

CROSSBREEDING AND ANALYSIS OF DESIRABLE TRAITS IN *DENDRANTHEMA GRANDIFLORA* AND *GAURA LINDHEIMERI*

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Summary

This project sought to improve chrysanthemums. In order to improve the ability of chrysanthemums to withstand winter weather, crossbreeding was done. Theoretically, the seeds produced from the crossbreeding will grow into plants that will withstand colder weather. This project also studied the growth of wildflowers over a three-month period. Determining which wildflowers developed fastest and largest will help identify which will sell the best on the market.

Introduction

The overall goal of this project was to improve chrysanthemums (*Dendranthema grandiflora*) and gaura (*Gaura lindheimeri*) ultimately for marketability. The focus of this project was to investigate developmental aspects of plants through propagation. The first specific goal was to create first-generation (F_1) hybrid populations of chrysanthemums to study the inheritance of winter hardiness. Through crossbreeding, the winter-hardiness in the offspring of the chrysanthemums increased. The second goal of this project was to test gaura seedlings for possible release as clonal cultivars, which are recognizable genotypes on the market today. The strongest and healthiest genotypes of either chrysanthemums and gaura are the most appealing to the consumer. These traits play an important role in the marketability of chrysanthemums and gaura.

The hypotheses of this project were: first, second-generation (F_2) chrysanthemums would vary in winter hardiness, producing a variety of plants, some more winter-hardy than the parents. Second, there would be differences in the percent rooting, date of first flower, height, width, percent root, and rooting systems in the 16 clonal genotypes of gaura.

Background

Chrysanthemums date back almost 3000 years, with references to them appearing in the writings of Confucius. They were introduced to the U.S. in 1798 when John Stevens imported them from Europe. However, breeding to improve chrysanthemums is relatively new (1).

The traits that breeders have sought to improve in chrysanthemums are winter hardiness, earliness of bloom, how well flowers bloom, frost tolerance, and new flower forms. Desired traits can be obtained through outcrossing and backcrossing. In outcrossing, unrelated or distantly related individuals are mated to achieve desired characteristics in offspring. Studies have shown that desired characteristics are not likely to appear in first-generation (F_1) offspring. Second or third-generation offspring (F_2 or F_3) produce desired results (1).

In backcrossing, father-daughter crossings or mother-son crossings are used to intensify a specific characteristic (1). Self-incompatibility, the inability of a plant to reproduce with

itself, is a restricting factor in any cross between directly related plants (2). Research has shown that most chrysanthemums cannot breed within the same family, because they are self-incompatible. This also restricts self-breeding or breeding with siblings in chrysanthemums (3).

Ongoing research at the University of Minnesota in the Horticultural Department is working to improve the winter-hardiness of chrysanthemums. Using outcrossing, backcrossing, and crossing of closely-related plants, this work has not only greatly improved chrysanthemum durability in harsh winter conditions, but it has produced offspring with new flower shapes and colors, offspring with early or late blooming flowers, offspring with thick or thin leaves and stems, offspring with larger or smaller blooming flowers, and offspring with improved winter-hardiness (4). To prevent regression in the breeding program, only plants with desired characteristics are kept for future crosses (1). As a result of the University of Minnesota program, 76 new genotypes of garden chrysanthemums and seven new genotypes of greenhouse chrysanthemums have been introduced (4).

Far more experimentation on crossbreeding of chrysanthemums has been done than on gaura; nevertheless, scientists regard gaura as an important plant worthy of being engineered to survive in Minnesota climates (5). Gaura are wildflowers in the *Onagraceae* family and are native to North America. They can be found in Texas and Louisiana and as far south as central Mexico. Gaura are vigorous, clump-forming perennials with long, branching stems that have sparse numbers of oval leaves (6). Pink and white flowers form at the ends of the stems. Although gaura do not share the popularity of chrysanthemums, research has been done to improve the winter-hardiness of gaura, similar to work done on chrysanthemums.

Methods

Part 1: Chrysanthemum Breeding

Chrysanthemums bloom in the fall when the photoperiod is short, therefore, it was important that they were exposed to a limited amount of light per day to simulate a fall-like environment. To this end, a black cloth was pulled over the plants at 4:00 pm and was retracted the next morning at 8:00 am to expose the chrysanthemums to only eight hours of sunlight daily. As a result, faster blooming occurred and allowed for more crosses to be made. Approximately two weeks prior to the actual breeding, every flower and all large buds were removed. The smaller buds were left on each plant so blooming of the chrysanthemums was coordinated. The plants were watered twice each day.

When flowers were fertile, they were clipped and stripped of leaves. The male chrysanthemum flowers were trimmed, and the female flowers were emasculated. Every male petal was completely removed to rid the flower of stigmas. Every female petal was trimmed to the tips of the stigmas, and the disc florets in the centers were trimmed to remove pollen so self-pollination could not occur. After the flowers were prepared, they were placed in professional floral preservative solution (1 cup sucrose mixed with 2 gallons water).

Winter-hardy chrysanthemums were crossed with non-winter-hardy chrysanthemums by dabbing male over female flower heads in a brush-like motion to apply pollen to the

stigmas of the female. The pollinated females then produced seeds. Once the seeds ripened, they were separated from the mother plant and cleaned of debris. The technique used to accomplish this was to allow the seed heads to dry by exposing them to hotter conditions for longer periods of time. When dry, they were crushed gently, and a small spatula was used to separate the seeds from any debris. The seeds were counted and placed in a packet to be planted.

Part 2: Container Production Trials of New *Gaura Lindheimeri* Selections

Approximately 20 cuttings of the 16 genotypes of *Gaura* were dipped in 1000 ppm indole butyric acid (IBA) in 50% ethanol to promote root growth and stem elongation. These were planted in plug trays and were kept in a mist house to encourage rooting.

After the *Gaura* took root, they were transplanted to an experimental site outdoors. During the process of transplanting, an analysis of the roots of every plant was conducted. Each *Gaura* genotype was planted in six large-sized pots, three of which had one plant, and three of which had three plants all in high-porosity soil mix. These were placed in a computerized random design for equal light-admittance.

Data collection was conducted as follows: rooting quality on a scale of 0 to 5, 0 being "no rooting system," and 5 being "fully developed rooting system;" date of first flower; and height and width of the genotype were taken each day. To keep the data constant, the height of the plants was continually measured from the soil surface up, and the width measured using the widest possible dimension of the plants. Data analysis was done using an Analysis of Variance computer program (ANOVA) to calculate mean separations.

Results

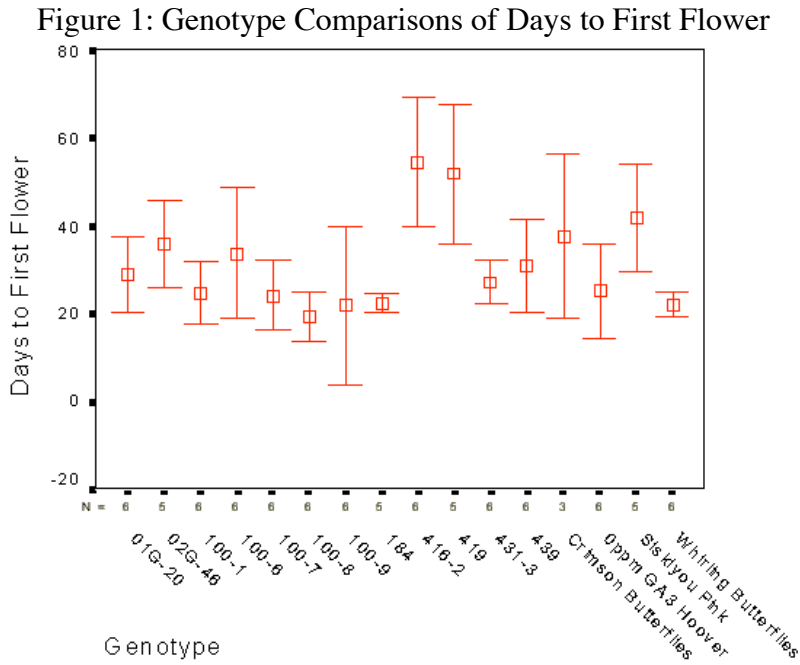


Figure 1 shows the earliness of bloom of each genotype of gaura. The lower the bars, the earlier the plants flowered. This figure visually compares both ranges and means between the 16 different types of gaura. The size of the bars represent the range, and the boxes represent the means.

Table 1: Days to First Flower Means Analysis

	Number of Samples	Mean Subset (days)			
Genotype		1	2	3	4
100-8	6	19.00			
100-9	6	21.67			
Whirling Butterflies	6	21.83			
184	5	22.00			
100-7	6	24.00	24.00		
100-1	6	24.50	24.50		
Oppm GA3 Hoover	6	25.17	25.17		
431-3	6	27.17	27.17		
01G-20	6	28.83	28.83		
439	6	30.67	30.67		
100-6	6	33.67	33.67	33.67	
02G-46	5	35.60	35.60	35.60	
Crimson Butterflies	3	37.33	37.33	37.33	37.33
Siskiyou Pink	5		41.80	41.80	41.80
419	5			51.60	51.60
416-2	6				54.33

Means for groups in homogeneous subsets are displayed.
The group sizes are unequal. The harmonic mean of the group sizes is used.

Table 1 shows number of plants measured and the mean of every genotype measured in days. This table separates each mean into subcategories, which classify genotypes as either weak or strong for early flowering. Plants found in the subcategory “4” demonstrate weak qualities in earliness of bloom compared to those found in the subcategory “1,” demonstrating earlier flowering.

Figure 2 shows the height of each genotype of gaura. The higher the bars, the greater the height of the plants. This figure compares ranges and means between the 16 different types of gaura.

Figure 2: Genotype Comparisons of Height

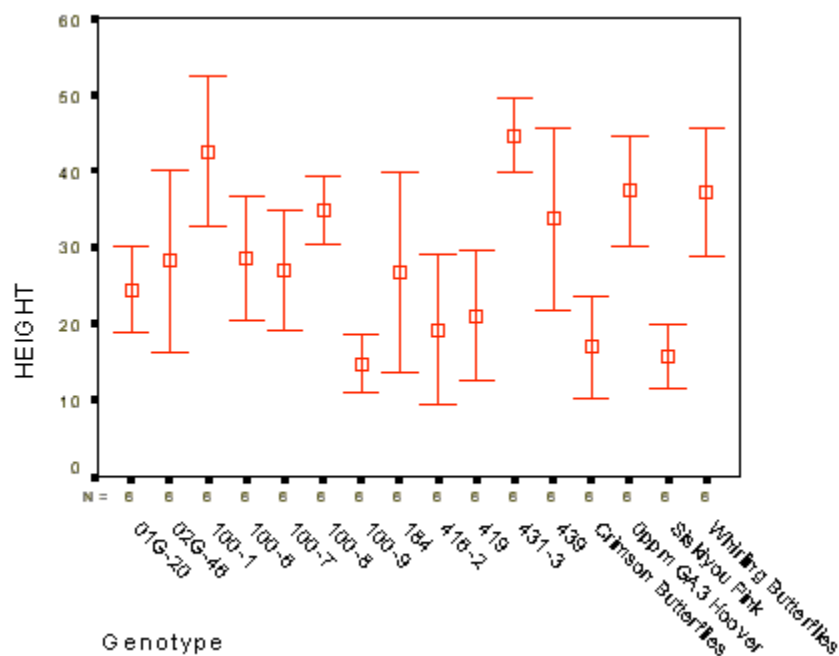


Table 2: Height Means Analysis

Genotype	Number of Samples	Mean Subset (cm)	1	2	3	4	5	6
100-9	6	14.67						
Siskiyou Pink	6	15.67						
Crimson Butterflies	6	16.83						
416-2	6	19.17	19.17					
419	6	21.00	21.00	21.00				
01G-20	6	24.33	24.33	24.33	24.33			
184	6	26.67	26.67	26.67	26.67			
100-7	6	26.83	26.83	26.83	26.83			
02G-46	6	28.17	28.17	28.17	28.17	28.17		
100-6	6	28.33	28.33	28.33	28.33	28.33		
439	6		33.67	33.67	33.67	33.67	33.67	
100-8	6			34.67	34.67	34.67	34.67	
Whirling Butterflies	6				37.17	37.17	37.17	
Oppm GA3 Hoover	6				37.33	37.33	37.33	
100-1	6						42.50	42.50
431-3	6							44.67

Means for groups in homogeneous subsets are displayed.

Table 2 shows the number of plants and the mean of height measurements of every genotype measured in centimeters. This table separates each mean into subcategories, which classify genotypes as either short or tall. Plants found in the subcategory “6” demonstrate taller height compared to those found in the subcategory “1,” demonstrating shorter height.

Figure 3: Genotype Comparisons of Width

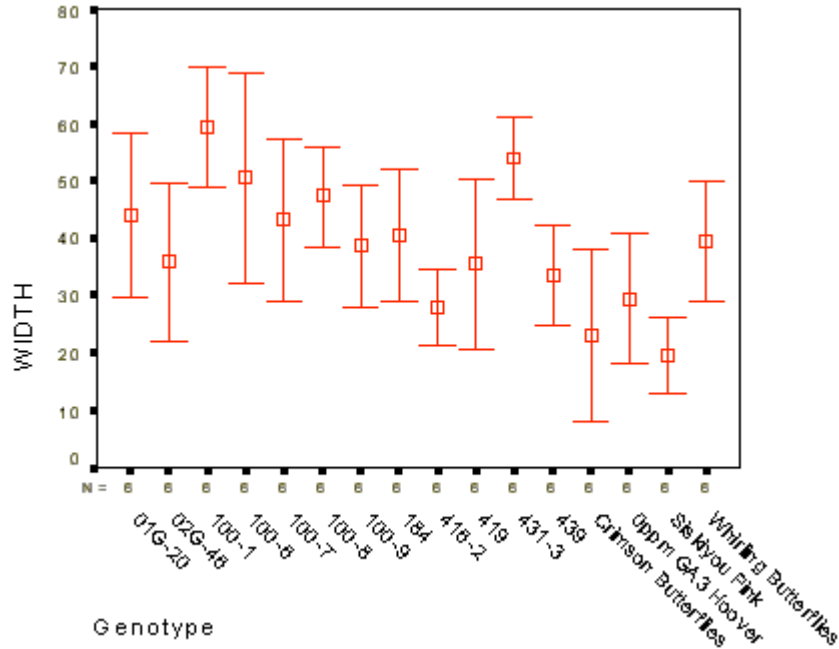


Figure 3 shows the width of each genotype of gaura. The higher the bars, the greater the width of the plants. This figure compares range and mean between the 16 different types of gaura.

Table 3: Width Means Analysis

Genotype	Number of Samples	Mean Subset (cm)	1	2	3	4	5	6
Siskiyou Pink	6	19.50						
Crimson Butterflies	6	23.00	23.00					
416-2	6	27.83	27.83	27.83				
Oppm GA3 Hoover	6	29.33	29.33	29.33				
439	6	33.33	33.33	33.33	33.33			
419	6	35.33	35.33	35.33	35.33	35.33		
02G-46	6	35.67	35.67	35.67	35.67	35.67		
100-9	6	38.50	38.50	38.50	38.50	38.50		
Whirling Butterflies	6	39.33	39.33	39.33	39.33	39.33	39.33	
184	6		40.33	40.33	40.33	40.33	40.33	40.33
100-7	6		43.17	43.17	43.17	43.17	43.17	43.17
01G-20	6			44.00	44.00	44.00	44.00	44.00

100-8	6			47.17	47.17	47.17	47.17
100-6	6				50.50	50.50	50.50
431-3	6					53.83	53.83
100-1	6						59.33

Means for groups in homogeneous subsets are displayed.

Table 3 shows the number of plants with the mean of width measurements of every genotype given in centimeters. This table separates each mean into subcategories, which classify genotypes as either wide or thin. Plants found in the subcategory “6” demonstrate greater width compared to those found in the subcategory “1.”

Figure 4: Genotype Comparisons of Root Score

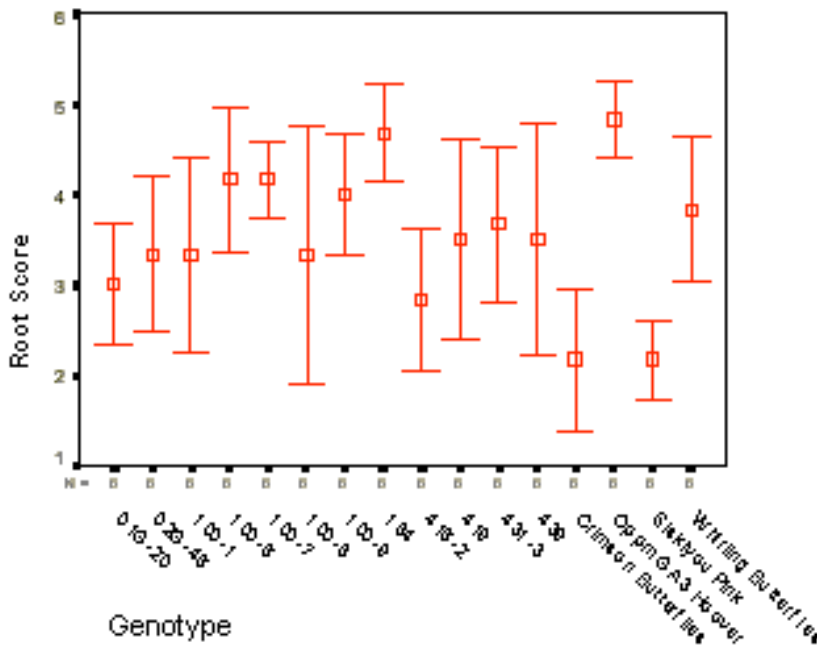


Figure 4 shows the quality of the rooting systems of each genotype of gaura. The higher the bars, the greater the quality of the rooting systems. This figure compares both range and mean between the 16 different types of gaura.

Table 4: Root Score Means Analysis

	Number of Samples	Mean Subset (Scored from 0 - 5)			
Genotype		1	2	3	4
Crimson Butterflies	6	2.17			
Siskiyou Pink	6	2.17			
416-2	6	2.83	2.83		
01G-20	6	3.00	3.00	3.00	
02G-46	6	3.33	3.33	3.33	3.33
100-1	6	3.33	3.33	3.33	3.33
100-8	6	3.33	3.33	3.33	3.33
419	6	3.50	3.50	3.50	3.50
439	6	3.50	3.50	3.50	3.50
431-3	6	3.67	3.67	3.67	3.67
Whirling Butterflies	6	3.83	3.83	3.83	3.83
100-9	6		4.00	4.00	4.00
100-6	6		4.17	4.17	4.17
100-7	6		4.17	4.17	4.17
184	6			4.67	4.67
Oppm GA3 Hoover	6				4.83

Means for groups in homogeneous subsets are displayed.

Table 4 shows the number of plants with the mean of root scoring for every genotype. This table separates each mean into subcategories, which classify rooting systems of the genotypes as either fully developed or underdeveloped. Plants found in the subcategory “4” demonstrate greater development of roots compared to those found in the subcategory “1.”

Discussion

The data support the hypothesis for the gaura production trial; the genotypes were not expected to develop at the same rate. Genotypes of gaura did differ in height, width, days to flower, and root score.

From analysis of the means of the genotypes shown in Table 2 and 3, the genotypes 439, 100-8, Whirling Butterflies, Oppm GA3 Hoover, 100-1, and 431-3 genotypes of gaura showed notably greater height. The Whirling Butterflies, 184, 100-7, 01G-20, 100-8, 100-6, 431-3, and 100-1 genotypes of gaura showed the greatest width. Of these larger plants, the genotypes 100-8, Whirling Butterflies, 100-1, and 431-3 grew to be consistently the largest in height and width in comparison with the other 12 genotypes of gaura. These four genotypes also proved to bloom rapidly and to grow developed rooting systems as seen in Tables 1 and 4. The four genotypes 100-8, Whirling Butterflies, 100-1, and 431-3 were always ranked under the mean subcategories demonstrating positive aspects of development; each showed the greatest height, rooting systems and width with

earliest bloom. Sources of error could include variances of sample sizes under days to first flower (see Table 1 and the results section).

So far, the chrysanthemum breeding procedure has not yielded results, because the first-generation (F_1) offspring have not yet been planted. Because winter-hardiness is being measured, first and second-generation offspring must be tested under cold conditions. Since this has not yet occurred, no data have been collected from the chrysanthemum crossbreeding procedure.

The next step in the project is to measure the winter-hardiness of the F_1 generation chrysanthemums. The plants will be exposed to a colder climate and tested in a freezer. The measurements of winter-hardiness will be tracked back to the original parents. The F_1 chrysanthemums will be self-pollinated or crossed with each other using full-sibling mating. Pollination will occur by brushing the males on the females as done in this project. The product of these crosses will produce an F_2 generation of chrysanthemums. This generation is expected to contain plants with a wide variance of winter-hardiness, some of which will surpass the original parents in tolerance to colder conditions.

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