Blueberries, like most calcifuges, have adapted to acidic soils that contain NH$_4^+$ as the predominant N form (Korcak, 1988). Several studies indicate that leaf N concentration and vegetative growth increase in highbush (Vaccinium corymbosum L.) and lowbush (V. angustifolium Ait.) blueberry and cranberry (V. macrocarpon Ait.) when fertilized with NH$_4^+\text{-N}$ vs. NO$_3^-$ (Cain, 1952; Greidanus et al., 1972; Peterson et al., 1988; Townsend, 1967; 1970). In other studies, no differences in vegetative growth due to N form have been observed (Hammitt and Ballinger, 1972; Oertli, 1963; Takamizo and Sugiyama, 1991).

Differences in growth may be due to differences in rhizosphere pH in addition to N form. In a factorial experiment of three N forms (NH$_4^+$, NH$_4$NO$_3$, and NO$_3^-$) and two pH levels (4.5 and 6.5), Rosen et al. (1990) found that ‘Northblue’ halfhigh blueberry (V. corymbosum L. x V. angustifolium Ait.) produced significantly more vegetative growth when grown hydroponically at pH 4.5 vs. 6.5, regardless of N form. At a given pH, vegetative growth was not affected by N form. In a similar study with hydroponically grown cranberry, vegetative growth was significantly greater in plants supplemented with NH$_4^+$-N compared to NO$_3^-$-N, and in plants grown at pH 4.5 vs. pH 6.0. There was no pH x N form interaction. However, Sugiyama and Hanawa (1992) observed an interaction between N form and pH in the growth response of hydroponically grown ‘Tifblue’ raspberry blueberry (V. ashei Reade). Shoot dry weight was greater in NH$_4^+$-fertilized plants vs. NO$_3^-$-fertilized plants at pH 3.0 and 4.0; however, there was no difference in shoot growth between N forms at pH 5.0. Although results from these experiments are not consistent, it is clear that pH can be a major factor in determining effects of N form on growth.

Growth differences attributed to different N forms and/or rhizosphere pH regimes may be due to differences in N uptake/assimilation patterns within the plant and/or differences in carbon-assimilation partitioning. Several studies indicate that NO$_3^-$-N uptake by blueberry is limited compared to NH$_4^+$-N uptake (Merhaut and Darnell, 1995; Peterson et al., 1988; Sugiyama and Hirooka, 1993; Sugiyama and Ishigaki, 1994), and this limitation has been associated with growth reduction in blueberries fertilized with NO$_3^-$-N. It has not been clearly demonstrated, however, that the reduced growth seen in NO$_3^-$-fertilized blueberries is due to limitations in NO$_3^-$ uptake.

The availability of carbohydrates to the site of N assimilation may have a marked effect on the extent of N uptake and/or assimilation and growth, since assimilation of both N forms requires C skeletons. In many herbaceous species, NO$_3^-$-N uptake and reduction appear to be carbohydrate limited after a period of darkness or during leaf development, when a significant decline in carbohydrate availability to the roots may occur. This limitation is closely correlated with rates of current carbohydrate flux from shoots to roots, rather than the carbohydrate status of the roots directly (Rideout and Raper, 1994). Similarly, NH$_4^+$-N uptake and assimilation appears to be limited if there is insufficient current carbohydrate available to the roots (Tolley-Henry and Raper, 1989). Reduction in growth of NH$_4^+$-fertilized plants has been attributed to the allocation of current C to support NH$_4^+$-N assimilation rather than root growth (Lewis et al., 1987).

There are limited studies on effects of carbohydrate availability on N uptake in perennial species. Weinbaum et al. (1978) reported that nonbearing prune trees (Prunus domestica L.) exhibited high NO$_3^-$-N uptake rates during rapid shoot development, suggesting that carbohydrate availability for NO$_3^-$-N uptake may not be limiting in woody perennials. However, NO$_3^-$-N uptake in holly (Ilex crenata Thumb.) was greatest between vegetative growth flushes (Gilliam and Wright, 1978), suggesting that insufficient C was available to support both N uptake and vegetative growth. Uptake rates of NH$_4^+$-N and NO$_3^-$-N as influenced by the availability of current C to roots, and the correlation with subsequent growth responses, have not been studied in blueberry.

The objective of the present study was to determine the effects of fertilization with NH$_4^+$-N or NO$_3^-$-N on vegetative growth of southern highbush (V. corymbosum L. interspecific hybrid) blue-
berries. Uptake and partitioning patterns of $\text{NO}_3^-$ and $\text{NH}_4^+$, as well as partitioning patterns of current C, were determined also in an attempt to relate differences in these processes to the observed growth responses.

**Materials and Methods**

**Plant material.** Rooted cuttings of ‘Sharpblue’ southern high-bush blueberry were grown for two years in 12-L pots containing 50% ‘Arrendondo fine sand’ and 50% perlite. During the 2-year pretreatment period, plants were fertilized every other week with 250 mg 20N–8.7P–16.6K containing 20% N as $(\text{NH}_4)_2\text{HPO}_4$, 30% N as $\text{KNO}_3$, and 50% N as urea. In March 1992, plants, which had about 200 cm of shoot growth, were removed from the containers and roots were cleaned of soil before repotting in 12-L pots containing acid-washed 20/30-mesh silica sand. Plants were grown from March 1992 to March 1993 in a greenhouse where day/night temperatures were maintained at 30 ± 7/18 ± 4 °C. On 20 Sept., daylength was extended to 14 h by installing fluorescent and incandescent lamps, which produced a PPF of 120 µmol·m$^{-2}$·s$^{-1}$ at the top of the plant canopy.

**Nutrient solution treatments.** Plants were fertilized every other day with 1 L of a modified Hoagland’s solution consisting of (mmol): 5.0 N, 1.4 P, 1.0 K, 0.5 Ca, 1.0 Mg, 0.4 Na, 1.7 S, 1.0 Cl, 9.0×10$^{-2}$ Fe, 4.5×10$^{-2}$ B, 9.1×10$^{-2}$ Mn, 1.1×10$^{-2}$ Zn, 1.6×10$^{-3}$ Cu, and 2.1×10$^{-3}$ Mo. The iron source was Fe-EDTA chelate.

Treatments consisted of fertilization with either $\text{NH}_4^+$ derived from $(\text{NH}_4)_2\text{SO}_4$ or $\text{NO}_3^-$ derived from NaNO$_3$. Therefore, there was an additional 2.6 mmol S supplied to the $\text{NH}_4^+$ treatments and an additional 5.0 mmol Na supplied to the $\text{NO}_3^-$ treatments at each fertilization time. The initial nutrient solution pH was adjusted to 3.0 for the $\text{NO}_3^-$ solution and 6.5 for the $\text{NH}_4^+$-N solution using HCl or Ca(OH)$_2$. Effluent pH was monitored after fertilization treatments, every other week by collecting the leachate in trays placed under the pots. Effluents were also analyzed for $\text{NH}_4^+$ and $\text{NO}_3^-$ content to verify that nitrification or reduction did not occur. Less than 0.02 mm NO$_3^-$ was recovered in the leachate from the $(\text{NH}_4)_2\text{SO}_4$ treatment. Additionally, there was no evidence of $\text{NH}_4^+$ contamination in leachates from the NaNO$_3$ treatment.

The pH regimes used in the present study were selected based on two preliminary studies (Merhaut, 1993). In the first of these studies, nutrient solution pH was maintained at 5.5 for both solutions. Effluent pH of the $\text{NO}_3^-$-treated plants increased continuously with each fertilization, which was accompanied by interveinal leaf chlorosis, suggesting Fe deficiency. Effluent pH of the $\text{NH}_4^+$-treated plants decreased continuously with each fertilization, reaching values less than 3.0. In the second preliminary experiment, initial nutrient solution pH for both treatments was adjusted to 5.5 as before; however, the nutrient solution pH was increased or decreased as the effluent pH decreased or increased in the $\text{NH}_4^+$-N and $\text{NO}_3^-$-N fertilized plants, respectively. Therefore, NO$_3^-$-nutrient solution pH was decreased to 4.0 after 98 days of growth in an attempt to prevent Fe deficiency symptoms. At the same time, the $\text{NH}_4^+$ nutrient solution pH was increased to 6.5 to prevent rhizosphere pH below 3.0, which can result in Ca, Mg, and K deficiency (Brady, 1990). However, slight chlorosis of young shoots still occurred in NO$_3^-$-fertilized plants. Therefore, in the present study, nutrient solution pH was adjusted to 3.0 and 6.5 for the NO$_3^-$-N and NH$_4^+$-N treatments, respectively at the beginning of the experiment. No visual nutrient deficiency symptoms were observed in either treatment throughout the one year experimental period.

To characterize further the effects of the $\text{NH}_4^+$ and NO$_3^-$-nutrient solutions on plant development, leaf tissue analyses were conducted. Mature leaves of the second vegetative flush were collected, oven dried at 70 °C, and ground to 40 mesh (0.417 mm) with a Wiley mill (Arthur H. Thomas Co., Philadelphia). A 500-mg tissue sample was placed in a ceramic mortar and ashed at 500 °C for 4 h. Ashed samples were suspended in 50 mL 1 n HCl, and filtered through no. 2 Whatman filter paper. Elemental concentrations of P, K, Ca, Mg, Fe, Mn, Cu, B, and Zn in solutions were quantified on an inductively coupled argon plasma spectrophotometer (ICAP-9000) (Thermo Jarrell-Ash Corp., Franklin, Mass.). Sulfur concentrations were determined by a Leco S analyzer (Leco Corp., St. Joseph, Mich.).

**Nitrogen and C partitioning.** At the end of the treatment period, when the plants were midway through the fourth growth flush, they were dual labeled with 105 mg N as 10% $^{15}$N-enriched $(\text{NH}_4)_2\text{SO}_4$ or NaNO$_3$ (Isotec Inc., Miamisburg, Ohio) and $^{14}$CO$_2$. Nitrogen was dissolved in 0.5 L deionized water and applied as a soil drench at 10:00 AM, 3 h after sunrise. No $^{15}$N-labeled solution leached out of the pots at the time of labeling. Immediately following $^{15}$N-labeling, plants were labeled with $^{14}$CO$_2$. Shoots of each plant were enclosed in a 48 × 60-cm clear bag and $^{14}$CO$_2$ was generated by reacting 1.30 MBq $^{14}$CO$_2$ (s.a. 2.2 GBq·mmol$^{-1}$) with 70 µL 10% H$_2$SO$_4$ inside a Teflon bag inside the bag. After 1 h, bags were removed. PPF and temperature averaged 950 µmol·m$^{-2}$·s$^{-1}$ and 21 °C, respectively, during the 1 h $^{14}$C-labeling period. During the 12-h period following $^{15}$N and $^{14}$C labeling, air temperatures increased from 21 °C at 10:00 AM to 30 °C at 3:30 PM, before decreasing to 21 °C by 9:30 PM. PPF averaged 800, 1440, and 124 µmol·m$^{-2}$·s$^{-1}$ at 9:30 AM, 1:00 PM, and 6:00 PM, respectively. After 12 h, plants were harvested, and total stem length and leaf area were measured. Plants were divided into roots, stems, leaves, and
new shoots (new stem and leaf tissue of the fourth flush), frozen in liquid N₂, oven dried at 70 °C, and ground to 40 mesh (0.417 mm) with a Wiley mill. Tissue N was determined by combusting and oxidizing 3 mg subsamples and quantifying the evolved N₂ on a NA 1500 gas chromatograph (Carlo Erba, Strada Riboltiana, Italy). The percentage of ¹⁵N was determined by mass spectrophotometry (Vacum Generators 602E, England).

To determine total ¹⁴C activity, 50 mg of dried tissue was extracted in boiling 80% ethanol for 2 min. Extracts were shaken for 20 min, centrifuged at 3500×g for 10 min, the supernatant decanted, and the pellet reextracted twice. The supernatants were combined and final volumes were measured. The ¹⁴C activity of a 1-mL aliquot was determined by liquid scintillation spectroscopy (LKB Instruments, Inc., Gaithersburg, Md.). The pellet was resuspended in 1 mL H₂O, solubilized with 250 µL tissue solubilizer (TS-1; Research Products International Corp., Mount Prospect, Ill.), and incubated at 60 °C for 12 h. Following incubation, 25 µL 0.1% acetic acid was added and samples were refrigerated 12 h to decrease chemiluminescence. The ¹⁴C activity of a 0.5-mL aliquot was determined. Total ¹⁴C activity of a tissue was calculated by adding the ¹⁴C activity of the ethanol-soluble and pellet fractions.

Statistical analysis. The experimental design was a randomized complete-block design with ten plants providing five replications of two treatments. The block effect was included due to the treatment interactions, these data were not × test. Results and Discussion

Treatment pH. Effluent pH decreased in the NH₄⁺-fertilized plants during the first 140 days of growth, stabilizing at about 3.0, while effluent pH in the NO₃⁻-fertilized plants increased, stabilizing at about 6.0 (Fig. 1). This gradual change in effluent pH is similar to changes observed in other studies (Hewitt, 1966; Townsend, 1967), and apparently reflects exchange of H⁺ and OH⁻ for NH₄⁺ and NO₃⁻, respectively, and/or cotransport of H⁺ with NO₃⁻ (McClure et al., 1990a, 1990b).

Nutrient analysis. Elemental analysis of leaf tissue and visual observations of leaves and roots indicated that concentrations of most nutrients were within the normal range for blueberry growth (Table 1) (Austin and Gaines, 1984; Ballinger, 1962; Clark, 1988; Eck, 1988; Korcak, 1986; Peterson et al., 1988; Spiers, 1978; 1983a; 1983b), with the exception of B, which was high, and Fe, which was low in leaf tissue of both treatments. Additionally, Na concentrations in the NO₃⁻-fertilized plants were high. Although Fe concentrations were below the sufficiency range, there was no difference in Fe concentration between N forms. Additionally, no visual symptoms of Fe deficiency, such as interveinal leaf chlorosis (Eck, 1988), occurred. This suggests that Fe was physiologically available for plant growth and development, and was not a contributing factor to the growth differences observed with different N treatments. Leaf necrosis associated with excess Na was not observed in the NO₃⁻ treatments in the present study, even though others have reported leaf necrosis on blueberry plants when Na concentrations in mature leaves were above 5.0 mg·g⁻¹ dry weight (Haby et al., 1986). Overall visual observations of shoot and root tissue indicated no apparent nutrient deficiency or toxicity symptoms in either treatment. Together, these data indicate that proper nutrient balances for both N treatments were maintained.

Leaf concentrations of Mg, K, S, and P were significantly greater in the NH₄⁺-N compared to the NO₃⁻-N fertilized plants, while Cu and B were lower (Table 1). Similar effects on Mg, K, and S concentration have been found in studies in which the NH₄⁺ and NO₃⁻ sources were (NH₄)₂SO₄ and NaNO₃ (Spiers, 1978; Townsend, 1967). In other studies, where Ca(NO₃)₂ was used as the NO₃⁻ source, concentrations of Mg and K were higher in NO₃⁻-N compared to NH₄⁺-N fertilized plants (Peterson et al., 1988; Rosen et al., 1990). These effects of NH₄⁺ and NO₃⁻ on Mg and K concentration may be due to the competition of the counter ions (i.e., Na or Ca) with other elements for uptake (Glass, 1989).

Vegetative growth. Leaf, stem, root, and total plant dry weights, as well as total stem length, were significantly greater in the NO₃⁻-N compared to the NH₄⁺-N fertilized plants (Table 2). The increased growth of blueberry when fertilized with NO₃⁻-N vs. NH₄⁺-N differs from other studies (Hammett and Ballinger, 1972; Oertli, 1963; Rosen et al., 1990), where NO₃⁻-N produced equal or less vegetative growth than NH₄⁺-N fertilized plants. It appears that blueberry can effectively utilize NO₃⁻-N, as long as rhizosphere pH is within an appropriate range. Acidic conditions in the rhizosphere may increase NO₃⁻ uptake due to increased H⁺/NO₃⁻ symport (McClure et al., 1990a, 1990b). Such enhancement of NO₃⁻ uptake at low rhizosphere pH would be consistent with the observation that blueberry growth is often independent of N form at acidic pH (Rosen et al., 1990).

Table 2. Vegetative growth of ‘Sharpblue’ blueberry plants fertilized with NH₄⁺ or NO₃⁻.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Dry wt (g)</th>
<th>Total leaf area (cm²)</th>
<th>Total stem length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH₄⁺</td>
<td>417.2</td>
<td>58.8</td>
<td>121.6</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>701.2</td>
<td>107.4</td>
<td>247.2</td>
</tr>
</tbody>
</table>

*NS* Nonsignificant or significant at *P* = 0.05 by *t* test.

Table 1. Leaf nutrient concentrations of ‘Sharpblue’ blueberry plants fertilized with NH₄⁺ or NO₃⁻.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>NH₄⁺</th>
<th>NO₃⁻</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca</td>
<td>4.1</td>
<td>4.3</td>
</tr>
<tr>
<td>Mg</td>
<td>2.9</td>
<td>2.0</td>
</tr>
<tr>
<td>K</td>
<td>12.3</td>
<td>9.1</td>
</tr>
<tr>
<td>S</td>
<td>6.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Na</td>
<td>0.2</td>
<td>10.7</td>
</tr>
<tr>
<td>P</td>
<td>2.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Zn</td>
<td>31</td>
<td>27</td>
</tr>
<tr>
<td>Cu</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Mn</td>
<td>*</td>
<td>NS</td>
</tr>
<tr>
<td>Fe</td>
<td>1604.4</td>
<td>108</td>
</tr>
<tr>
<td>B</td>
<td>126</td>
<td>*</td>
</tr>
</tbody>
</table>

*NS* Nonsignificant or significant at *P* = 0.05 by *t* test.
Table 3. Nitrogen concentration in the vegetative tissue of ‘Sharpblue’ blueberry plants fertilized with NH₄⁺ or NO₃⁻.

<table>
<thead>
<tr>
<th>Nitrogen concn (mg g⁻¹ dry wt)</th>
<th>New shoots</th>
<th>Leaves</th>
<th>Stems</th>
<th>Roots</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₄⁺</td>
<td>18.0</td>
<td>14.6</td>
<td>7.7</td>
<td>8.2</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>16.8</td>
<td>12.4</td>
<td>4.3</td>
<td>7.2</td>
</tr>
</tbody>
</table>

NS, Nonsignificant or significant at *P = 0.05 by t test.

Nitrogen concentrations, uptake, and partitioning. Leaf N concentration was significantly greater in the NH₄⁺ vs. NO₃⁻-fertilized plants, averaging 15 and 12 mg N/g dry weight, respectively (Table 3). The N concentration in the NO₃⁻-fertilized leaf tissue is slightly lower than the average for other southern highbush blueberry cultivars (Clark, 1988). Nitrogen concentrations in stems was also greater in NH₄⁺-N treatments, while N concentrations in new shoots and roots were similar between the two treatments. Higher N concentrations have been observed in roots (Hammett and Ballenger, 1972; Peterson et al., 1988), shoots (Takamizo and Sugiyama, 1991), or both roots and shoots (Rosen et al., 1990; Townsend, 1969) of NH₄⁺- compared to NO₃⁻-fertilized plants. In general, the increased leaf N concentration does not typically correlate with increased vegetative growth (Rosen et al., 1990; Smith et al., 1990; Spiers, 1983a; Sugiyama and Hanawa, 1992). In rabbiteye blueberry, greater shoot growth occurred in NH₄⁺ vs. NO₃⁻ treatments when grown at pH 3.0 or 4.0, but equal shoot growth between N treatments occurred when grown in solution pH 6.0 (Sugiyama and Hanawa, 1992). These growth responses could not be readily explained by tissue N concentrations, which were consistently higher in NH₄⁺ vs. NO₃⁻ treatments, regardless of solution pH. Similarly, Rosen et al. (1990) found greater N concentrations in tissues of NH₄⁺ vs. NO₃⁻-treated plants, even though no differences in plant growth were observed between the two N forms. These studies and the present experiment indicate that increased leaf N concentrations do not necessarily correlate with increased vegetative growth.

Total N accumulation derived from ¹⁵N-fertilizer did not differ between N treatments during the 12-h uptake period, averaging 45 and 43 mg N for NH₄⁺- and NO₃⁻-fertilized plants, respectively (Table 4). This occurred despite the greater plant dry weight of the NO₃⁻-fertilized plants. Uptake rates over the 12-h period averaged about 10 µg N/g plant dry weight per h for NH₄⁺-fertilized plants, and about 6 µg N/g plant dry weight per h for NO₃⁻-fertilized plants. Although these rates are somewhat less than the uptake rates observed in blueberries fertilized previously with NH₄NO₃, these findings support the earlier observation that NH₄⁺-N uptake rates in blueberry were 2-fold greater than NO₃⁻-N uptake rates (Merhaut and Darnell, 1995). The partitioning of ¹⁵N-fertilizer-derived N to the new shoots, leaves, stems, and roots was not affected by N treatment. Of the total ¹⁵N-fertilizer N taken up, 17% and 26% was recovered in the shoots of the NH₄⁺- and NO₃⁻-fertilized plants, respectively (Table 4).

The increased uptake rates in NH₄⁺-fertilized plants led to increased concentration of ¹⁵N-fertilizer-derived N in the whole plant compared to the NO₃⁻ treatments (Table 4). This was due primarily to a significantly higher N concentration in roots of NH₄⁺- vs. NO₃⁻-fertilized plants. The concentration of ¹⁵N-fertilizer-derived N in new shoots, leaves and stems was not affected by N form. The decreased N concentration in roots of NO₃⁻-fertilized plants may reflect decreased NO₃⁻ reduction due to low nitrate reductase activity (NRA) (Merhaut, 1993) and the subsequent feedback inhibition of NO₃⁻ uptake.

Although these data indicate that NO₃⁻-N uptake is restricted in blueberry compared to NH₄⁺-N uptake, this restriction clearly does not lead to inhibition of growth in NO₃⁻-fertilized plants. In fact, growth increased in NO₃⁻-fertilized plants compared to NH₄⁺-fertilized plants despite this restriction in NO₃⁻ uptake.

Carbon partitioning. The partitioning of ¹⁴C-labeled photosynthates is expressed as the relative specific activity (RSA) (Brun and Betts, 1984):

\[ RSA = \left( \frac{\text{dpm of plant organ/total dpm of plant}}{\text{(dry weight of plant organ/total plant dry weight)}} \right) \]

The RSA normalizes for differences in ¹⁴C uptake and recovery and allows estimation of the extent of C partitioning to a particular plant organ relative to its mass. Significantly more current C was partitioned to new shoots of NO₃⁻-fertilized plants compared to NH₄⁺-fertilized plants (Table 5). Carbon partitioning to other organs was not affected by N treatment. The increased allocation of C to new shoots of NO₃⁻-fertilized vs. NH₄⁺-fertilized plants may be a reflection of NO₃⁻ reduction occurring in the leaves, as is the case in many herbaceous crops (Lewis et al., 1987). Wang and Korcak (1995) have detected NRA in mature leaves of northern highbush and rabbiteye blueberries. The observation that the increased C demand by new shoots of NO₃⁻-fertilized plants did not reduce C partitioning to other plant parts suggests that the current C supply was sufficient for uptake of both N forms. Although the effects of C availability on uptake of different N forms in woody perennials has received little attention, there are a few studies on the effects of C availability on NO₃⁻ uptake. In mature prune trees (Weinbaum et al., 1978) and peach (Prunus persica L. cv. Maycrest) trees (Munoz et al., 1993), NO₃⁻ uptake rates were actually higher during rapid shoot development, suggesting that C availability was not limiting in these

Table 4. ¹⁵N-enriched fertilizer nitrogen content and concentration in vegetative organs, and the percentage of total fertilizer N recovered in the shoots of ‘Sharpblue’ blueberries fertilized with NH₄⁺ or NO₃⁻. Plants were fertilized with ¹⁵N-enriched NH₄⁺ or NO₃⁻ and harvested 12 h after labeling.

<table>
<thead>
<tr>
<th>Plant</th>
<th>New shoots</th>
<th>Leaves</th>
<th>Stems</th>
<th>Roots</th>
<th>Shoot N/total N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₄⁺</td>
<td>44.9</td>
<td>3.3</td>
<td>0.5</td>
<td>4.0</td>
<td>36.9</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>42.5</td>
<td>5.1</td>
<td>0.6</td>
<td>5.0</td>
<td>31.9</td>
</tr>
</tbody>
</table>

NS, Nonsignificant or significant at *P = 0.05 by t test.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Nitrogen concn (µg g⁻¹ dry wt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₄⁺</td>
<td>125.0</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>78.0</td>
</tr>
</tbody>
</table>

NS, Nonsignificant or significant at *P = 0.05 by t test.
N (as NO3−)  carbohydrates are available to support both vegetative growth and that, under conditions of this study, adequate current and/or total appear to be valid under the conditions of this study. It also appears blueberries is due directly to inadequate uptake of NO3− inhibit vegetative growth, provided that pH is maintained below berry growth, the uptake of NO3− both vegetative growth and N uptake. In the present study, the 2-year-old blueberry plants apparently had sufficient carbohydrates available to support both vegetative growth and N uptake.

Based on these observations, it appears that although southern highbush blueberry plants are able to take up NH4+-N and NO3−-N when pH is maintained in a range considered optimum for blueberry growth, the uptake of NO3−-N is limited relative to NH4+-N uptake. However, this limitation to NO3− uptake clearly does not inhibit vegetative growth, provided that pH is maintained below 6.0. Thus, the hypothesis that growth inhibition of NO3−-fertilized blueberries is due directly to inadequate uptake of NO3− does not appear to be valid under the conditions of this study. It also appears that, under conditions of this study, adequate current and/or total carbohydrates are available to support both vegetative growth and N (as NO3− or NH4+) assimilation in blueberry.

### Literature Cited


