Beyond Taro Leaf Blight: A Participatory Approach for Plant Breeding and Selection for Taro Improvement in Samoa

D.G. Hunter, T. Iosefa, C.J. Delp, and P. Fonoti

Abstract

The 1993 outbreak of leaf blight in Samoa resulted in the devastation of the staple taro crop and farmer's incomes from local and overseas markets. The preferred cultivars were all susceptible to the disease, and attempts to solve the problem through fungicides and changed cultural practices have had little impact. Efforts to evaluate exotic cultivars and breed taro with disease resistance commenced in 1996. Recent initiatives to facilitate the breeding program in Samoa include a university breeders' club and the Taro Improvement Project (TIP), involving university and ministry research staff, students, extension staff, and farmers. Both initiatives have been motivated by an interest in greater participation of students and farmers in the breeding process and evaluation of introduced taro cultivars. This paper reviews and evaluates experiences in Samoa with participatory approaches to plant breeding using a breeders' club and a farmers' group (TIP), highlighting the benefits of both.

Background

Samoa is a small independent Pacific Island country with two main islands (Upolu and Savaii) and five other small islands (figure 1). It has a population of about 160,000 largely involved in agriculture. Most agricultural households grow a variety of crops, including taro, bananas, breadfruit, cocoa, and coconuts. Prior to 1993, taro (*Colocasia esculenta*) was the most important export of the country, with 96% of agricultural holdings cultivating the crop. It is estimated that the area under taro at that time was 14,600 ha, of which 76% was grown as a monocrop. A single cultivar, taro Niue, dominated the cropping area because of domestic and export demand. The appearance of taro leaf blight (TLB), caused by *Phytophthora colocasiae*, in 1993 demonstrated how vulnerable the intensive production of taro had become, and production virtually ceased overnight. Since then the Ministry of Agriculture, Fisheries, Forests and Meteorology (MAFFM) has explored various approaches to overcoming the problem, including plant breeding. More recently, research staff at the University of the South Pacific (USP) have also become involved in breeding taro for resistance to the disease. There are clear signs that farmers in Samoa are slowly returning to taro again.

Taro in Samoa

Taro, an edible aroid that originated in the Indo-Malayan region, is grown as a staple or subsistence crop throughout the humid tropics but is of greatest importance in the Pacific Islands, where it accounts for about 20% of the root crop area. The corms are baked, roasted, or boiled and the leaves are eaten as *palusami*. Taro spread eastwards into the Pacific, probably reaching the Polynesian islands 2,000 years ago. There is now evidence to suggest that most cultivars found throughout the Pacific were not brought by the first settlers from the Indo-Malayan region but were domesticated from wild sources existing in the Melanesian region (Lebot 1992). There are now thought to be

D.G. Hunter is team leader of the Taro Genetic Resources: Conservation and Utilization (TaroGen) project based at the Secretariat of the Pacific Community (SPC), Suva, Fiji. T. Iosefa and C.J. Delp are with the University of the South Pacific (USP), Alafua Campus, Apia, Samoa. P. Fonoti is with the Ministry of Agriculture, Fisheries, Forests and Meteorology (MAFFM), Samoa.

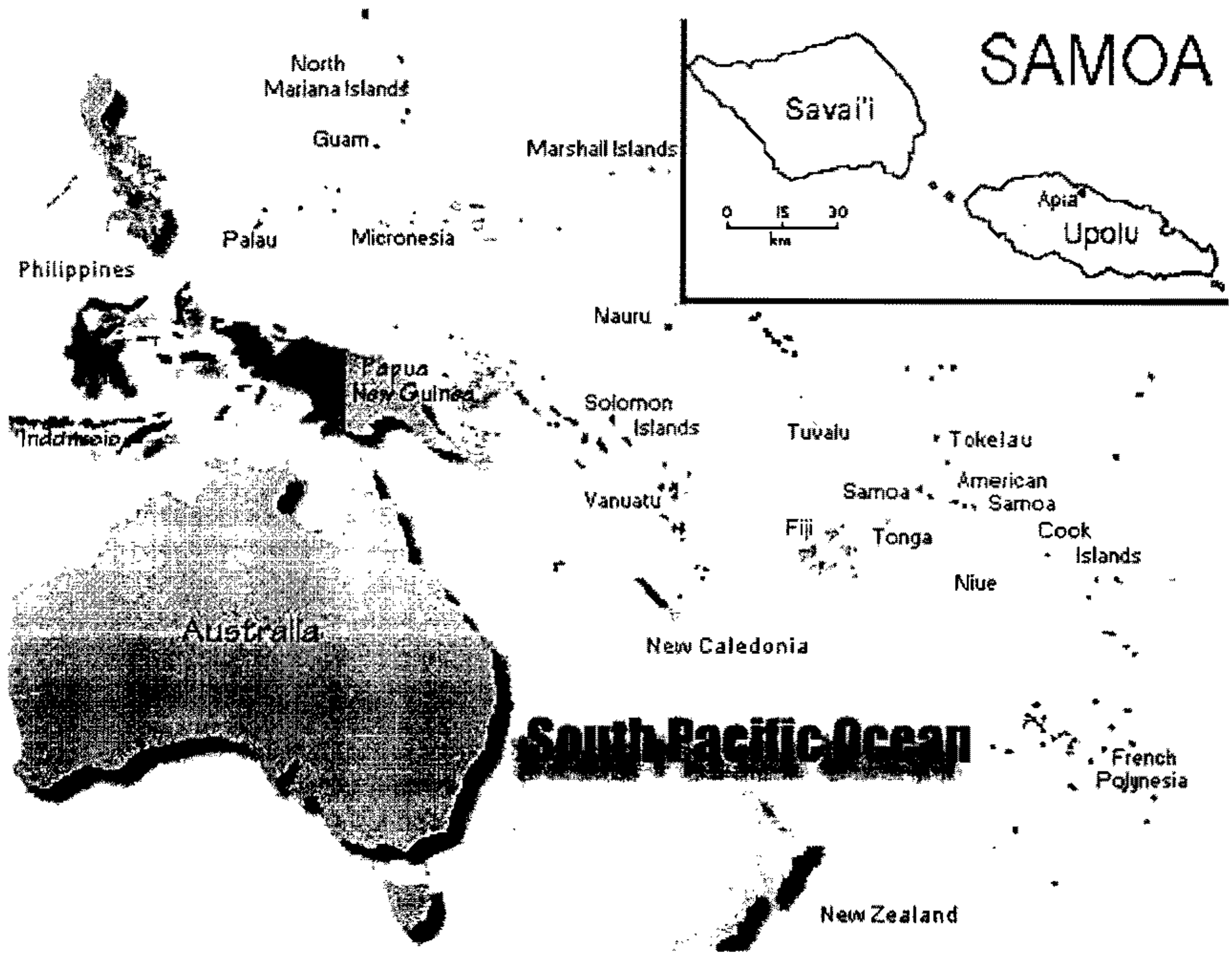

Figure 1. Samoa and its location in the South Pacific Ocean

approximately 2,000 taro cultivars in the Pacific region (Hunter, Pouono, and Semisi 1998). Prior to the arrival of TLB, farmers in the Pacific selected taro cultivars for a number of traits but not resistance to the disease. In the absence of this selection pressure, taro cultivars have reduced levels of resistance. At the turn of the century when the TLB pathogen began to spread into the region, it encountered a host plant that was genetically vulnerable.

Taro is the most important plant in Samoa, having special cultural, dietary, and economic importance. It is considered an essential component of an everyday meal. It is a plant with high prestige and great importance as a presentation on formal occasions. It is also favored for its considerable productivity in the fertile and high-rainfall environment of Samoa (Ward and Ashcroft 1998). In 1983, the returns from taro were three times higher than that from bananas and eight times higher than from coconuts (Asian Development Bank 1985).

Impact of taro leaf blight in Samoa

TLB was first observed on the island of Upolu at Aleipata and two days later from Saanapu and adjacent districts in July 1993. The disease spread rapidly throughout the country, severely affecting all local cultivars, but it was most devastating on taro Niue, the cultivar of choice for commercial production because of its quality and taste. Various factors contributed to the rapid spread of the disease in Samoa. The area planted to taro Niue at the time was extremely large and effectively ensured a monocrop situation. There was a continuous and abundant source of taro for the disease because of the practice of farmers to interplant on old plantations and stagger their cultivation. Combined with the widespread movement of infected planting material and ideal weather conditions, the disease quickly reached epidemic proportions.

In 1992, prior to the blight, the World Bank estimated taro exports from Samoa at US$10 million, with a similar value on the domestic market. This placed taro as the dominant export and domestic market commodity. By 1995, the export value of taro had fallen to US$60,750, or less than 1% of pre-blight figures. Initial efforts by MAFFM to contain the disease, including fungicide spraying, quarantine efforts, and a public-awareness program, failed dramatically. The disease spread rapidly, and by 1996 only 200 farmers were growing taro in Samoa.

Conventional taro breeding strategies in Samoa

In 1995, MAFFM, in conjunction with the Australian government-funded Western Samoa Farming Systems Project, initiated a program to evaluate exotic cultivars. Nine exotic cultivars were evaluated against taro Niue in preliminary trials in 1995 and 1996. The cultivars Pwetepwet, Pastora and Toantal (originating from the Federated States of Micronesia) and PSB-G2 (now known locally as taro Fili and originally obtained from the Philippine Seed Board) were assessed in on-station trials for resistance to TLB. These trials indicated that all four cultivars were more resistant than Niue, the locally preferred cultivar. MAFFM further evaluated these four cultivars in on-farm trials during 1996 and 1997. Farmers involved rated Fili as the best tasting and both Fili and Pwetepwet as the most resistant to leaf blight. MAFFM began recommending and distributing Fili to growers in late 1996.

The identification of taro Fili has allowed many farmers to return to taro production, and over the last few years, the area under taro has slowly increased. However, the release of this single cultivar has not been enough to meet the needs of all growers, and a few shortcomings have been reported, including the following:

- relative susceptibility to the disease, especially in wetter areas of the country
- low yields
- poor storability, which is a problem with growers starting to export to markets in American Samoa and the United States

In addition, MAFFM imported a range of exotic taro cultivars from Palau in 1995. Field trials at the University of Hawaii had shown that some of these cultivars had good levels of resistance to TLB. To date, no Palau cultivars have been released or recommended by MAFFM.

Efforts to breed taro with resistance to TLB in Samoa commenced in 1996. Crosses were made among introduced TLB-resistant cultivars and susceptible local cultivars. This cycle-1 population has been evaluated and 10 promising clones have been selected. These clones are being further evaluated in multilocational trials in Samoa.

Participatory approaches for taro breeding in Samoa

The apparent need for a more participatory approach to plant breeding in Samoa arose as a consequence of informal discussions with farmers, who often expressed dissatisfaction with the pace of release of resistant taro germplasm through the conventional taro-breeding program. Researchers at USP were also concerned with the rate at which resistant taro was released through conventional taro breeding and the rigorous testing over several years trying to identify a few clones or cultivars that might be of limited relevance to farmers. There is evidence from elsewhere that much of the germplasm officially released through conventional plant-breeding programs is of limited relevance to farmers, and much of the material that is rejected has been found to have subsequent acceptance among farmers (Maurya, Bottrall, and Farrington 1988). The conventional taro-breeding program was also doing little to increase the diversity of taro in the country.

A participatory approach to plant breeding, involving researchers, farmers, and extension staff, was considered as a means to

- learn more about what farmers want from improved taro cultivars and to involve them in the technology development process
- involve many farmers under diverse environments, providing them with a range of options so that they can select the best for their conditions, which would ensure that farmers gained quicker access to resistant taro
- increase the diversity of taro cultivars grown by farmers in Samoa. This was an important perception in minimizing a repeat of the disease outbreak. The danger of relying heavily on one or a few genotypes is only too apparent from events in Samoa in 1993
- strengthen the linkages between researchers, extension staff, and farmers
- make more effective use of limited time and resources of researchers and extension staff

Taro Improvement Project

The Taro Improvement Project (TIP), a large farmers' group, was initiated at USP in 1999. TIP aims to bring together taro growers and provide them with more options for improving production and managing taro leaf blight. It represents a partnership between USP research staff, MAFFM extension staff, and farmers. Currently, the project is working with 25 farmers on the island of Upolu to evaluate introduced taro cultivars from Palau, Micronesia, and the Philippines. Initiation of the TIP farmers' group was motivated by factors outlined above and the noticeable success of other similar farmers' groups implemented elsewhere to address problems aimed at farming systems improvement (Norman et al. 1988).

Farmers become members of TIP by either contacting staff at USP or notifying their district extension officer. When a farmer has been selected as a taro grower, he or she agrees to compare taro cultivars in a grower-participatory research program. Farmers have been selected from most districts on Upulo.

Cultivar selection. TIP supplies each participating farmer with planting material of several taro cultivars for a simple nonreplicated trial. Information is provided on trial layout, labeling, and simple data collection. The trials are maintained and managed by farmers. Farmers can record their own observations on the growth of taro cultivars using the simple data sheets provided. TIP research staff regularly visit participating farmers, help keep records on cultivar performance, and record yield data. To facilitate feedback and sharing of information on the evaluation of cultivars, the members of TIP hold regular monthly meetings at various locations. These meetings help growers to learn about other growers' experiences. Participants are also asked to bring corms of cultivars ready to harvest for taste-test evaluations. Growers also provide information on cultivars that have been prepared for home consumption.

Farmers have been evaluating cultivars from the Philippines, Federated States of Micronesia, and Palau. Recently, the TIP farmers who have been evaluating these cultivars, were asked to rank them on a scale from 1 to 4 for characteristics of vigorous growth, yield, TLB resistance, sucker production, and eating quality. These preliminary results are shown in table 1.

Table 1. Taro Cultivar Rankings by TIP Farmers

Culvivar	No. of growers	Vigor	Yield	TLB Resistance	Suckers	Eating Quality
Fili	12	3.1	2.4	2.0	3.4	4.0
Pastora	11	3.8	3.3	2.9	3.2	1.6
Pwetepwet	10	3.4	2.9	2.7	3.8	2.2
Toantal	10	3.3	2.3	1.7	2.7	3.5
Palau 3	8	3.3	3.0	2.6	3.1	2.9
Palau 4	9	3.1	2.1	2.6	3.9	3.1
Palau 7	8	3.5	3.0	2.8	2.8	2.4
Palau 10	12	3.9	3.8	3.5	3.2	3.2
Palau 20	11	3.7	3.5	2.6	2.9	3.6
Niue now	8	1.9	2.0	1.1	1.9	1.9
Niue before TLB	10	3.9	3.9	—	3.1	4.0
Alafua Sunrise	2	2.7	2.5	1.7	1.0	2.7

Note: 1 = Unacceptable; 2 = Okay, but not good; 3 = Good; 4 = Outstanding.

TIP meetings provide an excellent forum for conducting participatory rural appraisals (PRAs) to elicit information regarding problems facing taro growers, the important criteria of an ideal taro cultivar, and farmers' perceptions of the cultivars that they are evaluating. TIP meetings also allow research staff to address those issues that farmers would like more information about, such as disease management and the processes involved in breeding. TIP meetings also help to facilitate the organization of taro diversity fairs and farmers' field days in Samoa.

Clone selection. So far, farmers have been mostly involved with evaluation and selection of introduced cultivars. As the program develops, it is intended that farmers will become more involved in the breeding program and participate in the selection of clones. This process is already underway. In September 1999, a cycle-2 population of taro seedlings was transferred from USP to a farmer's field in the village of Safa'atoa. A farmers' field day organized at this location helped to explain the objectives of the breeding program currently underway in Samoa and how clones are selected from a seedling population. Farmers had the opportunity to observe firsthand the preliminary selections made by USP researchers. These preliminary selections totaled almost 200 clones. Duplicates (suckers) of these selections have been given to three farmers for evaluation on their own farms. The farmers as a group have also helped in narrowing the preliminary clones from 200 to the final 25 selections by participating in taste and quality tests during TIP monthly meetings. These 25 clones (table 2) are being multiplied for on-farm evaluation by TIP farmers later this year.

Table 2. Average Leaf Number, Months to Harvest, Yield, and Taste of the Top 25 Taro Clones Selected from a Cycle-2 Population in Samoa

Clone Number	Months to Harvest	Yield (kg)[1]	Average Leaf Number	Taste[2]
C2-30	5	1.0	6	3.5
C2-40	6	1.1	7	3.6
C2-47	6	0.7	5	3.5
C2-48A	6	0.8	5	3.6
C2-70	6	0.7	4	3.5
C2-77	6	0.7	5	3.7
C2-93A	5	0.9	5	3.6
C2-94	5	0.8	5	3.6
C2-97	6	0.7	6	3.7
C2-132	6	0.6	5	3.5
C2-144	6	1.1	5	3.8
C2-145	6	0.6	4	3.6
C2-147	6	0.6	5	3.6
C2-148	6	0.6	4	3.7
C2-152	5	0.8	5	3.8
C2-157	6	0.6	5	3.6
C2-160	5	0.6	5	3.8
C2-161	6	—	6	3.6
C2-194	6	1.1	7	3.9
C2-196	6	0.9	7	3.5
C2-227	5	0.6	7	3.6
C2-232	6	0.7	6	3.8
C2-234	6	0.9	6	3.7
C2-234A	6	0.8	5	3.8
C2-236A	6	0.7	7	3.5

1. Based on weight of single corm at harvest.
2. Evaluated as 1 = poor, 2 = OK, 3 = good, 4 = excellent.

University Taro-Breeders' Club

A university taro-breeding club was initiated at USP in 1999. The first university breeding club in the world was started in 1995 in Mexico. We believe that the club at USP is the first to be inaugurated outside of Latin America. The club represents an innovative approach to teaching and learning at USP. It is a cheap and easy approach to breeding. It ensures that there are many hands to do breeding work and has resulted in increased taro breeding activity. Robinson (1996, 1997) has proposed university breeding clubs as a "hands-on" approach for students to learn about breeding for horizontal resistance and a way of "scaling-up" farmer participation in plant breeding (see box 1). Robinson (1997) envisaged student-members of breeding clubs returning to their family farms with potential new cultivars for evaluation. After a few decades, there could be hundreds, or even thousands, of former club members testing new lines as they emerge from clubs. Additional breeding clubs would increase the output even more, providing the *widest extent and the highest possible quality of farmer participation in plant breeding.*

Box 1. Aspects of Breeding Clubs That Promote Student and Farmer Involvement and a "Scaling-Up" of Participatory Plant-Breeding Activity

- Clubs would provide a new "hands-on" approach to plant breeding in an effective group-learning context for students.
- Clubs could transfer plant-breeding skills to many amateur breeders working within a single agroecosystem involving a few thousand farmers.
- There would be a vast increase in breeding skills as graduates return to their villages and initiate local farmers' or amateur breeding clubs.
- Hundreds of plant breeding clubs worldwide could significantly improve crops by a huge increase in breeding activity.
- Clubs would re-establish links between researchers and farmers. High levels of farmer participation in plant breeding would result when farmers' children join university breeding clubs.

Source: Robinson (1997).

The overall aim of the USP taro breeding club is to produce high-yielding, good-quality taro cultivars that have high levels of horizontal resistance to TLB and other locally important taro pests, and that are adapted to a range of diverse environments. At the same time, the club allows students to learn about the breeding process in a practical way. The club is seen as an integral component of TIP, using selected farmers for evaluation of clones and multiplication of potential new cultivars. The club has a formal structure with elected officers, including a president, vice-president, treasurer, and secretary. A club constitution was drawn up and it is run along the lines of a student organization. Most members are students but some are professionals, such as lecturers, crop researchers, technicians, and university administrators, while a small percentage are farmers.

The club meets regularly at the University's Alafua Campus. This campus is the location for the club's breeding blocks and it is on-campus that most crossing takes place and where taro seedlings are raised. Screening and evaluation of seedling populations take place at locations with suitable disease pressure. To date, duplicate breeding blocks have been initiated on-campus. One block is for the use of researchers and the other for the use of students. The student breeding block is made available solely for the use of students, and they are encouraged to maintain their own subplot, make crosses within this, harvest seed, and raise seedlings for field evaluation. The committee decides on a program of topics and field visits to facilitate learning about plant breeding with assistance from university technical staff. The club is self-financed largely through the payment of member fees and fund-raising events.

Conclusions

Although TIP is a young organization, it is already showing that farmers can evaluate many different taro cultivars and select those they prefer. The membership of the program has expanded rapidly in its first year. The program has improved dialogue between researchers, extension staff, and farmers. Evaluation of cultivars is still underway and a considerable amount of quantitative and qualitative data have been compiled. This will be analyzed shortly. There are early indications that growers are selecting a range of cultivars. Taro *Fili* has been included as the preferred resistant cultivar to date. It is interesting to note that some growers are showing preferences for cultivars (*Toantal*, *Pwetepwet*, *Pastora*) that were evaluated by MAFFM at the same time as taro *Fili* but which were not recommended or widely promoted. Both *Pwetepwet* and *Pastora* were previously believed to be of poor quality, although they both have good levels of resistance to TLB and they are both high yielding. One farmer has observed that the quality improves if harvest is delayed for a few months. The same farmer has also reported that he likes *Pastora* despite its tendency to be *susu* (meaning wet, a quality not liked by Samoans). He removes the top (wet) half and uses the bottom part of this high-yielding cultivar.

There has been considerable confusion in Samoa about Palau cultivars. This has arisen as a result of unauthorized imports of batches of mixed cultivars from nearby American Samoa. There are 12 different cultivars from Palau in Samoa. Some are good quality and some are considered wet. TIP has been working to address this confusion, and gradually those cultivars of good quality are being identified. Early indications are that growers prefer Palau 20 and 10. Reports from American Samoa show that both Palau 20 and 10 are most preferred by growers there. Many of the growers have experimented with the harvest date of the Palau cultivars and report that this can significantly influence the corm quality. These findings are important. Some Palau cultivars are found to be wet if harvested early (five to six months), but this can be overcome, in some cases, by delaying harvest until seven to eight months. Research station evaluations of taro usually occur after six months.

As a result of the impact of TIP on Upulo, MAFFM have initiated a similar TIP program on the other main island of Savai'i. In May 2000, nine extension officers from Savaii spent time on Upulo visiting farmers involved with TIP and took part in the May monthly meeting to observe how the club operated. This should ensure that farmers on that island get quicker access to a range of resistant taros.

There are some aspects of the USP taro-breeders' club that make it different from other clubs like the one at the *Universidad Autonoma de Chapingo* in Mexico. The University of the South Pacific is a regional university, whereas the *Universidad* is a national university. USP draws a student body from over 12 individual countries dispersed in the Pacific Ocean. This poses one problem for a university breeders' club but it also has an advantage. Robinson (1997) highlights the positive interaction that may arise between a breeding club and farmer participation schemes. In the *Universidad* situation, students come from surrounding villages. Students can return to these villages with the progeny of the crosses they have made and carry out participatory selection with farmers on family farms. Certain selections may become potential cultivars but can also be fed back into the breeding club system to become future parents. Unfortunately, the majority of student members of the taro-breeding club come from countries other than Samoa and quarantine and unresolved ownership issues preclude taro germplasm leaving Samoa for evaluation on many family farms. The solution to this problem is to pool all crosses together and evaluate seedlings as one population through the TIP program. The advantage of having members from many different countries is the high potential for similar breeding clubs to be initiated elsewhere when students return to their home countries at the completion of studies. The club also plans a regular newsletter to maintain contact with members who have finished their studies.

The breeders' club has been successful as an innovative "hands-on" approach to teaching and learning, but club activities place considerable demands on student time. A three-year degree means that students have a packed timetable that allows little time for "extracurricular" activities. One possible solution to this problem is a cross-credit system to the conventional degree-level breeding courses that are taught at USP. This would allow students to obtain cross-credits for the breeding activities that they carry out as part of the breeders' club. Likewise, lecturers would also accrue teaching credits for their involvement in the breeders' club.

References

Asian Development Bank. 1985. *Western Samoa Agricultural Sector Study*. Vol. 2. Asian Development Bank.

Hunter, D.G., K. Pouono, and S. Semisi. 1998. The impact of taro leaf blight in the Pacific Islands with special reference to Samoa. *Journal of South Pacific Agriculture* 5:44–56.

Lebot, V. 1992. Genetic vulnerability of Oceania's traditional crops. *Experimental Agriculture* 28:309–323.

Maurya, D.M., A. Bottrall, and J. Farrington. 1988. Improved livelihoods, genetic diversity and farmer participation: A strategy for rice breeding in rainfed areas of India. *Experimental Agriculture* 24:311–320.

Norman, D., D. Baker, G. Heinrich, and F. Worman. 1988. Technology development and farmer groups: Experiences from Botswana. *Experimental Agriculture* 24:321–331.

Robinson, R.A. 1996. *Return to resistance*. Davis, California: AgAccess.

Robinson, R.A. 1997. Host resistance to crop parasites. *Integrated Pest Management Reviews* 2:103–107.

Ward, G.R. and P. Ashcroft. 1998. *Samoa: Mapping the diversity*. Suva, Samoa: Institute of Pacific Studies, USP; Apia, Samoa: National University of Samoa..