Progress in the Breeding of Cocoyam (*Colocasia* and *Xanthosoma*)

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Abstract

Gibberellic acid successfully promoted flowering in six clones and five seedling families of *Colocasia esculenta* and *Xanthosoma sagittifolium* planted three times during the dry season and grown under irrigation. However, environmentally induced pollen sterility was common and seed production was limited.

In *Colocasia,* variability was observed within and between seedling families for petiole color, susceptibility to *Sclerotium* rot and fecundity.

Observations on petiole color segregation in *Xanthosoma* seedlings indicated that purple petiole color was dominant to green.

Introduction

Genetic improvement of the cocoyams *Xanthosoma* spp. and *Colocasia esculenta* (L.) Schott through systematic breeding has become possible with the recent development of techniques for sexually propagating these crops. McDavid and Alamu (1976), IITA (1977), Alamu and McDavid (1978a, 1978b) and Wilson (1979) have reported using gibberellic acid to promote flowering. Techniques for artificial hybridization, seed germination and seedling establishment have been developed (Volin and Zettler, 1976; IITA, 1976; Wilson, 1979) and seeds of *Colocasia esculenta* resulting from natural flowering and pollination have been collected and reared by a number of researchers including Kikuta, *et al* (1938), Shaw (1975) Jacson *et al* (1977) and Jos and Bai (1977).

This sexual reproduction, by permitting recombination, generates a wealth of genetic variability and the next step is to exploit this variability in a practical breeding program. To facilitate rapid generation turnover, techniques for flower induction, hand pollination, seed germination and seedling establishment must be perfected to permit hybridization and seedling rearing throughout the year. Attention should be focused on assessing the variability available and identifying sources of those characters which are needed for improvement and concentrating them into improved varieties. It will be necessary to determine the mode of inheritance for the most important characters and to develop simple techniques for accurately screening large numbers of plants in early generations.

At IITA breeding programs for *Xanthosoma sagittifolium* (L.) Schott and *Colocasia esculenta* were initiated during 1978 and some of the observations made during the first year are presented here.

Flowering

Previous work conducted in the rainy season indicated that gibberellic acid (GA) at 1500 ppm successfully promoted flowering in Nigerian clones of *Colocasia* and *Xanthosoma* and that abundant seed could be produced on *Xanthosoma* during the rainy season (Wilson, 1979). A dry season observation trial was conducted to confirm these results and to test the applicability of the techniques over a broader range of genotypes, environments and times by planting. The following materials were grown:

1) Three local clones of *Colocasia* (TCe 23, TCe 15 and TCe 36);
2) Three local clones of *Xanthosoma* (TXs 11, TXs 17 and TXs 18);
3) Three segregating families of *Colocasia* seedlings reared from seed provided by Dr. G. V. H. Jackson, Solomon Islands (SI 1, SI 2, SI 3); and
4) Two segregating families of *Xanthosoma* seedlings, one hybrid (TXs 18 x TXs 17) and one self-pollinated (TXs 17 selfed).

Planting was done three times at 2-week intervals beginning in early December. Planting was on ridges at a spacing of 1½ x 1½ m. Irrigation was applied as necessary, and plants were fertilized one time at the rate of 50 kg N/ha, 50 kg P/ha and 40 kg K_2O/ha.

Promotion of Flowering. GA was applied sequentially when plants had reached the 3-5 leaf stage, with each plant sprayed one time with an aqueous solution of the potassium salt of gibberellic acid (GA_3) applied with surfactant (0.01% by volume). Approximately 20 ml/plant was applied so that most of the liquid accumulated in the cup formed by the petiole bases. 1500 ppm was used for the six local clones and the *Colocasia* seedlings and 1000 ppm for the *Xanthosoma* seedlings in each local clone and seedling family, some plants which had never received GA treatment were left unsprayed as controls (C-1). In addition, for each local clone, 5 plants propagated from plants which had been treated with 1500 ppm GA eight months previously were planted and left untreated (C-2).

Observations on flowering were taken weekly, beginning with the first appearance of inflorescences in early March and terminating in mid-June when most but not all, plants had finished flowering. Data for the three times of planting were pooled and the results are given in Table 1.

The results obtained for the local clones are similar to those found during the previous rainy season experiment. Although there are differences in the absolute values, the general behavior of each clone remained the same. TCe 15 (representative of *Colocasia* 2) was more responsive to GA treatment than TCe 23 (representative of *Colocasia* 1). It flowered earlier, had a higher percentage of the plants flowering and produced more spadices/plant. As in the previous rainy season, the response to GA treatment of TCe 36 (representative of *Colocasia* 3) was incosistent. TXs 17, the *Xanthosoma* clone tested in the rainy season, again responded very well to GA treatment although the number of spadices/plant produced was lower.

These data suggest that clonal response to GA can be characterized and it remains constant enough across different environments to permit the planning of stagger planting to insure simultaneous flowering of proposed parents.

Except in the case of TCe 36 which flowers more readily than other clones under natural conditions, those plants propagated from plants which had been treated with GA eight months previously (C-2) failed to produce inflorescences indicating that the effects of the GA treatment are not carried over after eight months.

GA successfully induced flowering in the additional materials tried, TXs 11, TXs 18 and the *Colocasid* and *Xanthosoma* seedlings (Table 1).

The *Colocasia* seedlings reared from seeds of clones adapted to the Solomon Islands displayed a greater propensity to flower compared to most Nigerian clones. In the ungibbed controls (C-1) 2.2, 80.0 and 43.6% flowered for SI 1, SI 2 and SI 3, respectively. GA-treated plants flowered somehwat earlier, had more plants which flowered and produced more spadices/plant.

In this seedling material, excessive numbers of GA-induced deformities and weak flowers were produced by the 1500 ppm treatment. This, together with the high frequency of natural flowering, suggest that these Solomon Island genotypes have a higher level of endogenous GA and therefore require lower concentrations of exogenous GA for optimal flower production.

All data were not collected on the *Xanthosoma* seedlings, but it was evident that they responded to GA treatment. However, it was obvious that 1000 ppm was too high a concentration when applied to seedlings at the 3-5 leaf stage. This treatment resulted in grossly deformed flowers on the selfed family and the GA-treated plants in the hybrid family flowered too early, producing inflorescences which, although normal, were not vigorous. This suggests that on seedlings the GA concentration should be reduced, perhaps to 750 ppm, or applications should be delayed until plants have reached the 5 leaf stage and leaves are large and vigorous.

Pollen Fertility. TXs 11 and TXs 18 have not produced pollen on either GA-induced or naturally produced spadices under any conditions in which they have been observed. TCe 23 and TCe 15 were typically poor pollen producers as were a number of the *Colocasia* and *Xanthosoma* seedlings. The fertility of the remaining clones and seedlings was environmentally sensitive. During the dry season, even when abundant irrigation water was supplied, a majority of the plants failed to produce pollen. This sterility appeared to be due to environmental stress and not to genetic factors since the same plants began to shed abundant, viable pollen with the onset of the rains. However, differences in susceptibility to this stress-induced sterility were noted among the three families of *Colocasia* seedlings and among individuals within families, which suggests that susceptibility is somewhat heritable. There was not enough pollen available during the dry season months to test for female sterility under stress conditions.

These observations indicate that abundant flowering can be induced with GA under irrigation during the dry season but that a high degree of pollen sterility may occur and limit seed production. Incipient wilting occurred during the hottest part of the day and this sterility may have resulted from moisture stress. It may be possible to alleviate this dry season problem by growing the cocoyams under shade, either artificial or that of a companion crop, or the problem may be avoided by planting and gibbing during the latter part of the dry season so that flowering commences after the onset of the rains.

Hand Pollinations. In *Colocasia* self-pollination within a flower was possible, Whereas *Xanthosoma* was protogynous, although selfing within a clone and within a plant was possible. In both genera one generation of selfing resulted in considerable reduction in vigor.

In Contrast to the findings of Jos and Bai (1977), under Ibadan conditions, the spathe of the *Colocasia* inflorescence unfurled to expose the male portion of the spadix the same day as pollen shed, not one day before. The fragrance was most intense one day before pollen shed and at that time the basal portion of the spathe was open by a crack.

In *Colocasia*, therefore, it was easy to determine when to emasculate the female parent in preparation for making cross pollinations the following day. If pollen was

limited, the excised male portion of the spadix was stored in a plastic bag at ambient temperatures. Under these conditions, it often shed enough pollen to be used as a male parent the following day. This procedure of storing male flowers worked equally well for *Xanthosoma.*

Xanthosoma flowers developed much more slowly than *Colocasia* and it was more difficult to determine the appropriate times to emasculate and pollinate, although with experience it was possible to become quite skillful.

Genetic Variability

Initially, priority has been given to creating populations with large genetic variation. The germplasm which has been collected in Nigeria, after eliminating duplicates as judged by morphological characteristics, narrows down to only three clones of *Colocasia* and three clones of *Xanthosoma.* A concentrated effort is now being made to collect the few addtional local cultivars. which are less frequently grown, but it is a fact that very little variability exists in Nigeria. The variability in the rest of West Africa appears to be equally limited. Therefore, an effort is being made to broaden the genetic base of the breeding program by importing seeds of cocoyams from other parts of the world. Local and exotic populations will be intercrossed and selected to create improved breeding populations.

In the *Colocasia* seedlings considerable variation was observed within and between families for petiole color (Table 2). In SI 1 and SI 3 the majority of the seedlings had green or green/purple petioles whereas SI 2 had predominantly dark green/purple petioles. Light colored longitudinal streaking was observed frequently only in Family 1 and it was always associated with color classes containing dark green, possibly because it was readily distinguished only on dark colored backgrounds.

Four months after transplanting to the field, differences in susceptibility to *Sclerotium* rot became marked (Table 3). Size of leaf, number of leaves/plant and general vigor were also variable. As already mentioned, differences were observed in natural flowering and in sensitivity to pollen sterility under stress. Also there was considerable variability between plants for the number of sterile flowers interspersed among the pistillate flowers.

In *Xanthosoma* the hybrid offspring resulting from a cross of the purple petioled clone (TXs 18) with the green petioled clone (TXs 17) segregated for petiole color (Table 4). Since there was some within-clone variability for petiole color depending on age and vigor of the plant, differences between color classes were not always clear cut; however, it was obvious that most hybrid seedlings resembled the purple-petioled parent and only a few resembled the green-petioled parent. In contarst all seedlings in the selfed family resulting from pollinations within the green-petioled clone had green petioles. It appears that purple petiole color is dominant to green and the green-petioled parent is homozygous for the recessive green color.

References

ALAMU, S. and C. R. MCDAVID. 1978a. Promotion of flowering in edible aroids by gibberellic acid. Trop. Agric. (Trinidad), 55(1):81-86.

ALAMU, S. and C. R. MCDAVID. 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(3): 235-241.

IITA. 1976. Annual Report. International Institute of Tropical Agriculture, p. 66.

IITA. 1977. Annual Report. International Institute of Tropical Agriculture, p. 44.

JACKSON, G. V. H., E. A. BALL and J. ARDITTI. 1977. Seed germination and seedling proliferation of taro, *Colocasia esculenta* (L.) Schott *in vitro*. J. of Hort. Sci., 52: 169-171.

JOS, J. S. and K. VIJAYA BAI. 1977. Stigma receptivity in *Colocasia*. J. Root Crops, 3(2): 25-28.

KIKUTA, F., L. D. WHITNEY and G. K. PARRIS. 1938. Seeds and seedlings of the taro, *Colocasia esculenta*. Amer. J. Bot., 25: 186-188.

MCDAVID, C. R. and S. ALAMU. 1976. Promotion of flowering in tannia (*Xanthosoma sagittifolium*) by gibberellic acid. Trop. Agric. (Trinidad), 53(4): 373-374.

SHAW, D. E. 1975. Illustrated notes on flowering, flowers, seed and germination in taro (*Colocasia esculenta*). Port Moresby New Guinea Res. Bul., 13: 39-59.

VOLIN, R. B. and F. W. ZETTLER. 1976. Seed propagation of cocoyam, *Xanthosoma caracu* Koch and Bouche. Hort Sci., 11(5): 459-460.

WILSON, J. E. 1979. Promotion of flowering and production of seed in cocoyam, *Xanthosoma* and *Colocasia*. Paper presented at the 5th International Symposium on Tropical Root Crops held in Manila, Philippines, September 17-21, 1979.

Table 1. The effects of GA treatments on the mean number of days from treatment to first spadix, percent plants flowering and mean number of spadices/plant of cocoyam

Material	Days to Flowering			Plants Flowering(%)			Spadices/plant		
	C-1[3]	C-2[4]	GA	C-1	C-2	GA	C-1	C-2	GA
Colocasia clones									
TCe 23	NF[1]	NF	125	0.0	0.0	24.0	0.0	0.0	0.2
TCe 15	NF	NF	66	0.0	0.0	80.0	0.0	0.0	4.7
TCe 36	96	96	66	60.0	60.0	50.0	2.6	2.4	0.8
Xanthosoma clones									
TXs 11	NF	–	131	0.0	–	55.0	0.0	0.0	0.9
TXs 17	NF	NF	92	0.0	0.0	96.0	0.0	0.0	7.6
TXs 18	NF	NF	91	0.0	0.0	79.4	0.0	0.0	2.8
Colocasia seedlings[2]									
SI 1	129	–	69	2.2	–	78.3	0.1	–	2.3
SI 2	97	–	83	80.0	–	95.0	7.6	–	13.9
SI 3	97	–	71	43.6	–	93.3	3.1	–	9.5
Xanthosoma seedlings									
TXs 17 selfed	–	–	–	0.0	–	98.0	–	–	–
TXs 18 x TXs 17	–	–	–	0.0	–	100.0	–	–	–

[1]No flowers produced

[2]Three segregating families from Solomon Islands

[3]Control plants which had never received GA

[4]Control plants propagation from plants which were treated with GA eight months previously.

Table 2. Distribution of petiole color (%) in seedlings of three families of *Colocasia*

Family	Parentage	No. of Plants observed	Petiole Color Class[1]								
			DG	DG+/G	DG/G	DG+/G	DG/P	DG+/P	G	G/P	P
SI 1	Yandina	103	5.8	2.9	7.7	1.0	10.6	8.7	29.8	33.7	0.0
SI 2	Sasagika-Gojoridge	31	12.9	0.0	0.0	0.0	83.9	0.0	0.0	0.0	3.2
S1 3	Kolodia	58	5.2	0.0	1.7	1.7	12.1	0.0	37.9	41.4	0.0

[1]Subjective petiole color classes established by visual evaluation:

DG = Dark green
DG/G = Dark green with green
DG/P = Dark green with purple
G = Green
G/P = Green with purple
P = Purple
\+ = With light colored, longitudinal streaking

Table 3. Frequency of plants susceptible to *Sclerotium* rot (%) observed in three seedling families of *Calocasia*

Family	Parentage	No. of PLants observed	Susceptible to *Sclerotium* rot
1	Yanlina	108	26.8%
2	Sasagika-Goiridge	31	9.7%
3	Kolodia	59	11.8%

Table 4. Distribution of petiole color (%) in seedlings of *Xanthosoma*

Family	No. of Plants observed	Petiole Color Class[1] G	G/P	P
TXs 17 selfed	331	100.0	0.0	0.0
Hybrid, TXs 18 x TXs 17	64	12.5	17.2	70.3

[1] Subjective petiole color classes established by visual evaluation:

G = Green, resembling male parent
G/P = Green with purple
P = Purple, resembling female parent