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Cultivar Resistance to Taro Leaf Blight Disease in American Samoa

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ABSTRACT

A taro leaf blight (TLB) epidemic struck American Samoa and (Western) Samoa in 1993-1994, almost eliminating commercial and subsistence taro production (*Colocasia esculenta*). In 1997, leaf blight-resistant cultivars from Micronesia were introduced into American Samoa. Some farmers, however, still try to raise severely diseased local cultivars among the resistant taro. This practice may increase the number of fungus spores in the field produced by *Phytophthora colocasiae* and endanger plant resistance. The objective of this study was to determine the effect of interplanting resistant and susceptible taro cultivars on TLB resistance and yield. Two resistant cultivars from the Republic of Palau, P16 (Meltalt) and P20 (Dirratengadik), were planted in separate plots and interplanted with Rota (Antiguo), a cultivar assumed to be susceptible to TLB. We were unable to raise local, susceptible cultivars for testing due to severe disease conditions. In two trials during 1999-2000, all three cultivars showed resistance to TLB, therefore, our objective was not tested. An average of 11% plant leaf area was destroyed by disease whether cultivars were interplanted or grown separately. Control plots treated with metalaxyl, a systemic fungicide, averaged 6% disease. There was no consistent correlation between TLB severity and corm weight in either trial. In general, taller, more vigorous plants produced heavier corms than shorter, less vigorous plants, suggesting conditions that promote plant vigor had a greater effect on yield than TLB. Since local susceptible taro cultivars grow poorly under severe blight conditions, their reduced height and leaf surface should not raise the level of spores in the field enough to threaten cultivar resistance. Further, American Samoans are accepting the taste and texture of the new cultivars and planting local taro appears to have declined.

INTRODUCTION

Taro has been a sustainable crop and dietary staple in the Pacific Islands for thousands of years (Ferentinos 1993). In American Samoa, it is grown on most family properties and is an important part of *Fa'a Samoa* — traditional Samoan culture. Local production of taro, *Colocasia esculenta* (L.) Schott, was devastated by an epidemic of taro leaf blight (TLB) in late 1993-1994 (Trujillo et al. 1997). Taro production fell from 357,000 kg (786,000 lb) per year before the epidemic to less than 5,000 kg (11,000 lb) by the end of 1994 (Figure 1). Prices in roadside stands and markets in early 1993 were about $1.10 kg ($.50 per pound). For the past five years, *C. esculenta* has not been available and today sells for $4-5.50 kg ($2-2.50 per pound).

In response to the TLB epidemic, taro cultivars from the Republic of Palau, Federated States of Micronesia, Hawai'i, and the Commonwealth of the Northern Mariana Islands were tested for TLB resistance in Hawai'i during 1994-1995 (Greenough et al. 1996). Most of the taro tested demonstrated some level of TLB resistance. Twelve promising Palauan cultivars from this screening were multiplied in tissue culture and sent to American Samoa for further evaluation (Trujillo et al. 1997, Wall & Wiecko 1998). The TLB resistance of these Palauan cultivars was tested at Taputimu, American Samoa, in a small trial at one site during 1997; results were similar to the Hawai'i trial (Trujillo et al. 1997). The cultivars were distributed to American Samoan farmers and are now growing in fields that have been without taro (*C. esculenta*) since the epidemic.

Taro leaf blight is caused by the fungus, *Phytophthora colocasiae* Racib. It spreads among leaves of the same plant and between plants by rain splash and wind-blown rain (Gregory 1983, Putter 1976). The epidemiology of TLB is similar to another airborne *Phytophthora* disease, potato late blight. The size of a *Phytophthora* population in the field at planting time often increases exponentially as the season progresses. The number of initial *Phytophthora* spores needed to severely reduce yields among susceptible cultivars, however, is small. An epidemic of potato late blight, for example, may be caused by one infected potato in 100,000 (Weste 1983). Most American Samoans prefer the taste and texture of their local taro to the introduced Palauan cultivars and sometimes plant these susceptible Samoan cultivars beside or among the newly introduced resistant taro. But planting heavily diseased susceptible taro could multiply the number of spores in the field, increasing TLB severity and decreasing the yield of the resistant cultivars.

Another value of maintaining a low number of spores in the field is to reduce selection pressure. This pressure, or influence, occurs when resistant plants differentially select individuals from a diverse pathogen population which are unaffected by the resistance (Fry 1982). Mathematically, chance mutations in a large pathogen population are more likely to produce spores capable of bypassing cultivar resistance than mutations in a small pathogen population. If both mating types are present, the sexual spores produced will be genetically more diverse and flexible and may not need mutation to be more aggressive. Those spores capable of causing infection will be favored and their numbers will increase, to the disadvantage of the resistant taro (Robinson 1996).

Studies have shown the usefulness of fungicides against *P. colocasiae* (Aggarwal & Mehrotra 1987, Jackson et al. 1980, Semisi et al. 1998, Cox & Kasimani 1990b) but taro growers in American Samoa appear reluctant to use them. This leaves resistant taro varieties as the only practical option for TLB management in the Territory.

A goal of the American Samoa Community College Land Grant Program (ASCC) is to help American Samoan farmers get the best results from their crops. Our concern about high populations of *Phytophthora* in the field and reliance on cultivar resistance alone for maintenance of taro production led to the research hypothesis: Resistant cultivars, such as Palauan P16 and P20, will have a higher percentage of taro leaf blight disease and lower corm weight when interplanted with a susceptible taro cultivar than when planted alone.

MATERIALS AND METHODS

SITE PREPARATION AND PLANTING

Two six-month trials were conducted at the ASCC facility on the main island of Tutuila, American Samoa. The first trial began during the dry season, 21 June, and ended in the wet season, 27 December 1999. The second trial was planted in the wet season, 14 February, and harvested during the dry season, 22 August 2000. The fields were treated with herbicide (glyphosate), tilled and planted; no herbicide, insecticide, fertilizer or irrigation was applied during the studies. Insect pests, such as taro horn worm (*Hippotion celerio*) and cluster caterpillar (*Spodoptera litura*) were removed from leaves by hand. Plots were mulched with coconut fronds and other plant material and hand weeded. Plant spacing and trial design for these studies were affected by a shortage of available land. Tiapula (planting material consisting of lower leaf petioles and part of the taro corm) were planted 75 cm x 75 cm apart, or 17,450 plants/hectare, and 15-20 cm deep. Plots were randomized with no repetitions. The main plot treatment was interplanting Rota, a cultivar assumed to be susceptible to TLB, among the resistant cultivars (P16+Rota, P20+Rota). Subplot treatments consisted of separate plantings of the two resistant cultivars, P16 and P20 (P16-only, P20-only); a Rota-only plot was added to the second trial. Main plots measured 6.75 x 3 m, subplots 3.75 x 3 m with 1 m between plots. In main plots, four three-plant rows of resistant taro alternated with four three-plant rows of Rota, producing 12 data plants of each cultivar: 26 border plants surrounded each main plot. Subplots each contained 12 data plants surrounded by 18 border plants. All border plants were resistant taro cultivars. Three subplots were established for comparison with test plots (P16-treated, P20-treated, Rota-treated). These plots were treated every 14 days with a 15-20 cm banded soil application of metalaxyl (Ridomil 2E, Ciba-Geigy, Greensboro, NC), at 8 ml a.i. per plot. This fungicide systemically inhibits *Phytophthora* spp. In the first trial, applications began at the initial sign of disease, 115 days after planting, but due to a wet season planting date and earlier onset of disease, fungicide for the second trial was applied from day 50.

TARO CULTIVARS

Taro leaf blight resistant cultivars from the Republic of Palau were given numbers during tissue culture multiplication in Hawai'i (Greenough et al. 1996) and are still known by these numbers in American Samoa. Cultivars P16 (Meltalt) and P20 (Dirratengadik) were selected as a result of Hawai'i field trials (Greenough et al. 1996, Trujillo et al. 1997) and discussions with local taro farmers. Farmers' preferences were based on either corm size, eating quality of corms or leaves, ability to form suckers, or a combination of these characteristics. Most American Samoans prefer a local taro, Niue, above all taro cultivars for flavor and texture. Due to its susceptibility to TLB, however, we have not been able to grow it successfully at ASCC. For this reason Rota, a popular taro from the Northern Mariana Islands was used as the susceptible cultivar in these trials. It was brought to American Samoa from Hawai'i as 'Antiguo' but renamed Rota for convenience (P. Gurr, pers. comm.). In the Hawai'i taro trials average leaf damage per cultivar was 8-10% for

P20 and P16 and 25-50% for Antiguo (Greenough et al. 1996, Trujillo et al. 1997). Taro leaf blight severity on the Rota cultivar was almost 50% in a 1997 trial in American Samoa (Trujillo et al. 1997). All taro used in our trials was grown in the ASCC multiplication plot and previously infected with TLB. Planting tiapula from this plot provided a natural source of trial inoculum (Cox & Kasimani 1988, Hicks 1967, Semisi et al. 1998).

Data Collection

Assessments began with the onset of taro leaf blight disease and continued at two-week intervals until harvest. Optimum time of harvest for different Palauan cultivars in American Samoa has not been determined; farmers suggest between six and nine months. Data plants were harvested at six months and corms weighed after removing roots and soil.

Disease severity was estimated for each leaf of a data plant: 0 = no disease, followed by increments of 5, 10, 25, 50, 75, 90 and 100% disease. If disease severity was between two increments, the higher increment was recorded during the first trial; estimates were rounded to the nearest increment during the second trial. Disease severity was defined as percent of plant leaf surface affected by taro leaf blight, either lesions or lesions plus lesion-related chlorosis and yellowing (James 1971). New, partially furled leaves and old leaves touching the ground (collapsed petioles) were not rated. We did not measure leaf surface area but assumed all assessed leaves were approximately the same size for a cultivar.

Data Analysis

Comparisons of taro leaf blight disease severity and corm weight for main plot and subplot treatments for each cultivar were made by one-way analysis of variance. Percent estimates of disease severity were converted before analysis by angular transformation (Little & Hills 1978). Means separations, when appropriate ($P < 0.05$), were made with Tukey's test for pairwise comparisons. Linear correlations between corm weight and disease severity for each cultivar were compared using Pearson's product-moment correlation (SigmaStat, SPSS Inc., Chicago, IL).

RESULTS

There was no significant difference in taro leaf blight severity in either trial between P16 and P20 planted alone or interplanted with Rota. Severity of TLB in the first trial (average of untreated plots) was 11%, 14%, and 13% for P16, P20 and Rota, respectively. In the second trial, disease severity was 10% for P16, 8% for P20, and 9% for Rota. Disease in treated plots averaged 6%, lower than in untreated plots, but was only significant in the first trial (Table 1). There was no correlation between disease severity and corm weight in the first trial and only a moderate positive correlation in two plots during the second trial ($r^2 = 30$).

DISCUSSION

The hypothesis, resistant Palauan cultivars will have a higher percent taro leaf blight disease and lower corm weight when interplanted with a susceptible cultivar than when planted alone, was not fully tested. The taro cultivar Rota (Antiguo), selected for this trial based on its reported susceptibility to taro leaf blight disease, was as resistant as the Palauan cultivars. A Rota-only plot was added to the second trial to determine if Palauan cultivars were protecting Rota from leaf blight, but the Rota-only plot had less disease than all interplanted plots (Table 1).

Our efforts to grow the favored local taro, Niue, as the susceptible cultivar for this trial were unsuccessful. Plant height in the ASCC multiplication plot over a twelve-month period never exceeded 0.5 m and the average number of leaves per plant was less than three. Average leaf life (n = 12) for Niue was 24 days, significantly less than Rota (29 days), P16 (32 days) and P20 (35 days). Niue formed few suckers or edible corms during this period and 80 of 100 plants died (Brooks, unpublished).

Disease severity is commonly associated with corm weight (Hunter & Pouono 1998, Cox & Kasimani 1990a, 1990b, Jackson et al. 1980) and researchers usually use diseased or healthy leaf area (Gollifer & Brown 1974, Semisi et al. 1998, Aggarwal & Mehrotra 1987) or total number of leaves (Cox 1986), as an indicator of yield. Plots treated with metalaxyl had less TLB than untreated plots, but there was no correlation between disease severity and corm weight for any plot. This suggests either little reduction in yield at these low disease levels, too small a difference between treated and untreated plots, or both. Cox (1986), however, states estimating TLB severity as a percent of diseased leaf surface, is not a valid measure of variation in yield; healthier, resistant plants will retain more diseased leaves and have higher disease ratings and corm yields than susceptible plants.

In a separate study on effects of different plant growth characteristics on corm yield, our results supported Cox's findings (Brooks, unpublished). We found a higher correlation between average number of leaves per plant and corm weight than between disease severity and corm weight. Plant height and number of suckers per plant were also better indicators of corm weight than disease severity in our trials. These results, along with field observations, suggest conditions in the field had more effect on yield at low disease levels than TLB.

Two years after their introduction, resistant taro varieties are being grown by most American Samoans. During years when disease pressure is high, susceptible taro cultivars are stunted, with small, short-lived leaves and poor yields. Smaller leaf surfaces produce fewer asexual spores so susceptible varieties should not pose an added threat to the genetic resistance of the new taro. Further, American Samoans are accepting the different taste and texture of some of the resistant cultivars and cultivation of local varieties is limited and usually confined to isolated locations.

A greater threat to TLB resistance is sexual reproduction of the fungus, *Phytophthora colocasiae*. Unlike asexual reproduction where all spores from a single parent are identical, except for mutations, reproduction between two parents produces genetically different spores. The chance of producing spores able to overcome host resistance increases with the number of genetically unique spores. Currently, isolates of *P. colocasiae* are being collected from around American Samoa to determine their mating type. To date only the A1 mating type has been found; results in (Western) Samoa are similar (Brooks & Delp, unpublished).

When a centuries-old, traditional farming system becomes unsustainable due to disease, options for recovery are few. American Samoans had little taro (*C. esculenta*) to eat and none to sell from 1994-1998, until the introduction of resistant cultivars. This project was not only a variety trial but also an attempt to learn more about and protect the resistance of these cultivars in American Samoa. Of 20 farmers interviewed, most thought the taro leaf blight problem had been solved. However, like potato late blight in Europe, the disease is probably here to stay and needs regular evaluation.

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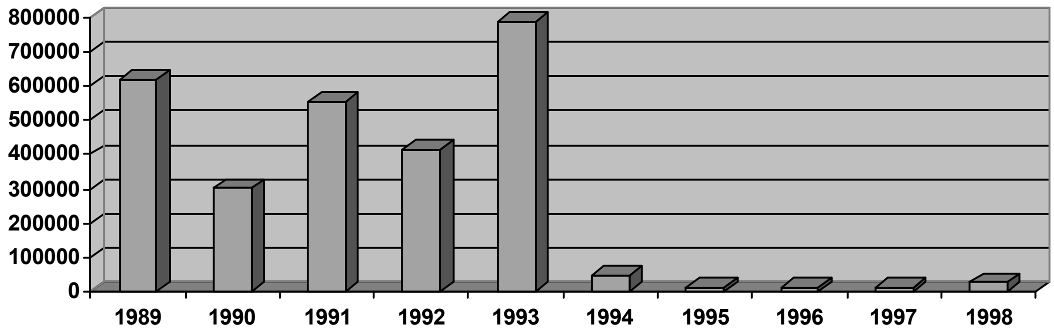

Figure 1. Effect of 1993-1994 taro leaf blight epidemic on taro production in American Samoa. Amounts, in pounds, are based on estimates by the American Samoa Department of Agriculture (unpublished) of taro brought to the central market in Fagatogo; taro is usually sold by number of corms, not weight (Economic Development Planning Office 1994).

Table 1. Pairwise comparison[1] of three taro cultivars (Colocasia esculenta) in trials conducted at the American Samoa Community College Land Grant facility, 21 June to 27 December 1999 and 14 February to 22 August 2000. Each entry represents 12 data plants, either in separate plots (-only), interplanted (+Rota), or treated with metalaxyl (-treated). The cultivar Rota was not planted separately in the first trial.

	Disease Severity (%)		Corm Weight (g)	
Cultivar	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
P16-only	12.5a	10.0a	238.7a	246.2a
P16+Rota	9.0a	9.3a	216.1ab	189.2b
P16-treated	5.5b	6.5b	155.2b	229.7ab
P20-only	13.5a	6.7a	484.1a	216.0a
P20+Rota	14.5a	8.9a	576.3a	339.0b
P20-treated	6.5b	5.2a	417.4a	280.3ab
Rota-only	—[2]	7.6a	—	113.3a
Rota+P16	11.8a	9.8b	224.3a	109.8a
Rota+P20	13.5a	9.2b	351.5a	146.0a
Rota-treated	6.5b	6.2a	281.5a	129.6a

[1] Differences between means within each column followed by the same letter are not significantly different (Tukey test, P<0.05). Comparisons are within each cultivar only and not between cultivars or trials.
[2] A subplot containing only the taro cultivar Rota was added to the second trial (see text).