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LITERATURE CITED

1. Aarts, J. F. T. 1957. Over de houbaarheid van snijbloemen (On the keepability of cut flowers). Mededelingen van de Landbouwhogeschool, Wagenigen, Holland 57: 1-62.
2. Anonymous. 1969. Bud-cut carnations nip shipping costs. U. S. Dept. Agr. Res. 17(9): 12.
3. Besemer, S. T. 1961. Shipping methods used for fresh cut-flowers. Calif. Agr. 15(3): 6-7.
4. Holley, W. C. and Cheng, L. 1967. Harvesting and handling of immature carnations. Proc. Amer. Soc. Hort. Sci. 90: 377-383.
5. Kohl, H. C., Jr. and Smith, D. E. 1960. Development of carnation flowers cut before fully open. Carnation Craft. 53: 7-8.
6. Larsen, F. E. and Cromarty, R. W. 1967. Microorganism inhibited by 8-hydroxyquiniline citrate *as related* to cut flower senescence. Proc. Amer. Soc. Hort. Sci. 90: 546-549.
7. Larsen, F. E. and Scholes, J. F. 1965. Effects of sucrose, 8-hydroxyquinoline citrate, and N-dimethyl amino succinamic acid on vase-life and quality of cut carnations. Proc. Amer. Soc. Hort. Sci. 87: 458-463.
8. Larsen, F. E. and Scholes, J. F. 1966. Effects of 8-hydroxyquinoline citrate, N-dimethyl amino succinamic acid and sucrose on vase life and spike characteristics of cut snapdragons. Proc. Amer. Soc. Hort. Sci. 89: 694-701.
9. Larsen, F. E. and Scholes, J. F. 1966. Effect of 8-hydroxyquinoline citrate, sucrose, and Alar on vase life and quality of cut stocks. Flor. Rev. 139 (3608): 46-47, 117-118.
10. Marousky, F. J. 1968. Vascular blockage, water absorption, stomatal opening and respiration of cut 'Better Times' roses treated with 8-hydroxyquinoline citrate and sucrose. Jour. Amer. Soc. Hort. Sci. 94(3): 223-226.
11. Marousky, F. J. 1968. Physiological role of 8-hydroxyquinoline citrate and sucrose in extending vase-life and improving quality of cut gladiolus. Proc. Fla. State Hort. Soc. 81: 409-414.
12. Marousky, F. J. 1968. Influence of 8-hydroxyquinoline citrate and sucrose on vase-life and quality of cut gladiolus. Proc. Fla. State Hort. Soc. 81: 415-419.
13. Marousky, F. J. 1969. Handling and opening bud-cut chrysanthemum flowers with 8-hydroxyquinoline citrate and sucrose. U. S. Dept. Agr., Mkt. Res. Rpt. Submitted for publication.
14. Scholes, J. F. 1963. Some effects of various chemicals on the post-harvest physiology of Velvet Times roses. M. S. Thesis. Cornell University, Ithaca, New York.
15. Waters, W. E. 1964. Influence of chemical preservative on keeping quality of asters, carnations, chrysanthemums and gerbera daisies. Proc. Fla. State Hort. Soc. 77: 466-470.

EFFECT OF RATIOS OF NH_4 TO NO_3 AND LEVELS OF N AND K ON CHEMICAL CONTENT OF *CHRYSANTHEMUM MORIFOLIUM*. "BRIGHT GOLDEN ANN"

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ABSTRACT

Three 5x3 factorial experiments in randomized block design with 4 replications were initiated under soil culture conditions to test effects of 5 ratios of NO_3 versus NH_4 nitrogen at 3 N-K levels on growth and chemical composition of *Chrysanthemum morifolium* 'Bright Golden Ann'. Only 8 of the 15 treatments survived. Samples of leaf tissue from plant mid-section were taken for chemical analyses 6 and 8 weeks after potting and at experiment termination. Termination samples also were analyzed for total oxalate content.

Plants receiving higher ratio of NO_3 to NH_4 at high N-K level and those receiving higher ratio of NH_4 to NO_3 at low N-K were tallest.

Plants receiving NH_4-N had higher N contents than those receiving NO_3-N. Increasing NH_4 ions depressed uptake of Ca. Increasing No_3 ions depressed P uptake. K was least effected by form of N. NO_3-N promoted oxalate formation.

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INTRODUCTION

Effects of different levels of N fertilization had been studied and reported for a large variety of plants, but the form of N supplied to plants has received less consideration. A few investigators have reported differences in growth responses and chemical composition of plants given NO_3- versus NH_4-N.

This experiment was established to test effects of NO_3 and NH_4-N at different ratios expressed in percentages and levels on growth and chemical composition of *Chrysanthemum morifolium*, 'Bright Golden Ann' at three harvest dates.

Colgrove and Roberts (4) studying Azaleas found plants receiving NH_4-N produced more growth, had better foliage color and required smaller amounts of N than those receiving NO_3-N.

Herath and Eaton (5) and Cain (2) reported that highbush blueberries had greater growth responses to NH_4-N than to NO_3-N. Tiedjens (13) found tomatoes required lower concentration of NH_4-N than NO_3-N to produce an equal volume of growth. Clark (3) reported that leaves of tomato plants receiving NH_4 averaged 6.73% N while plants receiving comparable levels of NO_3 averaged 5.36% N.

van der Merwe (14) found an average of 4.24% N in leaves of Navel orange trees receiving NH_4 while similar trees receiving NO_3 averaged 5.48% N. He also reported that Valencia trees receiving NO_3 as a N source averaged 3.92% while NH_4 trees averaged 5.08% N. Joy (6) produced sugar beets in nutrient solution and found that N content of those receiving NO_3 averaged 4.4% N, those receiving NH_4NO_3 averaged 5.4% and those receiving $(NH_4)_2SO_4$ averaged 5.3% N.

A higher content of P and lower contents of K, Ca and Mg. were found in plants receiving only NH_4-N as reported for barley by Arnon (1), by van der Merwe (14) in citrus and by Sideris and Young (11) in *Ananas comosus*. Herath and Eaton (5) in blueberry reported higher P and K in plants receiving NH_4-N. Shear (10) found no difference in P content of tung due to N source.

Herath and Eaton (5) found no difference in iron content of blueberries due to NO_3 vs NH_4-N, but Sideris and Young (11) working with *Ananas comosus* and Singer (12) with Bahiagrass reported that plants had higher iron content when receiving NH_4 compared with NO_3-N. Cain (2) stated that blueberry plants which received NO_3-N developed Fe dificiency symptoms although they contained as much or more Fe than plants receiving NH_4-N which did not show Fe deficiency symptoms.

Clark (3) found that 2.12% oxalic acid was present in tomato plants receiving NO_3 while only 0.12% was present in those receiving NH_4N. Marshall *et al* (8) reported that as per cent NO_3 supplied to Pigweed (*Amaranthus retroflexus*) increased, per cent oxalic acid in plants decreased and Joy (6) reported that sugar beet plants receiving NO_3 as the only N source had higher oxalate than those receiving only NH_4-N.

Meeuse and Campbell (9) studied inhibition of oxalic acid synthesis in beet extracts and reported that NO_3 was the sole factor responsible for inhibition of oxalic acid oxidase and NO_3 ions were able to paralyze oxalic acid activity in concentrations as low as 5 x 10-5M. Kitchen *et al* (73 reached the conclusion in an experiment with spinach that cations tended to promote oxalic acid synthesis while anions inhibited its formation.

Methods and Materials

Originally three 5x3 factorial experiments were established to test effects of 5 ratios of NO_3 to NH_4 at 3 N and K levels on growth and chemical composition of *Chrysanthemum morifolium*, 'Bright Golden Ann' at 3 harvest dates. N and K levels were 400, 900 and 1400 ppa per crop and ratios of NO_3 to NH_4 were 0:100, 25:75, 50:50, 75:25 and 100:0 per cent. Solution compositions are given in Table 1. Treatments were placed in randomized block design and replicated 4 times.

Five rooted cuttings were planted per 6 inch pot, containing a 1:1:1 by volume mixture of sand, imported peat and calcined clay. Four pounds superphosphate and 1½ pounds of "Perk" were added per cubic yard of medium at time of mixing. Three pots were planted per replication per treatment so that plants from one pot could be harvested for analysis on 3 sampling dates — May 6 and 22 and June 6.

Table 1. Ratios of NO_3 to NH_4 nitrogen and sources of N, K, Ca and Mg given *C. morifolium* 'Bright Golden Ann' (400 ppa N level).

	PER CENT OF ELEMENT SUPPLIED BY SOURCE				
	Ratio 1	Ratio 2	Ratio 3	Ratio 4	Ratio 5
SOURCE	0 NO_3 100 NH_4	25 NO_3 75 NH_4	50 NO_3 50 NH_4	75 NO_3 25 NH_4	100 NO_3 0 NH_4
NH_4OH	100	75	46	14	
NH_4NO_3			18	50	
HNO_3					26*
KNO_3 (N)		25	36	36	36
KNO_3 (K)		70	100	100	100
KOH	100	30			
$Ca(NO_3)_2$ (N)					18*
$Ca(NO_3)_2$ (Ca)					100
$Mg(NO_3)_2$ (N)					20*
$Mg(NO_3)_2$ (Mg)					100
$CaSO_4.2H_2O$	100	100	100	100	
$MgSO_4.7H_2O$	100	100	100	100	

* N level (ppa)	900	1400
HNO_3	47	53
$Ca(NO_3)_2$	9	6
$Mg(NO_3)_2$	8	5

Treatment solutions were applied weekly, beginning March 28, along with sufficient Ca and Mg to supply 100 and 70 pounds, respectively, of those elements per acre per crop. Potassium was supplied at same rates as N and plants were watered as needed.

Leaves from mid-section of the plants were harvested on each of the 3 sampling dates and analyzed for N, P, K, Ca, Mg and Fe.

Samples taken from June 6 were also analyzed for total oxalate content. Height measurements from top of pot to growing point of tallest plant per pot were taken on May 22 and June 6.

Many plants receiving all NH_4 or 75% NH_4-N were killed, particlarly at the highest N levels supplied. Eight of the original 15 treatments survived, including Treatments 2, 3, 4, and 5 consisting of 400 ppa N at 75:25, 50:50, 25:75 and 0:100 per cent NH_4 to NO_3. Results were statistically analysed by standard procedures and compared using Duncan's New Multiple Range Test.

Results and Discussion

The death of many plants in the high NH_4 treatments was probably due to the corrosive action of NH_4OH utilized as the NH_4 source.

Nitrogen.—The highest tissue N was found in plants receiving 25% or more NH_4 at low level of N and K (Table 2) at 2 harvest dates, apparently resulting from a greater relative availability of the NH_4 ion. Others (2,5,13) have reported greater mobility and availability of NH_4 due to its greater activity in the electromotive series than NO_3. There was as much N in tissue of plants receiving 400 ppa N with 75% from NH_4 source as in those plants receiving 1400 ppa N with only 0-25% supplied from an NH_4 source.

Phosphorus.—P increased in tissue as ratios of NH_4 to NO_3 increased at the low N-K level only on the May 6 harvest date possibly due to initial competitive effects between PO_4 and NO_3 anions (Table 2).

Potassium.—On May 22, highest levels of K were found in plants receiving higher NH_4 to NO_3 ratios at low N-K levels, but the reverse was true at medium N-K levels (Table 3). Mean tissue K increased as total N-K was increased in the substrate at June 6 harvest time. NH_4:NO_3 ratios did not affect K in tissue of the last samples. K ions are among the most active, according to the lyotropic series, and its close position to NH_4 in its activity capability probably explains its apparent independence to NH_4:NO_3 ratios.

Calcium.—Ca content of tissue was highest in high NO_3 treatments and decreased as NH_4 to NO_3 ratios increased at all harvest times and at low N-K (Table 3). Increasing total N-K depressed absorption of Ca by final sampling date. Generally, reactions between these elements can be explained by cationic antagonisms between NH_4 and K.

Magnesium.—Mg was not affected by levels of N-K or ratios of NH_4 to NO_3 except slightly at the May 22 harvest date (Table 4). At this time Mg was generally higher at low N-K levels with increasing NO_3. This was probably due to competition between K at higher N-K levels and NH_4 ions at increasing NH_4 to NO_3 ratios.

Iron.—Fe was unaffected by treatments. Previous authors (2,11,12) have indicated that NH_4 to NO_3 ratios were more important to Fe utilization and availability within plants than with N source effect on absorption. They have generally stated that at higher NO_3 levels Fe was assumed to be combined with oxalate to form an insoluble

Table 2. Effects of N-K levels and ratios of NO_3 to NH_4 percentages at 3 harvest dates on chemical content of C. morifolium, 'Bright Golden Ann' leaves as per cent dry weight.

TREATMENT				NITROGEN			PHOSPHORUS		
Treatment Number	N-K levels	N source		Harvest Date			Harvest Date		
		%NO_3	%NH_4	May 6	May 22	June 6	May 6	May 22	June 6
2	400	25	75	5.2ab[x]	4.0a	4.2a	.35a	.31a	.18a
3	400	50	50	4.6abc	4.5a	3.2bc	.27abc	.28a	.14a
4	400	75	25	4.4bc	4.0a	2.8c	.17c	.31a	.15a
5	400	100	0	3.6c	3.6a	2.6c	.21bc	.25a	.15a
9	900	75	25	4.9ab	4.4a	3.1bc	.20bc	.26a	.15a
10	900	100	0	4.9ab	4.0a	2.8c	.18c	.25a	.14a
14	1400	75	25	5.4a	4.6a	4.0ab	.23bc	.24a	.15a
15	1400	100	0	5.0ab		3.3bc	.29ab		.15a

[x]Means having letters in common are not significantly different at 1% level by Duncan's multiple range test.

Table 3. Effects of N-K levels and ratios of NO_3 to NH_4 percentages at 3 harvest dates on chemical content of C. morifoluim, 'Bright Golden Ann' leaves as per cent dry weight.

TREATMENT				POTASSIUM			CALCIUM		
Treatment	N-K	N source		Harvest Date			Harvest Date		
Number	levels	$\%NO_3$	$\%NH_4$	May 6	May 22	June 6	May 6	May 22	June 6
2	400	25	75	4.88a[x]	4.93b	2.25c	.15c	.12c	.18c
3	400	50	50	4.96a	3.95cd	2.00c	.19bc	.18ab	.24abc
4	400	75	25	5.19a	3.63d	2.37c	.28ab	.19ab	.29a
5	400	100	0	4.85a	3.30d	1.92c	.29a	.24a	.31ab
9	900	75	25	5.48a	4.67bc	2.95bc	.20abc	.11c	.23abc
10	900	100	0	5.50a	5.94a	3.67bc	.26abc	.11c	.21bc
14	1400	75	25	4.90a	6.15a	5.12a	.19bc	.12c	.17c
15	1400	100	0	5.44a		5.22a	.24abc		.15c

[x]Means having letters in common are not significantly different at 1% level by Duncan's multiple range test.

Table 4. Effects of N-K levels and ratios of NO_3 to NH_4 percentages at 3 harvest dates on chemical content of C. morifolium, 'Bright Golden Ann' leaves as percent dry weight.

TREATMENT				MAGNESIUM		
Treatment	N-K	N source		Harvest Date		
Number	levels	$\%NO_3$	$\%NH_4$	May 6	May 22	June 6
2	400	25	75	.30a[x]	.41ab	.75a
3	400	50	50	.39a	.53ab	.67a
4	400	75	25	.37a	.56a	.80a
5	400	100	0	.44a	.54ab	.76a
9	900	75	25	.37a	.38b	.65a
10	900	100	0	.34a	.37b	.59a
14	1400	75	25	.34a	.38b	.52a
15	1400	100	0	.30a		.52a

[x]Means having letters in common are not significantly different at 1% level by Duncan's multiple range test.

Table 5. Effect of ratios of NO_3 to NH_4 and N-K levels on oxalate content (per cent dry weight) and height at 2 sampling dates of C. morifoluim 'Bright Golden Ann'.

Treatment				Total		
Treatment	N-K	N source		oxalate	Height - Inches	
Number	levels	$\%NO_3$	$\%NH_4$	June 22	May 22	June 6
2	400	25	75	0.45c[x]	10.9bc	17.00bc
3	400	50	50	0.79bc	12.5a	18.25a
4	400	75	25	0.87bc	12.6a	18.35a
5	400	100	-	1.08b	12.7a	18.35a
9	900	75	25	0.92bc	12.1ab	18.35a
10	900	100	-	0.99bc	11.6abc	17.75ab
14	1400	75	25	1.26b	10.96c	16.62bc
15	1400	100	-	1.83a	10.2c	16.75c

[x]Means having letters in common are not significantly different at 1% level by Duncan's multiple range test.

compound, making Fe unavailable for normal plant nutritional uses.

Oxalate.—Highest total oxalate generally was found in plants receiving the highest NO_3:NH_4 ratios at low and high levels of N (Table 5). This can probably be attributed to inhibition of oxalic acid oxalase synthesis in the presence of high NO_3 (9).

Generally the most vigorous, healthy appearing plants were those receiving combinations of NH_4 and NO_3 compared with those utilizing either source alone.

LITERATURE CITED

1. Arnon, D. I. 1939. Effect of ammonium and nitrate nitrogen on the mineral composition and sap characteristics of barley. Soil Sci. 48: 295-307.
2. Cain, J. C. 1950. A comparison of ammonium and nitrate nitrogen for blueberries. Amer. Soc. Hort. Sci. 59: 161-166.
3. Clark, H. E. 1936. Effect of ammonium and of nitrate nitrogen on the composition of the tomato plant. Plant Phys. 11: 5-24.
4. Colgrove, M. S. Jr. and Roberts, A. N. 1956. Growth of the azalea as influenced by ammonium and nitrate nitrogen. Amer. Soc. Hort. Sci. 68: 522-536.
5. Herath, H. M. E. and Eaton, G. W. 1968. Some effects of water table, pH and nitrogen fertilization upon growth and nutrient element content of highbush blueberry plants. Amer. Soc. Hort. Sci. 92: 274-283.
6. Joy, K. W. 1964. Accumulation of oxalate in tissue of sugar-beet and the effect of nitrogen supply. Annuals of Bot. 28: 689-701.
7. Kitchen, J. W., Burns, E. E. and Lanston, R. 1964. The effects of light temperature and ion balance on oxalate formation in spinach. Amer. Soc. Hort. Sci. 85: 465-470.
8. Marshall, V. L., Buck, W. B. and Bell, G. L. 1957. Pigweed (**Amaranthus retroflexus**): An oxalate containing plant. Amer. J. of Vet. Res. 28: 888-889.
9. Meeuse, B. J. D. and Campbell, C. D. 1943. An inhibitor or oxalic acid oxidase in beet extracts. Plant Phys. 34: 583-586.

10. Shear, C. B. 1958. Responces of tung trees in sand and soil cultures to ratios of ammonium to nitrate nitrogen and levels of potassium and zinc. Amer. Soc. Hort. Sci. 72: 224-239.
11. Sideris, C. P. and Young, H. Y. 1946. Effects of nitrogen on growth and ash constituents of **Ananas comosus** (L.). Plant Phys. 21: 247-270.
12. Singer, L. 1942. The physiological response of bahia grass to different forms of nitrogen. M. S. Thesis. U. of Fla. Lib.
13. Tiedjens, V. A. 1934. Factors affecting assemilation of ammonium and nitrate nitrogen, particularly in tomato and apple. Plant Phys. 9: 31-57.
14. van der Merwe, A. J. 1953. Nitrogen nutrition of citrus in the nitrate and ammonium form. Union of S. Afr. Dept. of Ag. Sci. Bull. No. 299.

MECHANICAL JOINING OF SCION TO STOCK IN APICAL GRAFTING OF ROSES AND OTHER PLANTS

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ABSTRACT

The "Pin-loc" graft joining method, recently submitted by its originator for U. S. Patent, was compared with conventional cleft joining used for cutting grafts of *Rosa*. The number of successful grafts and later growth of these grafted plants were equal when the two joining methods were compared. Pins made from stainless steel wire and inserted into splice cut stem centers supplied the internal splitting of the pin-loc grafts. These metallic pins, which remained in the grafted plants, caused no apparent injury to growth during the 22 months of this test. Pin-loc grafting is of special interest because the operations involved can be mechanized more easily than formerly used graft fittings. Suitability of various grafting procedures for mechanization was reviewed with some consideration of designing mechanical grafting tools for general nursery propagation.

INTRODUCTION

Mechanization in large volume production of grafted plants has the potential of making desirable graft combinations less costly and more available from plant propagation centers. In the usual nursery grafting process, a sequence of mechanically different operations can be identified as: (A) cut to form the related graft wound surfaces on both scion (cion) and stock (rootstock), (B) insert and anchor a detached scion on a stock in joining cut surfaces and in matching locations of exposed cambial layers, (C) wrap to stabilize the union and/or to enclose graft wound area, (D) shield scion and union area from drying atmospheres and temperature extremes when total environs are not well regulated. The first operation is the most difficult to perform manually. Operations A and B are assigned to the most skilled grafters and budders available, but a scarcity of these experienced workers is often a production limitation in nurseries that attempt to supply grafted cultivars. Objectives in developing more efficient mechanical grafting tools, at least would be to permit less skilled workers to cut and join scions and stocks, also to speed the training of inexperienced labor for performing grafting operations A and B.

The general rule that graftage is done entirely by hand labor already has some exceptions in the production of grafted *Vitis*, grape vines (1; 5 p. 85). Various mechanized tools have been devised for making uniform graft wound cuts, after which the cut pieces are joined manually. Dormant *Vitis* stems used for grafting are usually regular, clean, hard, and otherwise unlike stems of most plant taxa. The machines devised for making *Vitis* graft cuts are therefore not likely to be useful in grafting other kinds of plants without changes. For example, stems of *Rosa* are shredded by the same electrically driven circular saw blades that cut a neat series of tongues and grooves in *Vitis* stem ends for a mortice and tenon joining of scion to stock (1).

The apical position of scions in production of mechanically grafted grape vines is of interest as a model of procedure. *Apical grafting*, in which a stem section scion is joined to the terminal cut on a decapitated stock, appears more easily adapted for mechanical handling than

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