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GROWTH OF SILVERNERVE PLANTS AS AFFECTED BY CHILLING TEMPERATURES, FERTILIZATION RATES, AND GROWTH REGULATORS[1]

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Abstract. **Intact plants were chilled at 2, 5, and 8°C for 2, 4, and 8 hr to classify visual, anatomical, and physiological symptoms. Symptoms were not apparent during chilling but within 4 hr after return to the greenhouse some plants wilted, inflorescences collapsed, and leaves developed necrotic spots. A 3 x 3 factorial with 504, 1008, and 2017 kg/ha/yr of N and K showed 1008 kg/ha of N and 1008 kg/ha of K per year produced optimum growth. Sprays and drenches of napthalene acetic acid (NAA) and 6-benzylamino purine (PBA) were evaluated for ability to reduce chill damage severity. Four wk after chilling, plants treated with NAA were taller than untreated plants, and plants treated with PBA had more leaves than untreated plants.**

Silvernerve plant (*Fittonia verschaffeltii argyroneura* Coem.) a creeping herbaceous perennial native to tropical regions of South America, is commonly grown in hanging baskets, or used in dish gardens and terrariums. Florida growers have suspected leaf spotting and necrosis and decreased growth of silvernerve plants during winter months to be the results of chilling exposure (6). Marousky and Harbaugh (3) reported that silvernerve plants were severely injured when subjected to 5.5°C for 2 days. These experiments were conducted to determine effects of fertilization rates, N:K ratios, and chilling temperatures and durations on selected growth parameters of silvernerve plants. In addition the use of growth regulators as a method of alleviating chilling damage severity was also evaluated.

Materials and Methods

Experiment one. Rooted cuttings were potted in 10 cm pots using bark, sand, peat (1:1:1 by volume) amended with 0.9 kg/m³ Perk (a micronutrient blend), and 4.2 kg dolomite/m³. Plants were grown in a shaded glass greenhouse under 32 klx natural light with a temperature range of 18 to 35°C (65 to 95°F). The experiment was a 3 x 3 factorial with all combinations of N and K at 504, 1008, and 2016 kg/ha/yr. Phosphorous levels were constant at 1008 kg/ha/yr. All fertilizers were applied weekly as liquids using stock solutions of H_3PO_4, KCl, NH_4NO_3, and KNO_3. There were 6 replicates per treatment with one plant per container as an experimental unit. Plant height, leaf spread, leaf number and leaf dry weight were determined after 10 wk.

Experiment two. Rooted cuttings were potted as in experiment one except 4.4 kg/m³ Osmocote 14-6-12 (N-P-K) was included in the potting mix. Plants were grown in the same greenhouse as in experiment one. After a 5 wk establishment period, plants were transferred to an unlighted walk-in refrigerated chamber on 3 consecutive days at temperatures of 2, 5, and 8±1°C for 0, 2, 4, or 8 hr. There were 7 replicates per temperature/duration treatment with one plant per container as an experimental unit. Plants were placed in the chamber at 2:00 am, 6:00 am, and 8:00 am, removed at 10:00 am for each temperature and returned to the greenhouse.

Leaf sections for anatomical observations were taken 30 days after chilling, killed in formalin alcohol acetic acid, sectioned at 10μm and stained with safranin 0 and fast green FCF. Eight wk after chilling plant height, root dry weight, leaf width, spread, number and dry weight were determined.

Experiment three. Rooted cuttings were potted as in experiment one and a 2x2x7 factorial experiment initiated. Two fertilizer rates 504 kg N:504 K/ha/yr and 1513 kg N:1260 kg K/ha/yr), 2 methods of chemical application (spray or drench), 7 growth regulator concentrations; 0, 300, 600, 900 ppm PBA [6-benzylamino-9-(tetrahydropyran 2-yl)-9H-purine], and 10^{-5}, 10^{-6}, 10^{-7} M NAA [naphthalene acetic acid] were used. There were 6 replicates per treatment with an individual container as the experimental unit. Treatment of sprayed plants was initiated one week after potting and plants were sprayed once weekly for 3 consecutive weeks. Drenched plants were treated once at the end of the third week. Eighteen hr after drenching and the last spray application all plants were chilled for 4 hr at 5+1°C and then returned to the greenhouse.

Results and Discussion

Experiment one. When all growth factors were considered, best growth was achieved with 1N:1K ratio with 1008 kg/ha/yr of each (Table 1). Increased levels of N resulted in less growth. However, this experiment was conducted during December and January and higher fertilizer levels during months with longer days, and consistently higher temperatures and light intensities might be required for best growth (2). The currently recommended fertilizer rate is 1345 kg/ha/yr of N using a 1-1-1 ratio (7). Foliar tissue analysis showed increased N and decreased K as N fertilization levels increased whereas tissue K increased and N decreased as K fertilization levels increased (Table 1). P rates were kept constant, but tissue levels decreased with increased N and K. Tissue levels, especially P, of silvernerve plant were higher than has been reported for other foliage plants (9). Two factors may account for this. A composite sampled of all leaves was analyzed. The lower leaves may have had residual traces of fertilizer on them. Silvernerve leaves are thin and pliable, with only a limited number of cells having high levels of cellulose, hemicellose, pectin, lignin, cutin, suberin and wax. Thus, there is little dilution effect from cells with low tissue N, P, or K.

Experiment two. Soil, foliage, and ambient air temperatures were determined during chilling by 24 gauge copper—constant thermocouples on a Esterline-Angus temperature recorder. Leaf temperatures dropped to ambient chamber temperatures within 10 min. Soil temperatures decreased rapidly from 18°C to an intermediate temperature, then slowly equalized to 2°, 5°, or 8° within 4 hr. After chilling and return to greenhouse, plant leaves and inflorescences were flaccid or collapsed. No plants were killed although

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Table 1. Influence of N and K fertilizer levels on growth parameters and leaf tissue levels of *Fittonia verschaffeltii argyroneura*.

Fertilizer level kg/ha/yr.	Plant ht. (cm)	Leaf spread (cm)	Leaves (no.)	Leaf dry wt. (g)	Tissue content dry wt. (%) N	P	K
N							
504	5.68	20.96	37.22	1.39	4.00	1.24	5.35
1008	4.28	20.86	32.64	1.33	4.45	1.20	4.32
2017	3.83	16.10	32.77	0.88	5.17	1.03	3.56
Linear	**z	**	N.S.	**	**	**	**
Quadratic	**	**	N.S.	**	**	**	**
K							
504	3.90	17.82	30.32	1.29	4.75	1.31	4.22
1008	5.15	20.18	41.25	1.39	4.55	1.14	4.27
2017	4.73	19.91	31.05	1.17	4.31	1.01	5.45
Linear	N.S.	N.S.	N.S.	N.S.	*	**	**
Quadratic	*	N.S.	*	N.S.	N.S.	**	**
N X K	N.S.	N.S.	N.S.	N.S.	**	**	**

zN.S. = non-significant, significant at the 5% (*) and 1% (**) levels.

inflorescences died on all chilled plants. The first pair of mature leaves from the apex showed the greatest amount of damage. Three wk after treatments brown necrotic spots were observed on 43% of plants exposed to 2°C for 8 hr, 35% of plants exposed to 5°C for 8 hr, and 25% of plants exposed to 8°C for 8 hr. Thus, silvernerve plant is extremely sensitive to chill damage, compared to other foliage plants which have been exposed to chilling temperatures for 24 to over 100 hr before damage has been reported (3, 8). Plant height, leaf spread, leaf number, and leaf dry weight were affected by chilling even after 8 wk of growth (Figs. 1, 2, 3, 4).

Microscopic examination showed the brown necrotic spots on chill injured plants resulted from mesophyll collapse. Cell collapse was usually more extensive in spongy mesophyll than palisade mesophyll. The most severe injury was characterized by a total collapse of mesophyll tissue, and only a layer of necrotic cells separated the upper and lower epidermal cells. The anatomical response of *Fittonia* leaves to chilling temperatures resembled *Phalaenopsis* (5) but differed from *Aglaonema* (1), which exhibited epidermal cell collapse.

Experiment three. Prior to chilling, height and leaf number of plants fertilized with 504 kg N:504 kg K did not differ from plants fertilized with 1513 kg N:1260 kg K but growth index and leaf spread were greater with the higher fertilizer levels (Table 2). Height and growth index of plants treated

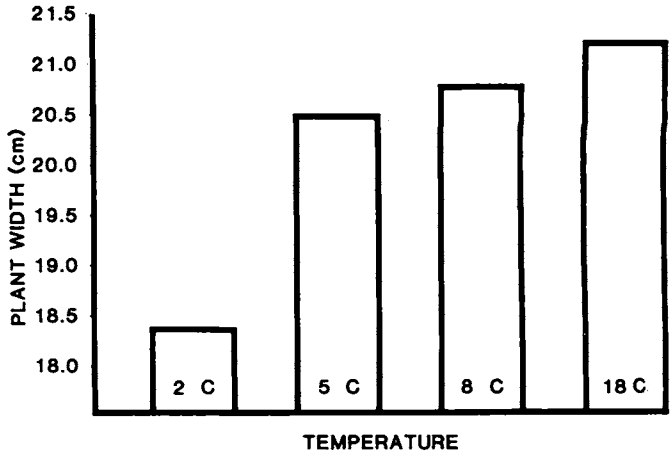

Fig. 2. Plant width after treatment for 2, 4, and 8 hr at respective temperatures. Each figure represents the mean of 7 replicates at each duration 8 wk after treatment.

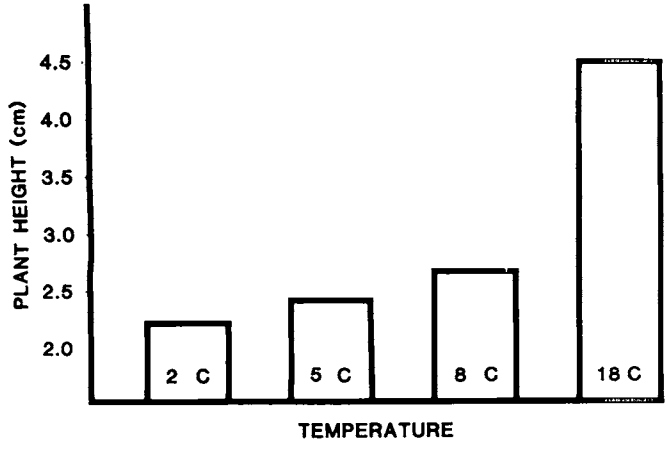

Fig. 1. Plant height after treatment for 2, 4, and 8 hr at respective temperatures. Each figure represents the mean of 7 replicates at each duration 8 wk after treatment.

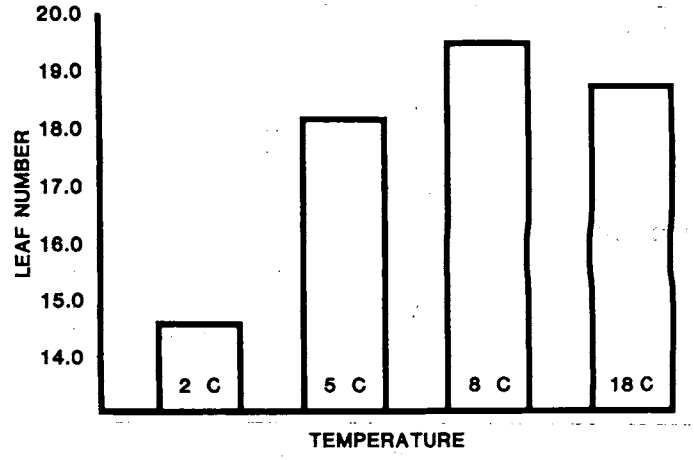

Fig. 3. Leaf number of plants after treatment for 2, 3, 4, and 8 hr at respective temperatures. Each figure represents the mean of 7 replicates at each duration 8 wk after treatment.

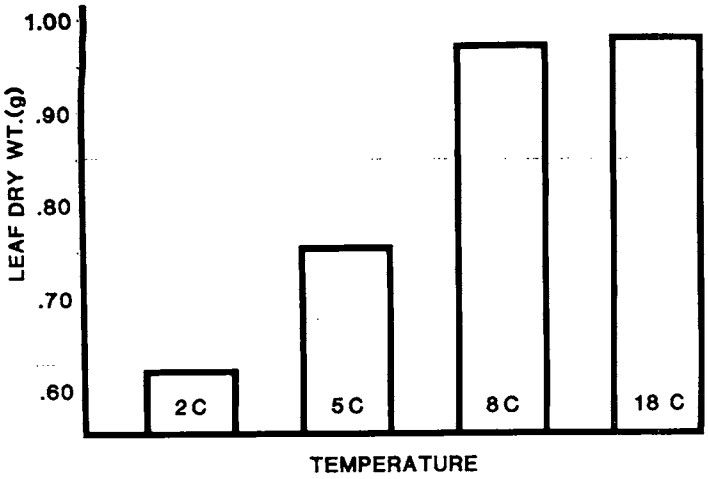

Fig. 4. Leaf dry wt. of plants after treatment for 2, 4, and 8 hr at respective temperatures. Each figure represents the mean of 7 replicates at each duration 8 wk after treatment.

with 10^{-6} M and 10^{-7} M NAA were greater than controls. Increasing NAA concentrations from 10^{-7} to 10^{-5} M decreased plant height at each concentration. Leaf spread and number were not affected. PBA plants did not differ from unsprayed plants except for larger number of leaves on plants treated with 600 ppm PBA.

After chilling stress at 5°C for 4 hr, plants treated with 10^{-5} M NAA wilted, and completely collapsed at both fertilizer levels and application methods. Plants drenched with 10^{-5} M NAA died within 2 wk after treatment. Leaves and apical meristems of plants sprayed with 10^{-5} M NAA died after chilling, but plants survived. Four wk after chilling, plants sprayed with 10^{-6} M NAA at high and low fertilizer rate were taller than corresponding controls (Table 3). Height of NAA drenched plants was not affected. NAA sprays and drenches caused some leaf distortion at 10^{-6} M and 10^{-5} M. Leaves were twisted with apices curled abaxially.

Compared to controls plants drenched or sprayed with 600 or 900 ppm PBA had an increased number of leaves. PBA has been reported to enhance axillary bud development in other foliage plants (4). In this study it increased axillary shoot and subsequent leaf development. However, leaf dry weights were not increased by any treatment, and plants sprayed or drenched with 900 ppm PBA had lower leaf dry weights than controls at the high fertilizer rate (Table 3).

The use of PBA and NAA reduced or eliminated some of the chilling injury symptoms. Based on this experiment, PBA could be used to increase leaf number of chilled plants and NAA to maintain normal plant height. However, serious phytotoxic reactions occured at the higher rates used in this experiment. Consequently, further testing is needed before any recommendations could be made.

Table 2. Effects of two fertilizer rates and NAA and PBA on plant height, leaf spread, growth index and leaf number of *Fittonia verschaffeltii* after 3 weekly sprays.

Fertilizer rate (kg/ha/yr.)	Concn.	Plant ht. (cm)	Growth index (ht. + leaf spread/2)	Leaf spread (cm)	Leaves (no.)
1513 N:1260 K	—	3.06a[z, y]	10.62a	18.13a	14.56a
504 N:504 K	—	2.75a	9.46b	16.53b	14.21a
PBA	300ppm	2.49cd[z, x]	10.22ab	17.94a	15.08ab
	600ppm	3.03bc	10.17ab	17.31ab	16.83a
	900ppm	2.39cd	9.18b	15.92b	14.17bc
NAA	10^{-7}M	4.29a	11.19a	18.09a	14.12bc
	10^{-6}M	3.41b	10.21a	17.00ab	14.00bc
	10^{-5}M	2.17d	9,94b	17.72ab	12.25c
Untreated	0	2.55cd	9.95b	17.35ab	14.25bc

[z]Each figure is mean of 84 replicates, each replicate a single plant.
[y]Mean separation within columns and groups by Duncan's multiple range test, 5% level.
[x]Each figure is mean of 24 replicates, each replicate a single plant.

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Table 3. Influence of two growth regulators and fertilizer rates on *Fittonia verschaffeltii*. Plants sprayed once a week during weeks 1, 2, 3, and drenched during week 3. All plants chilled during week 4. Data taken week 7.

Fertilizer (kg/ha/yr.)	Growth regulators	Concentration	Plant ht. (cm)		Leaf spread (cm)		Leaves (no.)		Leaf dry wt. (g)	
			Sprayed	Drenched	Sprayed	Drenched	Sprayed	Drenched	Sprayed	Drenched
1513N:1260K	PBA	300	3.53bc[z, y]	2.62abc	20.42a	19.6ab	31.0bc	29.0abc	0.82abcde	1.05ab
		600	3.03c	3.47abc	19.4ab	20.8ab	44.0a	32.2a	1.02ab	1.15a
		900	2.40c	3.42abc	16.43cd	19.4ab	35.8ab	26.7abc	0.53cde	0.60cd
	NAA	10^{-7}M	5.02a	3.38abc	19.53a	20.8ab	24.7cd	22.3cd	1.02ab	0.77bcd
		10^{-6}M	5.80a	3.88a	19.58a	20.6ab	20.7d	18.7de	0.78bcde	0.58d
		10^{-5}M	0.82d	—[x]	13.3d	—	6.3d	—	0.47e	—
	Control	0	3.45bc[w]	3.45abc	20.5a	20.5ab	24.5cd	24.5bcd	1.12a	1.12ab
504N:504K	PBA	300	3.13c	2.30bc	17.48bc	18.4bc	25.7cd	24.0bcd	0.63cde	0.78bcd
		600	2.95c	2.38bc	15.9c	17.9bc	38.3ab	27.2abc	0.68bcde	0.90abc
		900	2.47c	2.62abc	15.1c	17.4c	39.3a	29.8ab	0.77bcde	0.58d
	NAA	10^{-7}M	2.93c	2.38bc	17.5bc	18.1bc	24.00cd	18.0de	0.90abc	0.77bcd
		10^{-6}M	4.78ab	2.75abc	17.2bc	17.8bc	18.0d	22.0cd	0.75bcde	0.88abcd
		10^{-5}M	2.28c	—	13.4d	—	7.7e	—	0.50de	—
	Control	0	2.61c	2.61abc	18.2bc	18.2bc	22.2d	22.2d	0.77bcde	0.77bcd

[z]Each figure is a mean of 6 replicates. Each replicate is a single plant.
[y]Mean separation within columns by Duncan's multiple range test, 5% level.
[x]10^{-5} M NAA plants collapsed and died after chilling treatment.
[w]Each control figure is the mean of 12 replicates. Each replicate is a single plant.

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LIME REQUIREMENT OF SEVERAL SOILLESS MEDIA[1,2]

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Abstract. **Several soilless commercial media and various combinations of sand, Canadian peat, perlite, vermiculite, bark and calcined clay were treated with calcitic or dolomitic limestone at rates of 3.5, 7.0, or 14.0 lb./yd³. Soil pH was determined after 3 wk incubation. Individual components and limestone rates greatly affected final medium pH. More than half of the media required less than 3.5 lb. of either liming agent to bring the pH into a range of 5.0 to 6.0. Unamended media containing clay were within this range.**

In recent years growers of container crops have made a major change from mineral to organic media. Mineral media containing native soils are used less due to inconsistent quality and composition. Organic media generally contain no native soil and are composed of combinations of peat moss, bark, sand, perlite, and vermiculite, and can provide excellent aeration, drainage, and nutrient exchange capacity (1). Media pH is influenced by components present in the media, and indirectly affects plant growth. Media pH directly affects nutrient solubility and retention (CEC) and, thus, availability of nutrients to plants (2).

Solubility and leaching of nutrients such as K, Ca, and Mg in acid mineral media (below pH 6.0) is greater than in more alkaline media. Phosphates and ammonium may become soluble and leach at extremely low pH. On the other hand, alkaline mineral media decreases the solubility of most micronutrients (except Mo), rendering them unavailable (1). The recommended pH range for mineral media is 6.0 to 6.8, which is a compromise in availability of nutrients (3). Mineral media generally require 7 to 10 lb. of dolomite per yd³ to attain this pH range (1).

Peterson (2), showed that the optimum pH range for nutrient availability in an organic medium was as much as one full unit lower than that for mineral media. Thus, liming rates for organic media will be different than for mineral media.

Actual lime rate for specific pH changes depends on media components, and neutralizing value of the liming material (5). Medium pH cannot be calculated directly from component pH due to vast differences in chemical and physical properties of the components and interactions once in a mixture. This experiment was established to determine the amount of dolomite or calcite necessary to attain a pH range of 5.0-6.0 in several organic media.

Materials and Methods

Two factorial experiments with three replicates in completely randomized design were conducted with 23 organic media and 3 liming rates (Table 1). The first experiment used dolomite as the liming source and calcite was used in the second experiment. Acid washed builders' sand, Canadian peat, Grosorb calcined clay (a montmorillonite clay manufactured by Mid-Florida Mining Company, Box 63, Lowell, FL 32663), pine bark, horticultural grade perlite, vermiculite, and cypress shavings were components of media 1 through 20. Media 21 through 23 were commercially available soilless media specially prepared without the normal liming agents. Volume ratios for mixes were determined before wetting. Dolomite or calcite at rates of 3.5, 7.0, or 14.0 lb./yd³ were added to each medium. Dry medium and liming agent were placed in plastic bags, wet to saturation (water pH 6.5) and shaken to ensure mixing and wetting. Bags were closed and placed in a glass greenhouse maintained at 85°/70° F day/night temperatures for 3 wk. At experiment termination, media pH was determined from the saturated paste extract technique as described by Waters, et al. (4) and G. M. Geraldson (personal communication). The pH of deionized water used for pH determination was 5.6. All data reported are averages of 3 values.

Results and Discussion

The 7.0 lb. rate of dolomite or calcite resulted in pH values in excess of the range desired in almost all cases (Table 1). In fact, more than half the soils required less than 3.5 lb./yd³ of either liming material. The peat-sand-clay medium had an initial pH of 5.5 and would require no lime.

Only calcined clay and cypress shavings exhibited a pH which would not require lime as individual components. Sand, clay, perlite, vermiculite, and shavings were neutralized with 3.5 lb./yd³ of lime, greater amounts had little additional effect. Due to residual acidity, peat and pine bark continued to increase in pH as lime levels increased. Peat required 3.5 or 7.0 lb./yd³ of dolomite or calcite to bring the pH into the desired range.

Dolomite at the 3.5-lb. rate resulted in pH levels of 5.2

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