plants is instituted, the crop for the first time in its life from *in vitro* culture is exposed to possible field vectors. All attempts to transmit the yam viruses using several species of aphids, mealy bugs and scale insects have given negative results. However, these experiments do not completely exclude the possibility of the existence of field vectors. Appearance of the field symptom at this stage of multiplication has been rare, but we have found some of the symptom-free plants carrying infection of flexuous-rod viruses. This particular virus is not implicated with IBS, but it is widespread in all the food species of yam examined (*D. alata*, *D. trifida*, *D. cayenensis*, *D. rotundata*) in all the ten countries of the Commonwealth Caribbean in which the survey was conducted (Mohamed and Mantell, 1976). It is noteworthy that the tuber material which gave 90 per cent yield increase in trials conducted by George and Pilgrim (1982) was exposed in the open field for three seasons. We are of the opinion that as long as the yield increases are substantial and the incidence of Brown Spot imperceptible, the farmers should practice roguing and use the tubers for planting. When these advantages are lost, there will be a need to replace this stock.

The Registered Grower System

Registered growers have to be sophisticated farmers who can co-operate fully and who can institute rigid controls. Currently this is restricted to 6 plantation yam growers in Barbados, and CARDI units, but in future, other institutions are likely to be included. There has to be some incentive for the private registered growers to continue to be part of the scheme. Firstly, they benefit from replacing their own diseased stock. Secondly, their virus-tested seed tubers carry a premium price which is attractive to them but at the same time the buyers find the price worth paying for the quality seed tuber. Further, tubers which have not been sold as seed can be sold for consumption. Even the limited storage period of about four months at the present time, permits full utilization of all tubers produced.

"Toeless" White Lisbon Yams

The White Lisbon variety suffers from one very obvious disqualification - the large sized tubers are spatulate in shape with toe-like outgrowths. This characteristic tends to induce damage by cutting when harvesting is done by hand in particular. Further, for export, a high percentage of toes is undesirable both from the point of view of market acceptability and ease of packing.

The staff of the Ministry of Agriculture in Barbados and some plantation farmers, over the years, selected relatively toeless tubers of appropriate sizes. There is a general feeling that such a practice improves the stock. The Yam Project of CARDI has also used "toelessness" as one of the criteria in the selection process, and have encouraged growers to continue this selection. The genetic basis of this character is not known. Gooding (1971) reported increased yields due to closer spacing. Opinion has also been expressed that closer planting may encourage the production of a larger number of smaller sized, better shaped tubers. We regard continuous selection and closer planting as the best available approaches to alleviate the problem of large sized tubers with toe-like outgrowths.

Mechanization of Yam Planting and Harvesting

The implications of the mechanization of yam planting and harvesting have been discussed by Chandler (1973). Yam farmers in the early 1970's resisted the use of mechanization perhaps because of two reasons. Firstly, it involved growing the yam crop in pure stand. This was in contradiction to their traditional method of growing yam in "preparation land" which did not interfere with the normal planting of cane in October to November. With this traditional system of yam interplanted with cane, mechanization was impossible. At the time of yam harvesting, the cane plants were about 15 inches high and the yams were literally sandwiched between the rows of cane. Secondly, the labour situation for yam had not worsened to such an extent as to force yam growers to switch to the machines. But by the late seventies both the high cost and non-availability of labour had accentuated to such an extent that in many cases yams were ploughed in because of the non-availability of labour to harvest the tubers. Farmers in general, reacted by further reducing the acreage under yam.

Patrick Bethell, co-author of this paper and a Registered Grower for virus-tested yam multiplication, reacted positively. He switched to pure stand yam cultivation, using both mechanical planting and harvesting. He used the planter designed by Chandler (1973) which consisted of a tyne moulding discs, boxes for seed material and a large tube through which seed was dropped, all attached to a double tool bar. Bethell made a slight improvement to the machine which allowed seed to be spaced more accurately. Harvest was carried out with the Harvesting Aid built by Jeffers. This consists of a tool bar with two subsoiler units joined by a straight blade fitted with finger like rods. The harvesting aid lifted the tubers from the soil and the finger like rods helped to separate the soil from the tubers. The throughput of the planter was 3-4 acres per day depending on conditions with a labour requirement of only one tractor driver and one planter operator. The rate of the complete harvest operation including brush cutting of vines, lifting tubers, cleaning, placing on trailers, transporting to storage area and weighing was 1,100 lbs. per hour. Breakage with the mechanical harvesting operation was 8 per cent compared to as high as 23 per cent with hand labour. The total labour cost including two drivers for the tractors, two men to retrieve tubers from loosened soil and six women to clean and load on to trailer worked out at 3 cents per lb. as compared to 5 cents per lb. for manual harvesting.

In addition to a mechanized yam operation, Bethell has further demonstrated that cane can be planted immediately after yam harvest before the moisture is lost from the loosened soil. This idea came from Colin Hudson of Barbados Sugar Producers who designed a two row cane planter which is used in this planting operation. The system however, requires perfect coordination and timeliness of operations and the use of more than one tractor - a situation which could be obtained on most large estates. Others could achieve this by sharing of equipment. The system accommodates pure stand yam cultivation without sacrificing the main cane crop. Further, it is possible to plant larger acreages under yam with reduced labour cost and requirement. All these factors put together will lower the cost of production and should increase the acreage under the crop.

It is noteworthy that following the demonstration of the mechanized system during a CARDI Field Day, much interest has been stimulated, and a number of growers have since mechanized or partly mechanized their crops. In addition, Hudson has since built another harvester which uses a vibrating action to improve separation of soil from tubers.

This machine was tested by a number of growers during the 1982-83 season and found to be successful.

Various Levels of Technology for Yam Production

As has been pointed out earlier, yam is traditionally grown by small farmers under subsistence conditions in a number of Caribbean territories. George and Pilgrim (1982) conducted an ingenious trial in St. Lucia with 8 farmers to evaluate the performance of the virus-tested White Lisbon yam under subsistence conditions without fertilizer or pesticide. The virus-tested yam out yielded the local variety by over 90 per cent (average local yield 5.74 ton/acre, virus-tested 11.17 tons/acre. Virus-tested White Lisbon is therefore regarded as a unique variety which responds well to both low and high technology and can be safely recommended for small farmers, as well as large plantation farmers.

Prolongation of the Shelf-life of Ware Tubers

Harvested yams undergo a period of dormancy during which time they are best suited to consumption but once the tubers start sprouting, deterioration in quality begins. Therefore they cannot, normally, be stored for more than four months after harvest. Marketability of yam is therefore limited in time. Passam of Tropical Products Institute and Weckham and Wilson of the University of the West Indies (1982) did interesting work aimed at delaying the initiation of sprouts in *D. alata*. According to them, by soaking harvested tubers in a solution containing 150 ppm of gibberellic acid prolonged the life of the tubers by 14 weeks. After that time if the sprouts were removed and the tubers dipped again in the gibberellic acid solution, storage life was further extended.

Marketing of Yam

A comprehensive study of market and market prospects for Barbados yams was conducted by Clarke (1975). He critically analyzed both the local and export market of yam. Export of yam from Barbados varied between 2.1 M lbs. to 3.5 M lbs. between 1964 and 1969. It reached a peak of 3.9 M lbs. in 1970 and later fell continuously to a low of 0.5 M lb. in 1975. The export gradually came down until 1980, and then started rising again from 1981. In 1983, a total of 0.5 M lb. was exported. The main reason for the falling export has been the poor supply rather than a loss of market.

The major overseas market for fresh yam comprises United Kingdom, Canada and United States. Clarke (1975) justifiably recommended deepening of the traditional export market rather than its widening to new areas. He estimated the local market for fresh yams in Barbados to be approximately 23 M. lb. per year. This market has not been exploited fully because of the seasonality of supply .

DISCUSSION

For improvements in the production and productivity of any crop, the technology from production to marketing and consumption must be effective, acceptable and sustainable. This can be possible only if the enterprise is attractive, economically and otherwise, to all the parties concerned. Constraints and impediments are likely to develop, from time to time, as a result of changing dynamics of the various elements that comprise the whole enterprise. The history of the production and marketing of yams in Barbados presents an interesting case for study.

To begin with, Government's interest as a result of necessity for food production forced the sugarcane planters to grow yams. Planter's lack of interest in yam as an enterprise, created a situation where they grow yam as a catch crop without sacrificing the sugarcane crop, with low inputs. Nonetheless, they expanded their acreage under yam since labour for planting and harvesting was reasonably priced and adequately available. As a result, inspite of the low productivity per unit area, the export of yam from Barbados remained at a fairly high ebb and varied between 2.1 M lb. to 3.5 M lb. during 1964-1970. Thereafter, labour shortage and high cost of labour, made the manual harvesting of yam difficult and costly. The planters reacted by reducing the acreage under yam. And the IBS disease made the quality of yam unacceptable to overseas consumers. The export of yam fell drastically. Although machines for planting and harvesting were developed, which could solve the problem of labour supply and cost, it created a new problem of growing yam in pure stand which stood in contradiction with the interest of sugarcane. Solution to this problem has recently been found where sugarcane is planted immediately following the harvest of yam. A solution to IBS problem is now available which not only improves the quality but increases the yield as well. However, the production of virus-tested yam is not a once-for-all solution. Replacement of stock, as and when they become unattractive, will have to be done.

Institutional support for this work is in place. It will, however, need funding support, either from within or outside on a continuing basis. There could be various formulae to fund this scheme. Shelf-life of ware yams can be prolonged by gibberellic acid treatment, and yearlong supply and marketing of yam both for local consumption and export could be possible. The urgent need to earn foreign exchange has forced aggressive marketing strategies into action. Proven and cost effective information regarding such elements as spacing, set size, planting time, weed control, fertilizer requirements and control of other diseases are available.

It would appear that the potential of yam as a national enterprise to satisfy the needs and interests of all the parties concerned, namely the government, the plantation farmers, the small farmers, the exporter, the importer and finally the local and overseas consumers, is immense. A mass campaign and a well coordinated action plan could transform the poor man's crop into a vibrant industry.

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LITERATURE CITED

1. Bishop, M. B. (1963). The Economic Position of Selected Items from the Agricultural Sector. Part II - Yams.
2. Chandler, I. D. (1973). Mechanization of Yam Production in Barbados with Special Reference to Planting. Prepared for Eleventh Annual Meeting of Caribbean Food Crops Society, Barbados 1973.
3. Clarke, H. (1975). Market and Market Prospects for Yams in Barbados. Prepared for UWI Faculty of Agriculture Seminar/Workshop on Yam Production in Barbados 1975.

4. Garvey, G. V. J. and Hoad, R. M. (1975). Commercial Yam Production in Barbados Paper presented at UWI Faculty of Agriculture Seminar/Workshop on Yam Production in Barbados.
5. George, C. and Pilgrim, R. (1982). Evaluation of Recommended Virus-tested Yam - Dioscorea alata. c. v. White Lisbon ex Barbados on Small Farms in St. Lucia. Paper presented at 18th Meeting of the Caribbean Food Crops Society, Barbados 1982.
6. Gooding, E. G. B. (1971). Effects of Fertilizing and other Factors on Yams in Barbados. Exptl. Agriculture (1971) 7:315-319.
7. Haque, S. Q. and Mantell, S. H. (1980). Status of the Virus Diseases of Yams (Dioscorea spp.) in the Commonwealth Caribbean. Paper presented at the International Symposium on Yams, Guadeloupe 1980.
8. Harvey, W. O'N and Jeffers, J. P. W. (1973). Attempts at Mechanical Harvesting of Root-crops in Barbados. Proc. 11th CFCs Meeting, Barbados: 260-264.
9. Jeffers, J. P. W. and Chandler, I. D. (1974) Further Work on Mechanical Planting and Harvesting of Root Crops in Barbados. Proc. 12th Caribbean Food Crops Society Meeting, Jamaica:85.
10. Mantell, S. H. and Haque, S. Q. (1978). Incidence of Internal Brown Spot Disease in White Lisbon Yams (Dioscorea alata) during storage. Exptl. Agriculture 14:167-172.
11. Mantell, S. H., Haque, S. Q. and Whitehall, A. P. (1978) Clonal Multiplication of Dioscorea alata L. and Dioscorea rotundata Poir. Yam by Tissue Culture. Journal of Horticultural Science 53:95-98.
12. Mantell, S. H. (1978). Studies on the Internal Brown Spot Disease of White Lisbon Yams (Dioscorea alata L.) Ph.D. Thesis, University of the West Indies Library, St. Augustine, Trinidad.
13. Mantell, S. H., Haque, S. Q. and Whitehall, A. P. (1979). A Rapid Propagation System for Yams. Caribbean Agricultural Research and Development Institute, Yam Project. Bull. No. 1.

14. Mantell, S. H. and Haque, S. Q. (1979). Disease-free Yams: Their Production Maintenance and Performance. Caribbean Agricultural Research and Development Institute, Yam Project. Bull. No. 2.
15. Mantell, S. H. and Haque, S. Q. (1979). Internal Brown Spot Disease of Yams. Caribbean Agricultural Research and Development Institute, Yam Virus Project. Bull. No. 3.
16. Mantell, S. H., Haque, S. Q. and Whitehall, A. P. (1980). Apical meristem tip Culture for Eradication of Flexous Rod Viruses in Yams (Dioscorea alata). Tropical Pest Management. 26(2):170-179.
17. Mohamed, N. A. and Mantell, S. H. (1976). Incidence of Virus Symptoms in Yam (Dioscorea spp.) Foliage in the Commonwealth Caribbean. Tropical Agriculture (Trinidad) 53:256-261.
18. Mohamed, N. A. (1976). Virus-like Particles and Cytoplasmic Inclusions Associated With Diseased Dioscorea spp. in the Eastern Caribbean. Tropical Agriculture (Trinidad) 53:341-351.
19. Passam. H. C., Wickham, L. D. and Wilson, L. A. (1982). Comparative Observations on the Polarity of Sprouting of Bulbils of Dioscorea bulbifera L. and Dioscorea alata L. Ann. Botany 49:359-366, 1982.