THE ROLE OF THE PLANT BREEDER IN THE EVALUATION AND BREEDING OF NEW FLORICULTURAL CROPS

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Abstract

The plant breeder's responsibilities in public programs include teaching, research, and extension. One of his main roles is to educate, develop, and encourage students to become plant breeders. Although plant breeders are well educated in their field, they must interrelate with other disciplines, such as entomology and plant pathology, to produce a final product.

The traditional role-model of the plant breeder in the public sector of the floriculture world has been that of a horticulturist who recognized the assets and limitations of a particular crop and proceeded to make significant improvements in it by using classical genetic techniques. As a horticulturist, he was expected to know how to attain the maximum quality and growth from the plant, whether it was to be used in the landscape, as a containerized specimen, or as a cut flower. He had to know the method of propagation of the crop, its nutritional needs, any insect, fungus, viral, or bacterial problems (and their control), and the postharvest or postproduction qualities needed to make it a marketable product. When plant breeders were trained as horticulturists with an interest in genetics, the ability and interest to grow a crop to its maximum potential were inherent. As breeders and geneticists become more specialized, and as the plant sciences emphasize biotechnology (Frazier, 1985; Hess, 1984; Ryder, 1984; Vest, 1984), the breeders can easily lose touch with the plant and become more involved with the genetic system. The classical horticultural plant breeder is not a relic as some suggest, since his training in genetics and experiences with plants are needed to develop the final plant used for floricultural production.

The plant breeder in public programs, in addition to research, generally is involved in many activities within his institution, such as teaching and extension. Although not often recognized meritoriously or monetarily, the training of future plant breeders has to be one of the most important contributions of the plant breeder in public institutions (Brooks and Vest, 1985; Stroswider, 1984). This training should not only emphasize the basics of genetics, recombination, selection, and inheritance (Arisumi, 1978; Bobisud and Kamemoto, 1982; Ladd et al., 1984); breeding techniques and systems (Casali and Tigechelaar, 1975; Robacker and Ascher, 1981; Ronald and Ascher, 1975); genetic engineering (Bliss, 1984; Lawton and Chilton, 1984); and other forms of biotechnology (Arisumi, 1973, 1980; Grossman, 1983; Sink and Padmanabhan, 1977; Sink, 1984), but it should demonstrate, by example, how to recognize and produce the desirable attributes of the plant material being grown. One of the most successful methods of training new plant breeders is to actively involve them in an ongoing breeding program. Although new and different floricultural crops are always desirable, a greater contribution to the consumer might be in improving the diversity of flower color and plant form (Arisumi, 1978; Ladd, et al., 1984), insect and disease resistance (Al-Abbasi and Weigle, 1982; Maxwell and Jennings, 1980; Vanderplank, 1978), and environmental adaptation (DeVos, et al., 1980) of our present floricultural crops.

A breeding program encompasses a number of interrelated phases: 1) evaluation of the available germplasm, 2) identification of goals toward improvement of the germplasm, 3) collection and evaluation of new germplasm, 4) basic studies in entomology, pathology, physiology, genetics, and other biotechnological sciences, 5) hybridization through gene transfer and recombination, 6) selection, 7) evaluation in observational and replicated trials, and 8) release of breeding lines or new cultivars. It is the stepwise progression through these phases that makes a breeding program successful.

Evaluation of the presently available germplasm is time consuming but is the only way to learn the characteristics of the crop. Often trial gardens (Armitage, et al., 1985; Howe and Waters, 1984; Veilleux and Lyons, 1984) are good sources of information on a particular crop and how it performs in a given area. Generally, data from these trials are of new commercial cultivars or advanced lines. More diverse plant types frequently are available from The National Seed Storage Laboratory (Colorado) or from commercial seedsmen, such as Thompson and Morgan (New Jersey) or J. L. Hudson (California). Seed and vegetatively propagated materials often are collected and exchanged by specific plant societies, such as the American Rose Society, the North American Gladiolus Society, and many others. Rare plants and seed often are available from specialty plant producers who advertise in trade and popular journals. But, even after the best information is gathered on a crop, the breeder still must evaluate the plants under local environmental conditions.

Some of the factors which need to be considered in the preliminary evaluations are: 1) floriferousness - including all characteristics of the flower, such as timing, size, color, number, and keeping quality; 2) horticultural quality - characteristics of the plant habit as related to climate, production practices, and production of a marketable product; 3) disease and pest resistance - qualities needed for the ideal means of pest management through the use of genetic resistance; 4) adaptability - how the plant performs under a range of environmental conditions; and 5) market acceptability - characteristics desired by the wholesaler, retailer, and consumer, such as post-production longevity. To attain all this information so that realistic goals for improvement in the crop can be set, the plant breeder is required to make attentive and frequent observations of the plant materials.

Setting specific and realistic goals in a breeding program requires not only observation of the plant material by the breeder, but communication with others who have worked with the plants. Discussions with other breeders, growers, and retailers give great insight into the needs and possibilities for improvement. After observing the available germplasm, if the breeder feels confident that genes for the desirable traits are present, then procedures can be initiated to incorporate them into an improved product. Often, however, genes for the new characteristics are not readily available and more extensive collection of germplasm is required (Ewart, 1981). Pathways of germplasm collection are: 1) solicitation from botanical gardens, arboreta, and individual growers and scientists throughout the world; 2) privately funded collection expeditions by the breeder to centers of diversity of the crop; and 3) collection of plants through the coordination of the USDA Germplasm Resources Laboratory (Beltsville, Maryland) which does not fund exploration but will act as a coordinator and possibly provide personnel. The latter has proven to be of great value to floriculture, such as the 1970 release of the New Guinea impatiens (Winters, 1973), but federal funding for such collection explorations almost has become extinct. Private funding from botanical gardens, plant societies, and grower groups offer the best hope for obtaining new germplasm. Ideally, an international computer listing of all seed and plant materials in storage and culture would greatly facilitate plant breeders throughout the world. On a national basis The Germplasm Resources Information Network (GRIN) is operational at the USDA/ARS Plant Genetics and Germplasm Institute at Beltsville, and provides sources of plant material in the U.S.

Once the new germplasm is collected, it must be evaluated for the specific characteristics desired, such as a morphological trait (Ladd, et al., 1984), disease resistance (Palmer and Pryor, 1958), or insect resistance (Al-Abbasi and Weigle, 1982). No breeder should try to undertake the responsibility of screening for all these characteristics alone. Although the plant breeder is a well-trained and highly skilled scientist who combines educational training with intuition, imagination, patience, and often luck, he cannot be an expert in all fields. Breeders must integrate scientists of other disciplines in the research effort for the improvement of the plant material if the program is to progress efficiently. The breeder acts like the conductor of a major orchestra, where the disciplines are the various instruments. He takes their individual skills to form an integrated team to produce a harmonic final product - an improved plant. It is here that the breeder utilizes his colleagues in physiology (Arisumi, 1973, 1980), radiology (Grossman, 1983), or biotechnology who are involved in tissue culture (Reinert and Bajaj, 1977; Sink and Padmanabhan, 1977), somatic cell hybrids and protoplast fusion (Sink, 1984), and plasma mediated DNA transfer (Lawton and Chilton, 1984). He takes their accomplishments and incorporates them into the breeding program. Of course, even with all this assistance, success does not always result. A good example is a breeding program started by the author in 1970 with *Hoya* (Asclepiadaceae), a genus of some 100 species native to E. Asia and Australia. Called the "wax plant" because of its heavy thick leaves, it has many variations in leaf shape and color and is popular hanging in a basket or tied to totem poles. Many cultivars are available but all developed as natural mutations and were selected by amateur or professional propagators. A collection was made of 28 species and over 50 cultivars and these were evaluated. Many differences were observed and some qualities looked interesting, such as pubescent leaves (*H. keysii*) and individual flowers up to 4 cm diameter (*H. imperialis*). Unfortunately, all attempts to hybridize *Hoya* failed.

Fruit were occasionally observed in the greenhouse and in outdoor plantings, but manual pollination was not successful. A botanist was recruited to study the flowers and determine the method of pollination of this genus. To this day their sexual reproductive biology remains a mystery, but would be a good challenge for someone with a lot of time and patience.

Breeding *Gladiolus* tolerant to the disease caused by *Fusarium oxysporum* f. sp. *gladioli* produced more positive results and exemplifies how breeders and plant pathologists can interact constructively. Gladiolus constitute one of the major cut flowers in the U.S., but most of the cultivars are very susceptible to Fusarium wilt and corm rot (Palmer and Pryor, 1958). Collections of species from Africa and Europe were evaluated by plant pathologists for resistance to Fusarium. All species were susceptible, although there were degrees of tolerance. Screening commercial cultivars and seedlings and hybridizing among the most tolerant lines were started in 1950 in Florida. Continued hybridization, inoculation, and evaluation led to the release of several cultivars that are highly tolerant of this disease (Wilfret, 1981, 1983). It is believed that this type of horizontal resistance (Vanderplank, 1978) may be the limit for classical breeding methods, but the possibility of gene transfer from closely related genera not susceptible to Fusarium remains viable and could produce resistant cultivars. Progress now is being made to incorporate the Fusarium tolerance from the large flowered (10-12 cm diam.) cultivars into lines with smaller (5-7 cm) flowers which could develop a new cut flower more compatible with small containers (31).

Hybridization and selection, followed by seedling evaluation trials certainly require knowledge of plant breeding methods, but often stamina and patience are of equal importance. Selfing, backcrossing, and sib crossing (Casali and Tigechelaar, 1975) are all methods of realizing the objectives of the breeding program. Continuous ruthless roguing of the seedlings is the most difficult but necessary procedure towards advancement. Cooperators in different locations should evaluate the advanced lines and determine their adaptation to different environmental and cultural conditions. Once a seedling is determined to be of value to industry or science, it should be released. Many potentially useful cultivars probably have been lost forever due to procrastination on the part of the plant breeder looking for the "perfect plant." Breeders should release a new cultivar with the attitude that it either will be accepted or it will not, and then they must move on to new ventures. Some feel that a plant should be released if it has just one trait better than all available cultivars (breeding lines), while others expound that it should have this trait plus be equivalent to a comparable cultivar in all its other qualities. Since there are so few breeders in floricultural crops, traits found in breeding lines may be lost or never utilized unless they are incorporated into a final product by the public breeder. Present sentiment in administrative circles is for public breeders to develop breeding materials to a given point and then release them to private breeders for the development of cultivars (Ryder, 1984). However, the plant breeder who has been instrumental in understanding the genetic nature of the breeding material, in rearranging the genes, evaluating the combinations of genotypes, and evaluating their worth in new cultivars should be allowed the satisfaction and prestige gained with the release and utilization of a new cultivar.

Many floricultural crops are asexually propagated (chrysanthemum, poinsettia, gladiolus, lilies, etc.), but a good release mechanism has not been developed to disseminate the plants on a nationwide basis. Some institutions have foundations established for the release of plant materials, but most of these are efficient in handling seed propagated crops only. Current release of asexually propagated germplasm generally is in limited quantities to a number of growers or to a commodity group that distributes the plants. Both methods limit the availability of the plants to a large number of people and reduce the potential use of the new cultivar. Since it is inefficient for public institutions to be involved in large scale plant propagation, limited quantities of the germplasm probably will continue to be the norm. *In vitro* propagation of the germplasm (Reinert and Bajaj, 1977) might be an alternative; but valuable research space and technical support would be consumed. Close working arrangements with commercial propagators who are willing to gamble with the breeder and increase the germplasm as their contribution to public cultivar development may be the most feasible pathway at this time.

The excitement and satisfaction of being a plant breeder of floricultural crops does not diminish over time, especially with all the new areas of biotechnology becoming available (Lawton and Chilton, 1984; Sink, 1984). A disturbing fact is the number of breeding programs in florist crops and bedding plants that are scheduled to be eliminated within the next three years at the Land Grant Universities (Brooks and Vest, 1985). In 1983 there were 34 breeding programs with 10.61 FTE's in these two areas, but only 12 of these programs and 4.85 FTE's were expected to be maintained in 1990. The survey indicated that an additional 10 programs probably would be maintained in 1990. At the worst, there would be a 65% loss of programs and a 54% decrease in personnel. Additionally, only 21.5 scientists (12.5 with BS, 4.5 with MS, and 4.5 with Ph.D.) are breeding flowers and ornamentals at private seed companies in the U.S. (Stroswider, 1984). Hence, there is a very small pool of individuals breeding floricultural crops. The future training of plant breeders should be given serious consideration. As the world opens its doors to new plant explorations, and as collections of exotic germplasm become available. a sufficient number of breeders may not be working in floriculture to utilize the germplasm to its maximum potential. Rather than a decrease in plant breeding programs, plant breeding needs to be recognized as a full-fledged science (Frazier, 1985). New floricultural crops and variations of the old are needed to give mental pleasure to mankind and breeders must work towards that goal. The "age of transition" (Craig, 1968) for floricultural plant breeding has passed and it is the responsibility of the plant breeder to make accurate assessments of future needs in floriculture and to make this the "age of action and accomplishment."

References

Al-Abbasi, S. H., and Weigle, J. L. 1982. Resistance in New Guinea impatiens spcies and hybrids to the two-spotted spider mite. HortScience 17:47-48.

Arisumi, T. 1973. Morphology and breeding behavior of colchicine-induced polyploid impatiens spp. L. J. Amer. Soc. Hort. Sci. 98: 599-601.

Arisumi, T. 1978. Hybridization among diploid and tetraploid forms of New Guinea, Java, and Celebes impatiens spp. J. Amer. Soc. Hort. Sci. 103:355-361.

Arisumi, T. 1980. *In vitro* culture of embryos and ovules of certain incompatible selfs and crosses among *Impatiens* species. J. Amer. Soc. Hort. Sci. 105:629-631.

Armitage, A. M., Hamilton, B. M., and Laushman, J. M. 1985. The University of Georgia Horticultural Gardens. Ga. Hort. Dept. Rept., 106 pp.

Bliss, F. A. 1984. The application of new plant biotechnology to crop improvement. HortScience 19:43-48.

Bobisud, C. A. and Kamemoto, H. 1982. Selection and inbreeding in amphidiploid Dendrobium (Orchidaceae). J. Amer. Soc. Hort. Sci. 107:1024-1027.

Brooks, A. J., and Vest, H. G. 1985. Public programs in genetics and breeding of horticultural crops in the United States. HortScience 20:826-830.

Casali, V.W.D., and Tigechelaar, E. C. 1975. Computer simulation studies comparing pedigrees, bulk, and single seed descent selection on self-pollinated populations. J. Amer. Soc. Hort. Sci. 100:364-367.

Craig, R. 1968. Implications of the new genetics in horticultural plant breeding. HortScience 3:243-249.

DeVos, N. E., Hill, R. R., Jr., Hepler, R. W., Pell, E. J., and Craig, R. 1980. Inheritance of peroxyacetyl nitrate resistance in petunia. J. Amer. Soc. Hort. Sci. 105:157-160.

Ewart, L. C. 1981. Utilization of flower germplasm. HortScience 16:135-138.

Frazier, W. A. 1985. Horticulture, plant breeding, and genetic engineering. HortScience 20:171-173.

Grossman, H. H. 1983. Seed transmission of gamma radiation induced morphological changes in geranium. J. Amer. Soc. Hort. Sci. 108: 872-874.

Hess, C. E. 1984. Biotechnology: Implications for horticulture and society. HortScience 19:620-623.

Howe, T. K., and Waters, W. E. 1984. An overview of the cultivar evaluation program at the Gulf Coast Research and Education Center. HortScience 19:539.

Ladd, D. L., Albrecht, M. L., and Clayberg, C. D. 1984. Genetics of flower color in spider flowers. J. Amer. Soc. Hort. Sci. 109: 759-761.

Lawton, M. A., and Chilton, M. D. 1984. Agrobacterium Ti plasmids as potential vectors for genetic engineering. HortScience 19: 40-42.

Maxwell, F. G., and Jennings, P. R., eds. 1980. Breeding plants resistant to insects. John Wiley & Sons (New York). 683 pp.

Palmer, J. G., and Pryor, R. L. 1958. Evaluation of 160 varieties of Gladiolus for resistance to Fusarium yellows. Plant Dis. Reptr. 42:1405-1407.

Reinert, J., and Bajaj, Y.P.S., eds. 1977. Applied and fundamental aspects of plant cell, tissue, and organ culture. Springer-Verlag (New York). 803 pp.

Robacker, C. D., and Ascher, P. D. 1981. Sources of variations of self seed set in pseudo-self-compatible Nemesia strumora. J. Amer. Soc. Hort. Sci. 106:504-508.

Ronald, W. G., and Ascher, P. D. 1975. Transfer of self compatibility from garden to greenhouse strains of *Chrysanthemum morifolium* Ramat. J. Amer. Soc. Hort. Sci. 100:351-353.

Ryder, E. J. 1984. The art and science of plant breeding in the modern world of research management. HortScience 19:808-811.

Sink, K. C., and Padmanabhan, V. 1977. Anther and pollen culture to produce haploids: progress and application for the plant breeder. HortScience 12:143-148.

Sink, K. C. 1984. Protoplast fusion for plant improvement. HortScience 19:33-37.

Stroswider, R. E. 1984. A private seed company's views of the roles of public and private breeders. Cooperation and support. HortScience 19:800-802.

Vanderplank, J. E. 1978. Genetics and molecular basis of plant pathogenesis. Springer-Verlag (New York). 167 pp.

Veilleux, R. E., and Lyons, R. E. 1984. Inherent variability in seed propagated streptocarpus. J. Amer. Soc. Hort. Sci. 109:497-500.

Vest, H. G., Jr. 1984. The vegetable seed industry and public plant breeding. Some concerns. HortScience 19:167-168.

Wilfret, G. J. 1979. Pixiola: A new cut flower for Florida. Proc. Fla. State Hort. Soc. 92:313-316.

Wilfret, G. J. 1981. Florida Flame - a red gladiolus for a cut flower. Fla. Ag. Exp. Sta. Circ. S-274. 8 pp.

Wilfret, G. J. 1983. Dr. Magie - a salmon gladiolus for a cut flower. Fla. Ag. Exp. Sta. Circ. S-298. 10 pp.

Winters, H. F. 1973. New impatiens from New Guinea. Amer. Hort. 52: 16-22.