13. Lutz, J. M. and R. E. Hardenburg. 1968. The commercial storage of fruits, vegetables, and florist and nursery stocks. U.S. Dept. Agr., Agr. Handb. 66.
14. Pendergrass, A., F. M. R. Isenberg, L. L. Howell, and J. E. Carroll. 1976. Ethylene-induced changes in appearance and content of Florida-grown cabbage. *Can. J. Plant Sci.* 56:319-324.
15. Smock, R. M. 1977. Nomenclature for internal storage disorders of apples. *HortScience* 12:306-308.
16. Wu, M. T., and D. K. Salunkhe. 1972. Fungistatic effects of sub-atmospheric pressures. *Experientia* 29:866-867.

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Influence of Potting Media, Temperature, and Concentration of Ancymidol on Growth of *Chrysanthemum morifolium* Ramat.[1]

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Additional index words. controlled environment chambers, growth retardant

Abstract. **Influence of temperature, media and concentration of ancymidol (α-cyclopropyl-α-[p-methoxyphenyl]-5-pyrimidine-methanol) on the growth and flowering of selected cultivars of *Chrysanthemum morifolium* were studied. As day/night temperature increased or decreased from 22/18°C length of time required for the plants to come into flower increased. Stem elongation and leaf area decreased while fresh weight increased as temperatures decreased from 30/26° to 18/14°. Ancymidol applied at a concentration of 0.25 mg/pot of aqueous drench was sufficient to control height of plants grown in most media except pine bark humus. Incorporation of river sand, greenhouse soil or $Ca(OH)_2$ into pine bark humus increased ancymidol's effectiveness. Increasing growth regulator concentration also resulted in adequate height control for plants grown in pine bark humus.**

Ancymidol applied as either a foliar spray or an aqueous drench has provided good height control for many floricultural crops (2, 3, 5, 7, 11, 12, 15, 16). Substrate drenches are often the preferred method of application, since they are more precise and their effectiveness is less influenced by environmental factors than foliar sprays (14). Johnson (6) applied ancymidol as an aqueous drench to chrysanthemums grown in a 1 soil: 1 sand: 1 peat (by vol) medium and reported that as the concentration of ancymidol increased plant height decreased with a proportional increase in stem diameter. Larson and Kimmins (9) found that height of tall growing chrysanthemum cultivars was satisfactorily controlled by ancymidol drenches when plants were grown in a medium composed of 2 peat: 1 soil: 1 sand (by vol) but flowering was delayed slightly. According to Love et al. (10) flowering date of poinsettia was unaffected by application of ancymidol and height control was satisfactory for plants grown in a medium formulated from 2 soil: 1 acid peat moss: 1 sand (by vol). Larson and Bonaminio (8) reported that drench applications of ancymidol to 'Nob Hill' chrysanthemums grown in pine bark media were not effective in controlling height. Ineffectiveness of the retardant was attributed to medium composition since in the same glasshouse study foliar applications of ancymidol at the concentration of 264 ppm satisfactorily controlled plant height regardless of medium.

Based on leaching studies, Tschabold et al. (13), concluded that ancymidol applied as an aqueous drench did not vertically penetrate pine bark media uniformly. They concluded that nonuniform distribution of the chemical throughout a pine bark medium as compared to a soil would account for its low activity. However, in the same study it was observed that of the applied ancymidol only 0.2% was found in the leachate from a 2 pine bark: 1 sand (by vol) medium, whereas 48.8% was found in the leachate from the control (2 Brookston silty clay loam: 1 sand (by vol) medium). In neither medium was 100% of the applied ancymidol accounted for in the residue analysis.

Since all of the above studies were conducted in glasshouses, fluctuations in temperature could have been responsible for differences in plant response. The purpose of these studies was to investigate the influence of temperature and potting medium on the effectiveness of ancymidol in controlling height of chrysanthemum plants when grown in controlled environment chambers.

Materials and Methods

All studies were conducted in the controlled-environment glasshouses and chambers of the Phytotron at North Carolina State University and have been previously described (1). The chambers were set to provide a photon flux density of 670-735 $\mu Em^{-2}\ sec^{-1}$ between 400 and 700 nm at plant level. This energy is equivalent to 430-480 hlx.

All photoperiods were based on a 9 hr (0800-1700 hr) high intensity light period. Physiologically long days were provided by interrupting the dark period from 2300-0200 hr with 12 Wm^{-2} of photomorphogenic radiation (700-850 nm, 41 hlx) from incandescent lamps.

Day temperature was concomitant with the high intensity light period (0800-1700 hr) with an abrupt change from day to night and night to day temperature.

All irrigations were with either deionized water or Phytotron

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nutrient solution (1), unless otherwise specified. The range of concentration of growth retardant applied was chosen to bracket those recommended for height control of chrysanthemums (4).

Rooted chrysanthemum cuttings of uniform size were potted one to an 11.5 cm standard plastic pot. After potting plants were watered in with deionized water, placed on plant trucks in a Phytotron glasshouse and subjected to natural daylengths with a 3 hr (2300-0200 hr) night interruption. The glasshouse was set at a day/night temperature of 26/22°C. While in the glasshouse, the plants were misted from above 4 times daily with deionized water and for the duration of the study plants were irrigated twice daily with Phytotron nutrient solution.

Four days after potting, plants were shifted to Phytotron growth chambers which were programmed to provide long (9 + 3 hr) days. After the initial 2 weeks of long days and for the duration of the study, the chambers were reprogrammed to provide short (9 hr) days for floral initiation and development. At the commencement of short days, 4 plants in each substrate at each temperature had 0.00, 0.25, 0.50, or 0.75 mg of ancymidol in 100 ml aqueous drench applied per pot. In each chamber, plants were arranged in randomized complete blocks with 4 replications.

Individual plant height were recorded at the time of application of growth retardant, at biweekly intervals thereafter and at the termination of each study. Height was taken as the distance from the pot rim to the plant apex.

Study 1. Initiated Sept. 1975. Cuttings of 'Nob Hill' chrysanthemums were potted in the standard Phytotron mix (2 #16 gravel: 1 Redi Earth (1) v/v); pine bark humus; greenhouse soil (2 shredded acid peat moss: 1 Cecil clay loam soil: 1 sand (by vol); and river sand. The plants were grown in chambers set at temperatures of 30/26°C, 26/22°, 22/18° and 18/14°. At flowering fresh weight, leaf area and stem diameter were determined for each plant. Plants were severed at the intersection of the plane of the pot rim for fresh weight determination and were weighed with the flower head attached. Stem diameter was taken 5 cm basipetally from the calyx.

Study 2. Initiated Dec. 1975. Rooted cuttings of 'Giant #4 Indianapolis White' and 'Giant #4 Indianapolis Yellow' chrysanthemums were potted in standard Phytotron mix; pine bark humus; pine bark humus + greenhouse soil (by vol); and pine bark humus + river sand (by vol). The plants were grown in growth chambers at temperatures of 26/22°C and 22/18°. Plants were severed as described in Study 1, dried to a constant weight in a 60° drying oven and weighed with the flower heads intact.

Study 3. Initiated Feb. 1976. Rooted cuttings of 'Nob Hill' chrysanthemums were potted in standard Phytotron mix, pine bark humus, and pine bark humus amended with $Ca(OH)_2$ (10.0 g of $Ca(OH)_2$/kg pine bark humus). Plants were grown at temperatures of 30/26°C, 26/22°, 22/18° and 18/14°. Flowering date was determined for each plant and fresh weight was determined as described in Study 1. Flowering date was designated as that time at which the full complement of outermost florets were reflexed to the point at which they were perpendicular to the main axis of the stem.

Results

Study 1. Biweekly measurements indicate that maximum height control occurred during the first 4 weeks following application of ancymidol (Table 1), irrespective of temperature or medium. This would indicate that after a period of about one month the effects of the applied growth retardant diminished as the result of depletion, volatilization at these temperatures or leaching.

In all substrates the tallest plants were produced at a temperature of 26/22°C (Table 2). Control plants grown in river sand were not as tall as those grown in other media whereas those grown in pine bark humus were usually taller. Ancymidol applied in excess of 0.25 mg/pot to plants grown in pine bark humus usually resulted in an additional increase in the % height control (Table 3) and saturation levels were not apparent at all temperatures within the range of concentration used. Plants grown at 22/18°C in standard Phytotron mix, greenhouse soil or river sand and treated with ancymidol were similar in height. At 26/22°C plants grown in these 3 media were similar in height only when the concentration of growth retardant was 0.50 mg/pot or greater.

Plant fresh weight, leaf area and stem diameter were affected

Table 1. Growth increment of 'Nob Hill" chrysanthemum plants grown in 4 media at day/night temperatures of 26/22°C, Study 1.

		Growth (cm)			
		Weeks following application of ancymidol			
Medium	Ancymidol (mg/pot)	2	4	6	9
Pine bark humus	0.00	22.5	25.5	5.0	0.8
	0.25	15.0	16.6	5.4	0.5
	0.50	10.9	13.8	6.0	0.8
	0.75	9.8	8.9	5.1	0.6
River sand	0.00	15.1	24.8	5.8	0.6
	0.25	6.1	15.8	9.6	1.6
	0.50	5.9	11.9	7.6	1.3
	0.75	4.1	8.3	7.5	1.3
Greenhouse soil	0.00	21.6	24.1	5.5	0.6
	0.25	9.4	6.5	4.1	0.3
	0.50	8.5	5.0	2.6	1.4
	0.75	8.4	4.0	2.6	1.0
Standard Phytotron mix	0.00	20.6	23.4	5.1	0.9
	0.25	9.1	7.1	5.6	0.4
	0.50	7.9	4.4	4.3	1.4
	0.75	8.6	3.4	2.8	0.9
LSD 5%		2.6	3.7	3.1	1.3

Table 2. Effect of temperature, media and concentration of ancymidol on final height of 'Nob Hill' chrysanthemum plants, Study 1.

		Final plant ht (cm)[z]			
Day/night temp (°C)	Ancymidol (mg/pot)	Pine bark humus	River sand	Greenhouse soil	Standard Phytotron mix
30/26	0.00	60.3[y]	52.3	60.9	63.1
	0.25	47.6	40.3	35.0	33.6
	0.50	40.0	35.9	32.1	30.4
	0.75	38.0	33.1	31.4	29.6
26/22	0.00	68.1	57.3	67.4	66.0
	0.25	52.0	43.8	37.5	38.0
	0.50	46.0	36.1	31.9	31.8
	0.75	39.4	32.3	31.4	32.6
22/18	0.00	58.4	50.4	55.6	56.4
	0.25	45.0	27.3	28.6	26.9
	0.50	37.0	29.4	26.3	27.0
	0.75	32.5	25.3	25.3	25.8
18/14	00.0	59.6	48.4	58.1	59.5
	0.25	49.6	29.1	23.8	21.9
	0.50	41.1	27.9	22.6	20.6
	0.75	32.5	22.3	21.5	19.1

[z]Plant ht taken as distance from pot rim to apex of flower.
[y]LSD 5% = 4.8.

Table 3. Effect of media and concentration of ancymidol on % height reduction of 'Nob Hill' chrysanthemum plants grown at 4 day/night temperature conditions, Study 1.

Day/night temp (^{o}C)	Ancymidol (mg/pot)	Height reduction (%) compared to control plants grown in the same medium: Pine bark humus	River sand	Green-house soil	Standard Phytotron mix
30/26	0.00	--	--	--	--
	0.25	21	23	43	47
	0.50	34	31	47	52
	0.75	37	37	48	55
26/22	0.00	--	--	--	--
	0.25	24	24	44	42
	0.50	32	37	53	52
	0.75	42	44	53	51
22/18	0.00	--	--	--	--
	0.25	23	46	49	52
	0.50	37	42	53	52
	0.75	44	50	54	54
18/14	0.00	--	--	--	--
	0.25	17	40	59	63
	0.50	31	42	61	65
	0.75	45	54	63	68

Table 4. Effect of growth regulator concentration on fresh weight, stem diameter and leaf area of 'Nob Hill' chrysanthemums, Study 1.

Ancymidol concn (mg/pot)	Fresh wt (g)	Stem diam (mm)	Leaf area (cm^2)
0.00	110.9	6.3	857
0.25	89.3	6.4	791
0.50	82.0	6.6	757
0.75	79.9	6.8	731
LSD 5%	5.0	0.3	53

by concentration of growth retardant and by potting medium. As concentration of ancymidol increased from 0.50 mg/pot to 0.75 mg/pot fresh weight decreased from 110.92 g/plant to 79.91 g/plant and leaf area decreased from 857 cm^2/plant to 731 cm^2/plant (Table 4). However, with each increase in concentration of growth retardant there was an increase in stem diameter.

Study 2. All concentrations of ancymidol were effective in controlling height of both chrysanthemums cultivars grown at both temperatures in all media (Table 5). At 26/22^{o}C, 0.50 and 0.75 mg/pot were equally effective in controlling height of plants grown in pine bark humus, bark + sand and bark + greenhouse soil. At 22/18^{o}C height of 'Giant #4 Indianapolis Yellow' plants grown in all media was controlled equally as well by all concentrations of ancymidol. At both temperatures all concentrations of ancymidol were equally effective in controlling height of both cultivars of chrysanthemums when they were grown in standard Phytotron mix; an increase in the concentration of growth retardant above 0.25 mg/pot did not result in additional height control (Table 5).

Application of ancymidol to both cultivars of plants grown in standard Phytotron mix, regardless of temperature, resulted in a consistent decrease in dry weight. Plants grown in the other 3 media did not respond in this manner. 'Giant #4 Indianapolis White' plants grown in pine bark humus + river sand or pine bark humus + greenhouse soil exhibited a decrease in dry weight when treated with ancymidol at 26/22^{o}C but not when grown at 22/18^{o}. Similar concentrations of growth retardant applied to the same cultivar grown in pine bark humus at 26/22^{o} had no effect on dry weight and only at the higher concentration was dry weight affected for plants grown at 22/18^{o}. Application of ancymidol to plants of 'Giant #4 Indiapapolis Yellow' grown in pine bark humus + greenhouse soil at either temperature and those grown in pine bark humus at 26/22^{o} resulted in a decrease in dry weight.

Study 3. Control plants at each temperature grew equally as well in each of the 3 media. All concentrations of ancymidol were effective in controlling height of plants grown in standard Phytotron mix and increasing the concentration of growth retardant above 0.50 mg/pot did not result in any additional inhibition of height (Table 6). When plants were grown in pine bark humus each increase in concentration of growth retardant usually resulted in a parallel increase in inhibition of stem length. However, even plants grown in pine bark humus and treated with 0.75 mg/pot of ancymidol were taller than plants grown in standard Phytotron mix to which 0.50 mg/pot of retardant had been applied.

Incorporation of $Ca(OH)_2$ into pine bark humus increased growth regulator activity above that from equivalent concentration applied to plants grown in pine bark humus alone

Table 5. Influence of temperature, media and concentration of ancymidol on final height of 'Giant #4 Indianapolis White' (GIW) and 'Giant #4 Indianapolis Yellow' (GIY) chrysanthemums, in Study 2.

Day/night temp (^{o}C)	Ancymidol (mg/pot)	Final plant ht (cm) when grown in:[z] Std. Phytotron mix GIW[y]	Std. Phytotron mix GIY[x]	Pine bark humus GIW	Pine bark humus GIY	Pine bark humus + river sand GIW	Pine bark humus + river sand GIY	Pine bark humus + greenhouse soil GIW	Pine bark humus + greenhouse soil GIY
26/22	0.00	41.4	39.5	44.5	42.5	40.9	42.1	43.0	43.1
	0.25	17.4	16.0	31.0	26.3	25.3	23.3	23.4	20.1
	0.50	14.9	13.8	24.0	21.5	18.5	17.3	18.6	15.9
	0.75	15.6	12.6	22.0	20.1	17.9	17.0	17.0	15.4
22/18	0.00	33.5	35.5	35.2	34.8	35.3	37.5	30.8	35.6
	0.25	13.6	11.9	23.4	19.0	19.5	17.4	16.9	16.6
	0.50	11.3	10.6	19.5	16.4	17.0	14.4	15.6	14.4
	0.75	10.6	11.3	18.9	16.9	14.0	14.0	14.9	14.9

[z]Plant ht taken as distance from pot rim to apex of flower.
[y]LSD 5% = 4.4 (GIW).
[x]LSD 5% = 3.7 (GIY).

Table 6. Final height of 'Nob Hill' chrysanthemums as affected by temperature, media and concentration of ancymidol, Study 3.

Day/night temp (°C)	Ancymidol (mg/pot)	Final ht (cm) when grown in:[z] Std. Phytotron mix	Pine bark humus	Pine bark humus + $Ca(OH)_2$
30/26	0.00	43.0[y]	42.6	40.3
	0.25	17.1	32.5	26.4
	0.50	14.5	26.5	20.9
	0.75	16.9	22.9	15.5
26/22	0.00	42.1	38.5	38.1
	0.25	15.0	31.5	24.5
	0.50	12.8	23.9	18.4
	0.75	9.5	17.8	13.9
22/18	0.00	44.1	44.3	41.8
	0.25	14.4	33.5	35.3
	0.50	11.0	24.5	22.0
	0.75	8.9	17.0	13.6
18/14	0.00	42.0	38.8	37.1
	0.25	12.5	30.1	27.6
	0.50	10.4	22.5	21.0
	0.75	7.6	16.0	14.1

[z]Plant ht taken as distance from pot rim to apex of flower.
[y]LSD 5% = 5.4.

(Table 6). When ancymidol was applied at a concentration of 0.75 mg/pot there were no differences between plants grown in standard Phytotron mix and those grown in pine bark humus + $Ca(OH)_2$ at day/night temperatures of 30/26°C, 26/22° or 22/18°.

As day/night temperature decreased from 30/26°C to 18/14° plant and flower fresh weight increased (Table 7). The number of days for plants to flower increased as temperatures were either increased or decreased from 22/18°, with the longest time required for those plants grown at 30/26° (Table 8). Compared to control plants those treated with ancymidol had less plant and flower fresh weight and as concentration of ancymidol increased it took longer for plants to flower (Table 8). Number of days to flower was not affected by potting medium and although comparable to each other plants grown in pine bark humus and those grown in pine bark humus + $Ca(OH)_2$ had flowers with less fresh weight than those produced on plants grown in standard Phytotron mix. Plant fresh weight was also greatest when plants were grown in standard Phytotron mix and least when grown in pine bark humus.

Discussion

All of the variables (temperature, media and concentration of aqueous drenches of ancymidol) employed in the studies with selected cvs. of chrysanthemums affected one or more of the parameters measured. As concentration of growth retardant increased the number of days required for flowering and plant stem diameter increased while stem elongation was decreased. Furthermore, plant fresh and dry weight, flower fresh weight and leaf area decreased as concentration of retardant increased. This would suggest that while elongation of cells of subapical meristematic tissue is retarded by ancymidol, expansion of cells of the same tissue is promoted, thereby resulting in an increase in stem diameter. Since the increase in cell expansion is not proportional to the decrease in cell elongation there is a net decrease in plant weight which can be attributed to both the reduction of tissue mass and its capacity for retention of water. These factors could account for the reduction in both fresh and dry weight of the plants and fresh weight of the flowers from treated plants as compared to control plants. Similarly the reduction in cell elongation would have resulted in smaller leaves on treated as compared to control plants.

As temperature increased from 18/14°C to 30/26° there was a decrease in fresh weight of vegetative and floral portions of the plants. The effect on fresh weight could be attributed to an increase in transpiration rate for each increase in temperature, since on a dry weight basis (Table 6) there were no differences in plant weights. Decrease in stem elongation and leaf area as temperature decreased from 30/26° to 18/14° may have been the consequence of temperatures which were not conducive to the rapid progression of cellular activity and metabolism. Flowering time was increased as temperature increased demonstrating heat delay which is typically encountered when chrysanthemums are grown at night temperature exceeding 16°.

Plant growth was not satisfactory in all of the media. Those grown in river sand were chlorotic, had less leaf area and fresh weight and smaller diameter stems compared to plants grown in other media. However, aqueous drenches of ancymidol were as effective in controlling stem elongation when applied to plants grown in river sand as similar concentrations applied to plants grown in greenhouse soil or standard Phytotron mix at a day/night temperature of 22/18°C (Table 2). Ancymidol was least effective in retarding stem elongation when applied as an aqueous drench to plants growing in pine bark humus (Tables 2, 5 and 7). Incorporation of river sand or greenhouse soil into pine bark humus or incorporation of $Ca(OH)_2$ into pine bark humus increased the effectiveness of ancymidol over applications made to plants grown in pine bark humus alone. Aqueous drench applications of ancymidol at 2-3 times the recommended concentration also proved to be satisfactory for controlling stem elongation of plants grown in pine bark humus. While the last alternative does not increase the efficiency of any given concentration of ancymidol it could be utilized as an alternative to amelioration of pine bark humus with river sand, greenhouse soil, or $Ca(OH)_2$.

Table 7. Plant and flower fresh weight and number of days to flower for 'Nob Hill' chrysanthemum as affected by temperature, Study 3.

Day/night temp (°C)	Fresh wt (g) Plant	Flower	Days to flower[z]
30/26	88.5	39.8	71.0
26/22	99.5	59.4	60.3
22/18	110.8	69.5	58.3
18/14	119.4	80.1	65.6
LSD 5%	4.0	3.7	1.0

[z]From initiation of inductive photoperiod.

Table 8. Plant and flower fresh weight and number of days to flower for 'Nob Hill' chrysanthemum as affected by concentration of ancymidol, Study 3.

Ancymidol (mg/pot)	Fresh wt (g) Plant	Flower	Days to flower[z]
0.00	120.8	71.0	60.6
0.25	104.6	62.2	63.1
0.50	100.7	61.4	64.5
0.75	92.1	54.2	67.2
LSD 5%	4.0	3.7	1.0

[z]From initiation of inductive photoperiod.

Literature Cited

1. Downs, R. J. and V. P. Bonaminio. 1976. Phytotron procedural manual for controlled-environment research at the SouthEastern Plant Environment Laboratories. *N. C. Agr. Expt. Sta. Tech. Bul.* 244.
2. Einert, A. E. 1971. Response of pot chrysanthemums to growth retardant. EL-531. *Amer. Farm Res.* 20:7-8.
3. Gill, D. L. 1974. Ancymidol shortens Georgia Easter lillies. *Flor. Rev.* 154(3980):19, 61-64.
4. Heins, R. D., R. E. Widmer, and H. F. Wilkins. 1976. Growth regulator recommendations for floricultural crops. *Flor. Rev.* 158(4107): 36-37.
5. Hasek, R. F. and R. H. Sciaroni. 1973. Height control of pot chrysanthemums with A-rest. *Flor. Rev.* 151(3924):53-54.
6. Johnson, C. R. 1974. Response of chrysanthemums grown in clay and plastic pots to soil applications of ancymidol. *HortScience* 9:58.
7. Krauskopf, D. M. and P. V. Nelson. 1976. Chemical height control of Reiger Elatior Begonia. *J. Amer. Soc. Hort. Sci.* 101:618-619.
8. Larson, R. A. and V. P. Bonaminio. 1973. Application of A-Rest to chrysanthemums growing in a bark medium. *N. C. Flower Growers Bul.* 17:5-7.
9. Larson, R. A. and R. K. Kimmins. 1972. Response of *Chyrsanthemum morifolium* Ramat. to foliar and soil application of ancymidol. *HortScience* 7:192-193.
10. Love, J. W., R. A. Larson, and B. G. Hilliard. 1970. The effects of growth retardants and temperature on the growth and flowering of poinsettia cvs. 'Annette Hegg' and 'Eckespoint C-1'. *HortScience* 5:482-483.
11. Sanderson, K. C., W. C. Martin, Jr., K. A. Marcus and W. E. Goslin. 1975. Effects of plant growth regulators on *Lilium longiflorum* Thumb. cv. Georgia. *HortScience* 10:611-613.
12. Shanks, J. B. 1972. Chemical control of growth and flowering in hibiscus. *HortScience* 7:574.
13. Tschabold, E. E., W. C. Meredith, L. R. Guse, and E. V. Krumkalns. 1975. Ancymidol performance as altered by potting media composition. *J. Amer. Soc. Hort. Sci.* 100:142-144.
14. Tjia, B., S. Ohpanayikool, and J. Buxton. 1976. Comparison of soil applied growth regulators on height control of poinsettia. *HortScience* 11:373-374.
15. White, J. W. 1976. Lilium sp. 'Mid Century Hybrids' adopted to pot use with ancymidol. *J. Amer. Soc. Hort. Sci.* 101:126-129.
16. ___________ and E. J. Holcomb. 1974. Height control methods for poinsettia. *HortScience* 9:146-147.

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Total and Reduced Ascorbic Acid Levels in *Rin* and Normal Tomatoes.[1]

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Additional index words. Lycopersicon esculentum, fruit ripening, postharvest physiology, ethylene

Abstract. **Changes in reduced ascorbic acid in normal tomato fruits (*Lycopersicon esculentum* Mill.) during holding at 20°C seem to be related to ripening. No change in reduced ascorbic acid levels from mature green to yellow *rin* fruits was observed when detached from the plant. Apparently, a reduction mechanism from dehydro to reduced ascorbic acid is active in normal tomatoes but inactive in detached *rin* fruits. This mechanism was operative in normal and *rin* fruits left on the plant. Exogenous ethylene (10 ppm) neither affected reduced ascorbic acid levels in normal and *rin* fruits, nor the total ascorbic acid in normal fruits. Maintenance of initial levels of total ascorbic acid was noted in ethylene treated *rin* fruits. Similar total ascorbic acid levels were found in normal and *rin* fruits held on the vine to the red and yellow stages, respectively; and were higher than in comparable fruits held in storage.**

Tomatoes are considered a good source of vitamin C (23). Ascorbic acid (vitamin C) is found in plant tissue in 3 forms: reduced ascorbic acid (RAA); monodehydro-ascorbic acid (an unstable intermediate); and dehydro-ascorbic acid (DHA) (11). Dehydro-ascorbic acid is more stable at low pH, but can be lost by irreversible conversion to 2,3-diketogulonic acid (11). Reduced and dehydro-ascorbic acids are physiologically active in the animal body and have antiescurbic properties (17, 20) while 2,3-diketogulonic acid does not (17).

Clow and Marlatt (5) found that total ascorbic acid (TAA) in mature green and red tomatoes was the same. Brecht et al. (4) found similar results in 6 of 8 cultivars studied. Mapson (11) reported that the level of RAA in plant tissue is about 95% of the total ascorbic acid. However, Brecht et al. (4) found that in mature green tomatoes RAA values ranged from 21 to 72% of TAA depending on the cv. They also reported that RAA levels increased from mature green to the red stage to reach values that fluctuated from 83 to 100% of the TAA. The increase in RAA from mature green to red stages is supported by numerous reports (2, 3, 10, 21). However, others report no change (12, 22) or a decrease (16). Vine ripe tomatoes seem to have higher levels of RAA than fruits ripened in storage (2, 9, 21).

Exogenous ethylene has been reported to cause either no change (5) or a decrease (8) of TAA in treated fruits relative to non-treated. A slightly higher level of RAA was noted in ethylene treated fruits at the red stage (14, 22).

The *rin* mutant tomato lacks many of the changes associated with ripening (18). Due to this characteristic, the *rin* mutant was used in the present work to compare changes in TAA and RAA during ripening. Normal and *rin* tomatoes grown in the field or held in storage with or without ethylene treatment were studied in an attempt to relate changes of ascorbic acid to ripening.

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