

FLORAL MORPHOLOGY AND BIOLOGY, FRUIT AND SEED SET, SEED GERMINATION AND SEEDLING DEVELOPMENT OF TARO

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ABSTRACT

The natural flowering habit of taro was studied in a population comprising of 299 cultivars. The floral biology and the development of fruits and seeds were also determined. Very few cultivars readily produced flowers under natural conditions. Flowering in the field commenced in May and reached its peak in July or August. For many cultivars, flowering ceased towards the end of September or early October. The inflorescence of taro is a spadix type. A maximum of two spadices was present in any plant at a time. Floral abortion was very common while natural fruit and seed set was very rare. Artificial pollination within and between cultivars produced little success. Germination of taro seeds was also made and seedling development was studied. Seeds that developed from pollination between cultivars appeared to have better germination than those coming from pollination within variety. Seedling development was very slow during the early stage and their vigor varied. Some seedlings were normally green while others lacked the normal green coloration and subsequently died. Other seedlings appeared green during the early stage of development but did not grow beyond the cotyledonary leaf stage.

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INTRODUCTION

Hybridization work in taro (*Colocasia esculenta* L.) Schott) is practically difficult because of lack of background information on the sexual behavior of the crop as a result of poor flowering of many cultivars. Aside from this, there are

a number of factors that limit the production of fruits and seeds in taro thus making sexual propagation of this crop harder (Pardales, 1980). These constraints have caused the stagnation in the hybridization work in taro, virtually rendering the diverse genetical characteristic present in many populations useless for

crop improvement programs. Sufficient knowledge about the sexual behavior of any crop will therefore offer a way in the successful utilization of genetic variability present in large indigenous populations.

Some taro cultivars readily produce inflorescences under natural conditions. In the absence of simple flowering induction methods, for shy-flowering crops like taro, natural flowering will provide the only chance to effect crossbreeding to exploit genetic variabilities. However, before any successful breeding work could be initiated, an adequate information on the sexual behavior and natural flowering ability of the crop is necessary. This study presents the flowering pattern of taro including investigations on fruit and seed set and subsequent seed germination and seedling development.

MATERIALS AND METHODS

The 299 cultivars in the taro germplasm nursery at the Philippine Root Crop Research and Training Center are replanted in the field every year for maintenance. For the last 2 years the cultivars' capacity to flower was observed closely. During the peak of flowering, the cultivars were classified according to their flowering behavior. This was done to find the proportion of cultivars that produced inflorescence and those that did not. The morphology of the inflorescences taken from different cultivars was also studied.

Five readily-flowering taro culti-

vars were closely observed in the field for their physiology and mechanism of flower formation. The number of plastochron was recorded by counting the number of leaves per plant and deducting 1 at the time the first inflorescence appeared. Plastochronic observation indicates the number of leaves that developed at the time the plant has started to form inflorescences. The number of days from planting to first flowering, from floral initiation to anthesis, and from floral initiation to senescence were also determined. Likewise, the number of opened inflorescence per plant per week, number of inflorescence per plant per season, percent of naturally-developed fruit with seeds, and number of naturally-set seeds per plant were taken.

Using a large number of inflorescence developed under natural conditions, artificial pollinations were made within variety and between varieties. Pollinations were made following the procedures presented by Wilson (1980). The percentage of fruit and seed set resulting from artificial pollinations were recorded including the number of seeds present in each successfully-developed fruit. Mature fruits were harvested 30-35 days after pollination and the seeds were extracted after air-drying the fruits for 1-2 days.

For seed germination studies, the seeds were first surface-sterilized for 5 min in 1% sodium hypochlorite, with detergent added. Afterwards, the seeds were spread in petri dishes containing about 1/2 cm

dilute soil agar. The soil agar was prepared following the procedures presented by Wilson (1979). The seedlings were transplanted into "jiffy-7" pellets (Jiffy Products Ltd., Norway) when their cotyledons became fully expanded.

RESULTS AND DISCUSSION

Flowering Habit.

Some taro cultivars started forming inflorescence in the field in May and reached their peak in July or August and then gradually declined. Flowering ceased in September although some cultivars continued producing inflorescences sporadically until October. The percentage of cultivars that produced inflorescences naturally was very low (Table 1). The cultivars which flowered in the 1980 season also flowered in 1981. Few cultivars which did not flower in 1980 flowered in 1981.

It is speculated that natural flowering in some taro cultivars is induced by long day condition. Although no day-length datum is

available during the period when many cultivars are observed to flower in the field, i.e., from May to September, ViSCA normally has longer daylength. In Trinidad, West Indies, Alamu and McDavid (1978) observed that dasheen (taro) flowered naturally between May and July when the longest days of 12 1/2 hr occurred. On the other hand, Wilson (1980) believed that taro plants flower during the rainy season.

Floral Morphology.

The inflorescence of taro is of the spadix type where both the staminate and pistillate flowers are enclosed by an elaborately developed spathe which is usually yellow or purplish yellow in color. The staminate flowers are located on the upper portion of the spadix which are separated entirely from the pistillate flowers by an interposed neuter region consisting only of staminodes. Variation in pollen production was observed between inflorescences of different cultivars. The staminate flowers of some

Table 1. Number of naturally flowering and non-flowering cultivars in the taro germplasm.

Season	No. of cultivars	Percent of population
1980		
Flowering	53	17.7
Non-flowering	246	82.3
1981		
Flowering	61	20.4
Non-flowering	238	79.6

cultivars produced large amount of pollen while the others did not. The poor pollen production may account for the very limited fruit and seed set in some cultivars.

The pistillate flowers are located in the lower portion of the spadix. Each pistillate flower measures about 1-3 mm and may contain from 14-83 ovules depending on the cultivar. A single spadix may contain from 150-300 pistillate flowers. Receptivity of the stigma is indicated by the presence of shiny sticky fluid on its surface. Many cultivars are generally receptive on the same day when the pollens are shed. In some cultivars, however, stigmatic receptivity takes place 2-3 days ahead of pollen shedding.

The constriction of the spathe right in the neuter region between the staminate and pistillate flowers effectively prevents natural pollination in many taro cultivars. In some cultivars, however, this constriction relaxes during anthesis thus allowing some pollen to reach the pistillate flowers. The failure of the spathe to open at the neuter region during anthesis is the best under-

stood reason of poor fruit and seed development in taro (Jackson and Pelomo, 1979).

Physiology of Flowering.

Data on floral biology of some selected taro cultivars are presented in Table 2. Observation on the number of plastochron showed that different cultivars have different number of leaves when the first spadix appeared. This varies from 3.4 in PR-G 374 to 5.0 in PR-G 443. In terms of time from planting to flower emergence, some cultivars produced spadix ahead of the others. The earliest spadix development was observed after 106 days from planting in PR-G 323 whereas the latest was recorded after 146 days from planting in PR-G 374. Considering this, together with the short duration of flower production in many cultivars, a problem still exists on how to effect successful hybridization between 2 cultivars that do not produce inflorescence at the same time.

The mean number of days required from flower emergence to

Table 2. The floral biology of some taro cultivars.

Cultivar	Number of plastochron	Planting to first flowering (Days)	Flower emergence to anthesis (Days)	Flower emergence to senescence (Days)
PR-G244	3.8	137.0	8.6	21.7
PR-G323	4.7	106.0	8.5	21.9
PR-G374	3.6	146.4	8.5	18.9
PR-G443	5.0	116.7	8.9	21.4
PR-G475	3.4	115.7	8.5	20.1

Table 3. Number of opened flowers, naturally pollinated fruit and seed set in taro.

Cultivar	No. of opened flowers/plant/week	No. of flower/plant season	Naturally pollinated fruit (%)	No. of naturally set seeds/fruit
PR-G244	1.2	2.8	7.0	84.0
PR-G323	1.4	4.4	17.5	147.7
PR-G374	1.8	2.3	—	—
PR-G443	1.0	2.7	—	—
PR-G475	1.2	2.7	—	—

anthesis was practically similar in all cultivars. The time from initiation of the spadix to senescence of aborted spadix was almost the same in all cultivars studied except in PR-G 374 which senesced earlier at 18 days after emergence. For spadices that were either pollinated naturally or artificially, fruit maturity took place from 25-35 days after fertilization.

Of the whole spadix, the male portion matured and dried up 2-3 days after pollens were shed leaving the female portion intact for 18-35 days depending on whether fertilization had taken place or not. Fertilization is known to have taken place when the ovaries of the pistillate flowers swell indicating the presence of seeds on them. When the fruit matures, the peduncle bearing the original spadix turns brown and shrivel.

Under natural condition, the mean number of opened spadices per plant per week was almost the same in all cultivars studied (Table 3). A maximum of 2 spadices was present in any plant at a time. This observation generally affirms the shy-flowering nature of taro. The average number of spadices

produced per plant varied from the time it started to produce flower until it ceased flowering. Generally, the number of spadix was very few with no more than 4.44 spadices per plant in a profusely flowering cultivar (PR-G 323). Among the 5 cultivars observed, only 2 naturally produced fruits containing seeds while the other 3 cultivars did not produce fruits and set any seed. This observation partially explains that natural fruit formation and seed setting in taro depend on the cultivar.

Fruit and Seed Set.

Despite the many spadices that were artificially pollinated, only few fruits and seeds developed successfully (Table 4). Pollination within and between cultivars produced very low percentage of success (23.1 and 16.7%, respectively). The average number of seeds produced per developed fruit were 28.7 and 400.1 in the pollination within and between cultivars, respectively. On the other hand, out of 83 spadices tagged as unpollinated controls, only 9.6% produced seeds with an

Table 4. Artificial pollination, number of developed fruits and seed set in taro.

	No. of spadices pollinated	No. of developed fruits with seeds	Fruits with seeds (%)	No. of seeds per developed fruit
Pollination within variety	65	15	23.1	28.7
Pollination between variety	96	16	16.7	400.1
Unpollinated control	83	8	9.6	218.6

average of 218.6 seeds per naturally-pollinated spadix. Considering that a single pistillate spadix may contain about 150-300 flowers and that each flower may have an average of 48 ovules, it is estimated that as much as 7,200-14,400 seeds can be obtained from a single spadix if all conditions are normal. Therefore, it can be deduced from the result of the pollination work that seed set under artificial condition is likewise very low. Several factors, however, were generally reported to cause limited fruit and seed development in taro (Jackson and Pelomo, 1979; Wilson 1979; Pardales, 1980).

Seed size of taro ranges from 1.0-1.5 mm in length and 0.5-1.0 mm in diameter. Seed color is normally brownish-orange and its surface is longitudinally ridged. The general shape is ovate which tapers towards the apical end. The hilum or the scar of the seed is conspicuous at the basal end.

Notwithstanding the above results, production of seeds in taro, especially for crop improvement

purposes, could be possibly increased by painstaking pollination of a large number of spadices.

Seed Germination and Seedling Development.

There are several reports on germination of taro seeds under artificial conditions (Jackson, Ball and Arditti, 1977; Wilson, 1979; Abraham and Ramachandran, 1960). Kikuta, Whitney and Parris (1938) were able to germinate taro seeds between layers of moist filter paper, in soil and in agar culture but failed to mention the percentage of germination so as to determine the germination potential of taro. Wilson (1979) reported that germination of cocoyam seeds was more than 50% in soil agar, and that the seeds showed no apparent dormancy.

In this study, germination of taro seeds resulting from pollination within and between cultivars was attempted using soil agar as germinating medium. It was observed that seeds from the latter had better

Table 5. Germination of taro seeds resulting from pollination between cultivars.

Cultivar	GERMINATION		
	30 days from sowing (%)	Normal Seedlings (%)	Abnormal Seedlings (%)
PR-G212 x PR-G132	2.02	1.01	1.01
PR-G251 x PR-G230	2.00	2.00	—
PR-G256 x PR-G153	10.16	4.68	5.48
PR-G489 x PR-G343	25.61	17.10	8.51
PR-G027 x PR-G152	1.54	—	1.54

germination compared to that from the former, although generally, germination was relatively poor (Table 5). It was felt however, that failure to obtain good seed germination may be due largely to the absence of aseptic method of seed germination. Molds readily attacked the seeds probably because of the presence of sucrose in the medium. Work is being done to improve the germination potential of taro seeds.

The seeds became swollen with their color changing to dark brown in most cases one day after sowing the seeds in the medium. The longitudinal ridges in the seed surfaces became distinct. Some seeds of crosses between PR-G489 x PR-G343 and PR-G256 x PR-G153 showed ruptured seed coat with the radicle starting to emerge from the apical end after seven to eight days from sowing. A few days later, bilobed and almost circular cotyledonary leaves appeared. Chlorophyll developed immediately as soon as the cotyledonary leaves emerged, but some seedlings appeared pale and lacked the necessary green color. The seed coat remained

attached to the cotyledonary leaves for a considerable length of time. Similar observations were reported by Kikuta, Whitney and Parris (1938). Most of the seeds coming from the above crosses remained swollen and did not germinate. On the other hand, most of the seeds resulting from pollination within cultivar remained swollen with some having their radicles protruding. The growth of the radicles, however, never progressed and germination seemed to be arrested.

Seedling vigor varied few days after transplanting the seedlings into jiffy 7 pellets. Some seedlings were normally green while others lacked chlorophyll. Some of them were apparently green during the first few days after emergence of the cotyledons but later turned pale and did not grow beyond the cotyledonary leaf stage.

In normal seedlings, the first true leaf appeared about 10-12 days from germination. The petiole was attached to the leaf blade at its margin similar to what have been observed by Kikuta, Whitney and Parris (1938).

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