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Growth of Zoysiagrass from Vegetative Plugs in Response to Fertilizers

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Additional index words. *Zoysia japonica*, urea, ureaformaldehyde, isobutylidine diurea, composted sewage sludge

Abstract. **Little research has been conducted to determine the influence of fertilizer sources and rates on zoysiagrass (*Zoysia japonica* Steud.) establishment. Our objectives were to determine the influence of slow-release N sources, water-soluble N from urea, and N, P, and K combinations on rate of zoysiagrass establishment. Prior to field planting of zoysiagrass plugs, N rates of 98, 196, and 392 kg·ha^{-1} from ureaformaldehyde (UF, 38N–0P–0K), isobutylidine diurea (IBDU, 31N–0P–0K, and a composted sewage sludge (1.0N–0.9P–0.2K) were incorporated into a soil with existing high P (193 kg·ha^{-1}) and intermediate K levels (86 kg·ha^{-1}). In a separate study nitrogen from urea (46N-0P-0K, 195 kg·ha^{-1}), P from treble superphosphate (0N-19P-0K, 126 kg·ha^{-1}) and K from muriate of potash (0N-0P-32K, 103 kg·ha^{-1}) also were incorporated before planting. Five months after planting, none of the slow-release N sources or N–P–K combinations had enhanced coverage of the zoysiagrass. No additional fertilizer was applied in the 2nd year. Although statistically significant differences were found among treatments by the end of the 2nd growing season, the actual increases in zoysiagrass coverage provided by the fertilizers were no greater than 5% more than the unfertilized zoysiagrass. In a 3rd study, N (49 kg·ha^{-1}) from urea, applied as a topdressing either once, four, or seven times annually, resulted in a negative linear [coverage = 63.8 − 0.02 (kg N/ha per year), r^2 = 0.57] response in zoysiagrass coverage the initial year, but not in the 2nd year. Nitrogen from urea (49 kg·ha^{-1}) applied bimonthly or monthly the 2nd year had a greater beneficial effect on zoysiagrass growth than topdressing or preplant incorporation of N the initial year.**

Decline in quality of cool-season turfgrasses as a result of environmental stresses and disease in the transition zone has increased the use of warm-season turfgrasses, particularly zoysiagrass (*Zoysia japonica* Steud.). The transition zone is a region of turfgrass adaptation where neither warm- or cool-season grasses are well-adapted. 'Meyer' zoysiagrass is a desirable cultivar because of its excellent high and low temperature tolerance and drought and disease resistance. The major factor limiting more-extensive use of zoysiagrass is the substantial period of time required for establishment. In the transition zone, ≥2 years usually are required to achieve complete coverage from vegetative plugs (4). Although fertility generally is believed to be a prime factor in hastening zoysiagrass establishment, little research has been conducted to determine the influence of fertilizers on establishment rate. Fullerton et al. (1) reported that neither N, P, and K nor combinations of these elements encouraged the establishment of 'Emerald' zoysiagrass when plots were rated 11 weeks after planting. Hubbell and Dunn (2) observed a 10–20% increase in 'Meyer' coverage during the first 2 years of establishment when plugs were fertilized with UF prior to planting in 'Baron' Kentucky bluegrass turf. Urea, applied after planting in the Kentucky bluegrass, was not effective in encouraging 'Meyer' spread (2). According to Juska (3), N is the most important nutrient for rapid 'Meyer' zoysiagrass establishment, but P and K are also influential in encouraging rapid zoysiagrass growth. In Alabama, Sturkie and Rouse (5) observed increased clipping yield of field-grown 'Matrella' zoysiagrass (*Z. matrella* L.) after applications of P and K at a constant N rate. Furthermore, they reported that poor turf quality resulted when N was applied in the absence of P and K. Additional research is greatly needed to better define fertility practices that will provide an optimum growth rate of zoysiagrass during establishment. Hence, the objectives of these studies were to a) determine the influence of N source and rate and the influence of N, P, and K interactions on the establishment

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rate of 'Meyer' zoysiagrass; and b) evaluate the frequency of application of water-soluble N on the establishment rate of 'Meyer' and 'Belair' zoysiagrass.

Materials and Methods

These studies were conducted at the Univ. of Maryland Turfgrass Research and Education Facility in Silver Spring during 1983 and 1984. Prior to these studies, agronomic field crops were grown in the area where this research was conducted. The soil in all studies was a Sassafrass sandy loam (fine loamy, siliceous, mesic Typic Hapludult) with a pH of 6.9 and 1.0% organic matter. The initial soil P level was high (193 $kg \cdot ha^{-1}$), while the K level was intermediate (86 $kg \cdot ha^{-1}$).

Nitrogen source study. Ureaformaldehyde (UF) (38N-0P-0K), urea (46N-0P-0K), and isobutylidine diurea (IBDU) (31N-0P-0K) were applied uniformly on 29 May 1983 at rates of 98, 196, and 392 kg N/ha. Composted sewage sludge (obtained from Maryland Environmental Services, 177 Admiral Cochrane, Annapolis) (1.0N-0.9P-0.2K, pH 7.2) was applied uniformly (3, 6, or 12 kg/plot) to provide the same amount of N as the aforementioned fertilizers. All materials were incorporated to a depth of 8 to 10 cm with a rototiller. On 31 May, round plugs of 'Meyer' zoysiagrass measuring 5.1 cm (diameter) × 5.4 cm (deep) were planted on 30-cm centers. The control treatment received no fertilizer at any time. Turf was maintained at a height of 4 to 5 cm throughout the test period with a rotary mower. A relatively high mowing height was used due to some soil erosion, which elevated plugs and, in part, because most homeowners use high-cutting rotary mowers. The plot area was irrigated to prevent drought stress as described below, and to water in fertilizers. All plots were treated with a combination of 1.1 kg a.i./ha of (2,4-dichlorophenoxy)acetic acid (2,4-D) plus 0.6 kg a.i./ha of 2(2-methyl-4-chlorophenoxy) propionic acid plus 0.2 kg a.i./ha of 3,6 dichloro-o-anisic acid to control broadleaf weeds in July 1983 and June 1984. Slight yellowing was observed after the 1984 herbicide application, but the turf recovered rapidly. Percentage of zoysiagrass coverage was estimated visually using a 0–100% scale, where 0 = no zoysiagrass and 100 = entire plot area covered. Plots measured 2.1 × 2.1 m, and the statistical design was a randomized complete block with three replications. Orthogonal polynomial comparisons were made to compare each treatment to the control. Significant treatment means were separated using the Bayes least significant difference multiple comparison test.

N–P–K interaction study. The following N, P, and K rates were evaluated: N at 0 and 196 $kg \cdot ha^{-1}$ from urea (46N-0P-0K), P at 0 and 126 $kg \cdot ha^{-1}$ from treble superphosphate (0N-19P-0K), and K at 0 and 103 $kg \cdot ha^{-1}$ from KCl (0N-0P-32K). No additional fertilizer was applied during the test period. Fertilizers and rate treatments were arranged in factorial combination. Prior to planting 'Meyer' zoysiagrass plugs (5.1 × 5.4 cm), fertilizers were incorporated as described. Plugs were planted on 30-cm centers on 31 May 1983, and plots measured 2.1 × 2.1. Maintenance practices and statistical design and analysis were the same as those previously described.

Urea study I (1983) and study II (1984). In these studies, both 'Meyer' and 'Belair' zoysiagrass were used and plugs of each cultivar were planted separately in randomly arranged plots. Study I was initiated in June 1983 and continued through 1984, whereas study II was initiated in May 1984 and terminated in Sept. 1984. Hence, data were collected from study I for two full growing seasons, and one full season from study II. Prior to planting 'Meyer' and 'Belair' zoysiagrass plugs (5.1 × 5.4 cm) in studies I and II on 8 June 1983 and 25 May 1984, respectively, N at 49 $kg \cdot ha^{-1}$, P at 42 $kg \cdot ha^{-1}$, and K at 81 $kg \cdot ha^{-1}$ were broadcast and incorporated as previously noted. In both studies, zoysiagrass was plugged on 30-cm centers in plots measuring 2.1 × 2.1 m and were arranged in a randomized complete block design with three replications. In study I, urea was applied in increments of N at 49 $kg \cdot ha^{-1}$ to provide N at 49, 196, or 343 $kg \cdot ha^{-1} \cdot yr^{-1}$. In 1983, application dates for plots receiving N at 49, 196 and 343 $kg \cdot ha^{-1} \cdot yr^{-1}$ were, respectively: 8 June; 8 June, 6 July, and 3 and 31 Aug.; 8 and 22 June, 6 and 20 July, and 2, 17, and 31 Aug. In 1984, N at 49 $kg \cdot ha^{-1}$ from urea was applied on 25 May for the N at 49 $kg \cdot ha^{-1} \cdot yr^{-1}$ treatment; 25 May, 4 June, and 2 and 30 July for the N at 196 $kg \cdot ha^{-1}$ treatment; and 25 May, 4 and 18 June, 2, 16, and 30 July and 13 Aug. for plots receiving N at 343 $kg \cdot ha^{-1} \cdot yr^{-1}$. In study I, control plots receiving the initial 49 $kg \cdot ha^{-1}$ N treatment received no further fertilizer in 1983 or 1984. Plots in study II were fertilized on the same dates as study I in 1984. During the initial year of each study, irrigation was performed up to three times weekly the first month of establishment to prevent desiccation. Thereafter, 0.7 to 1.2 cm of water were applied after fertilization. On occasion, similar amounts of water were applied to avoid drought stress. When wilt did occur, irrigation was performed shortly thereafter to alleviate the stress. To elucidate the effect of these N applications on zoysiagrass stolon growth, stolons were harvested from three randomly chosen plugs per plot in studies I and II on 5 Oct. 1983 and 24 Sept. 1984, respectively.

Polynomial regression was performed on data collected from both studies using Statistical Analysis System's General Linear Models procedure (SAS Institute, Cary, N.C.). Significant (P = 0.05) linear effects were obtained, and equations for best fit lines were determined. Drought ratings in study I were made on three occasions in 1984 using a 0–5 scale, where 0 = no wilt and 5 = severe wilt. Overall quality was determined visually on a 1–10 scale, where 1 = brown, open turf and 10 = optimum color and uniformity.

Results and Discussion

Nitrogen source study. Data collected 6 Oct. 1983 revealed that none of the treatments significantly affected 'Meyer' zoysiagrass establishment in the initial year, compared to the untreated control (average coverage, 59%). In 1984, however, data collected on 28 Aug. and 16 Sept. indicated that pre-plant incorporation of some N sources had slightly encouraged 'Meyer' zoysiagrass growth during the 2nd year of establishment (data not shown). Plots treated with composted sewage sludge (N at 392 $kg \cdot ha^{-1}$, 95% coverage), IBDU (N at 98, 196, and 392 $kg \cdot ha^{-1}$, 93%, 94%, and 93% coverage, respectively), and ureaformaldehyde (196 and 392 $kg \cdot ha^{-1}$, 93% and 94% coverage, respectively), possessed a significantly higher percentage of 'Meyer' zoysiagrass coverage by fall of the 2nd year of establishment compared to the untreated control (90% coverage). No significant differences in zoysigrass coverage were observed among other treatments when compared to unfertilized plots. The observed differences, although statistically significant, are probably agronomically insignificant.

N–P–K interaction study. Only the main effect of N rate on zoysiagrass coverage was significant on 6 Oct. 1983 (Table 1). Plots receiving N at 196 $kg \cdot ha^{-1}$ possessed more zoysiagrass (61% coverage) than plots where no N (57% coverage) was applied. There was no measurable effect from P or K at the end of the initial year.

Table 1. Summary of statistical significance levels for N, P, and K treatments on 'Meyer' zoysiagrass coverage in 1983 and 1984.

Source of variation	df	1983 6 Oct.	1984 18 June	1984 31 July	1984 28 Aug.	1984 16 Sept.
N	1	*	*	**	**	*
P	1	NS	NS	NS	NS	NS
K	1	NS	NS	**	NS	*
N × P	1	NS	NS	NS	NS	NS
N × K	1	NS	NS	*	NS	NS
P × K	1	NS	NS	NS	*	NS
N × P × K	1	NS	*	*	*	**

*,**,NS Significant at $P = 0.05$ and 0.01 and nonsignificant, respectively.

In 1984, there were significant differences among N, P, and K treatments in zoysiagrass coverage on several dates (Tables 1 and 2), but there was no economically practical effect of the fertility treatments. Table 2 presents separations of the N × P × K interactions that were significant on four dates in 1984. On 18 June 1984 zoysiagrass coverage was higher in plots receiving either N (196 $kg \cdot ha^{-1}$), P (126 $kg \cdot ha^{-1}$), or K (103 $kg \cdot ha^{-1}$), except N + P and P + K. On 31 July, plots treated with N, P, or K alone or in any combination possessed a significantly higher percentage of zoysiagrass coverage than in the untreated plots (Table 2). In general, greatest zoysiagrass coverage on 31 July and 28 Aug. was observed in plots where N + P + K or K alone was applied. By 16 Sept., all treatments had greater zoysiagrass coverage than the untreated plots (Table 2). Overall quality differences throughout the test, however, were negligible among N, P, and K treatments (data not shown).

Previous researchers have reported similar results on the interaction of N, P, and K during the initial year of evaluation. For example, Fullerton et al. (1) found that after sprigging 'Emerald' zoysiagrass, N, P, and K rate interactions of 74N-49P-25K ($kg \cdot ha^{-1}$), 147N-98P-49K ($kg \cdot ha^{-1}$), and 245N-162P-78K ($kg \cdot ha^{-1}$) did not influence establishment when plots were rated 11 weeks after application. In a greenhouse study, Juska (3) reported that N significantly increased stolon production of 'Meyer' zoysiagrass when applied alone, but P (107 $kg \cdot ha^{-1} \cdot yr^{-1}$) and K (202 $kg \cdot ha^{-1} \cdot yr^{-1}$) did not. When N, P, and K were combined, Juska (3) observed improved growth and concluded that all three nutrients were needed for rapid establishment of 'Meyer' zoysiagrass. Our results have shown that N, P, and K, at the rates evaluated, had little effect on rate of zoysiagrass establishment in the initial year. The 2nd year, however, a beneficial response from N (195 $kg \cdot ha^{-1}$), P (126 $kg \cdot ha^{-1}$), and K (103 $kg \cdot ha^{-1}$) was demonstrated; however, enhancement of zoysiagrass coverage was small. Although significant, the greatest difference in cover between fertilized and nonfertilized plots on 16 Sept. 1984 was only 5%. With such slight enhancement of zoysiagrass spread, questions arise concerning the economic justification of preplant N, P, and K incorporation to encourage zoysiagrass growth. Perhaps where initial soil P and K levels are not high, a more dramatic growth response to N, P, and K fertilization would occur.

Urea studies I and II. Results from urea studies I and II indicate that frequent N application during the initial year of 'Meyer' and 'Belair' zoysiagrass establishment can inhibit growth (Fig. 1). In both studies, there were no significant cultivar × N rate interactions, and data were therefore combined over cultivars. In study I, data collected 19 Oct. 1983 demonstrated a significant, negative, linear relationship between zoysiagrass coverage and increasing N (Fig. 1). Study II was initiated in June 1984 to confirm 1983 test results. Data from study II also showed that frequent N application the initial year of establishment can inhibit zoysiagrass growth (Fig. 1). Total N application significantly ($r^2 = 0.46$ at $P = 0.05$) influenced zoysiagrass stolon production; i.e., with increasing N a corresponding decline in stolon production was observed (stolon number = 21.7 − 0.02 $kg \cdot ha^{-1} \cdot yr^{-1}$). Although there was a slight negative, linear response to N for stolon production in study II, the response was not significant. By 24 Sept. 1984, however, plugs in plots from study II receiving N at only 49 $kg \cdot ha^{-1}$ had the appearance of improved vigor when compared to plugs fertilized at N rates of 196 and 343 $kg \cdot ha^{-1}$.

After 18 June 1984, zoysiagrass established in 1983 (study

Table 2. Separation of three-way interaction means showing influence of N, P, and K applied in 1983 on 'Meyer' zoysiagrass coverage in 1984.

Fertilizer applied ($kg \cdot ha^{-1}$) N	P	K	Zoysiagrass coverage (%) 18 June	31 July	28 Aug.	16 Sept.
0	0	0	73 b*	84 d	91 c	91 b
0	0	103	79 a	90 a	94 ab	96 a
0	126	0	78 a	87 c	94 ab	94 a
0	126	103	75 ab	88 bc	93 b	94 a
196	0	0	79 a	88 bc	95 a	95 a
196	0	103	80 a	88 bc	95 a	95 a
196	126	0	77 ab	89 ab	95 a	95 a
196	126	103	79 a	90 a	95 a	96 a

*Means in a column followed by the same letter are not significantly different at the $P = 0.05$ level according to Bayes least significant difference multiple comparison test.

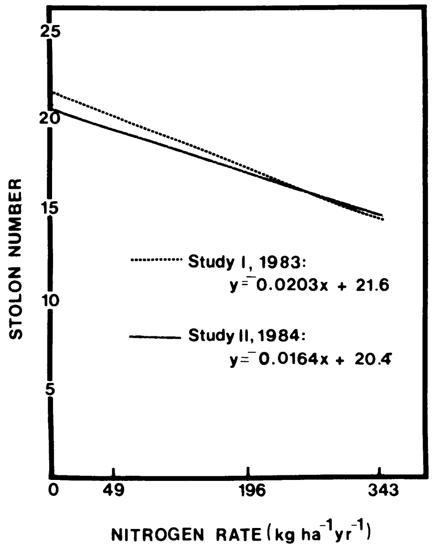

Fig. 1. Influence of nitrogen rate on zoysiagrass stolon production. Data were collected 19 Oct. and 24 Sept. in 1983 and 1984, respectively.

I) showed a favorable response to an increase in N rate throughout the summer and early fall (Fig. 1). Hence, there was a turnabout in the response of zoysiagrass to N from urea during the 2nd year of establishment. In addition, a positive linear [quality = 5.6 + 0.003 (kg N/ha per yr)] response to increasing total N was observed for overall quality on 17 Sept. 1984. On one of three rating dates in 1984 (21 Aug.), data revealed a positive, linear [wilt = 0.5 + 0.007 (kg N/ha per yr)] response from N rate (196 and 343 $kg \cdot ha^{-1}$) and observed symptoms of drought stress. Hence, where N was applied, the zoysiagrass entered drought stress before those plots receiving no N during 1984.

Juska (3) recommended that N up to 539 $kg \cdot ha^{-1} \cdot yr^{-1}$ during the initial year would benefit the establishment of 'Meyer' zoysiagrass from sprigs. Our results demonstrate that N rates < 49 $kg \cdot ha^{-1} \cdot yr^{-1}$ from urea applied as a topdressing can inhibit growth of 'Meyer' and 'Belair' zoysiagrass from plugs the initial year. However, N up to 343 $kg \cdot ha^{-1} \cdot yr^{-1}$ during the 2nd year of establishment may increase zoysiagrass coverage and overall quality. It is conceivable that, during the initial year, high N rates inhibited zoysiagrass growth by encouraging a more succulent plant that was less tolerant to adverse environmental conditions such as drought stress. During the 2nd year of establishment, however, mature plants with a better established root system were more responsive to N.

These data show that fertilizers provided little or no enhancement of zoysiagrass growth under the soil, irrigation, and environmental conditions of this test during the initial year. Preplant incorporation of moderate rates of slow release N (196 $kg \cdot ha^{-1} \cdot yr^{-1}$) combined with P and K may be beneficial in poorly nourished soils. In the 2nd year, however, applications of a soluble N fertilizer (N at 49–98 $kg \cdot ha^{-1} \cdot mo^{-1}$) can be applied to accelerate growth of 'Meyer' and 'Belair' zoysiagrass. It should be noted, however, that establishment studies can be quite variable due to differing irrigation frequencies as well as differing soil and environmental conditions within a state or region.

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