flower quality from normal exposures of 2 to 8 hours (Table 4).

Table 3. Control of petal spots caused by natural Botrytis infections in a commercial field of gladiolus. Treatments made on cut flowers 9 hours after last infection period; one dozen spikes per treatment.

| Treatment of spikes | Number of petal spots Hopmans Glory | Snow Cloud |
|---|---|---|
| No treatment | 3365 | 2713 |
| Ozone for 2 1/2 hours | 387 | 313 |
| Captan dip at 1/8% | 485 | 428 |
| L.S.D. 5% | 220 | 220 |

Table 4. Condition of gladiolus florets 5 to 7 days after treatment with ozone, each exposure being made on a different day.

| Treatment | Variety | No. of florets Wilted | Fresh | No. buds in color |
|---|---|---|---|---|
| Ozone for 8 hours | Leading | 46 | 39 | 15 |
| None - 8 hr. control | Lady | 47 | 39 | 15 |
| Ozone for 3 hours | Spic & | 91 | 77 | 37 |
| None - 3 hr. control | Span | 85 | 59 | 50 |
| Ozone for 2 hours | Leading | 70 | 58 | 47 |
| None - 2 hr. control | Lady | 74 | 56 | 41 |

## Discussion and Conclusions

Treatment of gladiolus spikes with ozone gas appears to be safer and as effective in controlling Botrytis disease as fungicidal dips. The teatment is less expensive than dipping and the flowers are kept dry. Ozone is most active under dry, cool conditions and could be used to best advantage in an air-conditioned packing house. Several models of the "Aire-Zone" ozonator were used in these tests. Their operation and maintenance are simple and inexpensive. These and other grid-type ozonators are safely used in hospitals and homes but the open-arc type should be avoided. Methods of determining the concentration of ozone near the flowers are crude but better methods are being developed.

### LITERATURE CITED

1. Magie, R. O. and W. G. Cowperthwaite, 1954. Commercial gladiolus production in Florida. Fla. Agr. Exp. Sta. Bul. **535**:41.
2. Magie, R. O. 1956. Gladiolus Botrytis control. Proc. Fla. State Hort. Soc. **69**:337-343.
3. Magie, R. O. 1958. Progress in controlling Botrytis disease of gladiolus. Proc. Fla. State Hort. Soc. **71**:406-410.

# BREEDING GLADIOLUS FOR FLORIDA

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Gladiolus has been the important commercial cut-flower crop in Florida for 30 years. The industry boomed after the introduction of the Picardy variety in the late "thirties". When Picardy faded out with disease 10 years later, Spic and Span became the "bread and butter" variety. In recent years, Spic and Span too is losing to other varieties because of susceptibility to diseases. In spite of improved growing-techniques, flower production per acre is low because of accumulation of disease organisms in corms of the standard varieties (1). The industry needs new varieties to boost yield and quality of flowers because the average wholesale price of flowers was no higher in recent years than it was 20 to 30 years ago.

Just any new variety will not help. Although 100 or more new varieties are introduced to the trade each year, it is unusual to find one that is really useful to Florida growers. The Gulf Coast Experiment Station has been interested in finding better commercial varieties, and nearly 1000 have been tested during the past 15 years. Fewer than 20 of this number were adaptable and all of these had one or more serious faults such as mediocre flower quality and susceptibility to disease.

With but one exception the 33 varieties now grown in Florida to supply the 200,000,000 flower spikes shipped to other states each year were bred and selected in northern climates. These varieties which were selected in the long days of summer are not well adapted to growing in winter (2). The breeding being done in other states and countries is largely for flower-show competition rather than commercial use. Furthermore, these breeding programs do not include selection for resistance to all diseases found in Florida. Some of the seedling discards from northern breeding plots proved to be good commercial varieties for Florida and a program of testing some of those discards is now in progress. Eleven years ago a breeding program was initiated to supplement the variety trials.

## Program of Work 1949-52

The varieties used in the early years of the breeding program were chosen for adaptation to Florida commercial production. Selections of progenies from these varieties were made

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with the following "ideal" gladiolus in mind: 1) Straight, tall stem with six or more open florets of about 5 inch diameter and of pleasing proportions and conformation. (The flower spike of Spic and Span variety approaches the ideal), 2) Spikes that open 12 or more florets from a tight-bud cut, 3) Low-branching, wide leaves which make possible a low stem-cut without loss of the four lower leaves, 4) Clean petals of good substance and clear colors, 5) Throat color absent, self color, or contrasting in pleasing proportions, 6) Spikes that do not "burn" in drying weather, 7) Spikes that do not crook or blow down easily, 8) Two large spikes per corm, 9) Cormels that germinate and grow vigorously, 10) Disease-resistant plants.

The usual methods of artificial pollination were used, including the removal of stamens from seed parent, placing pollen of known source on its pistil and tagging the flower with the record. Riciprocal crosses were usually made.

The young plants in the seed beds were extremely susceptible to diseases caused by the important fungus pathogens, *Botrytis gladiolorum* Timm. and *Curvularia trifolii* (Kauff.) Boed. Fungicidal sprays were therefore applied until the seedlings were four to five months old, after which diseases were allowed to progress or were fostered by artificial inoculations. Subjection of seedlings to the soil pathogens, *Fusarium oxysporum f. gladioli* Snyder & Hansen and *Stromatinia gladioli* (Drayt.) Whet., was delayed until enough corms of a clone were available to test part of them on heavily infested soil. All corms from the infested soil were discarded so that new varieties would not be contaminated with the Fusarium fungus.

Since no varieties combined all of the desired traits, crosses were made usually between a variety which might be weak in a certain trait and one which was strong in that trait. Blue flowers, immunity to Botrytis disease, and better flower quality for shipping were not found in any variety. Since these and other desirable traits may be determined largely by recessive genes, a program of inbreeding was begun with the purpose of revealing such recessive traits.

## Program of Work 1953-1957

Beginning in 1953 at least 2000 flowers of outstanding seedling varieties were self-pollinated each year until 1957. Seedlings were subjected to diseases and the survivors were selected on the basis of good flower traits for further selfing. By 1957 only 22 third generation inbreds (selfed clones) were saved. Most of the inbred seedlings lost the ability to produce viable pollen or to set seed by the second generation of inbreeding and much vigor was lost.

After 1956 inbreds were crossed in various combinations. Resulting hybrid vigor was outstanding but no new traits were found. The loss of nearly 90 percent of the seedlings to freezing and Botrytis disease in 1957-58 and the finding of field immunity to Botrytis infection opened a new program of breeding.

## Program of Work Since 1957

After 1957 no fungicidal protection has been given in the seed bed. About 96 percent of the seedlings were killed by the fungi, *B. gladiolorum* and *C. trifolii.* Therefore, the breeding program was revised and enlarged to produce about 30 times more seed than was grown in any previous year. The population of survivors has been kept large enough to insure a good chance of finding desirable horticultural traits as well as disease resistances in the main color groups.

Crossing of selected individual flowers is not done. Pollen from like-colored varieties is bulked in color groups of white, yellow, pink, red and lavender. The mixed pollen, taken largely from single plant selections and special breeding stock is generally placed on varieties in the same color group. Sometimes pollen from flowers of all colors is mixed to allow for better combinations of genes and to avoid the elimination of valuable traits in any color grouping.

Seed is planted in ground beds early in October. Weeds are controlled by preplanting soil treatment with Mylone and allyl alcohol. A water-solution of fertilizer is applied every week in wet weather and twice monthly in dry weather. The beds are kept moist at all times. About 10 percent of the seedlings bloom in May and June and the corms are dug in June or July. The cormels are planted in November in an area with little frost protection for the purpose of selecting cold-resistant plants. The corms are planted in a frost-protected area for selection of desirable flowers and other traits. Outstanding plants are saved for use as pollen parents and for possible introduction as commercial varieties.

A seedling variety that is better than any other in its color class is then tested on commercial farms. A stock of 50,000 large corms is desirable before releasing a new variety.

## Results

The selection and testing of seedlings has revealed unexpected and valuable traits which may be incorporated in future varieties. These traits are: 1) Less sensitivity to temperature changes, 2) Cold resistance of flowers, 3) Resistance to nematode damage, 4) Tolerance to prolonged holding in cold storage and 5) Lack of dormancy in corms.

A very vigorous and productive pink variety, Florida Pink (3), was introduced to supplement the Picardy and Spic and Span varieties. Florida Pink is better than Picardy in disease resistance and better than Spic and Span in tolerance of flowers to cold storage. Cormel production and growth are excellent. Several other seedling selections are now being propagated for possible use in cut-flower production.

A less obvious but more important result of the gladiolus breeding work is the stock of seedling lines being used as parents. An increasing proportion of disease-resistant selections adapted to commercial flower production has been found each year of the program. High resistance to Botrytis disease was an unexpected dividend. Several hundred seedlings with field immunity to Botrytis were selected in 1960, and incorporation of this resistance in future varieties is practically assured.

Incorporation of resistance to most gladiolus strains of *Curvularia trifolii* is also certain because susceptible seedlings are quickly eliminated by the fungus in the seedbed. The fungus is commonly carried on the seed as a contaminant and grows readily through the treated soil, killing the seedlings as a "damp-off" disease.

## Discussion of Results

Varieties adapted to the short days of winter provide two valuable benefits: Longer spikes and better quality. Bud rot, a disorder caused by calcium deficiency induced by rapid flower growth, is not found in growing seasons of longer days but has damaged northern-bred varieties growing in Florida. Varieties such as Picardy, Spotlight, June Bells and Spic and Span that flower in 85-95 days in northern gardens often flower in 60-75 days under short daylight conditions. Bud rot and similar physiological disorders have not been seen on varieties adapted to winter culture.

Varieties that are relatively insensitive to changes in temperature are badly needed. The present commercial varieties are unduly retarded by cool weather and accelerated by warm weather, resulting in alternating market scarcities and gluts. Later varieties, that produce a flower in 100 days or more, are less responsive to temperature changes. The use of late varieties, although costing somewhat more to grow, will result in less fluctuation of supply, more uniform quality of flowers, and practical control of calcium deficiency of buds. The production of such late-maturing, non-forcing varieties may be the most important achievement of the gladiolus breeding work.

As frost-protected lands become less available, the need of finding cold-resistant varieties increases. All varieties in commercial production are adversely affected by cold weather, though temperatures remain above freezing. Flower production is reduced both in quantity and in quality, since cold weather causes "blind" plants as well as short spikes. Cold weather did not affect some seedlings in this manner and some resisted temperatures as low as 26°F without damage. Selection of such plants is an important part of the breeding program.

High resistance or field immunity to all of the important diseases except *Stromatinia gladioli* have been found in certain seedlings. Breeding for resistance to Fusarium disease is complicated by the many strains of the fungus and the fact that testing for resistance must be delayed. Fortunately, the use of resistant parent varieties results in a small percentage of highly resistant seedlings. Resistance of roots to Stromatinia and Fusarium infection is tested in the same soil. Little effort has been expended in selecting for resistances to *Septoria gladioli* Pass, *Stemphylium* sp., or bacteria.

Selection of resistance to nematodes is difficult because the roots should be examined before the corm is mature, thus destroying the plant. Large differences have been found among seedlings in susceptibility to nematodes. Earliness of flowering is often accociated with extreme susceptibility, while late maturity and vigor of plants are often associated with resistance to nematodes.

SUMMARY

Some of the valuable traits found in the gladiolus breeding stock are resistances or immunity to *Botrytis gladiolorum, Fusarium oxysporum f. gladioli, Curvularia trifolii,* and *Stemphylium* sp.; resistance to cold weather; and flowering adaptation to short winter days. Many seedling selections, which are outstanding for disease resistance, color, size, vigor and other traits valuable in commercial production of cut flowers for long-distance shipping, are being propagated for further evaluation and testing. One variety, Florida Pink, was released to Florida growers in 1958.

LITERATURE CITED

1. Magie, R. O. Some fungi that attack gladiolus. U.S.D.A. Yearbook of Agr. for 1953, pp. 601-607, 1954.

2. ——————. Breeding gladiolus for disease resistance. Proc. Fla. State Hort. Soc. 64:210-212. 1951.

3. ——————. Florida Pink, a new gladiolus variety for Florida. Fla. Agr. Exp. Sta. Circ. S-113. 1958.

# THE EFFECT OF PERIODS OF LONG DAYS AND LEVELS OF FERTILIZATION ON CHINA ASTER, CALLISTEPHUS CHINENSIS, 'ALL SAINTS'

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The China aster, *Callistephus chinensis,* could be of commercial importance in Florida as a potted plant for production between crops of chrysanthemums. Previously, aster wilt and aster "yellows" have prevented large scale production of this crop, however, new resistant strains have largely resolved the disease problem.

Asters are normally classified as long day plants (4). However, research indicates that asters will flower under short day conditions but will produce small, stunted plants of little commercial value (3). Beibel (1) stated that China asters will flower at high temperatures even on the shortest daylengths of the year, but stems produced are short and thus long photoperiods are necessary for development of normal growth habit. Post (5) proved that plants under long day treatment produced greater plant diameter and height than did plants grown under short days. Laurie and Foote (2) reported that a reduction in number of long day photoperiods induced earliness in a number of varieties along with shorter stems and slightly smaller flowers. Beibel (1) cited work by Richmond where long day photoperiods had the greatest effect 18-45 days after aster seeds germinated. Lin and Watson (3) found floral initiation to occur 15 days earlier under high temperature (65°) and long days than high temperature and short days, and 30 days earlier at low temperature (50°) long days than low temperature short days. It appears, therefore, that by manipulating day lengths it is possible to produce potted specimens of China asters having proper height, diameter and degree of flowering.

The present investigation was established to determine the effect of various durations of long days and levels of fertilization on the subsequent vegetative growth and floral development of Chinese asters in an effort to produce a plant of proper proportion and flowering habit for commercial purposes.

## METHODS AND MATERIALS

An experiment was established on November 19, 1959, at the University greenhouse range on Archer Road to determine the effect of different periods of long day treatment and levels of fertilization on the growth and flowering of *Callistephus chinensis,* 'All Saints'.

Seeds were planted November 12, 1959. On November 19 the plants were removed from seed flats, transferred to 3 inch organic pots and long day treatments of 15 hours initiated. Plants were transferred to three-quarter size 4" plastic pots on December 18, 1959.

A split-plot design was utilized to combine 3 periods of long days – 7 ($L_1$), 10 ($L_2$), and 13 weeks ($L_3$) – 3 levels of fertilizer at the rate of 2 ($F_1$), 4 ($F_2$) and 8 ($F_3$) pounds as the equivalent of an 8-0-8 analysis fertilizer per one hundred square feet of soil and two color types of 'All Saints' asters—white and rose. The main plots consisted of light treatments, while fertilizer levels and phenotypes were factorially combined within the sub-plots. Two pots—one plant per pot—made up the experimental unit and each treatment was replicated six times.