Breeding Strategies for Controlling Diseases of Taro in Solomon Islands

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ABSTRACT

Progress towards breeding taro resistant to four severe diseases is described. Resistance to *Phytophthora* leaf blight was found in a wild taro from Thailand and appears to be monogenic and dominant. A backcross program to incorporate resistance to local cultivars has begun. Different reaction to dual infection by taro large and small bacilliform viruses exists in local cultivars. When those that are resistant buy low yielding ("female") were crossed with others that have high yields and are susceptible ("male") all the progeny died. Resistance is now sought from selfed and intercrosses F_1 plants derived from further 'male' x 'female' crosses. The only cultivar resistant to a corm and root rot caused by the nematode *Hirschmanniella miticausa* is low yielding and corms and leaves are acrid when cooked. Crosses have been made between this cultivar and those with more favoured taste and higher yields. The possibility of combining the breeding programs is discussed.

Introduction

Fundamental to improvement of subsistence agriculture based on root crop staples is providing growers with cultivars of superior agronomic characteristics. Selection among local, established cultivars often fails to reveal those with desired traits. Mass importation of germplasm from other countries, as vegetative propagating material, is hazardous and, in most countries, prohibited by plant quarantine regulations. Breeding programs based on selective, controlled importation of cultivars offers a better approach. In recent years this has been demonstrated at international institutes where breeding programs have been established to tackle problems of cassava, sweet potato and certain yams.

Taro, a forth major root crop of tropical countries, has received relatively little attention. In most tropical regions it is the least important of the root crops. However, in the South Pacific taro often dominates the subsistence economy. But in some countries of the region the crop is becoming difficult to grow.

In Melanesia, especially, a number of pests have jeopardized continued large-scale cultivation of the crop and threaten adjacent countries of the South Pacific. Of particular importance are *Phytophthora* leaf blight, taro large and small bacilliform virus diseases and a corm rot disease caused by the nematode

Hirschmanniella miticausa. Breeding programs have been started to produce plants with resistance.

In 1976, preliminary investigations began to define breeding techniques and to determine strategies for disease control. This work, supported by the International Foundation for Science, was summarized at the IFS-sponsored meeting on Taro and Cocoyam in 1979 (Jackson and Pelomo, 1980). Since then FAO/UNDP Root Crops Development Project for the Pacific Countries has assigned a plant breeder to assist the project. This paper describes progress to date.

Taro Leaf Blight

Taro leaf blight, a serious disease of taro caused by the fungus Phytophthora colocasiae occurs in many countries of South East Asia and the Pacific (Trujillo, 1967; Plucknett et al, 1970). In the South Pacific region it is in Papua New Guinea (Shaw, 1963), and Solomon Islands where it is considered to be the most important disease of taro (Barrau, 1958). Reductions in corm yield of 40% to 60% have been reported (Jackson et al., 1980). The fungus also causes a serious postharvest corm decay (Jackson and Gollifer, 1975).

Breeding for resistance to the disease began in 1979. Seed collected from a wild taro in Bangkok, Thailand and grown in Solomon Islands to have seedlings free of virus for use in transmission studies, produced plants that were immune to leaf blight. With the use of gibberellic acid (Alumu and McDavid, 1978) local cultivars were induced to flower and were crossed with the naturally flowering Bangkok variety (Jackson and Pelomo, 1980). The progeny (F1) were both resistant to leaf blight and, like the Bangkok variety, suckers were formed on runners. This initial success stimulated development of a backcross program using Solomon Islands cultivars as recurrent parents. The local cultivars used in the first crosses were not selected for particular agronomic merit but because they flowered at the same time as the Bangkok variety. Subsequently, two popular local cultivars were chosen as recurrent parents. Both have good taste. One (cv. Akalomamale) has only moderate corm yield but is resistant to a virus disease, whereas the other (cv. Luma'abu) is high yielding but dies from virus infection. Progeny from the first backcross segregated into an equal number of leaf blight resistant and susceptible plants, and in addition, half the progeny produced runners. This suggests that both leaf blight resistance and the method of sucker production are controlled by single, dominant, genes (Table 1).

Having established the mode of inheritance of leaf blight resistance it was then necessary to develop a method of testing the reaction of seedlings to leaf blight before field planting. The following procedures have been established: 3 to 4 months-old seedlings are sprayed with a dense suspension of zoospores induced to develop from sporangia, collected in distilled water, from taro leaves with lesions of P. colocasiae or from the surface of 10-day-old cultures of the fungus growing on lima bean agar, by refrigerating the sporangial suspension to c. 6°C for a minimum of 4 h and subsequently leaving the suspension in shallow trays for 2h at ambient temperatures (20° to 25°C). The two methods of collecting the spores are necessary because of insufficient quantities of naturally produced sporangia during periods of low rainfall, which frequently occur on the Guadalcanal Plains. After spraying, plants are held at high humidities for 72 h until lesions develop. Initial tests showed good correlation between disease reaction of seedlings, artificially inoculated in this manner, and that which occurred when they were transplanted to the field and subjected to natural epiphytotics of leaf blight. Thus about half the number of plants of each generation are discarded at seedling stage; thus, the limited area of irrigated land available at the research station is saved for assessment of yield and other important agronomic characteristics. Such assessment is required for leaf blight resistant plants of second backcross generation which have recently been field planted, but this work is hindered by plants, sprayed with gibberellic acid, invariably produce small corms. Because of this, plants must first be grown to maturity, without gibberellic acid treatment, to select those that are high yielding as parents for future generations.

Virus Diseases

Two bacilliform shaped virus particles of different size are associated with diseases known locally in Solomon Islands as alomae and bobone (Gollifer and Brown, 1972; James et al., 1973; Kenten and Woods, 1973). The diseases are also found in Papua New Guinea (Shaw et al., 1979), and one or the other particles occur in several countries in the South Pacific (Jackson, 1980). Taro in Solomon Islands is categorized by growers into two groups on the basis of susceptibility to infection by the two particles. One group, containing the so called "male" taro, is generally tall and high yielding. Infection of these plants by both particles causes alomae, a lethal disease. Infection by either large or the small bacilliform virus alone results in less serious diseases, causing mild mosaics and minor leaf distortions, from which plants eventually recover. The other group contains taro which are short and low yielding. These are known as "female" taro. They are resistant to alomae, but infection by the large bacilliform virus causes bobone. This is not lethal and plants eventually recover but corm yields are reduced (Gollifer et al., 1978).

The possibility that high yields and resistance to alomae could be combined was tested by making crosses between the "male" and the "female" cultivars. From three crosses in 1978 about 120 seedlings were planted at Dala Farm on Malaita, where the virus diseases are endemic. Contrary to expectations, disease spread among the seedlings was slow, although the block was infected with vectors of the virus particles, *Tarophagus proserpina* and *Planococcus pacificus*. Eventually the majority of plants developed symptoms similar to alomae and became stunted with severely chlorotic, distorted leaves, but took many weeks to die. These F_1 plants were either more susceptible to bobone or more resistant to alomae than their parents. After 13 months all but 26 had died. These survivors were retested and during three subsequent replantings all died from virus disease. To confirm the susceptibility of the F_1 plants a further 15 crosses between "male" and "female" cultivars were made in 1980, from which about 900 seedlings were planted on Malaita in early 1981. As occurred in the first planting, disease spread was initially slow, but after 12 months only 222 healthy plants remained. Three suckers from each were replanted and infested with large populations of the two insect vectors. Within 6 months most plants were dead.

These results indicate that resistance to alomae may be a recessive trait. Therefore, to increase desirable homozygosity, selfing, sib-mating and intercrossing among the F_1 plants of "male" and "female" crosses is now required. To achieve this the few survivors from the second plantings on Malaita, together with other seedlings raised from "male" and "female" crosses have been planted at the Dodo Creek Research Station on Guadalcanal.

Table 1. Number and percentage of plants forming runners and resistant to *Phytophthora* leaf blight in the first backcross generation.

Pedigree	*Total No. of plants	No. of plants with runners	% runners	Total No. of plants	No. of plants resistant to Phytophthora leaf blight	% resistant
(Tafaibeu x Bangkok) x Akalomamale	55	28	50.91	40	16	40.00
(Bangkok x Bobolo) x Oga	57	27	47.37	9	5	55.55
(Bangkok x Bobolo) x Akalomamale	48	22	45.83	33	15	45.45
(Kareto x Bangkok) x Akalomamale	77	37	48.05	138	66	47.83

*The two sets of data, for runners production and leaf blight resistance, recorded on different batches of plants.

For each cross, X^2 tests confirmed a 1:1 ratio of plants with and without runners and resistant and susceptible to leaf blight ($P = 0.01$).

Nematode Corm Rot

A corm and root rot disease caused by a nematode (Bridge et al., in press) is newly reported from two provinces of Solomon Islands (Mortimer et al., 1981). The disease also occurs in Papua New Guinea (J. Bridge, Rothamsted Experimental Station, personal communication). In both places infection renders the corms inedible. The disease is of particular interest in that it attacks taro grown under dryland cultivation, on rainfed mountain slopes, and also those grown in swamp pits, on low lying atolls. In the swamp pits the disease is devastating and in one locality taro cultivation has been almost entirely abandoned.

One cultivar has been found with resistance to the disease. This taro, often found in streams and swamps on all islands, is used only when other foods are scarce. The corms are usually very small and acrid when cooked. Crosses between this taro and cultivars that are high yielding have more acceptable taste. Several hundred seedlings have been grown from these crosses and will soon be planted in swamp pits where the nematode is present. A few seedlings from each of the crosses will be planted at the research station. These will be used to develop the program further if F_1 plants do not have acceptable corm size and resistance to the disease.

Discussion

Preliminary results show that breeding programs offer solutions to four serious diseases of taro in Solomon Islands. The results are particularly important because no other control methods are appropriate to subsistence agriculture in the country. For the virus and nematode programs it is too early to be confident that plants will be produced with disease resistance and high yields. The next generation of plants derived by selfing progeny of "male" and "female" crosses should indicate if the breeding strategy to obtain alomae resistance is correct.

More immediate success is likely from leaf blight program where resistance from the Bangkok variety is being transfered to local cultivars. Seed from these crosses was fortunately viable. Problems were anticipated because taro in Asia has greater variability in chromosome number than that of the Pacific (Yen and Wheeler, 1968) and hybridization between cultivars might have produced non-viable seed (Abraham, 1970).

Search for alternative sources of resistance will always be important to the leaf blight program. Breakdown of resistance to Phytophthora disease in other crops is well documented (Vander Plank, 1963; Wheeler, 1969). It will pose a constant threat to the durability of the resistance in taro produced from this breeding program, especially as this resistance is governed by a single, dominant, gene. Not only is taro from India important but also that in collections elsewhere.

Although treatment of plants with gibberellic acid is vital to promote flowering, its use on field-grown taro produces abnormally tall plants with small corms. This means that at each generation agronomic assessment and the production of seed takes 12 to 15 months. To reduce time between generations to one crop cycle, concentrations of gibberellic acid, lower than the routinely used rate of 250 ppm, will be tested. One, or at most two, large influorescences are required. At present several are produced which are small and contain a high proportion of sterile flowers. Failure to reduce the time between generations will seriously delay the programs and any subsequent attempt to combine them.

Acknowledgement

The authors thank Mr. D. Tua for technical assistance and the Permanent Secretary of the Ministry of Home Affairs and National Development, Honiara, Solomon Islands for permission to present this paper. Thanks also expressed for financial support from the International Foundation of Science, Stockholm, under Research Agreement Grant No. G604 and the FAO/UNDP Root Crops Development Project for the Pacific Countries (RAS/74/017).

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