Promotion of Flowering, Seed Production and Seedling Screening in Minor Edible Aroids

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ABSTRACT

In the Pacific, Colocasia is clearly the most important of the edible aroids and Xanthosoma is spreading rapidly and widely. The less well known Alocasia macrorrhiza and Cyrtosperma chamissonis have more restricted distributions and are considered minor crops in the region as a whole. They are, however, staple foods on some islands, Alocasia being frequently cultivated in Samoa and Tonga and Cyrtosperma on atolls and low coralline islands where few other crops survive.

Germplasm collections of Alocasia and Cyrtosperma have been assembled at Alafua and a genetic improvement program initiated. Studies related to the promotion of flowering with gibberellic acid, hand pollination, seed germination and seedling rearing are discussed.

In the Pacific region the edible aroids, Colocasia esculenta (L.) Schott, Xanthosoma sagittifolium (L.) Schott, Alocasia macrorrhiza (L.) Schott, and Cyrtosperma chamissonis (Schott) Merr. are cultivated. Of these, Colocasia (taro, talo) is the most important within the region as a whole. It is an ancient crop which has prestigious as well as economic value. In comparison, Xanthosoma (cocoyam, talo palagi) is relatively new to the region, having been introduced during the last century. Nonetheless, it has spread rapidly and widely because its high yields and disease, shade and drought tolerance often make it easier and more profitable to grow than Colocasia.

Alocasia (giant taro, ta'amu, kape) and Cyrtosperma (giant swamp taro, pula'a pulaka, babai) are less well known and have more restricted distribution in the region. However, they are dominant or co-dominant cultivated staples on some islands. Alocasia is frequently cultivated and marketed in Western Samoa, Tonga, the Wallis Islands, and Tuvalu and in Tonga it is socially and ceremonially important. To a lesser extent it is cultivated in American Samoa, Papua New Guinea, Vanuatu, Solomon Islands, New Caledonia and other parts of French Polynesia (Barrau, 1958, 1961; Plucknett, 1970; Fa'anunu, 1977; Mauala, 1977; Merrick, 1977; Thaman, 1977, 1981; Bourke, 1979; personal observations).

Cyrtosperma is the most important aroid on the resource-poor atolls and low coralline islands of Kirabati, Tuvalu, Tokelau, Papua New Guinea, Solomon Islands and Micronesia where it is grown in natural swamps or in large, manmade swamp pits dug down through sand and coral-limestone rock to the fresh water lens. It is

also cultivated as a supplementary and reserve food in the Cook Islands, in poorly drained areas of the Rewa River Delta, Fiji, in high island fresh water swamps of Papua New Guinea and in the coastal swamps of the Solomon Islands. In Western Samoa wild stands are infrequently harvested; only during times of food shortages (Catala, 1957; Barrau, 1958, 1961; Plucknett, 1970, 1977; Small, 1972; Wall and Hansell, 1976; Hadley, 1977; Bourke, 1979; Thaman, 1981; personal observations).

Traditionally, both Alocasia and Cyrtosperma are vegetatively propagated using head setts or suckers. In the Pacific some cultivars of Alocasia flower naturally, generally after at least one year's growth, but naturally-set seed has not been found. Viable seeds have, however, been collected in Australia (D.E. Shaw, personal communication) and in the Philippines (W.J. Cable, personal observation). Natural flowering occurs in many cultivars of Cyrtosperma, naturally-set seed is frequently found and farmers occasionally rear volunteer seedlings (Catala, 1957; Small, 1972; personal observations). Nonetheless, to facilitate the genetic improvement of these two aroids, techniques are required for promoting early, uniform and abundant flowering in all cultivars and for controlled hand pollination, seed germination and seedling rearing.

It is now well documented that gibberellins promote flowering in several aroids including Colocasia and Xanthosoma and techniques for pollinating and growing seedling populations have now been perfected for these two genera (McDavid and Alamu, 1976; IITA, 1977; Alamu and McDavid, 1978a, 1978b, 1978c; Cable, 1979; Jackson and Pelomo, 1980; Wilson, 1980a, 1980b, 1980c, 1981). The present study was initiated to adapt these techniques to Alocasia and Cyrtosperma. Two portions of the study, promotion of flowering in Alocasia and flowering, fruiting and seed germination in Cyrtosperma, will be discussed in this paper.

Materials and Methods

Promotion of Flowering of Alocasia

Seventeen accessions of Alocasia have been collected from Western Samoa and established at Alafua. From this collection two clones, Ta'amu Toga and Ta'amu Niu Kini, were selected for their contrasting propensity to flower naturally. Ta'amu Toga frequently flowers about one year after planting whereas Ta'amu Niu Kini does not flower naturally even when left undisturbed for 2 or more years. Plants were grown in the field from vegetative propagules planted at Alafua on 27 April at a spacing of 1.5x1.5 m. To insure vigorous growth, plants were fertilized one month after planting with 50, 11 and 80 kg/ha N, P and K respectively and 2 and 3 months after planting with 100, 22 and 40 kg/ha N, P and K respectively. A randomized complete block design with three replications, three plants to a plot, was used.

Plants were treated with aqueous solutions of technical grade gibberellic acid (GA, 75% potassium salt, ICN) at the concentrations of 750 and 1500 ppm or with a water control of 0 ppm GA. These were applied with surfactant (0.25% v/v Agral LN, ICI) as foliar sprays using a hand sprayer. Plants were treated once when they reached the 3 to 6 leaf stage, about 2 months after planting. Approximately 60 ml of solution was applied to each plant, covering all leaves to runoff and filling the cup formed by the petiole bases. Observations on flowering were recorded at two-day intervals beginning from the appearance of the first inflorescence and continuing until about 6 months after planting when most, but not all, plants had finished flowering.

Flowering, Fruiting and Seed Germination of Cyrtosperma

Twelve accessions of Cyrtosperma have been collected from Western Samoa and planted at Alafua. Although preliminary trials indicated that flowering can be promoted with 1000 ppm GA, adequate numbers of inflorescences were not available from the collection and therefore inflorescences and fruit clusters were collected from wild stands at five locations within the country. Seeds were extracted either by (1) removing seeds from fresh, mature fruits; (2) removing seeds from fresh, mature fruits and fermenting them overnight in small quantities of water; or (3) fermenting the entire fruit cluster for several days before washing out the seeds.

Since earlier observations indicated that dry seeds germinated poorly, a trial was designed to determine the effects of drying on percentage and rate of germination. Treatments consisted of (1) no drying, fresh seeds planted immediately after extraction, (2) drying and storing for 1 to 23 days, and (3) drying for 1 day, coating with melted candle wax, storing for 1 to 35 days and removing wax by scraping immediately before planting. All seeds were extracted by fermenting entire fruit clusters. Drying and storage were at ambient conditions (24-30°C, high RH) and seeds were sown in convered Petri dishes containing thin layers of steam sterilized soil and maintained at ambient conditions. Twenty-five seeds per treatment were planted and the trial was repeated five times whenever sufficient mature fruits were available. Germination data were recorded daily for 30 days after sowing. Seedlings were transplanted to pots in the greenhouse when cotyledons were fully expanded.

Results and Discussion

Promotion of Flowering in Alocasia

None of the water-treated control plants of Ta'amu Niu Kini and only one of the nine control Ta'amu Toga plants flowered during the 6 months experiment. In contrast, the percentage of plants flowering in the GA treatments ranged from 67% to 100% (Table 1). In Ta'amu Toga 750 ppm GA resulted in a higher percentage of plants flowering although this difference was not significant and in Ta'amu Niu Kini the percentage of plants flowering was not affected by GA concentration. Likewise, the mean number of normal inflorescences produced was higher in Ta'amu Toga plants treated with 750 ppm GA although the difference was not significant and in Ta'amu Niu Kini there was no difference between GA concentrations (Table 2) although the 1500 ppm treatment tended to produce weaker inflorescences. Ta'amu Toga yielded more inflorescences than Ta'amu Niu Kini.

Generally, GA-treated plants flowered earlier than water-treated controls but no consistent differences in number of days from treatment to appearance of the first normal inflorescence were observed between GA concentrations or between clones (Table 3).

In both clones GA-treated plants had shorter petioles and smaller leaf blades and some leaf deformities were observed. In Ta'amu Niu Kini, GA increased suckering so that flowering plants produced leaves and inflorescences simultaneously but, in contrast, most GA-treated plants of Ta'amu Toga terminated in floral buds and new leaves were not available to support developing fruits.

Both 1500 and 750 ppm GA gave satisfactory results in terms of time to flowering, percentage of plants flowering and number of inflorescences. In one clone tested 750 ppm gave better results and in both clones 750 ppm produced more

Table 1. Effects of GA on percent plants flowering in Alocasia.

GA Conc. (ppm)	Ta'amu Toga	Ta'amu Niu Kini	Mean ($\bar{T}$)
	Plants flowering (%)		
Water control	11	0	6
750	100	67	84
1500	89	67	78
Mean (GA treatment only)	94	67	
Mean ($\bar{C}1$) =	67	45	
LSD ($\bar{X}$) P = 0.05	44	LSD ($\bar{T}$) P = 0.05	31
P = 0.01	63	P = 0.01	45
CV (%)	77.0	LSD ($\bar{C}1$) P = 0.05	26
		P = 0.01	36

Table 2. Effects of GA on number of inflorescences produced in Alocasia.

GA Conc. (ppm)	Ta'amu Toga	Ta'amu Niu Kini	Mean ($\bar{T}$)
	Inflorescences/plant		
Water control	0.7	0.0	0.4
750	5.7	3.3	4.5
1500	4.2	3.9	4.0
Mean (GA treatment only)	5.0	3.6	
Mean ($\bar{C}1$) =	3.5	2.4	
LSD ($\bar{X}$) P = 0.05	1.8	LSD ($\bar{T}$) P = 0.05	1.2
P = 0.01	2.5	P = 0.01	1.8
CV (%)	72.8	LSD ($\bar{C}1$) P = 0.05	1.0
		P = 0.01	1.4

Table 3. Effects of GA on days to first normal inflorescence of Alocasia from time of application.

GA Conc. (ppm)	Ta'amu Toga	Ta'amu Niu Kini	Mean ($\bar{T}$)
	Days		
Water control	119	NF*	-
750	94	103	99
1500	100	98	99
Mean (GA treatments only)	97	101	
*No flowers produced No significant differences between 750 + 1500 ppm GA			
CV (%)	7		

vigorous inflorescences and is therefore more suitable for breeding purposes. Concentrations lower than 750 ppm should be tested on T'amu Toga to find a treatment which does not reduce leaf production so drastically.

Flowering, Fruiting and Seed Germination in Cyrtosperma

The inflorescence of Cyrtosperma consists of a large spadix, often 20 to 25 cm long, covered by an open spathe. In contrast to most edible aroids which are monoecious, the flowers of Cyrtosperma are hermaphroditic and distributed uniformly over the entire length of the spadix. Pollen shed begins at the apex of the spadix and progresses through the mid-section to the base. The fruiting head is a cluster of densely packed berries, yellow to orange-red when mature, each containing one to several large seeds measuring 5 to 10 mm in diameter. In 28 fruit clusters collected from five locations in Western Samoa the number of seeds/berry ranged from 1 to 4 with a mean of 2.4 and the number of seeds/fruit head ranged from 9 to 253 with a mean of 108. Most berries were located on the basal one-third to one-half of the spadix and on the side not enclosed by the spathe, suggesting that inflorescences are protogynous and rain pollinated. In western Samoa berries were rarely observed near the apex of the spadix, however in Kiribati, berries have been commonly found along the entire length of the spadix suggesting that insects or wind do transfer pollen between inflorescences in some locations.

Fruiting heads harvested when berries were fully developed but still green were successfully ripened by placing the cut end of the peduncle in water and storing until berries softened and turned yellow or orange-red. Generally seeds from less-than-fully developed berries were, however, too immature to germinate, even after post-harvest ripening.

All three methods of seed extraction resulted in good seed germination, but those two methods involving fermentation, either of the seeds or of the entire fruit cluster, were the most satisfactory since they removed the gelatinous coating encasing each seed.

Germination of fresh seeds planted without drying immediately after extraction ranged from 12% to 84%. Germination percentages were reduced by half or more after 2 or 3 days of drying and storage and all viability was lost after 5 to 8 days of drying and storage. Waxed seeds which were stored one and 2 days before sowing had lower percentage germination compared to unwaxed seeds stored for the same period, but waxing did tend to reduce somewhat the rate of decline in viability when seeds were stored for 4 to 7 days. Nonetheless, all viability was lost with longer storage.

Fresh seeds and seed dried for one day began germinating 6 to 15 days after sowing compared to 13 to 22 days for seeds dried and stored 2 to 7 days and 20 to 32 days for waxed seeds. Drying and waxing presumably delayed imbibition.

Establishment of seedlings in the greenhouse was good although growth was slow in the coral sand/soil potting mixture used. Plants are presently being maintained until they are large enough to screen for tolerance to salinity.

Literature Cited

Alamu, S. and McDavid, C.R. (1978a). Promotion of flowering in edible aroids by gibberellic acid. Trop. Agric. (Trinidad) 55:81-86.

Alamu, S. and McDavid, C.R. (1978b). Effect of time and method of application of gibberellic acid on the growth and promotion of flowering in tannia (Xanthosoma sagittifolium). Trop. Agric. (Trinidad) 55:235-241.

Alamu, S. and McDavid, C.R. (1978c). Flowering, pollen production and seed set in GA3 treated and untreated field grown tannia (Xanthosoma sagittifolium) plants. J. Root Crops 4:55-61.

Barrau, J. 1958. Subsistence agriculture in Melanesia. B.P. Bishop Museum Bulletin 219:1-111.

Barrau, J. 1961. Subsistence agriculture in Polynesia and Micronesia. B.P. Bishop Museum Bulletin 223:1-94.

Bourke, R.M. 1979. Root crops in Papua New Guinea. Paper presented at the 5th Intern. Symp. on Tropical Root Crops, Manila, Philippines, Sept. 17-21, 1979.

Cable, W.J. 1979. Flower promotion in taro. Alafua Agric. Bull. 4:6-7, 14-16.

Catala, R.L.A. 1957. The babai. Atoll Res. Bull. 59:67-75.

Fa'anunu, H.O. 1977. Traditional aspects of root crop production in the Kingdom of Tonga. South Pacific Commission Technical Paper No. 174:191-1199.

Hadley, K. 1977. Taro cultivation in Ponape district. South Pacific Commission Technical Paper No. 174:40-43.

IITA. 1977. 1977 Annual Report, International Institute for Tropical Agriculture. p44.

Jackson, G.V.H. and Pelomo, P.M. 1980. Breeding for resistance to diseases of taro, Colocasia esculenta, in Solomon Islands. IFS Prov. Rept. No. 5:287-298.

Mauala, N. 1977. Root crops production in Western Samoa. South Pacific Commission Technical Paper No. 174:167-169.

McDavid, C.R. and Alamu, S. 1976. Promotion of flowering in tannia (Xanthosoma sagittifolium) by gibberellic acid. Trop. Agric. (Trinidad) 53:373-374.

Merrick, J.E. 1977. Status of root crops in American Samoa. South Pacific Commission Technical Paper No. 174:122-124.

Plucknett, D.L. 1970. Colocasia, Xanthosoma, Alocasia, Cyrtosperma and Amorphophallus. Tropical Root and Tuber Crops Tomorrow I:127-135.

Plucknett, D.L. 1977. Giant swamp taro, a little-known Asian-Pacific food crop. Proceedings of the 4th Intern. Symp. on Tropical Root Crops. CIAT, Cali, Columbia:36-40.

Small, C.A. 1972. Atoll agriculture in the Gibbert and Ellice Islands. Dept. of Agriculture, Tarawa.

Thaman, R.R. 1977. The nature and importance of Tongan root crop production. South Pacific Commission Technical Paper No. 174:83-89.

Thaman, R.R. 1981. Intensification of edible aroid cultivation in the Pacific Islands: trends, prospects and the need to intensify urban and rural taro cultivation. IFS Prov. Rept. No. 11:194-227.

Wall, J.R.D. and J.R.F. Hansell. 1976. Land resources of the Solomon Islands. Vol. 8 Outer Islands. Land Resources Study 18, Min. Overseas Devel., Surbition, Surrey, England.

Wilson, J.E. 1980a. Promotion of flowering and production of seed in cocoyam (Xanthosoma and Colocasia). IFS Prov. Rept. No. 5:269-277.

Wilson, J.E. 1980b. Progress in the breeding of cocoyam (Colocasia and Xanthosoma). IFS Prov. Rept. No. 5:299-308.

Wilson, J.E. 1980c. Cocoyam breeding by flower induction, pollination and seed germination. IITA Manual Series No. 4. 15 pp.

Wilson, J.E. 1981. Effects of formulation and method of applying gibberellic acid on flower promotion in cocoyam. Expl. Agric. 17:317-322.