vested on 4 Oct. 1985 and 2 Oct. 1986. After harvest, yields of specific tuber grades and size classes were determined. Yield and petiole nutrient concentration data were tested by analysis of variance procedures (3).

Petiole analysis. Petiole NO_3-N concentrations for the five treatments in both experiments decreased from 22,000 ± 2000 $mg \cdot kg^{-1}$ at the first sampling in early July, to 10,000 ± 1500 $mg \cdot kg^{-1}$ at the fourth sampling in late August. However, P treatment did not significantly affect petiole NO_3-N concentration ($P = 0.05$) at any sampling date. These petiole NO_3-N concentrations indicate that N availability was adequate for maximum tuber growth (4, 8).

In contrast, fertilizer source had a signficant effect on the concentration of soluble P in potato petioles (Table 1). In 1985, soluble P concentrations for the check and the AUP-60 treatments were similar throughout the sampling period. However, the APP-60 treatment produced petiole P concentrations that were 25% to 40% higher than those for the check and the AUP-60 treatment at the first three sampling dates. Similarly, petiole P concentrations for the APP-120 treatment were higher than those for AUP-120 treatment throughout the sampling period.

Petiole P concentrations in the 1986 experiment deceased more rapidly than did those in the 1985 experiment, possibly due to the lower fertilizer rates and the use of two bands rather than one. However, P concentrations were again higher with APP than with AUP during the early stages of tuber growth. By the end of the tuber bulking period, differences in petiole P concentration among P treatments were negligible.

Research conducted in southern Idaho (7) has established 1000 mg P/kg as the critical petiole concentration for adequate P nutrition in 'Russet Burbank' potatoes. Our results show that petiole P concentrations remained above this level for a longer period with APP than with AUP.

These apparent differences in P availability for AUP and APP may be explained, in part, by the results of a study that compared changes in $NaHCO_3$-extractable P and pH in AUP and APP bands in a calcareous soil over a 75-day period (9). Extractable P concentrations in AUP bands were higher than those in the APP bands for the first 10 days, but then rapidly dropped to a level 30% to 36% below that of the APP treatment for the remainder of the sampling period. Soil pH in the bands was not affected by fertilizer source. The authors postulated that the rapid decrease in available P in the AUP bands may have resulted from the production of relatively unavailable calcium phosphate compounds from the reaction of H_3PO_4 and $CaCO_3$.

Yield. The yield results from our studies reflect the differences in petiole P concentration. In 1985, the AUP yield exceeded the control yield when applied at 120 kg P/ha, but not at 60 kg P/ha (Table 2). However, APP produced higher yields than AUP at both P rates. Yields of undersized (<114 g), midsized (114 to 283 g), and malformed tubers were not significantly affected by fertilizer treatment. Thus, the higher yields with APP resulted primarily from increased production of large (>283 g) tubers.

Yields were somewhat lower in 1986, but again the highest yield at either P rate was obtained with APP, which produced higher yields of midsized and large tubers than did AUP.

Percentages of U.S. No. 1 potatoes averaged 64% and 75.8% in 1985 and 1986, respectively. However, mean percentages for the P fertilizer treatments were not significantly different ($P = 0.05$).

The results of this study show that, during most of the growing season, potato petiole P concentrations were higher with APP than with AUP and that APP produced higher total yields by increasing the production of large tubers. By comparison, petiole NO_3-N concentrations were not affected by P fertilizer source.

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Growth and Nutrient Status of Celery Seedlings in Response to Nitrogen Fertilization and NO_3:NH_4 Ratio

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Abstract. **Celery seedlings (*Apium graveolens* L. cv. Florida 683) were seeded in multicell styrofoam trays containing a commercial peat mix. They were irrigated with nutrient solutions containing three N fertilizations (150, 250, or 350 mg N/liter) and three NO_3:NH_4 ratios (1:1, 2:1, or 3:1) in factorial combinations. Growth measurements and saturated medium extracts were obtained on days 38, 45, and 52 after seeding. Increasing N fertilization increased leaf area and shoot dry weight, but decreased root dry weight and root : shoot ratio. The lowest NO_3:NH_4 ratio had increased the percentage of shoot dry matter by the end of the experiment. Nitrogen was preferentially taken up as NH_4-N. The composition of the fertilizer solution had a greater effect on young celery seedlings than on older ones. A minimum of 250 mg N/liter at a NO_3:NH_4 ratio of 2:1 appears to be adequate for celery seedlings grown in multicells.**

The use of containerized vegetable transplants has increased yield and uniformity and allowed a more predictable timing of production relative to direct seeding (15). Nutritional requirements of vegetable seedlings were studied for lettuce (9), asparagus (1, 13), celery (2), muskmelon (3), and cauliflower (19). For celery, it was determined that high-quality transplants could be grown with nutrient solutions containing a minimum of 250N–125P–10K ($mg \cdot liter^{-1}$) (2). While K had apparently no effect, N and P modified growth of seedlings, either alone or in combination. Tremblay et al. (18) measured the effect of greenhouse CO_2 enrichment as well as N and P fertilization on growth

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Table 1. Effect of N dose on growth of celery seedlings. Data are the mean of 48 plants harvested 38, 45, and 52 days after seeding.

	Shoot growth				Root growth		
N dose (mg N/liter)	Leaf area (cm^2/plant)	Dry wt (mg/plant)	Dry matter (%)	SLA^z ($cm^2 \cdot g^{-1}$)	Dry wt (mg/plant)	Dry matter (%)	Root : shoot dry wt ratio
150	23.0	120	12.1	199	54	7.7	0.44
250	29.1	149	11.4	203	53	8.1	0.35
350	31.6	164	11.3	203	47	8.1	0.30
Significance^y	L***,Q*	L***	L***,Q*	NS	L***	NS	L***

^{z}Specific leaf area.

^{y}Linear (L) or quadratic (Q) effects significant at the 5% (*), 1% (**), or 0.1% (***) levels of probability or nonsignificant (NS). Significance of leaf area, shoot dry weight, and root dry weight tested after logarithmic transformation of the data.

Table 2. Effect of NO_3:NH_4 ratio on growth of celery seedlings. Data are the mean of 48 plants harvested 38, 45, and 52 days after seeding.

	Shoot growth				Root growth		
Ratio NO_3:NH_4	Leaf area (cm^2/plant)	Dry wt (mg/plant)	Dry matter (%)	SLA^z ($cm^2 \cdot g^{-1}$)	Dry wt (mg/plant)	Dry matter (%)	Root : shoot dry wt ratio
1:1	27.9	146	11.7	200	49	8.1	0.34
2:1	28.7	148	11.4	205	54	8.0	0.38
3:1	27.1	140	11.6	200	51	7.8	0.38
Significance^y	NS	NS	Q*	Q*	NS	NS	L**

^{z}Specific leaf area.

^{y}Linear (L) or quadratic (Q) effects significant at the 5% (*), 1% (**), or 0.1% (***) levels of probability or nonsignificant (NS). Significance of leaf area, shoot dry weight, and root dry weight tested after logarithmic transformation of the data.

Table 3. Covariance analysis on the influence of N dose, NO_3:NH_4 ratio, and date of sampling on pH, salinity, and nutrient concentrations ($mg \cdot liter^{-1}$) of the saturated medium extract.

Treatments	pH	Salinity ($dS \cdot m^{-1}$)	NO_3-N	NH_4-N	K
Nitrogen dose ($mg \cdot liter^{-1}$)					
150	3.95	0.43	5	0	115
250	3.99	0.68	44	4	182
350	3.78	0.97	97	18	228
Significance	NS	NS	***	***	NS
NO_3:NH_4 ratio					
1:1	3.73	0.64	54	19	62
2:1	4.29	0.68	50	2	197
3:1	3.84	0.76	43	1	267
Significance	***	NS	NS	***	NS
Sampling date (days after seeding)					
38	5.64	1.05	106	14	273
45	3.83	0.58	34	6	135
52	3.63	0.45	6	2	118
Significance	**	***	***	***	***
Interactions					
Dose × ratio	NS	NS	NS	***	NS
Dose × date	NS	**	***	***	*
Ratio × date	NS	NS	**	***	***

NS,*,**,***Nonsignificant or significant at the 5%, 1%, or 0.1% levels, respectively.

and yield of celery transplants grown in multicells. Carbon dioxide enrichment and urea-N level modified the various growth characteristics at planting, but P level had no effect. When planted in a commercial field and grown with no particular treatment, the only significant effect at harvest was N fertilization, with the intermediate urea-N level (400 $mg \cdot liter^{-1}$) maximizing marketable yield. However, urea is not commonly used as the sole source of N in nutrient solutions, and plants use mainly ammonium or nitrate ions effectively as N source. The media acidification associated with ammonium absorption (11, 14) is toxic to many plants, but the two forms together may be superior to either alone (12). NO_3 and NH_4 can effectively be used to modify root-shoot interactions (10).

The objective of this experiment was to examine the effect of various N fertilizations and NO_3:NH_4 ratios and to determine the best N fertilization for celery seedling growth, mineral nutrient composition, and sustainable characteristics of the artificial media.

Styrofoam trays (Todd Planter flats No. 080A) of inverted and truncated pyramid cells (8.5 cm^3 each) were cut to obtain 108 experimental units each containing 36 cells (6 × 6). They were filled with a commercial mix (Metro Mix 220, W.R. Grace & Co., Ajax, Ont.) for which averaged analysis of saturated medium extractions gave values of 5.72 for pH, 2.0 $mS \cdot m^{-1}$ for salinity, and nutrient concentrations ($mg \cdot liter^{-1}$) of 155 N, as NO_3, 6 P, 38 K, 163 Ca, and 92 Mg (8). Celery seeds were sown on 31 Oct. 1986 and the trays were placed in a 3.3-m^2 growth chamber maintained at 95% RH and a day/night temperature of 22/16C. The average PPFD measured with a LI-COR quantum sensor at 20.5 cm from the floor was 304 ± 14 $\mu mol \cdot s^{-1} \cdot m^{-2}$. The photoperiod was 18 hr from a combination of cool-white fluorescent and incandescent lamps at a 5:1 input wattage ratio. The medium was kept moist with distilled water until the 24th day and RH was decreased to 85%.

The plants were fertilized to run-off every day around 1600 HR, except on Mondays, when distilled water was used. The treatments were factorial combinations of low, intermediate, or high N fertilizations (150, 250, or 350 $mg \cdot liter^{-1}$) and NO_3-N:NH_4-N ratios (1:1, 2:1, or 3:1). All nutrient solutions had the same concentrations ($mg \cdot liter^{-1}$) of P (100), Ca (50), Mg (20), Fe (2), B (0.5), Mn (0.5), Cu (0.03), and Mo (0.02). The pH of the solutions was adjusted to 6.5 in part with NaOH and a variable amount of KOH. The latter was used following reports of Dufault (2) that K did not influence celery seedling growth variables measured in his study.

On days 38, 45, and 52 after seeding, the 16 centermost plants in each of four experimental units per treatment were sampled for growth measurements and saturated medium

Table 4. Influence of N dose, NO_3:NH_4 ratio, and date of sampling on nutrient concentrations of the saturated medium extract (SME).

Treatments	Nutrient concn in the SME (mg·liter^{-1})				
	P	Ca	Mg	Fe	Mn
Nitrogen dose (mg N/liter)					
150	60	42	15	1.3	0.16
250	64	68	21	1.5	0.20
350	67	90	26	1.5	0.24
Significance[z]	NS	L***	L***	NS	L***
NO_3:NH_4 ratio					
1:1	70	92	28	1.7	0.22
2:1	66	66	20	1.4	0.20
3:1	57	43	14	1.3	0.18
Significance[z]	L**	L***	L***	L***	L*
Sampling date (days after seeding)					
38	81	95	31	0.9	0.24
45	58	53	16	1.6	0.19
52	53	52	14	1.8	0.17
Significance[z]	L***,Q**	L***,Q***	L***,Q***	L***,Q***	L***
Interactions					
Dose × ratio	NS	L × L***	L × L***	NS	NS
Dose × date	NS	L × L*** L × Q***	L × L*** L × Q**	NS	NS
Ratio × date	L × L*** Q × L**	L × L*** Q × L*	L × L*** Q × L**	L × L***	L × L***

[z] Linear (L) or quadratic (Q) effects; significant at the 5% (*), 1% (**), or 0.1% (***) levels of probability or nonsignificant (NS).

Table 5. Influence of N dose and NO_3:NH_4 ratio on mineral composition of celery seedling shoot tissue sampled 54 days after seeding.

Treatments	Nutrient concn (dry-matter basis)						
	N	P	K	Ca	Mg	Fe	Mn
			g/100 g			*µg/g*	
Nitrogen dose (mg N/liter)							
150	1.76	0.69	3.99	1.50	0.35	90	34
250	2.69	0.77	4.39	1.48	0.37	131	39
350	3.30	0.78	4.40	1.40	0.35	125	41
Significance[z]	L***,Q**	L***,Q*	L***,Q*	L*	Q***	L**,Q**	L***
NO_3:NH_4 ratio							
1:1	2.68	0.74	3.06	1.69	0.38	107	47
2:1	2.57	0.73	4.58	1.39	0.35	109	36
3:1	2.51	0.78	5.14	1.30	0.33	130	32
Significance[z]	L**	L*	L***,Q***	L***,Q**	L***,Q*	L*	L***,Q***
Interactions							
Dose × ratio	NS	L × L* L × Q*	L × L***	L × L***	L × L* L × Q*	Q × L* Q × Q*	L × L*** L × Q***

[z] Linear (L) or quadratic (Q) effects; significant at the 5% (*), 1% (**), or 0.1% (***) levels of probability or nonsignificant (NS).

extraction. Fresh and dry weights of shoots and roots were reported on a per-plant basis. Leaf area was measured with a LI-3050A leaf area meter (LI-COR). Specific leaf area (leaf area/shoot dry weight = SLA), root : shoot dry weight ratio, and percentage of shoot and root dry matter were calculated. The data presented in Tables 1–4 concerning the effect of N fertilization and NO_3:NH_4 ratio were averaged for the three sampling dates and represent the overall effect of treatments over time.

The media + roots of 16 cells were placed in 150-ml Buchner funnels with fritted disks and saturated with distilled-deionized water for 2 hr before vacuum was applied for collection of the saturated medium extract (SME). After extraction, the medium around the roots was discarded by washing in a stream of tap water. The roots were blotted between sheets of absorbant paper and their fresh weights measured. They were then placed in paper bags for drying.

The SME were assayed for pH and salinity, stored in plastic bottles, and kept at 4C until mineral analysis. Nitrate-N and NH_4-N were determined the day following the extraction to limit N conversion. The Technicon AutoAnalyser II Industrial Methods No. 487-77A and No. 334-74W/B$^+$ were used for the simultaneous determination of NO_3-N and NH_4-N, respectively. Phosphorus in the SME was determined by the Technicon AutoAnalyser II Industrial Method No. 334-74W/B$^+$. Analysis of K, Ca, Mg, Fe, and Mn in the SME was done by Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) on a Jarrel–Ash Model ICAP-9000.

Shoot and roots were dried to constant weights at 70C. On day 52, 500 mg of ground plant materials were digested according to the procedures of Isaac and Johnson (6). Nitrogen and P analyses were obtained colorimetrically using the Technicon AutoAnalyzer II Industrial Method No. 334-74W/B$^+$. Analysis of K, Ca, Mg, Fe, and Mn in tissues was done by ICP-AES, as described above.

The experimental units were arranged in the growth chamber in a completely randomized design. Analysis of variance was performed on a factorial-split [(N fertilization × NO_3:NH_4 ratio) × sampling dates as subplots], with four replications and a 1-week interval between dates. Interactions between treatments were considered of importance whenever they represented 25% or more of the treatment sum of square of the model. Since nutrient solutions were not identical

Table 6. Influence of N dose and NO_3:NH_4 ratio on mineral composition of celery seedling root tissue sampled 54 days after seeding.

Treatments	N	P	K	Ca	Mg	Fe	Mn
	Nutrient concn (dry-matter basis)						
	g/100 g					*µg/g*	
Nitrogen dose (mg N/liter)							
150	1.57	1.04	3.90	2.12	1.17	3130	143
250	2.24	0.79	3.10	2.45	1.03	3340	153
350	2.90	0.65	2.75	1.96	0.80	2510	110
Significance[z]	L***	L***	L***	NS	L**	NS	L**,Q**
NO_3:NH_4 ratio							
1:1	2.55	0.91	2.21	1.82	0.91	2440	145
2:1	2.16	0.80	3.43	2.27	0.97	3020	129
3:1	1.99	0.78	4.10	2.44	1.13	3520	130
Significance[z]	L***	L**	L***	NS	NS	NS	NS
Interactions							
Dose × ratio	L × L**	NS	NS	NS	NS	NS	Q × L**

[z] Linear (L) or quadratic (Q) effects; significant at the 5% (*), 1% (**), or 0.1% (***) levels of probability or nonsignificant (NS).

with respect to N fertilization, NO_3:NH_4 ratio, K concentration, salinity, and, to a lesser extent, pH (adjusted to 6.5 ± 0.12), the initial levels of these variables in the nutrient solutions were used as covariates to determine the real effect of treatments on pH and salinity of the SME and its concentration in NH_4-N, NO_3-N, and K.

Leaf area and shoot dry weight increased with N fertilization, while percentage of shoot dry matter, root dry weight, and root : shoot ratio decreased (Table 1). Specific leaf area and percentage of root dry matter were not affected by N fertilization. With plants ready for planting, the intermediate N fertilization gave the highest root dry weight, but the lowest N fertilization yielded the highest root : shoot ratio (data not shown).

The NO_3:NH_4 ratio had no significant effect on leaf area, shoot dry weight, and root growth (Table 2). Root : shoot ratio increased with NO_3:NH_4 ratio. The highest NO_3:NH_4 ratio promoted the shoot portion as a percentage of dry matter, but the effect decreased with time, so that, at transplanting (day 52), the lowest ratio resulted in the highest percentage of dry matter (data not shown). According to Wurr et al. (19) and Kratky and Mishima (9), plants grown slowly at low nutrient levels are more able to withstand handling at transplanting than younger "softer" plants because of their higher percentage of shoot dry matter. Thus, sturdier celery transplants should be obtained with a low NO_3:NH_4 ratio.

An increase in N fertilization increased the NO_3-N and NH_4-N concentrations in the SME, but did not affect pH, salinity, or K concentration further than their initial levels in nutrient solutions (Table 3). pH was highest with the intermediate NO_3:NH_4 ratio. NH_4-N concentration decreased with increases of NO_3:NH_4 ratio. All variables of Table 3 were significantly reduced with time after seeding, but, for NH_4-N, the variation due to time was negligible.

Our data indicate a preferential NH_4 uptake by celery seedlings, as based on: 1) when they were given N at a NO_3:NH_4 ratio of 1:1, less NH_4 than NO_3 remained in the SME; 2) the pH of the SME were much more acid than the initial fertilizer solutions (pH 6.5) and this occured whatever the NO_3:NH_4 ratio (the nutrient solutions prepared with carbonate-free water, were virtually not buffered, and could not resist a downward shift to very acidic pH consecutive to the preferential uptake of the NH_4-N cation); 3) NO_3:NH_4 ratio had no influence on NO_3 concentration in the SME but a strong one on NH_4, which may be interpreted as a tendency of celery seedlings to first deplete NH_4 in the fertilizer solution, particularly when there was an abundant supply of NO_3. It was reported that greater amounts of ammonium than nitrate were assimilated when N was provided as NH_4NO_3 to clover and grass (17). Scherer and Mackown (16) have shown that NO_3 uptake was inhibited in the presence of NH_4 for various plant species.

On days 45 and 52, the nutrient medium contained only traces of N when the lowest N was provided (data not shown). This indicated a possible N shortage when low N (150 mg·liter^{-1}) was applied to older seedlings. The 250 mg N/liter level still provided 3 mg·liter^{-1} in the solution on day 52.

Calcium, Mg, and Mn concentrations in the SME increased linearly as N increased (Table 4). The increase of NO_3:NH_4 ratio linearly reduced all nutrients assayed (Table 4). Phosphorus, Ca, Mg, and Mn concentrations in the SME decreased with time of sampling, but Fe tended to accumulate. The nutrients P, Ca, Mg, and Mn were affected by important ratio × date interactions, since their nutrient concentrations converged towards a common point at the latest date, whatever the NO_3:NH_4 ratio (data not shown). This relationship might indicate a greater sensitivity of seedlings to treatments at early stages of growth than at later stages. Thus, the composition of the fertilizer solution would be more critical with young celery seedlings than with old ones.

An increase in N fertilization increased N, P, K, and Mn, but decreased Ca concentration in shoot tissue (Table 5). The highest Fe concentrations were measured at intermediate N (250 mg·liter^{-1}). When the proportion of NO_3-N increased in the nutrient solution, N, Ca, Mg, and Mn concentration decreased in the shoot. The inverse pattern held for P, K, and Fe concentration.

In roots, the increasing N fertilization increased N concentration, but decreased P, K, and Mg concentrations (Table 6). Manganese concentration was the highest at intermediate N. With a higher proportion of NO_3-N, the roots had a higher concentration of K but less N and P. Highest root Mn concentration was measured at low N when NO_3:NH_4 ratio was the lowest; otherwise, they were found at intermediate N (data not shown).

Elamin and Wilcox (4) found that increasing the proportion of NH_4 in nutrient solutions decreased Ca and Mg in shoots and roots of muskmelon seedlings. Peet et al. (12) reported a suppression of Ca uptake by NH_4 uptake when pH was not controlled. When NH_4 is absorbed, less of the other cations (especially Ca and Mg) is absorbed (14) and more of the anions (especially phosphate); when NO_3 is absorbed, more cations are absorbed and less phosphate (5). Such a relationship is confirmed by our data on Ca, Mg, and P concentrations in the SME and root nutrient concentration. However, in shoots, Ca and Mg were less concentrated as NO_3:NH_4 ratio increased. This discrepancy may be attributed to an effect of K nutrition on mineral uptake and accumulation. Since our treatments contained levels of K positively related to the N fertilization and NO_3 proportion in fertilizer solutions, K may have interacted to modify the effects of NO_3:NH_4 ratio. Increasing K concentrations in solution generally decreased Ca concentration in both tops and roots of barley plants (7).

The results of this research clearly show that N fertilization has a predominant effect on celery seedling growth. Shoot dry weight, root dry weight, and root : shoot ratio are linearly related to N fertilization over the range 150 to 350 mg·liter^{-1}. It appears that 250 mg·liter^{-1} is the minimal concentration to be used on large celery seedlings, since only minor amounts of N remained available in the SME. A low NO_3:NH_4 ratio helped to obtain transplants with high percentage of shoot dry matter and more able to withstand handling at transplanting, but it resulted in poor root development as compared to shoot development. Our data show that NH_4-N is preferentially taken up by celery seedlings. This difference leads to an important decrease in pH of the SME, which is accentuated by low NO_3:NH_4 ratios and by seedling development. Generally, the N composition of the fertilizer solution had more striking effects on the nutrition of young celery seedlings than older ones. A minimum of 250 mg N/liter at a NO_3:NH_4 ratio of 2:1 is recommended for celery seedlings grown in multicells.

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Growth, Nutrient Status, and Yield of Celery Seedlings in Response to Urea Fertilization

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Abstract. **Celery seedlings (*Apium graveolens* L. cv. Florida 683) were seeded in multicell styrofoam trays containing a commercial peat mix. They were fertilized with nutrient solutions at two nitrogen fertilizations (150 or 350 mg N/liter), two NO_3:NH_4 ratios (2:1 or 3:1), and two urea–N levels (0% or 50%) in factorial combinations to determine main and interactive effects of urea on seedling growth, nutrient status, and crop yield. Urea used in combination with low N improved the percentage of shoot dry matter and increased leaf area, shoot and root dry weight, and root : shoot ratio of the seedlings. Urea proved beneficial in improving transplant yield potential under high–N fertilization.**

Urea is a pure N source with no ballast cation or anion, and is a very soluble, non-corrosive, non-toxic, and inexpensive chemical. As a non-ionized molecule, urea can help reduce the osmotic potential of nutrient solutions (7). The effects of urea on plant growth and nutrition are not as well-known as NO_3-N and NH_4-N, partly because it undergoes a complete transformation to these N forms (5), and a significant fraction of urea may also be volatilized as NH_3 (2).

Klougart (7) recommended that urea should not be used in a universal nutrient solution for pot plants because of its unpredictable effects. Nevertheless, several commercial soluble fertilizers contain an important proportion (up to $\approx$80%) of urea, together with NO_3-N and NH_4-N, because of beneficial effects on growth and yield (6). Ammonium and urea-N sources yielded acceptable foliage plant quality without phytotoxicity, and sometimes outperformed NO_3-N sources (1). Information is lacking on the appropriateness of including urea in the fertilizer solution of celery transplants, as there is a need to determine its effect on seedling growth and nutrition and its effect on subsequent crop development.

The objective of this study was to determine the main and interactive effects of urea, N fertilization, and NO_3:NH_4 ratio on seedling growth, nutrient status, and yield of celery.

The growing conditions were as previously described (9), with the following differences: Styrofoam trays (Todd Planter flats No. 080A) were cut to obtain 48 experimental units each with 78 cells (13 × 6). Celery seeds were sown on 31 Mar. 1987 (day 0). The trays were placed in the growth chamber under photosynthetic photon flux of $309 \pm 16\ \mu mol\cdot s^{-1}\cdot m^{-2}$. The medium was kept moist with distilled water until emergence was completed (day 15).

The plants were then fertilized every day around 1600 HR, except on Sundays, when distilled water replaced the fertilization treatments. The treatments were factorial combinations of low- or high-N fertilizations (150 or 350 mg N/liter), NO_3-N:NH_4-N ratios (2:1 or 3:1), and percentage of N as urea (0% or 50%). All nutrient solutions had the same concentrations ($mg\cdot liter^{-1}$) of P (100), K

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