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# Screening a Cycle 1 Breeding Population of Taro (*Colocasia esculenta* (L.) For Resistance to Taro Leaf Blight in Samoa

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**Abstract:** The arrival of leaf blight in Samoa in 1993 devastated taro production in the country. Initial fungicidal efforts to manage the disease failed. Breeding taro for resistance to the disease was determined as the only long-term solution to the problem. A breeding programme, based on recurrent selection, was initiated in 1996 using exotic and traditional cultivars as parents. Breeding cycle 1 was screened for resistance to leaf blight during 1998 and 1999. Thirty clones were identified with good resistance to leaf blight and vigour. Following taste test evaluations 10 clones were selected for further multiplication and evaluation. MAFFM have officially released 6 of the clones to farmers. Clones C1-298 (Nu'u 16), C1-81 (Nu'u 5), C1-328 (Nu'u 21) and C1-40 (Talo Seve) yielded higher than the reference variety, PSB-G2, at the majority of sites in on-farm trials.

**Key words:** Taro leaf blight, breeding programme, recurrent selection, resistence, clones, taste tests, multiplication, evaluation, on-farm trials

## INTRODUCTION

The most recent introduction of Taro Leaf Blight (TLB) in the Pacific region was to the Samoan islands in 1993. The taro crop at this time was highly uniform and genetically vulnerable. The disease spread rapidly throughout the country severely affecting all local cultivars, but was most severe on taro cultivar Niue, which was unfortunate as this was 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 with taro Niue at the time was extremely large and effectively ensured a monocrop situation comprising a highly susceptible cultivar. There was a continuous and abundant source of taro for the disease because of the practice of many farmers to interplant on old plantations and stagger their cultivation. Combined with the movement of planting material and the ideal weather conditions that exist in Samoa for the disease, it is not surprising that the disease quickly reached epidemic proportions.

Prior to the disease outbreak taro was the major export earner in the country and over 90% of households in Samoa were growing the crop (Ward and Ashcroft, 1998). In the twelve-month period prior to the outbreak of TLB 180,191 kg of taro were brought for sale at the local market. In the twelve-month period subsequent to the outbreak of the disease 59,212 kg were brought in for sale. Seventy-five percent of this volume was brought in during the first 3 months of the 12 month period when the impact of the disease was still to be realised (Chan, 1996). Paulson and Rogers (1997) report that supplies of taro on the local market in June 1994 were only 1% of the supplies that were available in June the previous year. The massive losses due to the disease had a similar impact on the export of taro. The first 3 months of 1994 saw only 60,000 kg of taro exported which was valued at about WS$56,000 (Chan, 1996). This represents about 0.5% of the 1993 export figure.

One of the initial responses of the Samoan Government to disease was to encourage diversification of other crops and helping to explore alternative commercial agricultural enterprises. The government also provided assistance through the supply and distribution of planting material. Farmers quickly diversified into a range of other staple crops and bananas and *taamu* (*Alocasia macrorhiza*) replaced taro as the main staple. At the same time efforts to manage the disease included inter-island quarantine, fungicide spraying and cultural control but these had very little impact.

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Plant breeding offers the only long-term solution to the disease. The recent introduction of exotic taro cultivars with some resistance to TLB has allowed some growers to return to taro cultivation (Hunter and Pouono, 1998). However, there is a need to improve the levels of TLB resistance and quality. A breeding programme was initiated in Samoa to meet these objectives. This study reports on the evaluation of selected lines from the first recurrent selection cycle in Samoa.

## MATERIALS AND METHODS

Efforts to breed taro with resistance to TLB in Samoa commenced in 1996 with assistance from the AusAID-funded Western Samoa Farming Systems Project and USP. Crosses were made among the introduced TLB-resistant cultivars from the Philippines (PSB-G2) and Micronesia (Pwetepwet and Toantal) and susceptible local cultivars (Alafua Sunrise, Putemu and Tusitusi) in a breeding block established at USP.

Seeds were germinated at USP in small pots containing sterile potting mixture and after 2-3 weeks of sowing individual seedlings were transplanted to 'Jiffy-7' pellets and placed in flat pans containing water. All taro seedlings were transferred to the Nu'u Crops Research Centre, Ministry of Agriculture, Fisheries, Forests and Meteorology (MAFFM), for field evaluation. The seedlings were transplanted tot he field at Nu'u but due to drought and lack of facilities many plants died and less than 2,000 were remaining at the start of Taro Genetic Resources: Conservation and Utilisation (TaroGen) project in 1998. TaroGen had agreed to provide assistance to MAFFM to evaluate the seedlings for TLB resistance.

In September 1998, 1,814 seedlings were transferred from Nu'u to a farmer's field near the village of Siumu on the wet side of the island of Upolu. The high rainfall in the area provided maximum disease pressure for evaluation of TLB resistance. The plants were spaced 50 cm within rows with 1 m between rows and after every five rows, a row of Pwetepwet (moderately resistant to TLB) was planted as a control. The entire plot was surrounded by a guard row of PSB-G2 (moderately resistant to TLB). Regular weeding and 2 applications of NPK fertiliser were applied to promote growth.

The evaluation plot was monitored visually for the first 3 months to ensure that all plants were exposed to TLB. The extent of TLB on each plant was determined by visually estimating the percentage disease on each leaf using standard area diagrams prepared by Gollifer and Brown (1974). The average percentage disease for each plant was calculated by the total percentage disease for the plant divided by the number of leaves. From this data it was possible to calculate the Effective Healthy Leaf (EHL) number by multiplying total leaf number by percentage healthy leaf area. In addition, information was recorded on leaf size (medium, large and small) and overall plant vigour (high, medium and low).

It was felt that an indication of resistance other than average percentage TLB per plant was required, given that 2 plants could have very similar percentage disease levels but differ significantly in other aspects such as vigour and leaf number. For instance, 2 plants could have the same percentage of TLB infection but differ significantly in leaf number and healthy leaf area. As leaf number is ultimately related to yield, data was collected on number of leaves per plant. Average percentage TLB and leaf number per plant were combined to give an indication of the effective healthy leaves. This was obtained by multiplying the leaf number by percentage healthy leaf area. This gave a reliable indication of overall resistance without complicating measurements.

Following initial data collection and observations on 11 February 1999, 430 clones were selected visually, based on comparison with the check Pwetepwet, for further evaluation. All 430 clones were staked and numbered. Selected clones were denoted with the prefix C1 to indicate breeding cycle 1, followed by the appropriate selection number ( Table 1). These selected clones were closely monitored on a weekly basis up to the final evaluation at the end of March. After another 2 observations, further evaluations were made reducing the 430 plants initially selected to 200 and the same procedures continued until the top 30 plants were identified.

After the initial evaluation of the breeding population at Siumu, suckers of each of the top 30 selected clones were transplanted to a site nearby on the same farm in April 1999. This was to assist with multiplication of the selected clones, but also provided an opportunity to collect additional data on the performance of the clones. Data on the transplanted clones were collected over a 13-week period at Siumu from July to October 1999. The extent to TLB on each plant was determined and the Effective Healthy Leaf (EHL) number calculated as outlined above. Data were collected from an average of 3 plants of each selected clone.

Corms from clones were harvested in October 1999 for taste tests at Nu'u Crops Development Centre. Samples of corms were boiled and served to a taste panel of Samoan workers in blind taste tests. Panelists were requested to indicate whether each clone was 1 (poor), 2 (OK), 3 (good) or 4 (excellent).

Additional assessments of morphological characteristics were made on the vigour of clones, growth habit, leaf colour, stolon and flower formation, time to maturity and height.

Table 1: Resistance to taro leaf blight, vigour and average leaf number of 30 selected clones in Samoa

| Selection no. | Plant no. | Average TLB[1] | Average leaf no. | EHL[2] | Plant Vigour[3] |
|---|---|---|---|---|---|
| 1 | C1-346 | 6.3 | 6.8 | 6.3 | 2.88 |
| 2 | C1-40 | 7.4 | 6.4 | 5.9 | 3.00 |
| 3 | C1-281 | 8.8 | 5.8 | 5.3 | 3.00 |
| 4 | C1-218 | 9.6 | 6.4 | 6.0 | 2.38 |
| 5 | Cl-415 | 7.4 | 6.0 | 5.4 | 1.13 |
| 6 | C1-296 | 14.0 | 5.4 | 4.9 | 3.00 |
| 7 | C1-298 | 14.0 | 5.4 | 5.0 | 3.00 |
| 8 | C1-299 | 10.5 | 6.4 | 5.7 | 3.00 |
| 9 | C1-47 | 7.9 | 5.8 | 5.3 | 2.50 |
| 10 | C1-103 | 9.4 | 6.0 | 5.4 | 2.75 |
| 11 | C1-327 | 8.9 | 6.0 | 5.7 | 2.88 |
| 12 | C1-210 | 6.8 | 6.4 | 6.0 | 3.00 |
| 13 | C1-392 | 10.4 | 5.8 | 5.1 | 3.00 |
| 14 | C1-399 | 11.1 | 5.4 | 5.0 | 2.75 |
| 15 | C1-251 | 10.9 | 5.4 | 5.0 | 3.00 |
| 16 | C1-72 | 11.3 | 5.6 | 5.1 | 1.75 |
| 17 | C1-371 | 8.9 | 5.0 | 4.6 | 3.00 |
| 18 | C1-282 | 9.8 | 5.9 | 5.4 | 3.00 |
| 19 | C1-277 | 10.9 | 5.1 | 4.7 | 2.75 |
| 20 | C1-308 | 10.3 | 5.3 | 4.8 | 1.63 |
| 21 | C1-413 | 4.6 | 5.4 | 4.9 | 1.13 |
| 22 | C1-332 | 12.1 | 5.9 | 4.9 | 3.00 |
| 23 | C1-161 | 10.3 | 5.4 | 4.8 | 2.63 |
| 24 | C1-81 | 6.8 | 5.1 | 4.9 | 1.50 |
| 25 | C1-391 | 6.0 | 5.8 | 5.2 | 2.88 |
| 26 | C1-295 | 9.8 | 5.8 | 5.2 | 3.00 |
| 27 | C1-387 | 4.9 | 5.5 | 5.3 | 3.00 |
| 28 | C1-14 | 7.4 | 5.5 | 5.1 | 1.00 |
| 29 | C1-324 | 6.6 | 6.0 | 5.5 | 3.00 |
| 30 | C1-328 | 13.3 | 5.5 | 4.9 | 3.00 |

[1]Figures are averages of 8 weekly readings; [2]EHL = effective healthy leaves; [3]Evaluated as 1 = low vigour, 2 = moderate vigour and 3 = high vigour

In May 2000, MAFFM commenced on-farm trials to further evaluate the final top 10 clones. Five on-farm trials were planted in the villages of Falelatai, Vaivase-uta, Faleasi'u, Saleapaga and Siumu. A randomized block design was used. Each trial consisted of 2 blocks containing single plots of each of the clones plus PSB-G2 as a reference cultivar. Each site contained 20 data plants. Plants were harvested seven months after planting individual corm yields were collected.

## RESULTS AND DISCUSSION

The final 30 taro clones selected following preliminary evaluations presented Table 1. These represent the top clones selected over the 8 intensive evaluations for resistance to TLB and for general vigour. The results given in Table 1 represent the average values for the eight evaluations carried out. Over the preliminary evaluation period, clones C1-346, C1-210, C1-218, C1-40, C1-327 consistently had the highest number of effective healthy leaves (6.3, 6.0, 6.0, 5.9, 5.7 and 5.7, respectively) while clone C1-371 had the lowest number (4.6). The 30 selected clones all had higher values than the reference cultivar, Pwetepwet, which had an average EHL value of 4.4. Pwetepwet was considered one of the most TLB-resistant cultivars available in Samoa during the period of these evaluations (Hunter and Pouono, 1998). A summary of the overall vigour of the 30 selected clones is also presented in Table 1.

Table 2: Average effective healthy leaf (EHL) number for transplanted clones at Siumu

| Clone number | EHL[1] | Clone number | EHL[1] |
|---|---|---|---|
| C1-415 | 6.3 | C1-81 | 4.6 |
| C1-413 | 6.1 | C1-324 | 4.6 |
| C1-282 | 5.6 | C1-391 | 4.5 |
| C1328 | 5.5 | C1-327 | 4.5 |
| C1-332 | 5.4 | C1-218 | 4.5 |
| C1-392 | 5.3 | C1-371 | 4.5 |
| C1-299 | 5.2 | C1-210 | 4.5 |
| C1-277 | 5.1 | C1-298 | 4.4 |
| C1-295 | 5.1 | C1-161 | 4.2 |
| C1-281 | 4.9 | C1-47 | 4.1 |
| C1-40 | 4.9 | C1-251 | 4.0 |
| C1-14 | 4.8 | C1-346 | 3.8 |
| C1-103 | 4.8 | C1-387 | 3.8 |
| C1-399 | 4.7 | C1-296 | 3.7 |
| C1308 | 4.7 | C1-72 | 3.6 |

[1]EHL = Effective healthy leaves

Table 3: Evaluation of transplanted clones for taste

| Clone number | Taste[1] | Clone Number | Taste[1] |
|---|---|---|---|
| C1-81 | 3.5 | C1-299 | 2.4 |
| C1-328 | 3.3 | C1-72 | 2.0 |
| C1-14 | 3.2 | C1-103 | 2.0 |
| C1-327 | 3.2 | C1-251 | 2.0 |
| C1-324 | 3.2 | C1-277 | 2.0 |
| C1-399 | 3.1 | C1-218 | 1.9 |
| C1-295 | 2.9 | C1-371 | 1.9 |
| C1-298 | 2.9 | C1-282 | 1.9 |
| C1-296 | 2.9 | C1-413 | 1.6 |
| C1-40 | 2.8 | C1-415 | 1.3 |
| C1-391 | 2.7 | C1-281 | 1.3 |
| C1-210 | 2.7 | C1-346 | 1.2 |
| C1-387 | 2.7 | C1-47 | 1.1 |
| C1-332 | 2.6 | C1-308 | 1.0 |
| C1-161 | 2.6 | C1-392 | -2.0 |

[1]Evaluated as 1 = poor, 2 = OK, 3 = good, 4 = excellent; [2]No corm available for test

The results of evaluations on the transplanted 30 clones are summarised in Table 2 and 3. Based on the results of the taste test (Table 3), 10 clones were selected for further evaluation and multiplication: C1-81, C1-328, C1-14, C1-327, C1-324, C1-399, C1-295, C1-298, C1-296 and C1-40. In June 2000, MAFFM took the step of officially releasing 3 of the clones to farmers in Samoa. The released clones are C1-81 (Nu'u 5), C1-328 (Nu'u 21) and C1-298 (Nu'u 16). This was followed by further releases in 2001 which included C1-399 (*Talo semi*), C1-296 (*Talo suga*) and C1-40 (*Talo seve*). The parentheses refer to the official release name given to the clones by MAFFM. MAFFM plan to release the remaining 4 selected clones at a later date.

Morphological assessments made on the 10 clones are summarised in Table 4. The vigour of most clones was high or intermediate except for C1-14 which was low. All clones had an erect growth habit. All lines had stolons

Table 4: Morphological assessments of 10 selected cycle-1 lines in Samoa

| Clone number | Growth vigour | Growth habit | Stolon status | Leaf colour | Flower status | Maturity stage | Height (cm) |
|---|---|---|---|---|---|---|---|
| C1-14 | Low | Erect | Absent | Green | Absent | Intermediate | 46.4 |
| C1-40 | High | Erect | Present | Dark Green | Absent | Intermediate | 97.2 |
| SC1-81 | Intermediate | Erect | Present | Dark Green | Absent | Intermediate | 91.2 |
| C1-295 | High | Erect | Present | Dark Green | Absent | Intermediate | 94.6 |
| C1-296 | High | Erect | Present | Dark Green | Absent | Intermediate | 98.0 |
| C1-298 | High | Erect | Present | Dark Green | Absent | Intermediate | 100.2 |
| C1-324 | Intermediate | Erect | Present | Dark Green | Absent | Intermediate | 80.0 |
| C1-327 | High | Erect | Present | Green | Absent | Intermediate | 85.2 |
| C1-328 | High | Erect | Present | Green | Absent | Intermediate | 95.2 |
| C1399 | Intermediate | Erect | Present | Dark Green | Absent | Intermediate | 73.4 |

Table 5: Average yield (kg) per plant of the top 10 clones at five on-farm locations in Samoa

| | Location by Village | | | | |
|---|---|---|---|---|---|
| Clone | Falelatai | Vaivase-uta | Faleasi'u | Saleapaga | Siumu |
| C1-298 | 0.831 | 1.10 | 1.34 | 0.53 | 0.93 |
| C1-81 | 1.02 | 0.84 | 1.26 | m.d.[2] | 0.63 |
| C1-328 | 0.80 | 0.84 | 1.20 | 0.34 | 0.85 |
| C1-399 | 1.18 | 0.72 | 0.63 | m.d. | 0.49 |
| C1-40 | 0.69 | 0.95 | 0.60 | 1.15 | 1.27 |
| C1-296 | 0.27 | 0.61 | 0.70 | 0.68 | 0.63 |
| C1-295 | 0.81 | 0.98 | 0.96 | 0.8 | 0.73 |
| C1-14 | 0.49 | 0.48 | 0.56 | 0.75 | 0.31 |
| C1-324 | 0.33 | 1.13 | 0.59 | 0.99 | 0.44 |
| C1-327 | 0.57 | 0.68 | 0.38 | 0.98 | 0.56 |
| PSB-G2 | 0.87 | 0.83 | 0.96 | 0.46 | 0.72 |

[1]20 data plants/clone were planted at each trial site but in many instances theft reduced the number available at harvest; [2] m.d. = missing data, all plants removed prior to harvest

present except for C1-14. The leaf colour varied from green to dark green. At the time of the assessment no flowers were observed on any clone. In terms of maturity all clones were intermediate. The average height varied from 46.4 (C1-14)-100.2 cm (C1-298).

Table 5 highlights the average yield of the ten clones compared to the reference cultivar, PSB-G2 at the 5 on-farm trial sites. Clones C1-298 (Nu'u 16), C1-81 (Nu'u 5), C1-328 (Nu'u 21) and C1-40 (*Talo Seve*) yielded better than PSB-G2 at the majority of the sites. In some instances, theft of plants at trial sites caused problems with data collection and made comparisons impossible.

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