BREEDING AND EVALUATION OF TARO (*COLOCASIA ESCULENTA*) FOR THE SOUTH PACIFIC REGION

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Abstract

The objectives of the taro breeding program for the South Pacific region at the University of the South Pacific (USP) are to develop through a process of hybridization and selection high-yielding, disease- and pest-tolerant cultivars with good corm quality as well as tolerance to drought.

The seedlings derived from the crosses are evaluated in a series of trials: seedling, preliminary, intermediate, advance, and on-farm trials in Western Samoa and in some regional countries. In the advance trials in 1990, the clone 84045-9 gave yields comparable to 'Alafua Sunrise' and had high dry matter, high taste rating, and tolerance to drought. In the on-farm trials, 'Alafua Sunrise' out-yielded *Talo Niue* and *Manua* but was rated lower in taste tests by Western Samoans. In the advance and on-farm trials conducted in 1991, the clone 86038-38 yielded slightly lower than 'Alafua Sunrise', but it was similar to *Talo Niue* in quality with yields significantly better than *Talo Niue*. The clone 84014-5 also appeared to be promising as it gave high yields, had high dry matter, and was rated above 'Alafua Sunrise' in taste tests, but the corm shape was poor and the flesh color yellow.

Introduction

Root crops are the main staple food of the people in the Pacific. Among them, taro (*Colocasia esculenta* (L.) Schott) is the most widely consumed root crop in Western Samoa.

The total area under taro in Western Samoa in 1989 was about 11,031 ha, of which 76.3 percent was grown as a monocrop, 22.6 percent as a mixed crop, and 1.1 percent as scattered plants (Report on the Census of Agriculture 1989).

The total production of taro and quantity exported for five years during the period 1983 to 1991 are shown in Table 1. It shows a steady increase in both production and exports, although there was a slight decline in the quantity exported in 1991.

Table 1. Production and export of taro for five years during the period 1983-1991.

Year	Total production ('000 tonnes)	Total exports ('000 tonnes)
1991	29.6	6.3
1989	28.8	7.8
1987	27.4	6.6
1985	16.8	4.5
1983	15.5	3.2

Source: Bourne Sefu, Central Bank of Samoa 1992.

Annually, between 70 and 80 percent of the taro produced in Western Samoa was used locally both for consumption as well as for traditional cultural ceremonies, and the balance was exported. Taro ranks as the third major commodity exported to Australia, New Zealand, and the United States of America to cater to the needs of the migrant community from the Pacific region.

Background

Taro breeding is relatively new to the Pacific. Of the six taro breeding programs in the world, two are located in the South Pacific. A local selection evaluated in the national program conducted at the Koronivia Research Station in Fiji from 1979 was released as an improved cultivar,'Samoa Hybrid', in 1984. The regional program, which started at the Alafua Campus of the University of the South Pacific (USP) in 1982, released its first cultivar, 'Alafua Sunrise', in 1988.

Approach

There are three approaches to obtain improved cultivars of taro.

1. Collection, evaluation, and selection of promising local germplasm, to be released as cultivars and use them for crossing in a sexual breeding program.
2. Importation of elite cultivars from other countries and evaluate them under local conditions. The tissue culture laboratory of the Institute for Research,

Extension and Training in Agriculture (IRETA) has imported several pathogen-tested (virus indexed) taro cultivars from other countries to be tested in Western Samoa and also to be utilized in the breeding program. IRETA also distributed improved clones and cultivars to five regional countries for screening and evaluation.

3. Breed cultivars through sexual hybridization. The crosses would be evaluated and selected, first under local conditions in on-station and on-farm trials and then in national collaborative trials in the regional countries. Pathogen-tested promising clones would be sent to other regional countries later. A number of different clones having desirable attributes would be used for crossing, to have progenies with as widely different combinations of characters as possible.

Objectives

The main objective of the taro breeding program is to develop through sexual hybridization high-yielding, disease- and pest-tolerant cultivars with good corm quality characteristics acceptable to the farmers and consumers in the South Pacific region and migrants from the Pacific living in other countries.

Procedure

Since the inception of the regional taro breeding and evaluation program at the USP in Western Samoa, every year a large number of crosses were made among selected parents to produce seeds to create genetic variability. The seedlings derived from the crosses, each of which has the potential to become a new cultivar, were evaluated in a series of trials.

The simplified version of the sequential stages of the recurrent selection breeding program described by Wilson (1990) is shown in Fig. 1. These steps are followed in the breeding and evaluation program conducted at the USP.

The minimum time taken to evaluate and release a cultivar, from the time of crossing up to testing in on-farm trials, is six years. However, testing promising cultivars with local control clones for a few years in different agro-climatic zones is desirable, which means that it will take at least ten years for the farmers to receive improved cultivars. Breeding is a continuous process with a new crossing block started every year. In steps 4, 5, and 6, clones bred were evaluated and selected in a series of three trials conducted in the research station, followed by on-farm trials in step 7.

Several specific characters were evaluated at each stage. They included plant characters (plant type, petiole color), plant vigor, sucker number, resistance to pests and diseases (viruses, fungi, and insects), maturity, marketable and non-marketable yield, corm characters (shape, smoothness, color of buds, basal rings, petiole base, and flesh), and eating quality (dry weight percentage, specific gravity, taste tests).

Results

The results of the crossing program and evaluation trials conducted and/or reported in 1990 and 1991 are summarized below.

Crossing Program

1990: Crosses were made among 40 selected clones and cultivars in December, with emphasis on high yield, high corm quality, and dry-matter content. Of the 50 crosses made, only seeds of 30 remained viable, leaving about 1,000 seedlings for evaluation in 1991.

1991: Seeds were obtained from about 60 crosses made between 60 cultivars. The objectives were the same as for the 1990 program, but, in addition, emphasis was also placed in breeding for drought tolerance. However, seed viability was limited to 35 crosses, out of which 1,500 seedlings were raised for planting in 1992.

Seedling Trials

1990: About 800 seedlings developed from 1988/89 crosses were planted in January and harvested in August. Based on yield, disease resistance and corm shape, 60 clones were selected for evaluation in the preliminary trial. Further, six clones which gave slightly lower yields but showed early maturity were also selected for further evaluation.

1991: Over 1,000 seedlings from the 1990 crosses were planted in February and harvested in August, and 80 clones were selected based on the criteria used in the 1990 trials plus corm color. Yields of selected clones ranged from 250 g to 630 g per plant compared to the control cultivars, 'Alafua Sunrise' (328 g/plant) and *Talo Niue* (225 g/plant). Nearly 50 percent of the clones selected had one or more of the characteristics of *Talo Niue* (pink buds, pink basal ring, and pinkish-white corm flesh color) favored by the Samoans in the progenies.

Preliminary Trials

1990: Seventy-two clones from the 1988/89 seedling trial were planted with control cultivars, 'Alafua Sunrise' and *Talo Niue* (three plants/plot) in March and harvested in November 1989. Four clones 87020-020 (0.90 kg/plant), 86021-104 (0.89 kg/plant), 87018-017 (0.75 kg/plant), and 87006-014 (0.71 kg/plant) yielded higher than 'Alafua Sunrise' (0.70 kg/plant) and *Talo Niue* (0.35 kg/plant), and these appeared to have better tolerance to drought than *Talo Niue*.

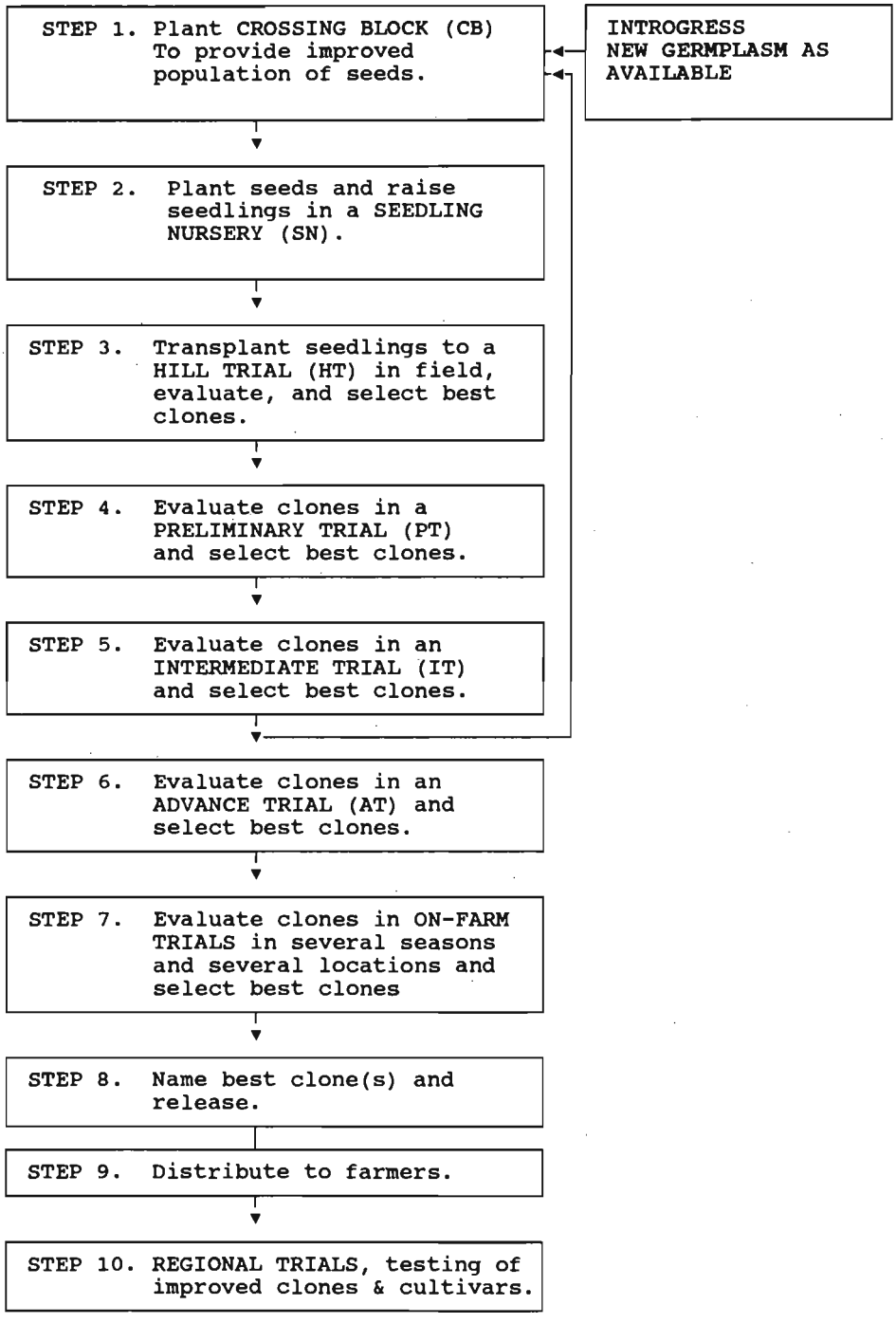

Fig. 1. Flow chart of the taro breeding program.

The trial was replanted in November 1989 and harvested in July 1990 and showed that three of the four drought-tolerant clones performed well, with 87020-020 having high yield and moderately high specific gravity. In all, 18 clones were selected for further evaluation.

1991: From the 1990 seedling trial, 96 clones were selected and planted in two trials in December 1990 and harvested in July 1991. From these, 22 clones were selected for testing in the intermediate trial in 1992. The yields of clones 86021-08 (0.73 kg/plant), UN4 (0.73 kg/plant), 89016-20 (0.71 kg/plant), and UN2 (0.70 kg/plant) were better than *Talo Niue* (0.48 kg/plant) and similar to 'Alafua Sunrise' (0.71 kg/plant).

Intermediate Trials

1990: Sixteen clones selected from the 1988 preliminary trial were planted in a replicated yield trial using randomized complete block design (RCBD) in March and harvested in November 1989 with 'Alafua Sunrise' and *Talo Niue* as control cultivars, but it was affected by drought. The clones 86021-113, 85001-140, 86038-065, 86009-007, 86021-052, 86020-037, and 'Alafua Sunrise' showed some tolerance to drought. Only the clone 86021-113 (0.80 kg/plant) yielded higher than 'Alafua Sunrise' (0.76 kg/plant).

The trial was repeated in November 1989 and harvested in July 1990. Five clones were selected for screening in the advance trial. Of these, the clone 86021-113 (9.7 t/ha) gave high yield and had the highest specific gravity, drought tolerance, and high-taste rating, but produced only a few suckers. The clone 86038-065 (8.4 t/ha) was similar to *Talo Niue* (4.4 t/ha) in corm color and taste. It yielded almost twice as much as *Talo Niue* but lower than 'Alafua Sunrise' (10.0 t/ha). The clone 86038-038 was similar to *Talo Niue* in color and taste rating but was affected by Pythium rot.

1991: Fifteen clones with two control cultivars were planted (RCBD, three plants/plot x three replicates) and harvested in September 1991. Four clones were selected on the basis of yield for evaluation in the advance trial in 1992. Of these, clones 87018-41 and 87018-181 gave significantly higher yields than *Talo Niue* but not 'Alafua Sunrise' and also had corms with high specific gravity.

Advance Trials

1990: Six clones selected from the intermediate trial were compared with two control cultivars in the dry season, in March 1989, in a RCBD (10 plant/plot x four replicates).

This trial was severely affected by drought. The clones 84014-5, 85045-9, and 'Alafua Sunrise' appeared to be tolerant to drought. The clone 84014-5 (0.72 kg/plant) gave the highest yield followed by 'Alafua Sunrise' (0.60 kg/plant) and 85045-9 (0.52 kg/plant).

The trial was replanted in November 1989 and harvested in July 1990. The highest-yielding clone 84037-9 (10.8 t/ha) had a low taste rating. The clone 84014-5 (10.0 t/ha) was high yielding and somewhat drought tolerant but had a poor corm shape. The clones 84045-9 (8.9 t/ha) had a high taste rating, high dry matter percent, and showed tolerance to drought but yielded slightly lower than 'Alafua Sunrise' (10.3 t/ha). However, the difference was not significant.

1991: Two and three clones from the 1990 advance trial and intermediate trials, respectively, with two control cultivars were planted in December 1990 (15 plant/plots, RCBD, x four replicates) and harvested in July 1991.

None of the clones yielded higher than 'Alafua Sunrise' but gave 26-44 percent higher yields than *Talo Niue.* The clone 86038-38 (6.4 t/ha) emerged as the most promising as it gave high yields and high dry-matter percentage and was rated high in taste tests and corm color was similar to *Talo Niue.* The clone 86038-65 (6.3 t/ha) was similar to *Talo Niue* with higher yields, but corm shape was poor and taste rating was low. The clone 85045-9 (6.5 t/ha) was very susceptible to orange leaf spot disease caused by *Colocasia jonstonia.*

Ten elite clones and cultivars were planted in April 1991 and harvested in November to determine their performance under conditions of moisture stress. The clone 86020-37 (7.5 t/ha) significantly out yielded the rest. There was no significant difference in yield between clones 86038-65, 85001-140, 84014-5, 85045-9 86038-38, and 'Samoa Hybrid'. Yield of *Talo Niue* ranged from 4.3 t/ha to 5.9 t/ha.

On-Farm Trials

1990: The improved cultivar 'Alafua Sunrise' was compared with *Talo Niue* at three sites to determine its acceptance by farmers and exporters. The yield could not be analyzed due to theft and unscheduled harvest. In general, 'Alafua Sunrise' performed better than *Talo Niue* and out-yielded it by 50-150 percent. 'Alafua Sunrise' was sold well in the export markets, but there was a shortage of taro after the cyclone and hence the preference of consumers could not be determined.

1991: In the first trial clones 84014-5 (6.1 t/ha) and 86038-38 (5.7 t/ha), which had high dry-matter percentage, out yielded 'Samoa Hybrid' (4.0 t/ha) and *Talo Niue* (4.0 t/ha) but not 'Alafua Sunrise' (6.2 t/ha). Two other trials conducted in sites with poor soil fertility gave unsatisfactory results.

Regional Trials

The objective of these trials was to screen and evaluate the promising cultivars released from the breeding programs of the USP and Fiji in six regional countries (Fiji, Tonga, Cook Island, Western Samoa, Vanuatu, and

Tuvalu) in the Pacific.

1990: Virus-indexed improved clones and cultivars in tissue culture were sent to the six countries in the program: Cook Island, 18; Tonga, 9; Tuvalu, 26; and Vanuatu 30. In all the countries except Fiji, the materials were multiplied for field screening later.

1991: Fiji trial: In the advance trial, 12 clones and cultivars were planted (20 plants/plot, RCBC x four replicates) in November 1990 and harvested in July 1991. Nine improved clones in the trial gave between 37-106 percent higher yields than the control cultivar 'Samoa Hybrid'.

In two on-farm trials planted in December 1990 and harvested in 1991, the improved clones gave between 27-113 percent higher yields than 'Samoa Hybrid'. Five clones (123/70, 123/98, 160/31, 160/32, and 191/37) have been selected based on yield, consumer acceptance (taste tests and acceptability ratings), and corm shape for extensive on-farm trials prior to release.

Two preliminary trials were carried out to screen and evaluate 51 cultivars introduced from elsewhere in the region. From these, 22 cultivars with high yields were selected for further testing, which included 'Alafua Sunrise'.

Western Samoa trial: In a preliminary trial, eight clones introduced as tissue culture plants were planted in January 1991 and compared with 'Alafua Sunrise'. The four highest yielding clones were from the Fiji breeding program, which have characteristics similar to *Talo Niue*.

Other countries: Introduced clones and cultivars were multiplied and field planted in about the middle of the year in single lines for preliminary evaluation.

Discussion

The taro breeding and evaluation program based at the USP in Western Samoa attempts to breed clones to meet the specific needs of the island nations in the Pacific. So far, two improved cultivars have been released from this program. The first was 'Samoa Hybrid', which is an introduction from Fiji breeding program, selected from a number of open pollinated seeds collected from the most popular taro cultivar in Fiji, 'Samoa'. The other, 'Alafua Sunrise', was bred at the USP and was the result of a hybridization program. Although both cultivars are high yielding, very few farmers have planted them (Liyanage and Misipati 1992).

Low acceptance of these cultivars by the farmers can be attributed to a failure to transfer the new technologies.

Pathogen-tested elite cultivars from other regional countries have been imported to the IRETA tissue culture unit in Western Samoa. The breeding program at USP has benefited in two ways. Firstly, these cultivars can be evaluated under Samoan conditions and those which satisfy the breeding objectives can be released to the farmers. Secondly, the promising cultivars can be used in a hybridization program to transfer the desirable characteristics to the progenies. The regional countries have also benefited from this germplasm exchange program, as many of these clones have been despatched to several countries for testing under their conditions.

Several high-yielding clones with good secondary characteristics are in the final stages of evaluation at the USP, prior to releasing them for regional trials. Making these clones available to the regional countries would help to identify high-yielding cultivars adapted to their conditions. It would also be possible to increase taro production and also widen the genetic base so that national breeding programs can utilize the cultivars in their own crossing programs.

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L. Ferentinos is the Project Coordinator of the Taro Production Systems Project at the University of Hawai'i at Manoa.

Jane C. Muench, an independent editor with J.C.M. Office Services, provided technical support.

Publication was supported in part by a grant from the USDA/CSRA Sustainable Agriculture Research and Education Program (formerly called L.I.S.A.). Additional support was provided by American Samoa Community College, College of Micronesia, Northern Marianas College, University of Guam, Yap Institute of Natural Science, and the University of Hawai'i under the Agricultural Development in the American Pacific (ADAP) Project.

The Library of Congress has catalogued this serial publication as follows:

Research extension series / Hawaii Institute of Tropical Agriculture and Human Resources.—001—[Honolulu, Hawaii]: The Institute, [1980–
v. : ill. ; 22 cm.
Irregular.
Title from cover.
Separately catalogued and classified in LC before and including no. 044.
ISSN 0271-9916 = Research extension series - Hawaii Institute of Tropical Agriculture and Human Resources.
1. Agriculture—Hawaii—Collected works. 2. Agriculture—Research—Hawaii—Collected works. I. Hawaii Institute of Tropical Agriculture and Human Resources. II. Title: Research extension series - Hawaii Institute of Tropical Agriculture and Human Resources.
S52.5R47 630'.5—dc19 85-646281
AACR 2 MARC-S
Library of Congress [8506]