Table 3. Effects of sod-soil type on turf quality of St. Augustinegrass at 2 and 4 weeks and growth rate at 4 weeks after planting.

Sod-soil type	Turf quality[z] 2 weeks	Turf quality[z] 4 weeks	Growth rate kg ha^{-1} day^{-1}
Organic	6.8 a[y]	7.8 a	1.31 a
Mineral	5.7 b	6.4 b	0.66 b

[z]Visual estimate on a 1 to 9 scale, 9 = best.
[y]Means in columns within main effects followed by the same letter are not significantly different at the 1% level.

Table 4. Effects of N rate and placement on turf quality at 2 weeks and of N rate on turf quality and growth rate at 4 weeks after planting.

N rate (gm^{-2})	Turf Quality[z] N placement: Sod surface 2 weeks	Turf Quality[z] N placement: Sodbed surface 2 weeks	Turf Quality[z] 4 weeks	Growth rate kg $ha^{-1}day^{-1}$
5	6.1 b[y]	5.9 a	6.3 b	0.74 b
10	7.2 a	5.8 a	7.9 a	1.24 a

[z]Visual estimate on a 1 to 9 scale, 9 = best.
[y]Means in columns for N rates followed by the same letter are not significantly different at the 1% level. Means in a row within N placement bracketed by a line are not significantly different at the 1% level.

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Nitrogen Effects on Monostands and Polystands of Annual Bluegrass and Creeping Bentgrass

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Abstract. **Annual bluegrass (*Poa annua* L.) and 'Penncross' creeping bentgrass (*Agrostis palustris* Huds.) were grown in monostand and polystand in silica sand and supplied with solutions in which 0%, 25%, 50%, 75% or 100% of the N was NH_4^+ and the remainder was NO_3^-. In polystand, annual bluegrass was more competitive than 'Penncross', producing more shoot and root dry weight and more tillers. Competitive ability of annual bluegrass was decreased as the percentage of NH_4^+ increased in nutrient solution. The decrease in competitive ability was reflected by a decline in tiller number and root and shoot dry weight. 'Penncross' was less affected by N form than was annual bluegrass.**

Annual bluegrass is an undesirable but persistent component of intensively cultured turf areas, particularly athletic fields and golf course greens, tees, and fairways. Its rapid tiller production and prostrate growth habit under close clipping makes it very competitive to most Kentucky bluegrass cultivars (3). Although it has been shown to invade 'Penncross' creeping bentgrass swards (4), little information is available on the differences in growth characteristics of annual bluegrass and creeping bentgrass to account for its ingress. Annual bluegrass is less invasive in a high density creeping bentgrass sward than in turf which has been injured through wear or maintenance practices (4). Waddington et al. (11) and Engel and Bussey (5) found that less annual bluegrass was present in 'Penncross' turf when the N source was urea, or a slow release nitrogen fertilizer containing urea, than when the nitrogen source was an activated sewage sludge. Whereas creeping bentgrass seems to be relatively unaffected by N form (7, 8), little information is available on the effect of N form on the growth of annual bluegrass.

The object of this study was to determine the effect of N form on the growth of annual bluegrass and 'Penncross' creeping bentgrass.

Three separate experiments were conducted from 2 Apr. 1981 to 9 Dec. 1981 on *Poa annua* L. (annual bluegrass) and *Agrostis palustris* Huds., 'Penncross' (creeping bentgrass) grown in monostand and polystand. The annual bluegrass plants, grown from seed, consisted of a normal distribution of *Poa annua* var. *annua* (L.) Timm and *Poa annua* var. *reptans* (Hausskn.) Timm. In monostand, 4 plants of either annual bluegrass or 'Penncross' were grown in a square arrangement at a 2 cm spacing. In polystand, 2 plants of annual bluegrass and 2 plants of 'Penncross' were grown on opposite corners of a square arrangement at a 2 cm spacing. Seeds were germinated in petri dishes and seedlings transplanted one cm deep into silica sand in 10-cm diameter plastic pots at the one-leaf stage. After a 3-week establishment period during which the seedlings were fertilized with Hoagland's (6) nutrient solution 3 times weekly, a fertility regime was started with N as 0%, 25%, 50%, 75% or 100% ammonium nitrogen, as described by Nittler and Kenny (9). Hoagland's number 1 nutrient solution (6) was the 0% NH_4^+ solution. Nitrate nitrogen constituted the remainder of the N in the complete nutrient solution as per Nittler and Kenny (9). The pH of the nutrient solutions ranged from 4.3 to 4.9. On Monday, Wednesday and Friday, the pots were separated into treatments, and each pot was treated with 100 ml of nutrient solution for a total of 0.5 g actual N per pot during the experiment. The pots were allowed to drain for 1 hr before they were returned to their location in each block. As some drainage continued after the 1 hr period, the pots were set on inverted petri dishes to avoid contamination from other treatments. The treatments were arranged in a randomized complete block design with 5 replications. The daylength was 16 hr. The greenhouse night and day temperatures were maintained at 16° and 21°C, respectively. Daytime temperatures sometimes exceeded 21° by 6°, and the plants were not mowed. The experiments were terminated 55 days

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Table 1. Influence of NH_4^+:NO_3^- ratio on annual bluegrass and 'Penncross' in mono-and polystands.

N(%)		Annual bluegrass		'Penncross'	
NH_4^+	NO_3^-	Monostand	Polystand	Monostand	Polystand
		Shoot dry wt (mg)			
0	100	406	442	288	97
25	75	514	500	339	152
50	50	445	418	363	124
75	25	449	403	313	126
100	0	331	299	265	104
F value[z]		L*Q**	L**Q*	Q*	NS
LSD (0.05) = 92.3					
LSD (0.01) = 122.8					
		Root dry wt (mg)			
0	100	94	88	83	17
25	75	133	88	70	23
50	50	104	73	72	13
75	25	111	56	39	14
100	0	63	52	29	8
F value		L*Q**	L**	L**	NS
LSD (0.05) = 27.5					
LSD (0.01) = 36.5					
		Tiller number (per plant)			
0	100	10.3	20.7	9.6	7.2
25	75	11.0	19.5	8.9	8.3
50	50	9.6	15.2	9.8	8.2
75	25	9.8	16.3	8.8	8.1
100	0	8.2	13.8	7.7	6.9
F value		NS	L**	NS	NS
LSD (0.05) = 3.25					
LSD (0.01) = 4.32					

[z]Treatment effects were nonsignificant (NS) or significant at the 5% (*) or 1% (**) level and were linear (L) or quadratic (Q).

after the N treatments were started. Shoots and roots were dried separately in a forced-air oven at 70° for 5 days and dry weights determined.

Annual bluegrass and 'Penncross' creeping bentgrass responded differently to NH_4^+ in the nutrient solution (Table 1). In polystand, the shoot dry weight, root dry weight and tiller number of annual bluegrass decreased when the concentration of NH_4^+ exceeded 25% of N in solution, whereas creeping bentgrass was not significantly affected. In monostand, the response of 'Penncross' to N form was similar to that reported by Mazur and Hughes (8). Markland and Roberts (7) found no difference in growth response of 'Washington' creeping bentgrass when N was applied from organic or inorganic sources. Although there is no specific information available on the response of annual bluegrass to N form or on the modification of competitive ability of 'Penncross' and annual bluegrass by nitrogen form, the results of this study and the observations of other workers on the success of annual bluegrass invasion into field plots appear to be similar. Both Engel and Bussey (5) and Waddington et al. (11) have shown that NH_4^+ releasing N sources significantly reduced annual bluegrass invasion in 'Penncross' swards when compared to an organic N source.

Annual bluegrass was more competitive than 'Penncross' when both were grown together in polystand. At all NH_4^+:NO_3^- combinations, annual bluegrass had greater shoot and root dry weight and more tillers than did 'Penncross'. The response of annual bluegrass to competition with 'Penncross' in this study was similar to the response of annual bluegrass to competition with three Kentucky bluegrass cultivars reported by Eggens (3). Tiller production, a good measure of competitive ability (10), was greater for annual bluegrass in polystand than in monostand whereas the slight decrease in tiller production for 'Penncross' when grown in polystand with annual bluegrass was not significant at the 5% level.

Neither the nutrient solution nor the silica sand pH was adjusted throughout the experiment. The high pH of the silica sand with NO_3^- nutrition and the highly significant linear decrease in pH values as NH_4^+ increased in the nutrient solution (Table 2) are similar to observations determined by other researchers (2). Both annual bluegrass and creeping bentgrass have an optimum soil pH range for best growth of pH 5.5 to pH 6.5 (1). The pH of the silica sand upon termination was not significantly different for annual bluegrass and 'Penncross' in both mono- and polystands. It is unlikely that the silica sand pH strongly influenced the differential response of annual bluegrass and 'Penncross' creeping bentgrass to N form at each NH_4^+ concentration.

Table 2. Silica sand pH on termination.[z]

N(%)		Annual bluegrass		'Penncross'	
NH_4^+	NO_3^-	Monostand	Polystand	Monostand	Polystand
0	100	7.1	7.0	7.0	7.0
25	75	6.7	6.8	6.8	6.8
50	50	6.8	6.8	6.7	6.8
75	25	6.6	6.7	6.7	6.7
100	0	6.5	6.6	6.6	6.6
F value[y]	L**	L**	L**	L**	L**
LSD (0.05) = 0.15					
LSD (0.01) = 0.20					

[z]Termination 55 days after treatments started.
[y]Treatment effects were nonsignificant (NS) or significant at the 5% (*) or 1% (**) level and were linear (L) or quadratic (Q).

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