der spikes in areas where sprinkler nozzles had openings of ⅛ inch. Figure 3 shows that protection on the calm night of February 5-6 was sufficient at station No. 13, receiving water from at least two sprinklers having ⅛ inch nozzles. Protection was 3° better at No. 9 where nozzle openings were 5/32 inch. This extra margin of safety will be required at times, particularly on cold windy nights such as depicted in Figure 1.

It was concluded that sprinklers should be turned on when air temperature reaches 32° and is expected to drop to critical levels during the night. It is necessary that liquid water be on the fern at all times since it is the latent heat of fusion that supplies heat to the plants. This was accomplished in these experiments where the nozzle openings of the sprinklers were 5/32 inch, the rotation rate was one rotation per minute, and the plants received water from at least two sprinklers. If liquid water is not on the fern at all times, the fern temperature can fall below its critical value. This is what happened at thermocouple No. 13 on January 30 (Fig. 1). Further, it is important that once begun, sprinkling should not be stopped unless there is positive evidence that no threat of danger to the fern exists. Other studies have shown that when sprinkling is stopped after plants are coated with ice, damage may be more severe than if they had not been sprinkled (4), (6).

In the past, many growers have let their sprinklers run until all ice had melted or at least until the ambient temperature had reached the forties or fifties outside the fernery.

A better criterion for stopping the sprinkling would be the wet bulb temperature. When this temperature becomes greater than 32° F, the sprinklers can be safely turned off. Lacking the instrument to obtain wet bulb temperatures, sprinklers can be safely turned off when the air temperature is several degrees above freezing and ice is observed to be melting in shaded areas.

Within the limits of the weather conditions experienced during the winters of 1964-65 and 1965-66, data from the Pierson experiment indicate that fern can be effectively protected against frost and freeze damage by the proper use of correctly chosen and correctly installed sprinklers. Observations of results in other ferneries using this method of protection confirm this conclusion.

REFERENCES

1. Businger, J. A. 1963. **Frost Protection with Irrigation.** Mimeo paper presented at 5th National Conference Agricultural Meteorology, Lakeland, Florida.

2. Dean, Rollo H. 1952. **Critical Temperature and Heating of Fern.** Mimeographed report, Federal-State Frost Warning Service, Lakeland, Florida.

3. ———————. 1965. **Preliminary Report on Use of Water Sprinklers for Protection of Fern Against Freeze Damage.** Weather Forecasting Mimeo WEA 65-13, Federal-State Frost Warning Service, Lakeland, Florida.

4. ———————. 1963. **The Use of Water Sprinklers for Protection of Citrus Nursery Trees Against Freeze Damage.** Citrus Industry, Vol. 44, No. 3.

5. Garber, J. F. and D. S. Harrison. 1964. **Sprinkler Irrigation for Cold Protection of Citrus.** Transactions of the ASAE, Vol. 7, No. 4, pp. 464-468.

6. ——————— and J. D. Martsolf. 1965. **Protecting Citrus From Cold Damage.** Circular 287, Agricultural Experiment Stations, University of Florida, Gainesville, Florida.

7. Sherouse, Ray T. 1939. **Frost Protection of Ferns by Sprinkler Irrigation.** Monthly Weather Review, U.S. Weather Bureau, Vol. 67, No. 3: 61-62.

8. Smith, Cecil M., Donald L. Brooke and TZE I. Chiang. 1962. **Marketing Florida Ferns.** Bulletin No. 647, Agricultural Experiment Stations, University of Florida, Gainesville, Florida.

GARBAGE COMPOST AS A POTENTIAL SOIL COMPONENT IN PRODUCTION OF CHRYSANTHEMUM MORIFOLIUM 'YELLOW DELAWARE' AND 'OREGON'

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ABSTRACT

Two 6 x 3 factorial experiments were initiated to test effects of media and fertilizer levels on growth and composition of 2 chysanthemum varieties. Media consisted of all garbage compost, garbage compost-sand, peat-sand, shredded pine bark-sand and garbage compost-vermiculite in 1:1 by volume mixtures and garbage compost-sand ⅓:⅔ by volume combination. N and K were supplied at rates of 200, 400 and 800 pounds per acre each during the experiments.

Growth measurements included average diameter of the 4 largest flowers per pot, growth index $\frac{(\text{height} + \text{width})}{2}$, in cm. total number of flowers per pot showing color, analyses of mid-section leaf tissue for N, P, K, Ca and Mg,

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and soil analyses for P, K, Ca, Mg, soluble salts, cation exchange capacity, percent drainable pore space and percent maximum water content.

Generally, addition of garbage compost to media increased number of flowers per pot and decreased time of flowering. Increasing fertilizer levels increased flower diameter with both varieties, but increased flower number only with 'Oregon.'

INTRODUCTION

Container growing of plants present special problems of watering, fertilizing and handling not common to field production. Frequent heavy watering of restricted soil volumes causes severe leaching, necessitating selection of media components to maintain high water and aeration relationships and be retentive of nutrients. Media must also be lightweight to reduce handling and shipping costs and be readily available and economical.

Considerable research has been accomplished on container soil mixes in recent years (11). Peat moss has been a main ingredient of most container mixes, but is becoming less available, more expensive and more variable. Growers and researchers are, therefore, searching for other organic materials that are relatively inexpensive but contain the desirable properties of peat. Recent work by the authors (1, 7, 8) on shredded pine bark as a medium component has indicated its potential use in container growing of ornmamentals. They also found that cation exchange and water-holding capacities of shredded pine bark are similar to peat.

Recent developments in controlled decomposition of municipal refuse have made available large quantities of plant and animal compost which appears to have many properties common to peat. Products presently being marketed contain approximately 0.5 percent each of N, P and K, lesser amounts of S, Ca and Mg and includes Zn, Cu, B and Fe.

Much information has been published on use of composts in plant production, but little can be utilized since garbage compost used in this experiment was different from previously available materials. Composting normally requires 6 to 12 months before fresh materials are sufficiently decomposed for use, but the process recently developed decomposes raw garbage to compost within 3 weeks.

Work by De Groote (2, 3) has shown composted town refuse to be an acceptable field soil amendent if used at a rate of 25 to 30 percent by volume. Many plants, including chrysanthemums, responded favorable to garbage compost in tests where compost contained 0.52-0.65% N, 0.42-0.50% P_2O_5, 0.23-0.31% K_2O, 2.59-3.8% CaO and 0.15-0.25% MgO.

Objectives of this investigation were to determine feasibility of using garbage compost as a soil amendment in production of chrysanthemums and to acquire information on chemical and physical charactertics of such mixes.

METHODS AND MATERIALS

Two 6 x 3 factorial experiments were initiated to test effects of media and fertilizer levels on growth and composition of 2 chrysanthemum varieties. Media consisted of all garbage compost[2] (M_1), garbage compost-sand (M_2), peat-sand (M_3), shredded pine bark-sand (M_4) and garbage compost-vermiculite (M_5) in 1:1 by volume mixes and garbage compost-sand (M_6) in a ⅓:⅔ by volume combination. N and K from ammonium nitrate and potassium nitrate were supplied at rates of 200, 400 and 800 ppa during the experiment. Treatments were placed in randomized block design in a clear glass greenhouse and replicated 4 times with one 6-inch clay pot containing 4 plants constituting the experimental unit. 'Yellow Delaware' was used for Experiment 1 and 'Oregon' for Experiment 2. During the experimental period pots of 'Oregon' in the peat-sand medium were pilfered, and therefore this experiment was analyzed statistically as a 5 x 3 factorial with medium M_3 eliminated. Each medium received 3 pounds of superphosphate and 8 pounds of dolomite per cubic yard at time of mixing.

Rooted chrysanthemum cuttings[3] were potted January 1, 1966 and lighted for 1 week after which short day conditions were begun. Plants were pinched January 24 and fertilizer treatments initiated January 18 and applied weekly thereafter until March 21.

Measurement of treatment effects included average diameter of the 4 largest flowers per pot, growth index $\frac{\text{(height + width)}}{2}$, in centimeters, total number of flowers per pot showing

[2]Processed garbage compost was supplied by the International Disposal Corporation, St. Petersburg, Florida.

[3]Chrysanthemum cuttings were supplied by the California-Florida Plant Corporation.

Table 1. Simple Effects of Media and Fertilizer Levels on Growth Responses and Chemical Composition of Pot-Grown Chrysanthemum morifolium 'Yellow Delaware'

Media and Fertilizer Treatments		Days Delay In Flowering	Flower Diameter	Growth Index	Number Flowers	% Tissue N	% Tissue P	% Tissue Ca	% Tissue Mg
M_1 - Garbage Compost		2.5	10.6	34.8	17.3	5.0	0.28	0.67	0.40
M_2 - Garbage Compost - ½ Sand		0.2	11.6	35.5	17.0	4.6	0.36	0.83	0.52
M_3 - ½ Peat Moss - ½ Sand		5.7	11.5	39.8	15.5	4.5	0.60	0.44	0.70
M_4 - ½ Shredded Pine Bark - ½ Sand		3.7	11.9	35.4	14.2	4.3	0.56	0.53	0.67
M_5 - ½ Garbage Compost - ½ Vermiculite		0.5	12.0	35.2	16.3	4.4	0.34	0.85	0.46
M_6 - 1/3 Garbage Compost - 2/3 Sand		0	11.9	35.9	17.8	4.9	0.38	0.72	0.38
LSD	.05	1.1	0.6	1.8	1.6	0.5	.08	.12	.09
	.01	1.5	0.9	2.4	2.2	0.6	.11	.15	.12
F_1 - 200 lbs. N and K		0.9	10.9	33.8	15.9	3.9	0.52	0.51	0.42
F_2 - 400 lbs. N and K		0.6	11.5	36.8	16.2	4.5	0.42	0.67	0.53
F_3 - 800 lbs. N and K		0	12.3	37.7	16.9	5.4	0.32	0.84	0.61
LSD	.05	0.8	0.5	1.3	NS	0.3	.06	.08	.06
	.01	NS	0.6	1.7	NS	0.4	.08	.11	.08

color and analyses of stem mid-section leaf tissue for N, P, K, Ca and Mg and soil analysis for P, K. Ca, Mg, soluble salts, cation exchange capacity (CEC), percent drainable pore space and percent maximum water content.

Results and Discussion

Addition of garbage compost to media caused earlier flowering of 'Yellow Delaware,' possibly due to rate of flower initiation and/or developments (Table 1). Treatments receiving ⅓ to ½ garbage compost by volume had fully developed flowers 3 to 5 days earlier than those in media containing no compost. Plants grown in 100% garbage compost flowered at a time intermediate between those grown in media containing no compost and those in media containing part compost.

'Oregon' was less affected by garbage compost than 'Yellow Delaware' (Tables 1 and 3) and, although both were 10-week varieties, 'Oregon' flowered at least a week later than 'Yellow Delaware.' 'Oregon' plants in garbage compost-vermiculite media developed flowers faster with those in other media containing garbage compost developing next and the bark-sand combination producing latest flower initiation or slowest development except for M_6.

Reasons for faster floral initiation and/or development with addition of garbage compost to media are not clear from the data, but flower-

Table 2. Interaction Effect of Media and Fertilizer Levels on K in Leaf Tissue of Pot-Grown Chrysanthemum morifolium 'Yellow Delaware'

Media Treatments	F_1 200 lbs. N&K	F_2 400 lbs. N&K	F_3 800 lbs. N&K
M_1 - Garbage Compost	6.2	6.0	6.2
M_2 - ½ Garbage Compost - ½ Sand	5.0	5.7	6.6
M_3 - ½ Peat Moss - ½ Sand	3.6	4.8	7.3
M_4 - ½ Shredded Pine Bark - ½ Sand	4.1	4.7	7.2
M_5 - ½ Garbage Compost - ½ Vermiculite	4.8	4.5	5.3
M_6 - 1/3 Garbage Compost - 2/3 Sand	4.7	5.7	6.3
LSD between means with table	.05	0.9	
	.01	1.3	

Table 3. Simple Effects of Media and Fertilizer Levels on Growth Responses and Chemical Composition of Pot-Grown *Chrysanthemum morifolium* 'Oregon'

Media and Fertilizer Treatments	Days Delay In Flowering	Flower Diameter	Growth Index	Number Flowers	% Tissue Ca	% Tissue N
M_1 - Garbage Compost	3.5	11.2	37.2	12.2	0.62	4.1
M_2 - ½ Garbage Compost - ½ Sand	4.0	11.5	38.1	12.7	0.71	4.0
M_4 - ½ Shredded Pine Bark - ½ Sand	7.1	11.4	40.3	10.7	0.56	3.6
M_5 - ½ Garbage Compost - ½ Vermiculite	0	11.9	39.1	11.3	0.82	4.1
M_6 - 1/3 Garbage Compost - 2/3 Sand	5.0	11.7	38.2	12.1	0.63	3.7
LSD .05	2.5	0.3	1.7	1.0	.08	0.4
.01	3.4	0.5	2.3	1.3	.11	0.6
F_1 - 200 lbs. N and K	0	11.2	36.7	11.6	0.58	3.4
F_2 - 400 lbs. N and K	2.3	11.5	39.3	11.4	0.67	3.9
F_3 - 800 lbs. N and K	2.1	11.9	39.7	12.4	0.76	4.5
LSD .05	2.0	0.3	1.3	0.8	.02	0.3
.01	NS	0.4	1.8	1.0	.03	0.4

ing time correlated with Ca in tissue of both varieties (Table 1). Garbage compost contained high levels of Ca and thus affected Ca in the tissue, and plants containing highest levels of Ca flowered earliest. Compost also contained high levels of Fe and B and these micro elements could have affected flower initiation and development. Hillman (5) stated that Fe requirements for floral induction in photoperiodically responsive plants were higher than requirements for vegetative growth only. Gaugh and Dugger (4) reported that high levels of B affected floral development and stated that highest levels of B in plant tissue usually occur in floral parts. Ca could have affected flowering indirectly by its effect on micro element absorption.

Increasing fertilizer levels delayed flowering by an average of 2 days with 'Oregon,' but reduced flowering time by approximately 1 day with 'Yellow Delaware' (Tables 1 and 3). Work by Joiner and Smith (6) and others indicate that high levels of fertilizer, especially N, delay flower development. Apparently the top level of fertilization given was sufficient to result in flower delay with 'Oregon,' but not with 'Yellow Delaware.'

Generally, with both varieties adding garbage

Table 4. Interaction Effect of Media and Fertilizer Levels on Percent P in Leaf Tissue of Pot-Grown *Chrysanthemum morifolium* 'Oregon'

Media Treatments	F_1 200 lbs. N&K	F_2 400 lbs. N&K	F_3 800 lbs. N&K
M_1 - Garbage Compost	0.28	0.20	0.22
M_2 - ½ Garbage Compost - ½ Sand	0.39	0.29	0.24
M_4 - ½ Shredded Pine Bark - ½ Sand	0.66	0.44	0.32
M_5 - ½ Garbage Compost - ½ Vermiculite	0.37	0.31	0.29
M_6 - 1/3 Garbage Compost - 2/3 Sand	0.40	0.30	0.25
LSD between means within table	.05	.09	
	.01	.12	

Table 5. Interaction Effect of Media and Fertilizer Levels on Percent K in Leaf Tissue of Pot-Grown *Chrysanthemum morifolium* 'Oregon'

Media Treatments	F_1 200 lbs. N&K	F_2 400 lbs. N&K	F_3 800 lbs. N&K
M_1 - Garbage Compost	5.9	5.6	6.0
M_2 - ½ Garbage Compost - ½ Sand	4.7	5.6	4.2
M_4 - ½ Shredded Pine Bark - ½ Sand	2.3	3.1	5.9
M_5 - ½ Garbage Compost - ½ Vermiculite	4.9	5.4	5.9
M_6 - 1/3 Garbage Compost - 2/3 Sand	4.5	5.1	5.4
LSD between means within table	.05 .01	0.9 1.2	

compost to media increased number of flowers per pot; however, with 'Yellow Delaware' the peat-sand mixture produced as many flowers as garbage compost-vermiculite and with 'Oregon' garbage compost-vermiculite was not better than bark-sand (Tables 1 and 3). Flower diameter was significantly affected, but with one exception. Differences were so slight they could not be detected visually and thus were commercially unimportant. With 'Yellow Delaware' the 100% garbage medium produced visibly smaller flowers which probably could be explained by the high soluble salt content of the garbage compost medium (Table 7). The increased number of flowers in media containing garbage compost can probably be attributed to higher availability of nutrients during beginning growth periods provided by garbage compost. The importance of adequate nutrition early in growth of chrysanthemums has been reported by Lunt and Kofranek (9) and confirmed in unpublished work by the authors.

Increasing fertilizer levels increased flower diameter with both varieties, but increased flower number only with 'Oregon' (Tables 1 and 3).

Growth index, and thus plant size, of 'Yellow Delaware' was largest in the peat-sand mixture and for 'Oregon' the bark-sand and garbage compost-vermiculite produced largest plants. Those treatments producing the most growth caused the greatest delay in flowering. If flowering delay resulted from flower initiation, the

Table 6. Interaction Effect of Media and Fertilizer Levels on Percent Mg in Leaf Tissue of Pot-Grown *Chrysanthemum morifolium* 'Oregon'

Media Treatments	F_1 200 lbs. N&K	F_2 400 lbs. N&K	F_3 800 lbs. N&K
M_1 - Garbage Compost	0.16	0.19	0.22
M_2 - ½ Garbage Compost - ½ Sand	0.15	0.16	0.25
M_4 - ½ Shredded Pine Bark - ½ Sand	0.47	0.47	0.37
M_5 - ½ Garbage Compost - ½ Vermiculite	0.14	0.20	0.22
M_6 - 1/3 Garbage Compost - 2/3 Sand	0.15	0.16	0.26
LSD between means within table	.05 .01	.10 .13	

Table 7. Physical and Chemical Properties of the Various Media.

Media Treatments	pH	Total Soluble Salts ppm	CaO Lb/a	MgO Lb/a	P_2O_5 Lb/a	K_2O Lb/a	CEC me 100 Gm.	CEC Total me per Pot	% Drainable Pore Space Vol.	% Maximum Water Content by Vol.
M_1 - Garbage compost	7.2	3612	18,005	1803	570	3387	28.1	177.2	3.47	86.06
M_2 - ½ Garbage compost - ½ Sand	6.8	1579	9,646	1230	364	1983	17.4	178.8	2.86	74.91
M_3 - ½ Peat moss - ½ Sand	6.1	723	4,113	1879	138	315	17.1	137.6	4.31	79.65
M_4 - ½ Shredded pine bark - ½ Sand	6.0	639	3,749	1547	121	317	12.6	103.7	4.47	72.43
M_5 - ½ Garbage compost - ½ Vermiculite	7.3	2681	14,742	1596	871	1885	24.2	105.7	5.81	91.28
M_6 - 1/3 Garbage compost - 2/3 Sand	6.4	1148	7,038	1189	208	1274	12.2	138.4	2.68	68.14

resulting additional vegetative growth period could explain the larger plants. As expected, increased fertilizer levels increased growth index (Tables 1 and 3).

Tissue N was affected only slightly by media although such effects were statistically significant. Since garbage compost contained about 0.5% N on a dry weight basis, it tended to increase tissue levels of this element. P and Mg were inversely correlated with Ca levels in tissue of 'Yellow Delaware' (Table 1). The plants in peat-sand and bark-sand media contained considerably less Ca than other media, but higher levels of P and Mg. The positive correlation between P and Mg absorption has been previously reported (10). Increasing fertilizer levels increased N, Ca and Mg, but decreased P in plant tissue.

Increased fertilizer levels increased K in tissue of 'Yellow Delaware' except in media 1 and 5 where K did not vary due to fertilizer intensity (Table 2). Apparently garbage compost contained such high levels of K that levels added caused no further effect on plant absorption. Vermiculite in M_5 probably fixed K to such an extent that with the amount applied availability was not increased.

Interactions between media and fertilizer levels on tissue content of P, K and Mg in 'Oregon' are given in Tables 4, 5 and 6. High fertilizer levels decreased P in tissue from plants in M_2, M_4 and M_6 but had no effect in M_1 and M_5. High fertilizer levels increased content of tissue K from plants in M_4, M_5 and M_6 compared with low and F_2 level produced the highest leaf K from plants in M_2 and K in plants from M_1 were unaffected by fertilizer levels.

Increasing fertilizer levels had no effect on Mg in tissue from plants grown in M_1 and M_5, increased tissue Mg in plants from M_2 and M_6 and decreased Mg in plants grown in M_4. Data taken were insufficient to explain the interactions produced with 'Oregon.' In no combination of treatments, however, did any of the elements appear to be at a deficiency level.

Physical characteristics of the various media are given in Table 7. High soluble salts in M_1 partly explain the relatively poor plants produced in this media. As the authors have previously reported (7) there is no correlation between CEC by weight and by volume.

Drainable pore space was low in all media while percent maximum water on volume basis was high (1).

LITERATURE CITED

1. Conover, C. A. 1963. Effects of media, nitrogen and phosphorus levels on container-grown **Lantana pictavi** and **Ligustrum japonicum**. M. S. Thesis. University of Florida.
2. DeGroote, R. 1956. The use of town compost in horticulture. Rev. Agric. Brux, 9: 165-171.
3. DeGroote, R. 1961. Use of composted town refuse in the culture of ornamental plants in the Ghent district. Rev. Agric. Brux. 14: 517-523.
4. Gauch, H. G. and W. M. Duggar, Jr. 1954. The physiological action of boron in higher plants: a review and interpretation. Univ. of Md. Bul. A-80.
5. Hillman, W. S. 1959. Experimental control of flowering in **Lemma**. I. General methods. Photoperiodism in **L. perpusilla** 6746. Amer. Jour. Bot. 46: 466-473.
6. Joiner, J. N. and T. C. Smith. 1960. Effect of nitrogen and potassium levels on flowering characteristics of **Chrysanthemum morifolium** 'Bluechip.' Proc. Fla. Sta. Hort. Soc. 73: 354-358.
7. Joiner, J. N. and C. A. Conover. 1965. Characteristics affecting desirability of various media components for production of container-grown plants. Soil and Crop Sci. Soc. 25:320-328.
8. Joiner, J. N. and C. A. Conover. 1966. Comparative properties of pine bark and peat as amendments in media for container-grown crops at different nutrient levels. Proceedings of the 17th International Horticultural Congress. Vol. I. pp. 490.
9. Lunt, O. R. and A. M. Kofranek. 1958. Nitrogen and potassium nutrition of chrysanthemums. Proc. Amer. Soc. Hort Sci. 72: 487-497.
10. Pinchot, G. V. 1953. Phosphoralation coupled to electron transport in cell free extracts of **Alcaligenes faecalis**. Jour. Bio. Chem. 205: 65-74.
11. Reisch, K. W., 1958. A Compilation of research concerned with Nursery stock grown in metal containers. O.A.E.S. Journal Article No. 108-58. Published by the American Association of Nurseymen, 29 pps.