DEVELOPMENT OF NEW TARO VARIETIES THROUGH BREEDING

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Abstract

The production of new crop varieties through hybridization is the only stable method of crop improvement. As a program, crop improvement through breeding has been a major project of most research centers and institutes. An example of the value of plant breeding was demonstrated by the release of IR-8 or "miracle rice" by the International Rice Research Institute in the mid-1960's. Other crops like corn and wheat had similar dramatic and valuable contributions. In Hawaii, new variety development has been and continues to be an important and well supported program of the Hawaiian Sugar Planters Association. Although taro is considered to be one of the oldest cultivated crops, there has virtually been no research program aimed at improving the varieties existing throughout the world. Because of the importance of taro as a commercial and staple crop in Hawaii and many countries in Asia and the Pacific area, an organized crop improvement program through breeding should be established and supported. Some of the advantages, problems, and general method of hybridizing taro are discussed.

Introduction

Production of new varieties of plants through breeding is the only stable method of improving crops. Crop yields and quality can be improved through pest and disease control, fertilizer application and cultural manipulations but all these have to be repeated each time the crop is grown (Abbott and Atkin, 1987; Hawkes, 1987; Hayes and Immer, 1942; Martin and Leonard, 1949). There are three general methods of crop improvement and these are (1) Introduction, (2) Selection, and (3) Hybridization. Introduction sometimes replaces hybridization when a superior variety is introduced from another source but often introduction provides foundation materials for hybridization. Selection follows and/or precedes either introduction and hybridization.

The process of developing new crop varieties or hybrids through breeding has been an important research program of the many international as well as national research centers and institutes. The International Rice Research Institute (IRRI) has become well known very quickly because of the success in producing the famous "miracle rice" or IR-8, a short stature, high yielding variety developed by plant breeder Henry Beachell shortly after the institute opened (IRRI, 1967). The corn and wheat programs of the U.S. as well as that of CIMMYT in Mexico produced new corn and wheat hybrids and varieties which gave similarly outstanding yield potentials and qualities.

Aside from increasing yields, plant breeding has been used to produce new plants which have resistance to some pests and diseases. The California rice breeding program has as one of its objectives the production of new varieties with resistance to low temperatures at the time of flowering. Most tropical rice varieties to not produce grains when exposed to temperatures below 60°F at flowering. Eating and processing qualities are also very important characteristics that are incorporated in new varieties or cultivars.

Taro, a crop of commercial importance in Hawaii and many Asian-Pacific countries is one of the oldest known cultivated food crops (de la Peña, 1970; Plucknett and de la Peña, 1971; Whitney, Bowers and Takahashi, 1939). In spite of its importance, there has virtually been no effort or work in improving its production potential through plant breeding. One reason for this lack of research activity is the difficulty of performing the work of cross-pollination due to the infrequent flowering habit of the taro plant. In its natural habitat, the taro plant rarely flowers and when it does, its flower anatomy discourages natural pollination (Plucknett, de la Peña and Obrero, 1970). The discovery of gibberellic acid as an aid in inducing flower formation in taro and the other edible aroids has encouraged some plant breeders to look at the possibility of producing new taro varieties or hybrids (Wilson and Cable, 1984). In a very limited breeding program at the University of the South Pacific in Apia, Western Samoa, Dr. J. Wilson was able to produce some hybrids and released a new variety which was named "Alafua Sunrise". This variety has a better yield potential than many of the commercial varieties in Western Samoa, however, its eating quality is not as good and acceptable as the popular variety, Niue. Aside from this breeding work, there has been little or no known breeding program in taro and the edible aroids elsewhere.

A Taro Breeding Program

I. Requirements

1. Foundation materials or parents for cross pollination - Without plants of known characteristics and/or quality, a breeding program can not be initiated.
2. Techniques for inducing flowering

a. Gibberellic acid spray.
b. Photoperiod manipulations (short and long days) and temperature treatments.
c. Natural flowering (not reliable, not all taro varieties flower under natural conditions).

II. Procedure

When all the necessary requirements of a breeding program are available, immediate objectives can be established to serve as a guide in the selection of parent materials. Usually, the first objective is to develop a new hybrid or variety with a potential for high yields. Once a high yielding material has been produced, other important characteristics such as resistance to pests and diseases, good eating quality, etc. are added.

The actual procedure involved in making crosses in taro is fairly simple and straight forward. Basically, pollens from one parent material is transferred or used to pollinate the flower of another plant. Figure 1 illustrates the parts of the taro flower. The inflorescence of the taro plant is called a spadix, enclosed by a part called spathe. When the flower emerges, the spadix is completely enclosed by the spathe. In approximately seven days, depending on the variety, the flower matures and reaches a stage when the pistillate part or female part becomes partly opened exposing the pistillate part. The upper tubular portion of the spathe also emits a very strong pleasant odor at this stage. When touched with the fingers, the pistillate parts or ovaries are sticky.

When pollens are shed, the upper part of the spadix or staminate part becomes covered with pollen grains which are powdery in appearance. Care should be exercised in removing this part of the flower so that the pollens will not drop or shed. Cross pollination can be accomplished by shaking the pollens over the pistillate flower, replacing the covering or spathe and bagging the whole flower to avoid further pollination by insects or other agents. Wrapping the flower with plastic flagging tape has been found to be satisfactory.

It should be noted that when the pistillate flower is receptive to pollination, pollens from the staminate part are usually not ready or available. This makes self-pollination of the flower difficult. In addition, the constriction between the male and female parts of the flower tightens preventing pollens from the same flower to reach the female part or ovaries. In cross pollination this characteristic of the taro flower is an advantage.

In approximately four weeks after pollination, the taro fruit starts to ripen and it can be harvested and the seeds extracted. Once extracted, the seeds should be stored in the refrigerator to preserve their viability. The seeds can also be planted immediately in fine peatmoss, either in a petri dish or any suitable container.

Under favorable conditions, taro seeds germinate in about five days after sowing. In another week, the seedlings can be transplanted in jiffy pots or bigger containers. When the seedlings reach a height of approximately six inches, they can be planted in the soil or field for initial evaluation.

The following slides will illustrate the various steps discussed in making crosses or producing taro hybrids. Some slides will also show the early growth of the seedlings.

Depending on the major objectives and/or priorities, evaluation of seedlings can be initiated as early or late during the first year of growth. Sometimes, evaluation for resistance to pests and diseases can be initiated as soon as the seedlings are big enough to be inoculated with the appropriate pathogen or pest.

For obvious reasons, evaluation for yield potential can not be started until at least some appreciable growth has been attained to indicate yield potentials. Usually, a fast growth or establishment accompanied by large stems and high leaf area index can be used as indicators for yield potential which means that some of these parameters have to be measured at regular intervals during the growth of the plants. The corm color which is important in the final utilization of the variety can be determined as soon as the plants are big enough to be cut into "hulis" or planting setts.

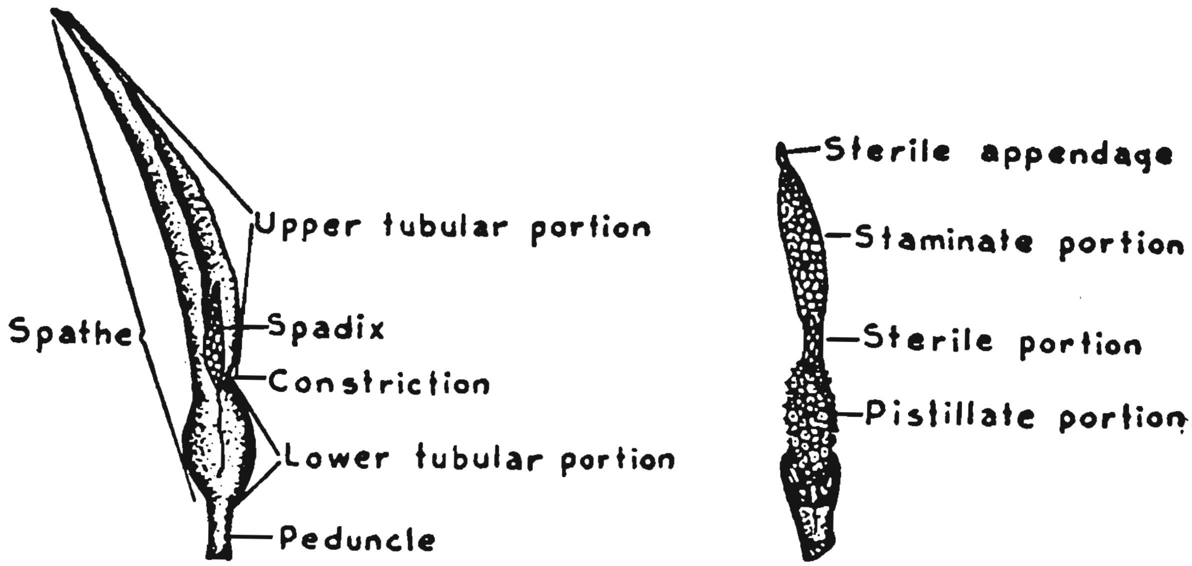

Figure 1. Anatomy of taro flowers (Adapted from Whitney, Bowers & Takahashi, 1939).

The following slides show some of the genetic variabilities than can occur when two different varieties or plants are cross-pollinated. Lehua Maoli was used as the male parent or source of pollens and Niue was the female parent of these particular hybrids.

III. Benefits

Improvement of crops through breeding offers several benefits for farmers. Production of hybrids or new plants from a breeding program increases the genetic base of any crop. The increased genetic base provides lines with different characteristics some of which could be resistance to some pests and diseases. This will prevent a catastrophic loss in crop production which might be caused by an epidemic of a plant pest or disease which in turn can cause a severe disruption of the flow of food supply to any population. The potato disaster which caused famine in Europe is a good example.

Superior agricultural productivity of the U.S. is in large part due to the high yields and quality of hybrids and varieties of crops such as corn, wheat, rice, potato, etc. grown by our farmers. Varieties and hybrids with resistance to the major plant pests and diseases account for the high production efficiency in the farms. The high yielding rice varieties patterned after IR-8 have now replaced most varieties grown in the Sacramento area accounting for the very high average production of rice in California. The flower and foliage industry of Hawaii is based on varieties produced through plant breeding.

A continuous plant breeding program such as the program of the HSPA provides new varieties with high yield potentials which are used as replacement after the yields of existing varieties have started to decline. The causes of yield decline in many existing varieties of various crops are not fully understood but one possible cause is the accumulation of non-lethal viruses in vegetatively propagated plants like sugarcane and taro.

IV. Problems

Before any plant breeding program can be initiated, germplasm nursery or foundation stocks must be available as parent materials. Initiation and maintenance of a germplasm nursery can be expensive. Collecting existing varieties can be accomplished by traveling to areas where the crop is growing. To prevent inadvertent introduction of pests and diseases, proper quarantine procedures must be followed.

In the case of taro, a known and consistent technique of inducing flowering is necessary to enable plant breeders to perform the necessary cross-pollinations. Spraying with GA or manipulation of the daylength can give satisfactory results. Researchers can not rely on natural flowering because many of the existing varieties of taro do not flower under natural conditions in Hawaii and one of these varieties is Bun-long. Bun-long and many varieties will only flower when sprayed with GA.

Plant breeding programs require manpower support for the pollination, seedling production and care, evaluation and increase of promising lines, and field plantings for advanced testing and evaluation.

The IRRI released IR-8 in a relatively short period of five years because of the tremendous support given their scientists in terms of funding and manpower but some crop improvement or breeding programs can be very time consuming depending on the objectives of the program.

Once a new material has been identified as promising and worth releasing for commercial use by farmers, planting materials can be produced and increased through conventional methods or tissue culture techniques.

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