# EFFECTS OF LEVELS OF CALCIUM AND IRON AND SOURCES OF PHOSPHORUS ON GROWTH AND LEAF COMPOSITION OF *CHRYSANTHEMUM MORIFOLIUM* 'ICEBERG'

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## *INTRODUCTION*

Use of artificial media has expanded in the past decade as the need for light weight, consistent and readily available potting materials has developed. The need to reduce production and shipping costs at a time of increasing scarcity of good locally available potting soil has spurred the search for suitable substitutes.

Artificial media vary widely in their physical and chemical properties depending upon amount and source of organic matter, calcined clay, perlite, sand or other materials used. Growers must adapt their fertilization practices to the medium being used. Basic fertilization practices have been established for some of these media (1, 3 and 5) but micronutrient deficiencies (which are common on high organic soils) have not been fully investigated.

## *REVIEW OF LITERATURE*

DeWerth and Odom (4) worked with several ornamental greenhouse crops, including chrysanthemums, in media containing sphagnum peat moss and perlite and reported excellent results. Their fertilization program included chelated iron. Boodley and Sheldrake (3) recommended sphagnum peat moss mixed half and half by volume with either perlite or vermiculite, but did not mention need for iron fertilization. Neither did Baker (1) mention Fe fertilization being necessary with peat and sand mixtures.

Several hypotheses concerning causes of iron deficiency are summarized by Thorne et al (9). These include high levels of calcium, phosphorus, pH and soil moisture, low and high temperatures and Fe/Mn ratio. Brown et al (4) used a split-root technique in which soybean plants were grown in soil with sufficient iron for normal growth while some roots were permitted to grow down thru a wire screen into different nutrient solutions. They found iron was internally inactivated in soybean primarily due to combined effects of P and Ca. Calcium stimulated root growth thus increasing absorption and translocation of P and Ca but decreasing absorption and translocation of Fe in the presence of P.

Taper and Leach (8) found increasing Ca narrowed the optimum Fe/Mn range in solution culture. A Fe/Mn ratio of 0.5 to 5.0 produced healthy dwarf kidney bean plants with 42 ppm Ca in

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solution but raising the Ca level to 143 ppm narrowed the Fe/Mn range for healthy plants to 2.0. Fe/Mn ratios below the optimum range resulted in Fe deficiency symptoms and above it in Mn deficiency symptoms.

Waters (10) found 3.0 gm 20% superphosphate to a 6" azalea pot, mixed into the soil prior to planting was insufficient for normal chrysanthemum growth. Three grams of superphosphate in split applications was satisfactory, but 4.5 gm was better. He reported a minimum of 0.13 to 0.15 percent P in leaves of chrysanthemum at maturity necessary for normal growth.

Metal ammonium phosphates and coated fertilizers have been described by Kofranek and Lunt (6) as capable of supplying nutrients over extended periods sufficient to produce quality potted chrysanthemums. The materials may be incorporated or top dressed in one initial application.

An experiment thus was devised to apply all fertilizer nutrients in one application utilizing several sources of phosphorus, with varying levels of calcium and iron in an artificial medium.

## *METHODS AND MATERIALS*

A factorial experiment in randomized block design with 4 replications was initiated August 8, 1963 to determine effects of three levels of Ca and Fe, and three sources of P on growth and flowering of *Chrysanthemum morifolium* 'Iceberg', a tall white pompon variety. Four rooted cuttings per 6 inch clay azalea pot constituted the experimental unit.

The experiment was located under saran (20% shade) at the Florida Agricultural Experiment Station Horticultural Unit, 8 miles northwest of the university campus.

Treatments consisted of 0.65 gm ($Ca_1$), 1.30 gm ($Ca_2$) and 1.95 gm ($Ca_3$) Ca per pot in the form of calcium sulfate; 0 gm ($Fe_1$), 0.006 gm ($Fe_2$) and 0.052 gm ($Fe_3$) Fe per pot in the form of ferrous ammonium phosphate; and 1.0 gm $P_2O_5$ in the forms of magnesium ammonium phosphate ($P_1$, 20% superphosphate ($P_2$) and low leach coated treble superphosphate (P3)[2]. In addition 0.786 gm Ng as magnesium sulfate, 1.0 gm N and 1.45 gm $K_2O$ as low leach coated materials were added per pot. Table 1 shows amounts of fertilizers added for each treatment. These were adjusted to compensate for the additional N and P contained in Fer-Amp and Mg and N in Mag-Amp so that each pot received the same amount of N, P, an Mg.

All fertilizer treatments were applied as topdress 4 days after potting cuttings [3]. An artificial potting mixture of 1½ bales shredded

1 Magnesium ammonium phosphate (Mag-Amp) and ferrous ammonium phosphate (Fer-Amp) supplied by W. R. Grace & Co.

2 Lop leach coated materials furnished by Archer Daniels Midlan Co.

3 Rooted cuttings donated by California-Florida Plant Corp., Stuart, Fla

TABLE. 1. *SOURCES AND AMOUNTS OF FERTILIZERS USED IN TREATMENTS*

| Treatment | | | | Fertilizer added (grams/pot) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $CaSO_4$ $2H_2O$ | Low Lecah Coated K | Fer-Fer- | Low Leach Coated N | Mag-Amp | 20 % Super-Phosphate | Low Leach Coated P | $MgSO_4$ $-7H_2O$ |
| 1 | Ca1 | Fe1 | P1 | 2.81 | 2.68 | 0 | 5.06 | 2.50 | | | 4.4 |
| 2 | Ca1 | Fe1 | P2 | 2.81 | 2.68 | 0 | 5.26 | | 5.00 | | 8.1 |
| 3 | Ca1 | Fe1 | P3 | 2.81 | 2.68 | 0 | 5.26 | | | 2.22 | 8.1 |
| 4 | Cal | Fe2 | P1 | 2.81 | 2.68 | .02 | 5.06 | 2.48 | | | 4.4 |
| 5 | Ca1 | Fe2 | P2 | 2.81 | 2.68 | .02 | 5.26 | | 4.96 | | 8.1 |
| 6 | Ca1 | Fe2 | P3 | 2.81 | 2.68 | .02 | 5.26 | | | 2.20 | 8.1 |
| 7 | Ca1 | Fe3 | P1 | 2.81 | 2.68 | .20 | 5.05 | 2.32 | | | 4.6 |
| 8 | Ca1 | Fe3 | P2 | 2.81 | 2.68 | .20 | 5.25 | | 4.65 | | 8.1 |
| 9 | Ca1 | Fe3 | P3 | 2.81 | 2.68 | .20 | 5.25 | | | 2.04 | 8.1 |
| 10 | Ca2 | Fe1 | P1 | 5.6 | 2.68 | 0 | 5.06 | 2.50 | | | 4.4 |
| 11 | Ca2 | Fe1 | P2 | 5.6 | 2.68 | 0 | 5.26 | | 5.00 | | 8.1 |
| 12 | Ca2 | Fe1 | P3 | 5.6 | 2.68 | 0 | 5.26 | | | 2.22 | 8.1 |
| 13 | Ca2 | Fe2 | P1 | 5.6 | 2.68 | .02 | 5.06 | 2.48 | | | 4.4 |
| 14 | Ca2 | Fe2 | P2 | 5.6 | 2.68 | .02 | 5.26 | | 4.96 | | 8.1 |
| 15 | Ca2 | Fe2 | P3 | 5.6 | 2.68 | .02 | 5.26 | | | 2.20 | 8.1 |
| 16 | Ca2 | Fe3 | P1 | 5.6 | 2.68 | .20 | 5.05 | 2.32 | | | 4.6 |
| 17 | Ca2 | Fe3 | P2 | 5.6 | 2.68 | .20 | 5.25 | | 4.65 | | 8.1 |
| 18 | Ca2 | Fe3 | P3 | 5.6 | 2.68 | .20 | 5.25 | | | 2.04 | 8.1 |
| 19 | Ca3 | Fe1 | P1 | 8.4 | 2.68 | 0 | 5.06 | 2.50 | | | 4.4 |
| 20 | Ca3 | Fe1 | P2 | 8.4 | 2.68 | 0 | 5.26 | | 5.00 | | 8.1 |
| 21 | Ca3 | Fe1 | P3 | 8.4 | 2.68 | 0 | 5.26 | | | 2.22 | 8.1 |
| 22 | Ca3 | Fe2 | P1 | 8.4 | 2.68 | .02 | 5.06 | 2.48 | | | 4.4 |
| 23 | Ca3 | Fe2 | P2 | 8.4 | 2.68 | .02 | 5.06 | | 4.96 | | 8.1 |
| 24 | Ca3 | Fe2 | P3 | 8.4 | 2.68 | .02 | 5.26 | | | 2.20 | 8.1 |
| 25 | Ca3 | Fe3 | P1 | 8.4 | 2.68 | .20 | 5.05 | 2.32 | | | 4.6 |
| 26 | Ca3 | Fe3 | P2 | 8.4 | 2.68 | .20 | 5.25 | | 4.65 | | 8.1 |
| 27 | Ca3 | Fe3 | P3 | 8.4 | 2.68 | .20 | 5.25 | | | 2.04 | 8.1 |

sphagnum moss to 1 bag horticultural grade perlite was used. Watering was automatic using the Chapin system controlled by a platform scale. Plants were shaded with black sateen cloth from 4:30 p. m. to 8:15 a. m. beginning 4 days after potting, and pinch was delayed 1 week after shading to shorten plants. Each plant was pruned to 3 laterals making 12 stems per pot. Plants were sprayed twice weekly for disease and insect control.

Two plants from each pot were harvested October 22, 1963 and leaves removed for tissue analysis and leaf color. Remaining plants were harvested individually as flowers matured beginning October 24 and growth measurements taken. Days until bloom were measured from the beginning of the experiment to time of treatment termination. Plant height was measured in centimeters (cm) from top of the pot to top of the tallest flower in the pot. Total number of flowers, including buds showing color, were counted multiplied by two Diameters of the three largest flowers on one stem per pot were measured in cm.

## RESULTS

*Growth measurements.* Treatments had no effect on flower diameter or number of flowers per pot, but plants receiving phosphorus in the form of 20% superphosphate were much taller, while those receiving the coated material were much smaller than those receiving Mag-Amp (Table 2). The use of Mag-Amp shortened the number of days to bloom compared to all but the highest level of Fe (Table 3 and Fig. 1).

*Leaf composition.* Levels of Fe had no effect on leaf color or chemical composition. Plants receiving 20% superphosphate were lower in N and K, and higher in Ca and Mg than those receiving other forms of P (Table 2). The coated form was least available and Mag-Amp most available as judged by percent leaf P at termination of experiment.

Levels of Ca had no effect on leaf composition except leaves receiving $Ca^1$ had less Ca than those receiving the other 2 levels (Table 2). Leaf color was lighter at $Ca^3$ than at other levels of Ca but no chlorosis was visible.

[4] Half of the plants were previously removed for tissue analysis

TABLE 2. SIMPLE EFFECTS OF LEVELS OF CALCIUM AND SOURCES OF PHOSPHORUS ON GROWTH AND LEAF COMPOSITION OF *CHRYSANTHEMUM MORIFOLIUM* 'ICEBERG

| Treatment | Height (cm) | Leaf Color* | Leaf Composition N | P | K | (% Dry Weight) Ca | Mg | Fe |
|---|---|---|---|---|---|---|---|---|
| $P_1$-Mag-Amp | 44.10 | 85.97 | 3.29 | 0.38 | 2.48 | 1.14 | 0.50 | 0.069 |
| $P_2$-Superphosphate | 46.20 | 85.61 | 3.09 | 0.33 | 2.21 | 1.46 | 0.55 | 0.065 |
| $P^3$-Coated TSP | 42.23 | 85.57 | 3.28 | 0.27 | 2.68 | 1.21 | 0.40 | 0.068 |
| L. S. D. .05 | 1.24 | N. S. | 0.11 | 0.02 | 0.24 | 0.07 | 0.04 | N. S. |
| .01 | 1.64 | N. S. | 0.14 | 0.03 | 0.32 | 0.09 | 0.05 | N. S. |
| $Ca_1$ - 0.65 gm | 44.38 | 86.11 | 3.19 | 0.33 | 2.36 | 1.21 | 0.48 | 0.068 |
| $Ca_2$ - 1.30 gm | 44.19 | 86.04 | 3.22 | 0.33 | 2.47 | 1.28 | 0.48 | 0.067 |
| $Ca^3$ - 1.95 gm | 43.96 | 85.57 | 3.24 | 0.32 | 2.54 | 1.33 | 0.48 | 0.067 |
| L. S. D. .05 | N. S. | 0.46 | N. S: | N. S. | N. S. | 0.07 | N. S. | N. S. |
| .01 | N. S. | 0.62 | N. S. | N. S. | N. S. | 0.09 | N. S. | N. S. |

* % light absorbed equals 100 minus reflected light reading.

TABLE 3. EFFECTS OF LEVELS OF IRON AND SOURCES OF PHOSPHORUS ON DAYS TO BLOOM OF *CHRYSANTHEMUM MORIFOLIUM* "ICEBERG"

| Levels of Iron | Mag-Amp | superphosphate (Sources of Phosphorus) | Coated TSF | Means Iron Level |
|---|---|---|---|---|
| $Fe_1$ 0.000 gm | 81.67 | 85.58 | 86.33 | 84.53 |
| $Fe_2$ - 0.006 gm | 79.75 | 86.83 | 86.75 | 84.44 |
| $Fe^3$ - 0.052 gm | 84.75 | 86.08 | 83.58 | 84.80 |
| Level Means | 82.06 | 86.17 | 85.56 | |

| L. S. D. | .05 | .01 |
|---|---|---|
| Between iron and phosphorus means | 1.89 | 2.50 |
| Between means within table | 3.27 | 4.34 |

## DISCUSSION

An attempt was made to balance all macro-nutrients and Fe in the fertilizers used, so only levels of Ca and Fe would vary according to treatment. Unfortunately, the calcium in 20% superphosphate was overlooked. This superphosphate contains 28.6% CaO (7) or approximately 20% Ca in the form of gypsum which added 1.0 gm. Ca to the $P_2$ treatments. This was 50% greater than increments between levels of Ca used in this experiment. If the increased Ca in superphosphate was responsible for increased absorption of Ca and Mg and decreased absorption of N and K at the $P^2$ treatment then the percent N, K, Ca and Mg for treatments $Ca_1$, $P_2$ (0.65 / 1.00 gm Ca) should lie between that obtained with $Ca^2$, $P_1$ or $P_3$ and $Ca^3$, $P_1$ or $P_3$ (1.30 and 1.95 gm Ca respectively). This did not occur (Table 4) nor did Ca have any effect on percent N, K or Mg in leaves (Table 2).

By the same argument sulfur could be eliminated since it was contained in the superphosphate as the sulfate of Ca (gypsum).

The exact reason for the changes in leaf composition when superphosphate was used, are not apparent from the data taken.

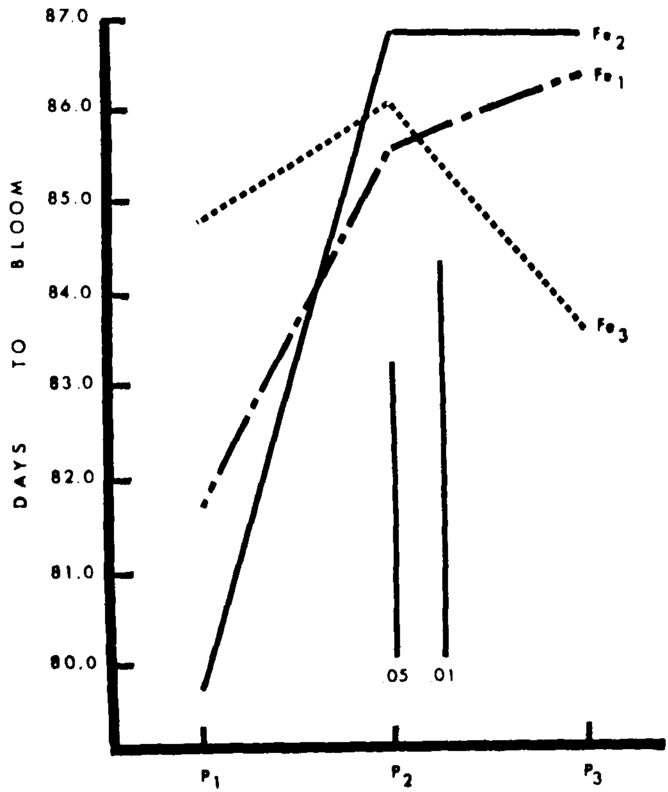


Fig. 1. Effects of levels of iron and sources of phosphorus on days to bloom of *Chrysanthemum morifolium* 'Iceberg'.

TABLE 4. COMPARISON OF PHOSPHORUS SOURCES AT DIFFERENT LEVELS OF CALCIUM ON PERCENT OF NITROGEN, POTASSIUM, CALCIUM AND MAGNESIUM IN LEAVES OF *CHRYSANTHEMUM MORIFOLIUM* 'ICEBERG'

| Calcium Levels | Sources of Phosphorus Mag-Amp $P^1$ | Superphosphate $P^2$ | Coated TSP $P^3$ |
|---|---|---|---|
| *% N* | | | |
| $Ca^1$ - 0.65 gm | 3.23 | 3.10 | 3.24 |
| $Ca^2$ - 1.30 gm | 3.27 | 3.11 | 3.29 |
| $Ca^3$ - 1.95 gm | 3.35 | 3.08 | 3.29 |
| *% K* | | | |
| $Ca^1$ - 0.65 gm | 2.44 | 2.16 | 2.47 |
| $Ca^2$ - 1.30 gm | 2.41 | 2.19 | 2.80 |
| $Ca^3$ - 1.95 gm | 2.59 | 2.27 | 2.76 |
| *% Ca* | | | |
| $Ca^1$ - 0.65 gm | 1.10 | 1.45 | 1.08 |
| $Ca^2$ - 1.30 gm | 1.12 | 1.44 | 1.27 |
| $Ca^3$ - 1-95 gm | 1.20 | 1.50 | 1.28 |
| *% Mg* | | | |
| $Ca^1$ - 0.65 gm | 0.50 | 0.56 | 0.38 |
| $Ca^2$ - 1.30 gm | 0.50 | 0.53 | 0.41 |
| $Ca_3$ - 1.95 gm | 0.51 | 0.55 | 0.40 |

The lack of growth and nutrient absorption response to levels of Fe, and the fact that $Fe_1$ plants (no iron) contained as much leaf Fe as $Fe^2$ and $Fe^3$ would indicate iron was supplied by some external agency. A test for iron in the irrigation water showed no trace. therefore, the source was probably new clay pots wich had not been used previously. Clay pots are often an excellent source of micronutrients depending upon the clay used.

Excessive N or deficient P have been known to delay maturity of many crops (2). There was no difference in leaf N between plants fertilized with Mag-Amp or coated treble superphosphate although significant differences in days to bloom existed. Increasing Fe offset the early flowering obtained with Mag-Amp. Also P was highest in the Mag-Amp fertilized plants. Since none of the plants were deficient in P the effect that Mag-Amp had on earliness to bloom was probably due to increased P availability early in the plants growth which may have been counteracted at the high level of Fe by precipitation as iron phosphate.

## *CONCLUSIONS*

The use of slow realease fertilizer materials deserves careful consideration.

Where clay pots are used, or calcined clay added to the artificial medium, no additional source of iron may be needed.

## *SUMMARY*

A factorial experiment in randomized block design was initiated to determine effects of 3 levels of Ca and Fe and 3 sources of P on growth and flowering of *Chrysanthemum morifolium* 'Iceberg' in artificial medium.

All fertilizer was added as top dress at the beginnings of the experiment.

Levels of Fe and Ca had little effect of growth or leaf composition. while sources of P were largely effective. Probable causes of these results are discussed. The use of slow release fertilizer materials in one application appears practical from a horticultural point of view.

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