Table 2. Influence of temperature on the amounts of leachable NH_4-N measured at hr 0 (initial N measurement) and hr 48 (final N measurement) during nitrate accumulation rate (NAR) determinations and NAR (Expt. 2).

Temp (°C)	Day 6	12	18	24
	Hr 0 leachable NH_4-N (μg (NH_4-N/g of bark)			
10	108 ± 5[z]	136 ± 8	107 ± 11	80 ± 5
20	90 ± 5	97 ± 6	80 ± 5	64 ± 5
30	82 ± 4	104 ± 7	83 ± 5	66 ± 3
40	154 ± 12	179 ± 8	200 ± 10	200 ± 13
	Leachable NH_4-N remaining after 48 hr (μg NH_4-N/g of bark)			
10	86 ± 6	86 ± 2	71 ± 7	54 ± 6
20	17 ± 3	25 ± 3	10 ± 1	10 ± 1
30	13 ± 2	18 ± 2	10 ± 1	12 ± 1
40	146 ± 6	154 ± 8	176 ± 4	180 ± 6
	NAR (μg NO_3-N/g of bark per hr)			
10	0.59 ± 0.25	0.97 ± 0.13	1.36 ± 0.07	0.37 ± 0.09
20	1.49 ± 0.26	2.02 ± 0.17	2.04 ± 0.13	1.78 ± 0.60
30	1.90 ± 0.23	2.28 ± 0.33	1.96 ± 0.16	1.56 ± 0.14
40	0.53 ± 0.16	0.26 ± 0.15	0.26 ± 0.08	0.02 ± 0.02

[z]Mean ± SE (n = 5).

(9, 10). The lack of consistent differences in medium solution NO_3-N concentrations between 10° and the 20° and 30° treatments also may be explained by limiting amounts of NH_4-N. If most or all of the available NH_4^+ had been oxidized to NO_3^- at these temperatures during the 6-day interim period, then similar NO_3-N concentrations would be found despite the fact that NO_3-N was being accumulated at different rates.

Nitrate-N rather than NH_4-N fertilizers generally are recommended for cooler times of the year for container-grown crops (4). This recommendation is based on the assumption that applied NH_4-N will not be nitrified and NH_4^+ toxicity will develop. However, results of this study indicate that considerable nitrification occurs at 10° in a pine bark medium. The NH_4-N concentration of the nutrient solution (100 ppm) in this study is within the range of concentrations applied commercially; however, the potential for NH_4^+ toxicity would increase if higher NH_4-N concentrations were applied. Other factors, such as the frequency of NH_4-N application, the amount of NH_4-N absorbed by roots, and plant species also would influence the potential for NH_4^+ toxicity.

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Influence of NH_4-N Application Rate on Nitrification in a Pine Bark Medium

Alexander X. Niemiera[1] and Robert D. Wright[2]

Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

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Abstract. **Nitrification in a pine bark medium in response to a range of applied NH_4-N levels (25, 100, and 200 ppm) was studied. Medium solution NH_4-N concentrations at the 25 ppm N treatment decreased from 30 ppm at day 1 to 0 ppm at day 40. Ammoniacal-N concentration values decreased from 64 to 6 ppm and from 105 to 20 ppm for the 100- and 200-ppm N treatments, respectively, by day 60. Rapid increases in medium solution NO_3-N concentrations coincided with these NH_4-N decreases, resulting in low medium solution NH_4-N:NO_3-N ratios. During the periods of NO_3-N increase, medium solution pH decreased 0.3, 0.7, and 1.3 units for the 25-, 100-, and 200-ppm N treatments, respectively. Similarly treated bark without plants was used to determine a NO_3-N accumulation rate (NAR). NAR data indicated that the NH_4-N supply of the 100- and 200-ppm N treatments exceeded the oxidative capacity of nitrifiers during a 96-hr period.**

Ammoniacal fertilizers are used widely in the culture of nursery plants, and the amount of N in the medium solution usually depends on the method and frequency of N application. Research has shown that nitrification was responsible for low medium solution NH_4-N levels (20 ppm), despite periodic applications of a solution containing a relatively high NH_4-N level (100 ppm) (6). Also, nitrification was increased 3-fold in pine bark when fertilizer was increased from 100 to 300 ppm NH_4-N (7). The proportion of NH_4-N that remains as NH_4-N relative to the amount applied is of interest, since the NH_4-N:NO_3-N ratio has an influence on plant tissue nutrient concentration and growth (2, 3, 5). Thus, the objective of this research was

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[1]Graduate research assistant. Present address: Division of Agriculture, Arizona State Univ., Tempe, AZ 85287.

[2]Professor.

to determine the extent of nitrification in a pine bark medium treated with a range of NH_4-N concentrations.

Pine bark used in this experiment had a particle size distribution of 22% < 0.5 mm (U.S. sieve series #35), 22% > 0.5 and < 1.2 mm (U.S. sieve series #16), 18% > 1.2 and < 2.4 mm (U.S. sieve series #8), 24% > 2.4 and < 5.6 mm (U.S. sieve series #3.5), and 14% > 5.6 mm. This bark had a bulk density of 0.32 $g \cdot cm^{-3}$ and was primarily from *Pinus taeda* L.

Bark was moistened and amended with 0.58 kg urea, 6 kg dolomitic lime, and 1 kg Micromax/m^3 (Sierra Co., Milpitas, Calif.). Rooted cuttings of *Ilex crenata* Thunb. 'Convexa' were transplanted into 1-liter bark-filled plastic containers on 24 Jan. 1984 and grown in a glasshouse with day/night temperatures of 24°/18°C. Plants were arranged in a randomized complete block design with three containers per treatment in each of five blocks.

Plants were irrigated with 210 ml of nutrient solution containing either 25, 100, or 200 ppm N as $(NH_4)_2SO_4$; 10 ppm P as H_3PO_4; and 25 ppm K as K_2SO_4. Plants were irrigated with 420 ml of tap water after every two nutrient solution irrigations to prevent excessive salt accumulation. This sequence was repeated throughout the experiment, with the frequency of irrigation dependent on plant need. At least once every 30 days the medium solution was extracted 4 to 6 hr after the second nutrient solution irrigation using the pour-through technique (9). Distilled water (75 ml) was applied to the surface of the bark, and the leachate was collected and analyzed for pH, NH_4-N, and NO_3-N using ion-selective electrodes.

A NO_3-N accumulation rate (NAR) was determined using bark that was treated and irrigated as previously described; however, no plants were transplanted into these containers. A sufficient number of containers was prepared to allow for one container per treatment in each of five blocks to be sampled on the same days the medium solutions were extracted. Following irrigation, containers to be sampled were allowed to drain for 1 hr, bark in each container was stirred (to ensure uniform sampling), and a bark subsample (≈50 cm^3) was removed. This

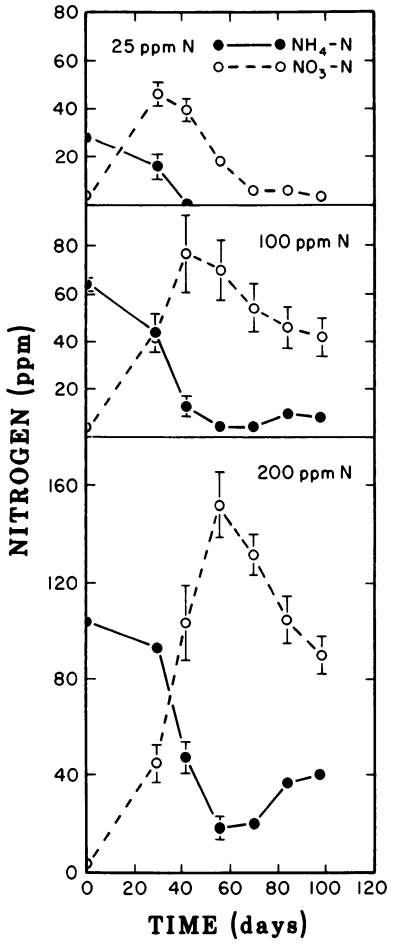

Fig. 1. Influence of NH_4-N concentration on medium solution NH_4-N and NO_3-N concentrations. SE < 2.0 if bars are not indicated.

subsample is termed the hr 0 subsample. Containers with remaining bark were enclosed in plastic bags and stored in an incubator at 25°C for 96 hr, when a second subsample (termed hr 96) was taken. Each subsample was put into a PVC tube (2.5 × 15.2 cm) with the bottom end covered with cheesecloth. Distilled water (210 ml) was dripped onto the bark-filled tubes at a rate of 70 $ml \cdot hr^{-1}$, and leachates were collected and analyzed for NH_4-N and NO_3-N. After leaching, bark from each tube was dried and weighed. Volume of leachate collected was multiplied by NH_4-N and NO_3-N concentrations to determine total amounts of leachable NH_4-N and NO_3-N in each sample. An amount of N/g of bark then was determined and the hr 0 value was substracted from the amount at hr 96 and divided by 96 to get NAR expressed as μg NO_3-N/g of bark per hr.

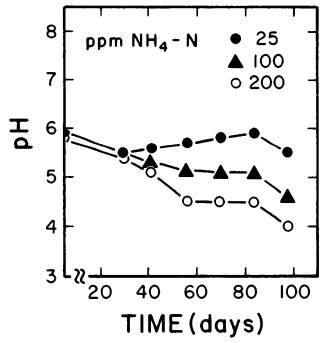

Fig. 2. Influence of NH_4-N concentration on medium solution pH. SE values for all points are <0.2.

NH_4-N concentration in extracted media solutions decreased from 30 ppm at day 0 to 0 ppm at day 40 in the 25-ppm treatment (Fig. 1). Ammoniacal-N concentrations in the 100-ppm N treatment decreased from 64 ppm at day 0 to 6 ppm at day 56 and remained relatively low. At the 200-ppm N treatment the decrease was from 105 ppm at day 1 to 20 ppm at day 60, after which the concentration increased to 40 ppm. A rapid increase in NO_3-N concentration coincided with the decline in NH_4-N for each treatment.

By day 56 there was a 0.7 and 1.3 pH unit decrease in the medium solution at the 100- and 200-ppm N treatments, respectively (Fig. 2). There was a 0.3 pH unit decrease between days 10 and 47 (the period of NH_4-N decline) in the 25-ppm treatment.

Although not statistically different in each instance, NAR for the 100- and 200-ppm N treatments were greater than the 25-ppm N treatment (except at day 41), with no consistent differences between the 100- and 200-ppm N treatments (Table 1). The hr 0 amount of leachable NH_4-N from bark-filled PVC tubes was greatest at 200 ppm N and least at 25 ppm N for all sampling dates (Table 1). Relatively low amounts of leachable NH_4-

Table 1. Influence of NH_4-N concentration on the amount of leachable NH_4-N measured at hr 0 and hr 96 (final N measurement) during NO_3 accumulation rate (NAR) determination.

N treatment (ppm)	Day 41	56	70	84	98	107
	Hr 0 leachable NH_4-N (μg NH_4-N/g of bark)					
25	122 ± 10[z]	57 ± 7	41 ± 7	27 ± 3	23 ± 4	14 ± 2
100	268 ± 15	154 ± 24	126 ± 7	121 ± 9	124 ± 7	129 ± 13
200	468 ± 25	370 ± 22	334 ± 25	377 ± 11	452 ± 35	372 ± 10
	Leachable NH_4-N remaining after 96 hr (μg NH_4-N/g of bark)					
25	59 ± 13	7 ± 1	4 ± 1	7 ± 1	4 ± 1	6 ± 1
100	202 ± 8	20 ± 4	14 ± 3	42 ± 3	28 ± 4	53 ± 8
200	430 ± 14	296 ± 16	151 ± 20	303 ± 7	432 ± 23	338 ± 11
	NAR (μg NO_3-N/g of bark per hr)					
25	2.22 ± 0.38	1.24 ± 0.38	0.55 ± 0.15	1.57 ± 0.15	0.86 ± 0.15	0.75 ± 0.15
100	2.08 ± 0.15	2.60 ± 0.23	1.76 ± 0.23	2.14 ± 0.53	1.26 ± 0.30	2.00 ± 0.38
200	1.76 ± 0.54	3.16 ± 0.38	1.32 ± 0.46	2.50 ± 0.61	1.13 ± 0.38	1.30 ± 0.30

[z]Standard error of mean, N = 5.

N at hr 0 as well as at hr 96 indicate that the NH_4-N supply for the 25-ppm treatment limited nitrification. In most instances, the NAR for the 200-ppm N treatment were not greater than the 100-ppm N treatment. Yet, higher medium solution NO_3-N concentrations were found at 200 ppm N than at 100 ppm N (Fig. 1). This apparent anomaly may be explained on the basis of NH_4-N availability during the NAR determinations. The lower amount of hr 0 leachable NH_4-N at 100 ppm N (Table 1) compared to the 200-ppm N treatment apparently did not limit nitrification, since there were no consistent differences in NAR between these treatments. However, after day 41, the hr 96 amount of leachable NH_4-N for the 100-ppm N treatment was only 6% to 16% of the amount found for the 200-ppm N treatment. NAR determinations characterized nitrification 96 hr after fertilization. Thus, more NH_4-N was available beyond the 96-hr period for the 200-ppm treatment than at the 100-ppm N treatment.

Extracted medium solution data indicate that nitrification and, presumably, NH_4-N absorption by roots contributed to the removal of NH_4-N from solution. The fact that NH_4-N was found after 96 hr in NAR leachates (Table 1) for the 100- and 200-ppm N treatments indicates that the amount of N supplied by these treatments exceeded the oxidative capacity of nitrificers.

The greater amount of NH_4-N oxidation at 200 ppm N resulted in a greater medium solution acidification as evidenced by the 0.6-unit difference in pH after day 41 between the 100- and 200-ppm N treatments (Fig. 2). Ingram and Joiner (4) also showed that pine bark medium pH decreased as the NH_4-N application rate increased. Since nitrification is directly related to pH (1), the lower pH at 200 ppm N may have contributed to the lack of difference in NAR between the 100- and 200-ppm N treatments. The relatively small difference between hr 0 and 96 leachable NH_4-N amounts during the last two sampling dates for the 200-ppm N treatment (Table 1) may be related to the inhibitory influence of a low pH on nitrification. Thus, a description of a treatment variable on nitrification should take into account the changing NH_4-N and pH status of the medium solution. Previous experiments (6, 7) also have noted the dynamic nature of the medium solution with regard to the N and pH status.

Concentrations of applied NH_4-N solutions and the resulting medium solution N concentrations in this experiment are representative of those concentrations applied to and found in the media solutions of nursery-grown container crops (8). The relative rapidity at which nitrification occurs in a pine bark medium is given in the following example: If the medium solution of a 3.8-liter bark-filled container (1250 g of bark) was at 200 ppm NH_4-N and, assuming that the bark was at 100% moisture holding capacity (gravimetric basis), then there would be 0.2 mg NH_4-N in solution per gram of bark. At a NAR of 2 μg NO_3-N/g of bark per hr (as found in this experiment), the medium solution NH_4-N content would be oxidized in 100 hr. This speculation is consistent with the low NH_4-N:NO_3-N ratios found in the media of commercially grown containerized plants fertilized on a relatively frequent basis through the irrigation system with a predominantly NH_4-N fertilizer (personal observation).

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Effects of High Temperature on Lateral Shoot Growth of Salvia and Impatiens After Pruning

Haruzo Higuchi, Wakanori Amaki, Meguri Minami, and Shigetoshi Suzuki

Department of Agriculture, Tokyo University of Agriculture, Setagaya, Tokyo, 156 Japan

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Abstract. **Seventeen-week-old plants of *Salvia splendens* Sello ex Nees and *Impatiens sultanii* Hook. f. were treated with high temperature for 1, 2, 3, 4, or 5 weeks. One week after the high temperature treatment, the plants were cut back to a height of 7 cm from the pot rim and grown in the greenhouse. The high-temperature treatment retarded the primary shoot growth of *Salvia* and *Impatiens;* however, after cutting back, lateral shoot growth was markedly stimulated in salvia and slightly increased in impatiens. Maximum growth of lateral shoots was attained at 850°C × hr of high temperature for salvia and at 400° × hr for impatiens, when expressed as the integrated temperature above 30° minus the temperature in the greenhouse.**

Temperature affects various plant growth and development processes, such as seed germination, dormancy, vernalization, and cold and heat hardiness (4). Larcher (3) indicated that temperatures above 45°C for 30 min caused considerable damage to various plants. Itai et al. (1) also reported that heat treatment of 2 min at 46° to 47° to root systems of *Nicotiana rusitica* and *Phaseolus vulgaris* reduced the growth of shoots and roots. Thus, high temperature stress injuries have been shown on plants (2). However, we observed that *Salvia* plants exposed to high temperature stress produced lateral shoots rapidly after pruning.

In this paper, we describe the relationship between the amount of high temperature and the promotion of lateral shoot growth in salvia and impatiens after pruning.

S. splendens cv. St. John's Fire and *I. sultanii* cv. Super Elfin Blush were used. Seeds of both species were sown on 14 Mar. 1985; seedlings were transplanted on 28 Apr. into 13.5-cm clay pots that contained a mixture of 5 loam : 3 leaf mold (v/v). Plants were grown on a greenhouse bench, watered, and fertilized with 100 mg·liter^{-1} N (5N–10P–5K) weekly until the start of high temperature treatment.

On 24 July 1985, 50 impatiens and salvia plants were transferred to the high-temperature treatment bench. The bench was enclosed with clear polyvinylchloride film 0.01 mm thick. The enclosure measured 1.0 m

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