FACTORS LIMITING FRUIT AND SEED SET IN TARO

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ABSTRACT

The factors which limited fruit and seed development in taro were determined through laboratory and field observations in the flowers of 18 selected cultivars from the taro germplasm in the Philippine Root Crop Research and Training Center in ViSCA, Baybay, Leyte. The limited fruit and seed set in some taro cultivars were attributed to the following factors: (1) failure of the staminate flowers to produce pollen; (2) short receptivity period of the stigmas; (3) relatively low pollen fertility; (4) irregular number of ovules in the ovaries; (5) presence of trinucleate pollen; and (6) short life duration of the flowers. Low seed set in taro may also be influenced by (a) fungal infection causing decay in many flowers, especially after controlled pollination; and (b) presence of insects found to be feeding on the pollen grains during pollen shedding.

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INTRODUCTION

The development of fruits and the production of seeds have remarkable impact on the utilization of germplasm and the varietal improvement of crop plants. In taro *(Colocasia esculenta* (L) Schott), the exchange of genetic stocks and the breeding programs are impeded by poor fruit and seed development even under controlled pollination. The broad genetic diversity present in this crop when produced from seeds would provide plant breeders with many new characteristics which unfortunately are found separately in vegetatively propagated populations.

Taro is extensively cultivated in many tropical and subtropical countries (Abraham and Ramachandran, 1960; Plucknett, 1970) This crop is commonly propagated vegetatively, either through the use of the main root stock or the smaller side tubers. The continuous vegetative propagation of this crop and the low frequency of cross-breeding between cultivars may lead to the fixation of its genetic characteristics and most probably to the stagnation of varietal improvement programs.

Taro sometimes produces flowers but fruit and seed set is very rarely observed under natural conditions in the field (Wilson, 1979). Hence, this crop is considered very

highly sterile (Jos, Vijaya Bai and Hrishi, 1979). Non-flowering and shy flowering of many taro cultivars are the best understood hindrances to successful development of fruit and seeds. Many workers attributed this limited seed production in taro to cytological causes (Jos, Vijaya Bai and Hrishi, 1979; Jos, Vasudevan and Magoon, 1967; Jos and Rajendran, 1976) and the failure of the spathe to open at the neck region (Jos, Vijaya Bai and Hrishi, 1979; Jackson and Pelomo, 1979). However, further investigation on this matter showed that some factors other than those popularly reported by many workers (Jos, Vijaya Bai and Hrishi, 1979; Wilson, 1979) were found to be associated with the limited fruit and seed set in taro.

MATERIALS AND METHODS

To determine some factors that may be associated with poor fruit and seed set in taro, 18 flowering cultivars were selected from the existing taro germplasm at the Philippine Root Crop Research and Training Center in ViSCA, Baybay, Leyte. The cultivars were planted in single row plots with 10 plants per row. The plants were planted at a distance of 50 cm and were fertilized with 60-60-60 kg NPK per ha at planting to ensure vigorous growth.

Flowers that were about to open the following day were tagged and were picked from the plants belonging to the selected cultivars. The flowers were observed in the laboratory for time of pollen shedding, time and duration of receptivity of the stigma, pollen fertility, pollen cytology, pollen germination and number of ovules. The time and duration of stigma receptivity was determined from the time sticky glistening fluid or exudate appears on the stigma surfaces until the exudates dry up and turn dull in color. If additional flowers were needed these were taken from the same plants in the field. Pollen fertility was determined through stainability test using Iodine-potassium-iodide (I_2KI) stain. Percent pollen fertility was estimated using the following formula:

$$\text{\% Fertile Pollen Grains} = \frac{\text{Number of staining pollen grains}}{\text{Total number of pollen grains counted}} \times 100$$

Only newly-shed pollens were collected and used for this purpose.

Ovule counts were done from 20 female flowers coming from a single flower bunch. The ovaries were cut transversely with a sharp razor blade to expose the ovules which were then carefully squeezed out of the ovaries and counted under a magnifier lens.

Pollen germination was determined by dusting newly-shed pollen grains into petri dishes containing a culture medium made of 0.01 g yeast extract, 0.001 g boric acid and 10 g sucrose. The petri dishes were labelled indicating the source of pollen. Percent pollen germination was estimated using the following formula:

$$\% \text{ Pollen Germination} = \frac{\text{Number of germinated pollen}}{\text{Total number of pollen germinated}} \times 100$$

RESULTS AND DISCUSSION

Pollen Shedding and Stigma Receptivity.

Pollen shedding and stigma receptivity seemed to be dependent on the cultivar. Of the 10 cultivars whose flowers were observed *in vitro,* 6 produced very little amount of pollen while 2 did not produce any pollen at all. The flowers of the other 2 cultivars, however, produced sufficient pollen as shown by the profused deposits of grains on the surfaces of the staminate flowers during dehiscence. Field observations made while the flowers were still intact to the plants showed the same result as that made in the laboratory. Wilson (1979) made a similar report when she noted that some clones of *Colocasia* fail to produce pollen. She attributed this phenomenon to environmental stress and not to the genetic factors of the plants since she made her observation during the dry season. In this study, no field observation was made during the dry season because many taro cultivars do not produce flowers during this season. Since poor pollen production was observed after the onset of the rainy season, this may suggest that the failure of some cultivars to produce pollen is due to their genetic nature rather than to physiological disorders. The genetic nature of some taro cultivars is an important factor that may help restrict fruit and seed development.

In terms of stigma receptivity, some cultivars, particularly PR-G096, PR-G364 and PR-G486, have very short receptivity period that do not coincide with the shedding of the pollen. Their receptivity, as shown by the presence of sticky, glistening exudate on their stigma surfaces, was found to occur 2 to 3 days before the pollens were shed by the staminate flowers. The same observation was noted by Jos and co-workers (1979) in *Xanthosoma.* The short stigma receptivity period in taro can be considered as another factor that can impede successful fruit and seed set.

Pollen Fertility.

Data on percent pollen fertility and number of ovules are presented in Table 1. The results showed that pollen fertility varies among the cultivars studied. The lowest pollen fertility (34.98%) was found in PR-G323 and the highest (74.29%) in PR-G502. Of the 18 cultivars studied, 10 were found to have less than 50% pollen fertility, while 8 cultivars have pollen fertility which ranged from 54-74%. Although there is no standard scale from which to base an acceptable level of fertility, the fact that many cultivars studied have pollen fertility below 50% may indicate that a considerable number of taro cultivars have

Table 1. Number of ovules and percent fertile pollen of eighteen selected taro cultivars.

PRCRTC Number	Cultivar Name Origin	Number of Ovules		Pollen Fertility (%)
		Range	Mean	
PR-G005	Ulaula Moano	21-37	29.0	48.28
PR-G016	Mana Kea Naie	16-51	33.5	44.64
PR-G068	Kalpao	6-22	14.0	45.47
PR-G092	Kanipis	18-40	29.0	42.09
PR-G094	Hinunangan #2	17-37	27.0	66.35
PR-G111	Babatngon #3	18-47	32.5	64.10
PR-G118	Babatngon #10	12-44	28.0	39.86
PR-G142	Los Baños #14	59-94	74.5	42.37
PR-G244	Aklan #8	8-24	16.0	48.37
PR-G251	Antique #2	43-78	60.5	41.09
PR-G287	PAEC #9	30-56	43.0	58.03
PR-G323	Tagibo	12-45	28.5	34.98
PR-G329	Lupon #4	14-43	28-5	65.62
PR-G486	Sorsogon #13	42-66	54.0	68.53
PR-G502	Bataan #1	12-33	22.5	74.29
PR-G509	San Miguel	56-110	83.0	58.83
PR-G519	La Castillana #2	15-51	33.0	49.20
PR-G530	La Castillana #14	41-91	66.0	55.00

relatively low pollen fertility.

Number of Ovules.

The ovaries of the female flowers were found to be normally four-loculed and contained many ovules in each cell. Table 1 shows that ovule number varies among the female flowers in a single flower bunch as indicated by the range of ovule distribution. The smallest number of ovules ranged from 6 to 22 in PR—G068, with an average of 14 ovules per ovary. On the other hand, the highest number of ovules ranged from 56 to 110 in PR-G509, with an average of 83 ovules per ovary. The sterility of some taro cultivars may be explained by the irregular number of ovules in the ovaries and the occurrence of other factors contributing to low seed set like low pollen fertility.

Generally, the mean number of ovules as observed in this study is relatively high compared with that of sweet potato which has 2 to 4 ovules per ovary (Burnham, 1967). The variation in the number of ovules may explain the limited seed set in some taro cultivars since fertilization under normal conditions will be limited to the number of ovules contained in the ovaries. Nevertheless, under conditions where flowering could be initiated through physical or chemical means, this irregular ovule number will be considered too low to influence poor seed production.

Pollen Cytology and Germination.

Binucleate and trinucleate pollens were found in taro, with more of the former than the latter. The presence of trinucleate grains may contribute to the sterility of some taro cultivars. Brewbaker (1957) reported that trinucleate pollens are deficient in sucrose or metabolite that promotes good germination because of the occurrence of the second mitotic division in microsporogenesis. Thus, pollen tube growth becomes restricted or inhibited on the stigmatic surfaces. Martin and Ortiz (1966) attributed the failure of sweet potato pollen to germinate *in vitro* to the trinucleate condition of its pollen. In taro, although the genetics of incompatibility is not fully explored, the presence of trinucleate grains and the sign of pollen growth inhibition may be similarly evident as in many other plant species (Brewbaker, 1957).

The percentage germination of taro pollen *in vitro* was 10.39, 5.68, 14.29, 12.06 and 12.16% in PR-G111, PR-G118, PR-G251, PR-G486 and PR-G530, respectively (Table 2). The pollen grains began to show tube growth 4 hours after being sown in the medium. Considering the length of time that lapses from sowing to germination, this result may show that the sucrose level used in the medium is still insufficient to enhance good germination of taro pollen. As was previously mentioned, binucleate grains constitute a greater percentage in the total amount of pollen dehisced. Poor germination *in vitro* may indicate that binucleate grains are also deficient in germination-promoting metabolites which is very possible especially when available metabolites in the grain had been utilized (Brewbaker, 1957). Notwithstanding this, the difference in percentage germination and probably the rate of pollen tube growth may correspond to the variation which are commonly observed in the fruit and seed number among taro cultivars.

Table 2. Percentage germination of taro pollen *in vitro*.

PRCRTC Number	Total Pollen Counted	Germination (%)
PR-G111	356	10.39
PR-G118	440	5.68
PR-G251	420	14.29
PR-G486	315	12.06
PR-G530	518	12.16

Other Factors.

Other factors may also influence restricted fruit and seed development in some taro cultivars. One of these is the short-lived condition of the flowers. Even after controlled pollination, the flowers of some cultivars dry up and the peduncles collapse preventing the fruit and the seeds to develop and mature.

In some instances, a population of small insects was observed to be feeding on the pollen grains, especially on the flowers of some cultivars that produce a characteristic aroid odor during anthesis. Aside from feeding on the pollen grains,

these insects also fed on the staminate flowers thereby reducing the amount of potential pollen that may fertilize the pistillate flowers. After controlled pollination, fungal diseases were also found to cause decay in many flowers. Fungal infection was observed to start in the incisions made when the spathe was removed prior to pollination. However, this may be avoided using sterile instruments.

Generally, therefore, it could be concluded that some factors other than what have been reported (Jos, Vijaya Bai and Hrishi, 1979; Jackson and Pelomo, 1979) were found to be associated to poor fruit and seed set in some taro cultivars. These limiting factors are: (1) failure of the staminate flowers to produce pollen; (2) short receptivity period of the stigmas; (3) relatively low pollen fertility; (4) irregular number of ovules in the ovaries; (5) presence of trinucleate pollen; and, (6) short life duration of the flowers. Any single factor, however, such as the failure of the staminate flowers to produce pollen, will aid in the explanation of low seed set in specific cases and together with other factors that have been mentioned. These include the effects of diseases and other unknown physiological aberrations in the flowers that will collectively contribute to the general low seed set in taro. Singly, each factor may be of limited specific importance, but the presence of a number of them together, some with possibly unknown causes can be considered responsible for low fruit and seed set. One way, however, of circumventing some of these problems is to develop means by which taro cultivars can be initiated to flower successfully. The more the number of flowers to be pollinated even under uncontrolled conditions the greater is the probability of successful fruit and seed set.

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