



New York State Flower Growers INCORPORATED

BULLETIN 227

Secretary, Charles Wilton, Prattsburg, Steuben Co., N. Y. 14873

OCT. 1964

Mist-Fertilization of Pot Chrysanthemums

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Morton has shown that a small amount of fertilizer applied through low-pressure, intermittent mist was beneficial to the propagation of poinsettias (N.Y.S.F.G. Bul 203, Oct. 1962). Similar applications of mist-fertilizer resulted in increased rooting, and subsequent growth of chrysanthemums propagated in the same manner (2).

Seeley and Stinson (4) showed that foliar applications of urea made twice weekly with 3.32 pounds of urea (46% N) per 100 gallons of water produced plants equal in growth to those that were regularly soil fertilized. Meyer (1) found that optimum rate of foliar urea applications was 3.32 pounds per 100 gallons applied weekly. Concentrations greater than this or made more frequently resulted in plant injury. Meyer's plants were grown in solution culture whereas those of Seeley and Stinson were grown in soil media.

With a commercial material 23-19-17, Meyer found that weekly applications of 6.6 to approximately 10 pounds per 100 gallons of water could be made with no plant injury resulting.

These results suggested a frequency-concentration relationship existed for foliar applied nutrients. With high concentrations of fertilizer only infrequent applications could be made otherwise plant injury would result. If low concentrations were used then perhaps foliar applications could be made often enough that would supply sufficient nutrients to support growth without any injury.

To study the effect of low concentrations of fertilizer applied through low-pressure mist lines, three crops of pot chrysanthemums were grown. The materials and methods used and the results obtained will be discussed separately for each crop.

Crop #1 November 1962 to February 1963

The varieties Princess Anne, Bronze Princess Anne, Golden Yellow Princess Anne and Commander were used. Five cuttings per variety were potted to 5-inch clay pots with four replications. Three growing media were used: Mix A, composed of 50% sphagnum peat moss and 50% vermiculite, (Terralite #2) by volume. Mix B, composed of 50% sphagnum peat moss and 50% horticultural perlite by volume. A soil mix composed of the following parts by volume: 9 loam soil, 6 peat moss, 4 perlite and 2 coarse sand. Fertilizer amendments prior to planting were added as follows: 2 ounces of 20% superphosphate per bushel of media to mixes A, B and Soil. To the light weight media, mixes A & B, dolomitic limestone was added at the rate of 4 ounces per bushel of media.

The fertilizer treatments were as follows: 1) Check, regular feeding with $1\frac{1}{2}$ pounds 20-20-20 per 100 gallons of water alternated weekly with potassium nitrate at the same rate; 2) Urea (46% N) applied through the mist lines at $\frac{1}{4}$ pound per 100 gallons of water; 3) 23-19-17 applied through the mist lines at $\frac{1}{4}$ pound per 100 gallons of water. The mist fertilizers were pumped from a supply tank with a Gould BF03-balanced flow pump. The misting cycle was 10 seconds every 20 minutes from 8 am to 5 pm daily. Mist fertilizer was started one day after the cuttings were potted and continued until January 25 when color was well developed in the buds. Except for the initial applications of limestone and superphosphate no other N-P-K fertilizers were applied to the plants in treatments 2 and 3 except that which went on through the mist. Upon potting, all cuttings were intermittently misted with tap water for the first day. The frequency of the tap water mist was dependent on weather conditions the day of potting. The plants were hose-watered as needed.

Rooted cuttings were obtained from Yoder Brothers, Inc., Barberton, Ohio, and potted November 29, 1962. Long days were provided from November 29 until December 12. A minimum of 10-foot candles of light from incandescent bulbs was provided daily from 10 pm to 2 am. Short days, 9 hour photoperiods, were given by pulling black sateen cloth from 5 pm to 8 am daily. Short days were started December 13 and continued until the plants were in flower.

The day and night greenhouse temperature was 65°F constant. However, on sunny days, day temperatures often reached 70°F.

The results of this first study showed that visually the plants were quite similar (Fig. 1). On January 14, the urea treated plants began to show some slight tip burn of the leaves. At the end of the experiment this tip burn extended about $\frac{1}{16}$ to $\frac{1}{8}$ inch on the margins of the uppermost leaves of the plants. There was some evidence of potassium deficiency on the plants grown in peat and perlite and in the soil mix that received only urea as a mist applied fertilizer.

At the termination of the study data obtained were height, fresh and dry weight. Leaves from the middle third of the plants were removed, washed twice in distilled water, dried in a forced draft oven at 65°C and foliar analyses were made for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg).

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Mist-Fertilization

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The results of this first study showed differential flowering dates, table 1. Commander flowered first regardless of fertilizer treatment or media used. Treatment with urea delayed flowering by four days. Golden Yellow Princess Anne flowered earlier in the check treatments than with urea or 23-19-17 fertilizer.

Table 1. Date of recording data (Time of flowering of mist-fertilized mums crop #1. Planted November 29, 1962.

Fert. Treat.	Media	Pr. Anne	Variety			Comm.
			Br. Pr. Anne	G. Yel. Pr. Anne		
Check	Soil	Feb. 21	Feb. 21	Feb. 21	Feb. 18	
	Mix A	"	"	"	"	
	Mix B	"	"	"	"	
Urea	Soil	Feb. 25	Feb. 25	Feb. 25	Feb. 18	
	Mix A	"	"	"	"	
	Mix B	"	"	"	"	
23-19-17	Soil	Feb. 21	Feb. 21	Feb. 25	Feb. 18	
	Mix A	"	"	"	"	
	Mix B	"	"	"	"	

Mix A—Peat and vermiculite
Mix B—Peat and perlite

Height in centimeters. Height of the plants as measured from the soil line to the apex of the flower varied with varieties (Table 2). Urea fertilized plants were generally taller (40.9 cm), than those of the check (35.8 cm) or 23-19-17 (36.6 cm) treatment. The average height of plants grown in soil disregarding varieties or fertilizer treatments was 39.6 cm; in mixes A & B 37.1 cm., a difference of one-inch.

Table 2. Average finishing height in centimeters. Crop #1, planted November 29, 1962. Grown single stem 5 stems per pot. Averages of 4 pots.

Fert. Treat.	Media	Pr. Anne	Variety			Comm.	Avg.
			Br. Pr. Anne	G. Yel. Pr. Anne			
Check	Soil	37.8	34.8	37.1	38.5		
	Mix A	36.5	31.3	36.2	36.4		
	Mix B	36.9	33.3	36.1	35.4		
	Avg.	37.1	33.1	36.4	36.8	35.8	
Urea	Soil	46.3	43.4	45.8	39.1		
	Mix A	42.4	36.0	40.7	40.7		
	Mix B	39.2	43.3	44.4	36.4		
	Avg.	39.3	40.9	44.6	38.7	40.9	
23-19-17	Soil	39.2	36.9	38.8	38.4		
	Mix A	38.7	33.6	34.8	37.9		
	Mix B	39.8	35.3	32.6	33.2		
	Avg.	39.2	35.3	35.4	36.5	36.6	

Mix A—Peat and vermiculite
Mix B—Peat and perlite

Dry-weight in grams. Dry weight figures were variable among varieties (Table 3). Commander was the lightest in weight. Disregarding growing media and varieties the average dry weight of the plants grown with the check fertilizer treatment was heaviest, 23.0 grams; with urea 22.2 gms and with 23-19-17, 19.6 gms. Disregarding fertilizer treatments and varieties soil grown plants averaged 24.0 gms, those in mix A 23.1 gms and those in mix B 17.9 gms. Visual appearance of the plants in mix B attested to the fact that they were of poorer quality than the other plants. This was probably due to limiting growth caused by potassium deficiency as was shown by the leaf analysis of the plants (Table 4).

Table 3. Average dry weight per pot in grams. Crop #1, planted November 29, 1962. Grown single stem 5 stems per pot. Averages of 4 pots.

Fert. Treat.	Media	Pr. Anne	Variety		Comm.	Avg.
			Br. Pr. Anne	G. Yel. Pr. Anne		
Check	Soil	22.5	27.5	26.1	20.9	
	Mix A	20.9	28.9	27.6	18.8	
	Mix B	19.6	25.0	21.0	17.6	
	Avg.	21.0	27.1	24.9	19.1	23.0
Urea	Soil	25.7	28.8	25.5	18.3	
	Mix A	25.3	23.3	25.1	21.8	
	Mix B	17.1	22.4	18.3	14.9	
	Avg.	22.7	24.8	22.9	18.3	22.2
23-19-17	Soil	22.9	26.7	22.9	20.0	
	Mix A	23.7	19.0	21.8	21.1	
	Mix B	15.4	16.9	12.2	13.9	
	Avg.	20.4	20.8	19.0	18.3	19.6

Mix A—Peat and vermiculite
Mix B—Peat and perlite

Nutrient Content. Tissue analysis showed that the nutrient content varied with variety, media used and fertilizer treatment. These figures are presented in Table 4.

Nitrogen. The highest average N content was contained by plants that had received urea. The check plants were second and those plants that received 23-19-17 contained the lowest amount of N.

Phosphorus. Although equal amounts of P were added to all media prior to planting, the check plants received additional P as did the 23-19-17 plants during their growing period. Nutrient analysis showed that P was highest in those plants that received the 23-19-17, and lowest in the urea treated plants. The check plants were intermediate in the P content.

Potassium. The figures for the K content of the plant tissue are the most interesting. Type of media had the greatest influence on the K content of plant tissue. Plants grown in peat and vermiculite always had the highest content of K. These results show that vermiculite does have K available for plant growth and the plants will absorb it. Urea fertilized plants grown in soil or peat and perlite contained less than 1.00% K which resulted in typical deficiency symptoms on the plant leaves. The symptoms first appeared as small, 1 cm diameter light colored spots on the basal leaves; as the condition of deficiency continued the spots became more numerous. The margins of the affected leaves eventually became light cream in color before becoming necrotic and turning brown.

Although the soil and mix B grown plants fertilized with 23-19-17 contained low levels of K, there were no visual symptoms of K deficiency on the leaves.

The results obtained with this study suggested a second trial be made during the spring months to see if season of the year had any effects.

Crop #2 February 1963 to May 1963

Materials and Methods

The same physical set-up was used as for crop #1. Some modifications were made to correct inadequacies found in the first study. To the peat and perlite media, a 32.0% fritted potash material was added at the rate of 1½ pounds per 40 bushels of soil.

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Fig. 1. Potted chrysanthemums of crop number 1 grown in three media with three fertilizer treatments. See individual pictures for treatments. Background squares are 6 x 6 inches. Note: Fertilizer treatment 23-21-17 was redesignated as 23-19-17.

Mist-Fertilization

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Table 4. Percentage nutrient content of mist-fertilized mums. Crop #1 planted November 29, 1962. Averages of 4 replications.

Variety	Fert. Treat.	Media	N	P	K	Ca	Mg	
Princess Anne	Check	Soil	3.36	.555	3.47	1.36	.507	
		Mix A	3.77	.534	4.79	0.82	.423	
		Mix B	3.47	.445	3.35	1.22	.463	
		Avg.	3.53	.511	3.87	1.13	.464	
	Urea	Soil	3.43	.210	0.60	1.50	.528	
		Mix A	3.65	.140	4.35	1.71	.595	
		Mix B	4.22	.164	0.49	2.07	.816	
		Avg.	3.96	.171	1.82	1.76	.646	
	23-19-17	Soil	3.14	.544	1.57	1.59	.528	
		Mix A	3.33	.511	4.94	1.23	.473	
		Mix B	3.23	.695	1.24	1.39	.543	
		Avg.	3.23	.583	2.58	1.40	.514	
	Bronze Princess Anne	Check	Soil	3.57	.468	3.30	1.11	.481
			Mix A	3.77	.550	5.08	0.96	.499
			Mix B	3.82	.425	3.82	1.28	.559
Avg.			3.23	.583	2.58	1.40	.514	
Urea		Soil	4.01	.213	0.68	1.90	.696	
		Mix A	3.54	.172	3.78	1.37	.527	
		Mix B	4.50	.206	0.47	2.30	.672	
		Avg.	4.02	.197	1.63	1.86	.632	
23-19-17		Soil	2.99	.519	2.28	1.35	.451	
		Mix A	2.59	.608	4.63	1.14	.429	
		Mix B	2.93	.630	1.58	1.37	.535	
		Avg.	2.84	.585	2.83	1.29	.472	
Golden Yellow Princess Anne		Check	Soil	2.85	.504	3.06	1.52	.545
			Mix A	3.51	.566	5.86	1.06	.481
			Mix B	3.36	.548	3.90	1.11	.475
	Avg.		3.24	.539	4.27	1.23	.500	
	Urea	Soil	4.21	.278	0.39	1.51	.576	
		Mix A	3.58	.164	4.16	1.40	.509	
		Mix B	4.50	.199	0.20	1.96	1.135	
		Avg.	3.78	.213	1.58	1.62	.740	
	23-19-17	Soil	2.81	.623	1.32	1.21	.459	
		Mix A	2.93	.601	4.11	1.06	.440	
		Mix B	2.78	.553	1.01	1.14	.484	
		Avg.	2.84	.592	2.15	1.13	.461	
	Comm.	Check	Soil	3.78	.501	2.70	1.27	.405
			Mix A	4.43	.513	4.72	0.98	.406
			Mix B	4.53	.468	3.40	1.18	.455
Avg.			4.25	.494	3.60	1.14	.422	
Urea		Soil	4.81	.384	0.96	1.69	.591	
		Mix A	5.14	.189	3.95	1.46	.508	
		Mix B	5.01	.195	0.40	2.38	.900	
		Avg.	4.98	.256	1.77	1.84	.666	
23-19-17		Soil	3.79	.595	1.66	1.16	.435	
		Mix A	3.93	.550	4.13	0.89	.369	
		Mix B	3.54	.608	1.61	1.21	.511	
		Avg.	3.76	.584	2.47	1.09	.438	

The fertilizer treatments were:

1. Check, started one week after potting using potassium nitrate and 17-17-17 alternated weekly at 1½ pounds per 100 gallons of water.
2. Urea (46% N) was used at ¼ pound per 100 gallons of water, plus 1 pound of hydrated lime per 100 gallons of water. Schneider and Snyder (3) reported that the addition of hydrated lime would counteract the burning effect of the urea.
3. The complete fertilizer 23-19-17 was used at ¾ pound per 100 gallons of water. For this study the misting cycle was increased to 12 seconds of mist every 20 minutes from 8 am to 5 pm daily.

Five rooted cuttings were planted in 6-inch clay pots. The cuttings were potted, soft pinched and short days started February 14, 1963. Short days were provided by covering the plants with black sateen cloth from 5 pm to 8 am daily. The three benches received tap water mist only for the first two days. The regular fertilizer treatments were started the third day after planting. To offset the possibility that the additional humidity from misting was a contributing factor in the growth of the plants the check benches received 12 seconds of regular tap water mist every 20 minutes.

The varieties used were the same as in Crop 1. There were four pots of each variety for each media in each fertilizer treatment. The pots were randomized on the bench to offset any positional effects. The plant spacing used was approximately 12 x 12 inches on centers. There were 3 pots per row across the bench.

Results

On March 26 it was noted that a brown fungus was growing on the pot surface and stems of some of the plants. This was identified as *Ostrocoderma* commonly known as "after-steaming fungus." Although not known to be a disease organism the appearance of the fungus was unsightly. Misting on all benches was discontinued and the plants were sprayed with ½ pound Zineb and 1 pound Captan per 100 gallons of water.

The plants were sprayed again on March 28 with the same fungicide materials and rates of concentration previously used. The mist was turned on March 29 and continued until April 11 at which time the flower buds were showing color. There was no further recurrence of the fungus problem following the corrective treatment.

Observations made on April 7 showed that marginal burning caused by urea injury similar to that obtained with crop #1 was apparent. The inclusion of hydrated lime had failed to control the burning has had been reported (3).

Development to maturity as affected by fertilizer treatment occurred in the order of 23-19-17 first, urea treated plants second, and the check plants were slowest to develop. The order of development according to variety was Commander, Golden Yellow Princess Anne, Princess Anne and Bronze Princess Anne. Bronze Princess Anne was slow to bloom as may be seen from Table 5.

Table 5. Date of recording data (time of flowering) of mist-fertilized mums. Crop #2. Planted February 14, 1963.

Fert. Treat.	Media	Variety			Comm.
		Pr. Anne	Br. Pr. Anne	G. Yel. Pr. Anne	
Check	Soil	May 7	May 9	May 9	Apr. 30
	Mix A	May 7	May 9	May 2	Apr. 30
	Mix B	May 7	May 9	May 2	Apr. 30
Urea	Soil	May 7	May 4	May 5	Apr. 30
	Mix A	May 2	May 4	May 2	Apr. 30
	Mix B	May 2	May 4	May 2	Apr. 30
23-19-17	Soil	Apr. 30	May 7	Apr. 30	Apr. 30
	Mix A	Apr. 30	May 2	Apr. 30	Apr. 30
	Mix B	Apr. 30	May 2	Apr. 30	Apr. 30

Mix A—Peat and vermiculite
Mix B—Peat and perlite

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Fig. 2. Potted chrysanthemums of crop number 2 grown in three media with three fertilizer treatments. See individual pictures for treatments. Background squares are 6 x 6 inches. Note: Fertilizer treatment 23-21-17 was redesignated as 23-19-17.

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The plants were harvested as they matured, Table 5. Data taken were height, number of flowers (dry weight), and median leaf samples for foliar analysis of N, P, K, Ca, and Mg. The plants are shown in Fig. 2.

Height in Centimeters

Fertilizer treatment had the greatest effect on the height of the plants, Table 6. The urea fertilized plants were tallest. Disregarding media used the average height was 32.1 centimeters. Complete analysis mist fertilized plants averaged 30.9 cm and the check plants averaged 29.1 cm tall.

The effect of media disregarding fertilizer treatments was slight. Soil grown plants averaged 31.7 cm; plants in both lightweight media averaged 30.0 cm in height.

Table 6. Average finishing height in centimeters. Crop #2 planted February 14, 1963. Grown pinched, 5 plants per pot. 3 replications.

Fert. Treat.	Media	Variety				Avg.
		Pr. Anne	Br. Anne	G. Yel. Pr. Anne	Comm.	
Check	Soil	31.4	30.5	29.8	25.8	
	Mix A	30.9	29.0	30.0	26.1	
	Mix B	30.1	29.8	30.7	25.5	
	Avg.	30.8	29.8	30.2	25.8	29.1
Urea	Soil	35.2	33.9	35.7	31.1	
	Mix A	33.2	32.0	34.2	28.5	
	Mix B	33.2	30.4	31.7	26.9	
	Avg.	33.9	32.1	33.9	28.8	32.1
23-19-17	Soil	32.5	31.9	31.7	30.8	
	Mix A	33.8	31.7	30.3	26.3	
	Mix B	32.6	27.7	33.3	28.3	
	Avg.	33.0	30.4	31.8	28.5	30.9

Mix A—Peat and vermiculite
Mix B—Peat and perlite

Dry weight in grams

The average dry weight varied both with fertilizer treatment used and growing media, Table 7. The average dry weight due to fertilizer treatments disregarding growing media was: check plants 37.2 gms; 23-19-17 plants 34.0 gms and urea plants 33.0 gms. Disregarding fertilizer treatments soil grown plants weighed an average of 36.1 gms; those in Mix A, 35.4 gms and those in Mix B, 32.8 grams.

Table 7. Average dry weight per pot in grams. Crop #2, planted February 14, 1963. Grown pinched, 5 plants per pot. 3 replications.

Fert. Treat.	Media	Variety				Avg.
		Pr. Anne	Br. Anne	G. Yel. Pr. Anne	Comm.	
Check	Soil	43.3	40.5	37.9	28.8	
	Mix A	36.7	33.9	37.9	31.7	
	Mix B	38.6	47.4	39.7	30.4	
	Avg.	39.5	40.6	38.5	30.3	37.2
Urea	Soil	31.3	40.6	39.8	28.0	
	Mix A	40.5	35.5	37.8	26.4	
	Mix B	30.2	32.5	29.7	24.2	
	Avg.	34.0	36.2	35.8	26.2	33.0
23-19-17	Soil	36.5	37.1	35.4	34.1	
	Mix A	39.7	37.8	36.0	31.0	
	Mix B	30.6	30.7	30.5	28.1	
	Avg.	35.6	35.2	33.9	31.1	34.0

Mix A—Peat and vermiculite
Mix B—Peat and perlite

Number of flowers per pot

In Table 8 the figures for the average number of flowers per pot show that the mist fertilized (23-19-17) plants averaged one-half flower less than the check plants. Urea, mist-fertilized plants averaged 1½ flowers less than the check plants and 1 flower less than the 23-19-17 fertilized plants.

Table 8. Average number flowers per pot. Crop #2, planted February 14, 1963. Grown pinched, 5 plants per pot. 3 replications.

Fert. Treat.	Media	Variety				Avg.
		Pr. Anne	Br. Anne	G. Yel. Pr. Anne	Comm.	
Check	Soil	16.0	16.0	14	18.6	
	Mix A	15.6	14.6	16.6	21.3	
	Mix B	15.3	17.0	15.6	21.3	
	Avg.	15.63	15.86	15.4	20.4	16.82
Urea	Soil	15.0	14.6	15.3	17.0	
	Mix A	16.0	14.3	16.3	16.6	
	Mix B	14.0	14.3	13.6	15.0	
	Avg.	15.0	14.4	15.6	16.2	15.30
23-19-17	Soil	16.0	16.6	14.3	15.3	
	Mix A	15.3	16.3	15.6	20.0	
	Mix B	16.3	15.3	15.6	19.3	
	Avg.	15.87	16.06	15.16	18.2	16.32

Mix A—Peat and vermiculite
Mix B—Peat and perlite

Nutrient Content—Nitrogen:

The N content of the plants was highest for those that received urea as a foliar applied fertilizer regardless of the growing media used, Table 9. The N content of the check and 23-19-17 fertilized plants varied with the growing media and the variety of chrysanthemums grown. All plants in crop 2 had a higher N content than the plants of crop 1. This could be attributed to better growing conditions due to higher, light intensities.

Phosphorus

Phosphorus content was dependent on the fertilizer applied. The check and 23-19-17 fertilized plants contained more P than those that received only urea through foliar applications. However, in no instance was the P content below that deemed adequate for plant growth.

Potassium

Potassium content was similar to that of crop number 1. Regardless of variety or fertilizer treatment, plants grown in vermiculite always contained the highest amount of K. The application of fritted K₂O to mix B at the time of potting was insufficient to maintain adequate levels of K in the plant tissue. However, only those plants grown in soil and fertilized foliarly with urea showed visual symptoms of K deficiency on the plant leaves.

Calcium

The Ca content of the plant tissue was lowest on those plants that received 23-19-17 as a foliar spray. Generally Ca levels were low when K content was high. This reciprocal relationship of K and Ca has been shown many times. The higher Ca levels in the leaves treated with urea was probably due to the inclusion of calcium hydroxide in the solution to attempt to overcome the burning effect of urea.

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Table 9. Percentage nutrient content mist-fertilized mums. Crop #2 planted February 14, 1963. Averages of 3 replications.

Variety	Fert. Treat.	Media	N	P	K	Ca	Mg
Princess Anne	Check	Soil	4.10	1.023	4.28	1.12	.532
		Mix A	4.50	1.013	5.34	.91	.498
		Mix B	4.53	.930	4.18	1.39	.638
		Avg.	4.32	.989	4.60	1.14	.556
	Urea	Soil	5.23	.456	0.90	1.78	.589
		Mix A	5.63	.268	4.74	1.99	.438
		Mix B	6.34	.330	0.80	2.25	.612
		Avg.	5.73	.351	2.15	2.01	.546
	23-19-17	Soil	5.47	1.580	2.34	0.75	.307
		Mix A	4.62	1.203	5.74	0.68	.390
		Mix B	4.72	1.160	2.52	0.96	.408
		Avg.	4.93	1.314	3.53	0.80	.368
Bronze Princess Anne	Check	Soil	4.19	.815	2.62	1.21	4.27
		Mix A	4.30	.680	4.11	1.20	.473
		Mix B	4.21	.622	3.42	1.46	.477
		Avg.	4.23	.706	3.38	1.29	.459
	Urea	Soil	4.82	.358	0.67	2.08	.547
		Mix A	4.98	.188	3.52	1.71	.390
		Mix B	5.56	.183	0.75	2.18	.575
		Avg.	5.12	.243	1.65	1.99	.504
	23-19-17	Soil	4.39	1.020	1.31	1.12	.415
		Mix A	4.58	.912	4.71	0.83	.408
		Mix B	4.70	1.060	1.75	1.08	.457
		Avg.	4.56	.997	2.59	1.01	.427
Golden Yellow Princess Anne	Check	Soil	4.15	1.013	4.22	1.29	.437
		Mix A	4.70	1.043	6.11	1.05	.435
		Mix B	5.07	.807	4.93	1.62	.527
		Avg.	4.64	.954	5.09	1.32	.466
	Urea	Soil	5.83	.467	0.792	2.24	.578
		Mix A	5.72	.220	5.23	2.06	.457
		Mix B	5.80	.220	1.48	2.22	.562
		Avg.	5.78	.302	2.50	2.17	.532
	23-19-17	Soil	5.03	1.408	1.57	0.94	.388
		Mix A	4.58	1.317	3.08	0.72	.273
		Mix B	3.17	.998	1.38	1.06	.367
		Avg.	4.93	1.241	2.01	0.91	.343
Comm.	Check	Soil	5.03	.889	4.48	1.25	.515
		Mix A	5.72	.728	4.82	1.23	.507
		Mix B	5.68	.737	4.42	1.53	.557
		Avg.	4.93	1.241	4.42	0.91	.343
	Urea	Soil	7.10	.675	0.825	2.15	.640
		Mix A	5.83	.407	4.71	1.53	.478
		Mix B	7.21	.253	1.25	2.26	.643
		Avg.	6.71	.445	2.26	1.98	.587
	23-19-17	Soil	6.41	.942	2.03	1.31	.580
		Mix A	5.93	.943	5.16	0.73	.478
		Mix B	6.44	1.093	1.91	0.97	.623
		Avg.	6.27	.993	3.03	1.00	.561

Magnesium

Magnesium varied slightly with fertilizer treatment. Generally, Mg was lowest in the plants that received 23-19-17 fertilizer except with the variety Commander.

The development of the fungus was cause for a third crop to be grown. Since this crop would be produced during the long days of summer, black cloth would be needed to provide the necessary short days for flowering. Covering with black cloth immediately following misting should provide conditions favorable for the development of dis-

eases. A second factor to be checked was whether mist fertilized plants would receive sufficient nutrients to support growth during this period of high temperature and high light intensity.

Crop #3 August 1963 to November 1963

Materials and Methods

The same physical set-up for crop #3 was used as for the first two crops. Since urea applications resulted in plant injury this treatment was not used in the third study. The media were the same; however, the fritted K₂O was used at twice the rate as in crop 2. Fritted K₂O was added to mix B at the rate of 3 pounds per 40 bushels or 34 grams per bushel. Five rooted cuttings of Princess Anne, Golden Yellow Princess Anne and Commander were planted August 15 to a 5-inch pot. There were 6 replicates per media for each variety in each fertilizer treatment. Ten foot candles of supplementary incandescent light applied daily from 10 pm to 2 am was provided from August 15 to August 20. On August 20 short days were started. The plants were covered daily with black sateen cloth from 5 pm to 8 am. The plants were soft-pinned August 26.

The check plants were fertilized weekly with 20-20-20 alternated with potassium nitrate each applied at the rate of 2 pounds per 100 gallons of water.

Mist fertilized plants received 23-19-17 at $\frac{3}{8}$ pound per 100 gallons of water 12 seconds every 20 minutes from 8:00 am to 5:30 pm daily. Mist fertilizer was started August 17 and stopped October 10. At this time the plants were all showing good flower color in the buds. Check plants were misted with tap water during the same period of time at the same frequency.

All plants were hose watered as needed.

At harvest, data on height, dry weight, number of flowers and nutrient content as determined by foliar analysis were obtained.

Height in Centimeters

The foliar fertilized plants were approximately one-fourth taller than the check plants, Table 10. This effect was primarily due to the fertilization program since the differences due to media used disregarding fertilization applied were less than 2 centimeters.

Table 10. Average finishing height in centimeters. Crop #3, planted August 15, 1963. Grown pinched, 5 per pot, 5 replications.

Fert. Treat.	Media	Pr. Anne	Variety G. Yel. Pr. Anne	Comm.	Avg.
Check	Soil	22.8	26.9	25.4	
	Mix A	24.5	27.3	25.4	
	Mix B	25.8	27.7	24.6	
	Avg.	24.4	27.3	25.1	25.6
23-19-17	Soil	31.3	33.2	29.1	
	Mix A	35.4	39.3	28.6	
	Mix B	35.0	35.0	28.3	
	Avg.	33.9	35.8	28.7	32.8

Mix A—Peat and vermiculite
Mix B—Peat and perlite

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Dry Weight in Grams:

The average dry weight differences were also due to the fertilizer treatment used, Table 11. Plants that received 23-19-17 were approximately one-fourth heavier than check plants disregarding the media in which they were grown. Differences due to media used disregarding fertilizer treatments or varieties were less than 2 grams with the plants in mix B heaviest. This was a change from the two previous studies in that plants previously grown in mix B were always lightest in weight. This difference could be attributed to the increased K availability from doubling the amount of fritted K₂O that was added.

Table 11. Average dry weight per pot in grams. Crop #3 planted August 15, 1963. Grown pinched, 5 plants per pot, 5 replications.

Fert. Treat.	Media	Pr. Anne	Variety G. Yel. Pr. Anne	Comm.	Avg.
Check	Soil	24.0	27.6	27.8	
	Mix A	28.8	28.6	29.4	
	Mix B	27.5	32.0	26.6	
	Avg.	26.7	29.4	27.9	28.0
23-19-17	Soil	36.0	41.6	35.9	
	Mix A	38.6	39.9	32.3	
	Mix B	40.1	44.6	33.4	
	Avg.	38.2	42.0	33.8	38.0

Mix A—Peat and vermiculite
Mix B—Peat and perlite

Number of flowers

Mist fertilized plants averaged 2.3 more flowers per plant than the check treatments, Table 12. Varietal differences existed with Commander producing the greatest number of flowers.

Table 12. Average number of flowers per pot. Crop #3 planted August 15, 1963. Grown pinched, 5 plants per pot, 5 replications.

Fert. Treat.	Media	Pr. Anne	Variety G. Yel. Pr. Anne	Comm.	Avg.
Check	Soil	21.2	17.0	27.2	
	Mix A	18.6	19.8	29.2	
	Mix B	19.4	19.4	25.6	
	Avg.	19.73	18.73	27.3	21.92
23-19-17	Soil	22.4	21.6	28.6	
	Mix A	25.2	19.8	27.0	
	Mix B	22.7	21.7	29.4	
	Avg.	23.43	21.03	28.2	24.22

Mix A—Peat and vermiculite
Mix B—Peat and perlite

Nutrient Content—Nitrogen:

The N content of the plants treated with 23-19-17 was substantially greater than those grown as check plants, Table 13. Generally plants grown in mix B had a greater N content than those grown in other media.

Phosphorus

Plants that received complete fertilizer applied to the leaves contained the greatest amounts of P. The levels contained in the check plants were approximately one-third that of the mist fertilized plants; however, these levels were considered adequate for growth.

Potassium

As with the previous crops, plants grown in mix A had the greatest amount of K. Unlike N, the check plants contained a greater amount of K than did the mist fertilized plants. The incorporation of increased amounts of K-frit in mix B was reflected in higher levels of K within the plant tissue. There were no symptoms of K deficiency on any of the plants grown regardless of media used or fertilization practice followed.

Calcium

The Ca content of the plants was completely different from that obtained in the previous crops.

Calcium levels of the check plants were 5 times higher than those that were fertilized with 23-19-17. This is unusual in that none of the previous crops grown had levels of Ca that were near these amounts.

Magnesium

The Mg content was higher in the check plants than those that received 23-19-17. Levels of Mg adequate for plant growth were contained in all plants regardless of variety grown, media or fertilizer treatment used.

Table 13. Percentage of Nutrient content of mist-fertilized mums. Crop #3 planted August 15, 1963. Averages of 5 replications.

Variety	Fert. Treat.	Media	N	P	K	Ca	Mg
Princess Anne	Check	Soil	3.58	.368	4.800	6.33	.799
		Mix A	3.96	.362	5.150	5.77	.832
		Mix B	3.94	.400	4.850	6.04	.826
		Avg.	3.83	.377	4.933	6.02	.819
23-19-17	Soil	Soil	5.31	1.352	2.635	1.84	.496
		Mix A	5.51	1.175	4.600	1.88	.571
		Mix B	5.77	1.298	2.910	1.92	.550
		Avg.	5.53	1.298	3.382	1.88	.539
Golden Yellow Princess Anne	Check	Soil	3.74	.359	4.650	5.80	.694
		Mix A	3.97	.324	5.395	6.36	.909
		Mix B	4.39	.413	5.140	5.72	.768
		Avg.	4.03	.365	5.062	5.96	.790
23-19-17	Soil	Soil	4.84	1.270	3.175	1.55	.455
		Mix A	5.47	1.059	4.910	1.76	.575
		Mix B	5.54	1.202	2.885	1.48	.441
		Avg.	5.28	1.177	3.657	1.60	.490
Comm.	Check	Soil	4.34	.441	5.070	4.28	.747
		Mix A	4.38	.409	5.370	4.43	.792
		Mix B	4.74	.610	4.595	3.57	.694
		Avg.	4.49	.487	5.012	4.09	.744
23-19-17	Soil	Soil	5.91	1.212	2.740	1.51	.499
		Mix A	5.45	.912	4.475	1.91	.529
		Mix B	5.93	1.001	2.875	2.37	.457
		Avg.	5.76	1.042	3.363	1.93	.478

Mix A—Peat and vermiculite
Mix B—Peat and perlite

Discussion and Conclusions

The results of these trials show that small amounts of a complete fertilizer may be applied frequently by means of low-pressure, intermittent-mist without causing injury. The amount of liquid applied each time the mist cycled was approximately 5 fluid ounces. The bench area covered

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by these 5 ounces was 9 square feet. When the plants were small there was some wetting of the media surface which could have resulted in some infiltration of fertilizer into the root media. However, as the plants became larger the leaf area extended over the media which prevented fertilizer from contacting the media. The fertilizer solution was retained by the upper leaves of the plant where it is concluded that absorption took place. The amount of fertilizer applied was not enough to have resulted in runoff from the leaves.

The growth and nutrient content of the check plants and the mist fertilized plants that received 23-19-17 was similar. Urea fertilized plants in crops 1 and 2 developed marginal burn after a period of several weeks. Attempts to reduce this injury by the incorporation of hydrated lime were unsuccessful; therefore, urea was not used in production of the third crop.

Season of the year had an effect on fresh weight and nutrient content. The winter grown crop was lighter in weight and contained a smaller amount of nutrients than the spring and summer crops.

In crop 3 the nutrient content of the mist fertilized plants was highest. This could have been the result of leaching of available nutrients from the growing media of the check plants due to more frequent waterings required by warm weather. Since the mist-fertilized plants were not dependent on media nutrient reserves this leaching effect was of no consequence to the growth of the plants.

The use of vermiculite in the growing media proved to be a longlasting, readily available source of K. Under the conditions of this study, pot mums in crop 2 grown with vermiculite in the media contained a greater amount of K than plants that had received a 32% K_2O fritted material at the rate of 3 pounds per 40 bushels of peat and perlite media.

Although the continual application of mist to the foliage should have provided a favorable environment for the development of disease there was none. Crop 2 was affected when the non-pathogenic, after steaming fungus *Ostroco-derma* started to grow on the pots and lower stems of some plants. This was quickly controlled with a fungicidal spray and no further occurrence developed. There were no problems with mildew or leaf spot.

Although watering of the plants was done by hose it is conceivable that a simple by-pass system would enable a grower to water the plants through the mist system without applying fertilizer at that time.

Summary

Three crops of potted chrysanthemums were grown in three media. Fertilizers were applied conventionally and through a low pressure intermittent mist line. A complete analysis (23-19-17) fertilizer was applied as a mist at $\frac{3}{8}$ pound per 100 gallons of water 12 seconds every 20 minutes, 9 hours daily from the time the cuttings were potted until good bud color developed—usually 8 weeks after planting.

Mist fertilized plants were equal or superior in size, flower number and nutrient content to plants that received

fertilizer to the root media.

Vermiculite as a media component resulted in a greater potassium content in plant tissue than when plants were grown in soil, and peat and perlite that received regular applications of K.

There were no problems due to pathogenic disease organisms even though environmental conditions were considered good for their development.

Chrysanthemums grown in spring and summer were heavier and had a greater nutrient content than those produced during winter.

The use of mist applied fertilizers on potted chrysanthemums could result in further progress toward semi-automated growing of the crop.

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YOUR EDITOR,

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