THE CREATIVE SEARCH FOR NEW F_1 HYBRID FLOWERS

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There is a small group of companies, about 6 in the U.S. and perhaps 15 worldwide, that have caused a gardening revolution during the last 20 years. This revolution is the change by the gardening public from the sowing of seed in the garden to the purchasing and planting of started plants. The companies largely responsible for this revolution are those developing F_1 hybrid annual flowers.

It is not a coincidence that the rapid development of the bedding plant industry coincides with the tremendous increase in the use of the F_1 method for the production of flower seed. In fact, neither industry could have developed to the extent they have without the other. The bedding plant industry needed and has used the greatly improved cultivars in order to have a superior product which the public would buy, and the seed companies needed the professional grower who had the experience and facilities to grow the expensive seeds.

Hybrid flowers offer the same advantages over open-pollinated sorts that are found in vegetables and field crops: those of uniformity and increased vigor resulting in stronger plant growth; more abundant flowering and larger flowers blooming over a longer season; a generally all-around superior garden plant. Also in flowers the hybrid method can result in flower colors, flower types, and habits that are the result of the heterozygous condition for certain genes.

There is a truly amazing contrast between the small-flowered, poor colored, and usually rather weak-growing and loose petunias that were sold before the F_1 hybrids, and the large-flowered, vigorous, compact, very free-flowering, pastel and bright colored hybrid petunias. The contrast between an open pollinated snapdragon mixture and vigorous hybrids like the Rockets, and the difference between the new F_1 semi-dwarf African marigolds and the existing open pollinated cultivars is equally great.

Today one can purchase F_1 hybrids of at least 15 species of annual garden flowers, including ageratum, begonia (fibrous rooted), dianthus, geranium, iceland poppy, impatiens, marigold (*Tagetes erecta* and *Tagetes erecta* × *T. patula*), nicotiana, pansy, petunia, primula, portulaca, salpiglossis, snapdragon, and zinnia. In addition, F_1 hybrid seed of four greenhouse pot plants is available: calceolaria, cyclamen,

gloxinia, and saintpaulia. Twenty years ago F_1 hybrids were only available in three species: petunia, begonia, and the greenhouse cut flower snapdragon.

It is interesting to note that not only has the flower seed industry intensively used this method of breeding, but was one of the first to offer commercial seed of F_1 hybrids with the introduction of *Begonia gracilis* 'Prima Donna' by Ernst Benary in 1909.

Economic as well as horticultural reasons have influenced the rapid and widespread use of F_1 hybrid flowers.

Because of the relatively small amount of seed needed when compared to a vegetable or field crop, hybrids can be hand produced in flower species that would be prohibitively expensive in some other crops. A large proportion of the hybrid seed is sold to professional growers who in turn market plants to the consumer.

The desire to protect one's product has also been a strong contributing factor to the rapid increase in the adoption of the F_1 hybrid method. Having this protection has permitted companies to invest more in their breeding programs, both in facilities and in personnel.

ADVANTAGES OF F_1 HYBRIDS

Let me enlarge on the advantages of F_1 hybrids and the accomplishment a breeder can make using this breeding method in addition to the most obvious one of hybrid vigor or heterosis.

Two important flower types in petunia, the large-flowered or grandiflora type and the double-flowered form are completely dependent upon the hybrid method for production. The grandiflora character is semi-lethal in the homozygous state giving a very weak plant. The character is dominant to the small-flowered or multiflora type. Commercial F_1 hybrid grandiflora petunia seed is produced by crossing multiflora and grandiflora lines, usually using the multiflora line as the seed parent. Likewise double-flowered petunia seed production is dependent upon the hybrid method. Double-flowered petunia lines have pollen, but are essentially female sterile with only an occasional functional pistil. In commercial seed production the double-flowered inbred lines are maintained vegetatively and used as pollen parents in crosses with single-flowered lines. The double-flowered character is dominant and so the resultant F_1 hybrid is double-flowered. Most double parents are small-flowered, so depending upon the flower type of the single parent, the F_1 hybrid is either multiflora double or grandiflora double.

In both zinnia and African marigolds some recent desirable intermediate habit types result from crossing tall and very dwarf forms. The F_1's are intermediate and cannot be "trued up". 'Peter Pan' zinnias and marigold cultivars, Apollo, Moonshot and the Lady hybrids, are examples of this.

In some genera, such as *Dianthus*, there is, during the inbreeding process to get uniformity, a strong inbreeding depression or loss of vigor. Species such as this are good candidates for using the hybrid method.

Also by the hybrid method very desirable F_1 hybrids can sometimes be made between different species. *Dianthus* 'Queen of Hearts' is an F_1 hybrid between an inbred line of *Dianthus chinensis* and *D. barbatus*. The F_1 hybrid is sterile, as one would expect, and is very free blooming. The very popular triploid marigolds, hybrids between *Tagetes erecta* and *T. patula*, are another example of F_1 hybrids between species. Like the 'Queen of Hearts' dianthus, these hybrids are very free blooming and superior in many horticultural traits to either species.

In recent years there has been a dramatic shift in the method of propagation of garden geraniums from asexual propagation by cuttings to the growing of plants from seeds. This change has been possible because of the outstanding new F_1 hybrid cultivars that have been developed. These are early and free blooming, with compact habit giving much better garden performance than the cutting grown cultivars.

DEVELOPMENT OF NEW F_1 HYBRID CULTIVARS

There are three steps in the development of a new F_1 hybrid cultivar.

(1) *The development of inbred lines.* Inbred lines may be selected out of commercial open-pollinated cultivars, but more likely will be developed from recombination of segregating breeding material. For example, in the development of inbred lines to produce snapdragon 'Bright Butterflies' by our company, over 15,000 F_2 plants were grown from crosses of strong normal-flowered snapdragons and 'Juliwa' snapdragons with the desired open-faced flower form. From these populations 26 plants with the character we wanted were selected. These were inbred and further selected to give us the inbred lines used to make the F_1 hybrid mixture 'Bright Butterflies'.

(2) *Making test hybrids.* The breeder armed with knowledge of the inheritance of the characters, such as flower color, flower form and habit, plans and makes hybrids which he predicts will give the F_1 hybrid he wants.

(3) *Testing of hybrids.* These are tested in the greenhouse

for performance at the time a plant grower would sell them and in the field for garden performance. Before a cultivar is introduced it is tested in trial gardens conducted by seed companies, public parks and universities. The University of Illinois and Pennsylvania State University have been leaders in this type of testing.

Particularly outstanding new developments may be entered in competitive trials such as the All-American Selections or the more recently formed counterparts in Europe, the All-Britain Trials and Fleuroselect. Winners of awards in these trials receive promotion that results in greatly increased sales.

SEED PRODUCTION

Many of the F_1 hybrid cultivars in crops such as petunia, snapdragon and pansy are produced by hand emasculation and pollination. Because of the large amount of hand labor involved, the production is centered in low labor cost areas of the world such as Central America and parts of Asia. These areas also have the advantage of climates that permit construction of relatively inexpensive greenhouses without heating or cooling facilities.

In some crops male-steriles have been used to eliminate emasculation, but the plants are still pollinated and the seed picked by hand. Examples of this are geraniums and dianthus. F_1 hybrid marigolds are produced in field plots using alternating rows of seed and pollen lines. Two distinct forms of pollen sterility are used in the seed line. One method is to rogue a population segregating for full double (all ray flowers) and semi-double, leaving only the full double type. The other method is to incorporate a recessive apetalous character into the seed line. The line maintained in a 50:50 normal to apetalous ratio is rogued to the apetalous type. Neither type of male sterility is without its problems. The full double method is difficult because age and environmental stress can cause plants that had been full double to produce some flowers with disc flowers. Pollination is a problem with the apetalous flower form. Not having petals, it is less attractive to pollinating insects.

Hybrid zinnia seed is produced using an apetalous character similar to the one in marigolds and maintained in the same manner. However, the apetalous flower form is even less attractive to insects than in the marigold, and the pollen is usually collected and applied by hand.

If you are using F_1 hybrid flowers in your business, planting them in your garden, or only enjoying them in parks and gardens, I hope you have a better understanding of what is involved in their breeding and production.

RAY HASEK: Now is the time for questions for our panelists.

VOICE: In using the acids or bases, would there be a problem with the workers using them because of their caustic nature — being injured by them?

WES HACKETT: I certainly think that is a concern. I talked with a man from Monrovia Nursery who said they were trying it experimentally and I am not sure whether they had involved their workers or not, or whether they were using other kinds of personnel to do that work.

BILL BARR: Yes, we are using it for experimental purposes and are just letting one person do all the work with the acid and bases and that one person does all the preparation.

WES HACKETT: You do have to realize that sodium hydroxide is lye; it is a very caustic material. Sulfuric acid is also a very caustic material. It could be very injurious to eyes and other delicate parts of the human anatomy.

JOLLY BATCHELLER: Do you use total immersion of the cuttings?

WES HACKETT: No, just the base of the cuttings. The same way you would dip a cutting into an IBA solution.

VOICE: What is the normality of the sodium hydroxide solution?

WES HACKETT: pH is 10.5. This is the easiest way to measure it.

VOICE: What would be the concentration percentage you are using of sulfuric acid, sodium hydroxide, and IBA?

WES HACKETT: We pre-treat with either the acid or base depending on the species. The acid is the 2 N solution; take concentrated sulfuric acid, dilute it down to 2 N. With sodium hydroxide the easiest way to prepare the solution is with a pH meter. We add the concentrate NaOH to water until the pH gets to 10.5. The cuttings are then dipped for an appropriate length of time, washed thoroughly, and then re-dipped in whatever kind of auxin material you use. We use 3000 ppm as a general concentration of IBA.

BRUCE BRIGGS: Do you have any comparisons where you wound the cuttings.

WES HACKETT: No, we did not compare wounding with the acid-base treatment.

PHILIP BARKER: I would like to ask Harold Tukey a question. Would you explain what you know about the triggering mechanism of fall leaf coloration.

HAROLD TUKEY: This information is in the horticultural

and plant physiology literature. The rest, dormancy, begins in many woody plants in mid-summer with the setting of a terminal bud, which involves a hormone relationship triggered in many plants by a photoperiod reaction. As the fall season approaches, the red-colored pigments, anthocyanins, begin to accumulate. This is enhanced by low temperatures, by a good carbohydrate supply, and perhaps by nutrients such as nitrogen and potassium. But the process begins in mid-summer.

VOICE: Mr. Goldsmith, could you discuss your record keeping system in your breeding work?

GLENN GOLDSMITH: Actually you might be surprised by the lack of detailed note taking. What we want to know in most cases is "what is the best selection or hybrid of a group of a similar type?" My book therefore is filled with ×'s, double ×'s and triple ×'s to indicate the best within a series. I will make detailed notes on new breeding material and hybrid combinations. We also don't save any selections that we don't intend to plant the next generation. We automatically sow everything saved the year before. As some of these cultivars approach the finished product, we will get involved more with our sales people, and they will take more detailed notes so that they can do the descriptive and catalogue work. We use a pedigree system in our inbreeding, in which each year we simply add another dash and 1, 2, 3, depending on the selection. This system is pretty much patterned after what I used at Pan American Seeds when I was there.