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Fertilizer Burn Comparisons of Concentrated Liquid Fertilizers Applied to Kentucky Bluegrass Turf

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Abstract. **Concentrated solutions of Fluf, Fluf-Plus, Tuf, Fan NPK, Formolene, Maxigro-Plus, urea, and Folian were applied at 12.2, 24.4, and 48.8 kg N/ha with a gravity-fed, spinning disk, liquid applicator to a blend of Kentucky bluegrasses (*Poa pratensis* L. 'Adelphi', 'Aquila', 'Glade', and 'Parade') at times when environmental conditions were conducive to foliar burn. The methylene ureas, including Fluf, Fluf-Plus, and Tuf caused minimal burn at all rates of N. Formolene could be safely applied at 12.2 and 24.4 kg N/ha, and remained marginally acceptable at 48.8 kg N/ha. Fan NPK, urea, and Folian caused unacceptable levels of fertilizer burn at rates greater than 24.4 kg N/ha.**

Liquid fertilizer usage in the United States has been increasing and presently accounts for 30% of all fertilizer applied each year (3). Because of its versatility, an estimated 60% of the commercial lawn care industry applies some liquid fertilizers (3).

Phytotoxicity can be a problem when liquid fertilizers are applied to turfgrasses as concentrated solutions. Fertilizer burn can occur as a physiological drought when there is an excess of salt, either directly on the foliage or in the soil solution (2, 6, 9) or it may result from phytotoxic effects caused by the rapid release of ammonia from urea and ammonium-containing compounds (1, 10). Factors affecting foliar burn severity include plant and soil moisture, fertilizer salt index (2), temperature, humidity, and the time of day of application (7, 8). Leaf tip browning indicates minor burn damage, and browning or bleaching of the entire leaf blade indicates major damage (2, 9).

Fertilizer burn potential can be minimized by washing salt off turfgrass foliage and into the soil solution (2), and by making applications when plant water requirements are low (4, 5, 8). Commercial applicators often must make applications under suboptimal conditions, with little knowledge of the potential fertilizer damage which may occur. With trends toward liquid fertilizer use in turf have come application equipment innovations, such as spinning-disk applicators designed to apply liquid fertilizers and pesticides, and other equipment designed to apply these materials with low volumes of water. These applicators apply materials in a more concentrated form than normally used. Knowledge of liquid fertilizer burn potential would be beneficial in further development of equipment, application techniques, and in the design of future fertilizer application methods.

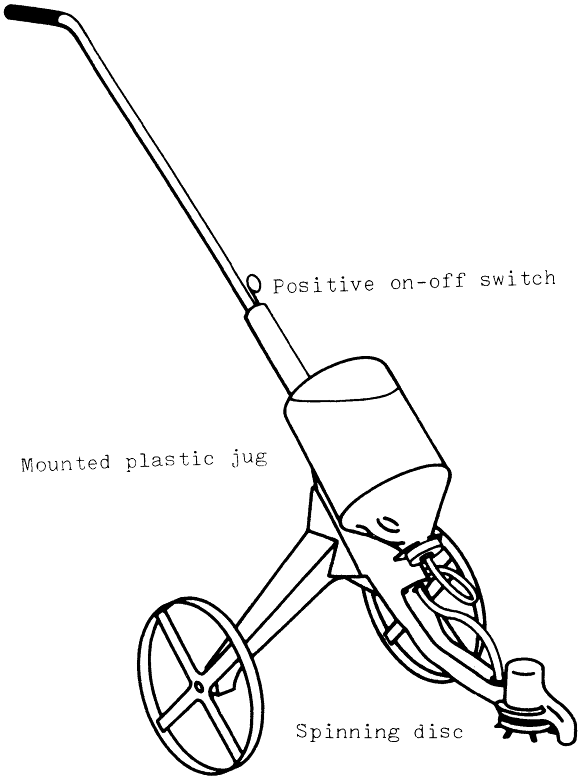

Fig. 1. The Spreader King spinning-disk liquid applicator that was used to apply concentrated fertilizers to turfgrass in the foliar burn studies.

The objective of this study was to investigate several commercial and experimental N-sources for turfgrass foliar burn tendencies when applied in a concentrated liquid form.

Materials and Methods

Eight liquid fertilizers were included in the turfgrass foliar burn studies (Table 1). Fluf, Formolene, Maxigro-Plus, Folian,

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Table 1. Descriptions of 8 liquid fertilizers screeded for foliar burn tendencies.

			Percentage of total N		g N/liter	
Material	N Source	Total N (%)	Free urea	Water insoluble N	Stock solution	Producer
Fluf	Methylene urea	18	16	25	203.9	W.A. Cleary
Fluf-Plus	Methylene urea	17	16	20	199.1	W.A. Cleary
Tuf[zy]	Methylene urea	18	16	25	212.3	W.A. Cleary
Fan NPK[y]	Alkyldiene urea	16	16	0	194.3	W.A. Cleary
Formolene	Methylol urea	30	50	0	389.8	Hawkeye Chemical
Maxigro-Plus	Methylol urea	20	63	0	242.3	Eldon C. Stutsman, Inc.
Urea[x]	Urea	17	100	0	163.1	---
Folian	Urea	12	100	0	140.3	Allied Chemical

[z] Contains a nitrification inhibitor.

[y] Was not included in the July, 1983, application.

[x] A granular turf grade urea (45–0–0), dissolved in water.

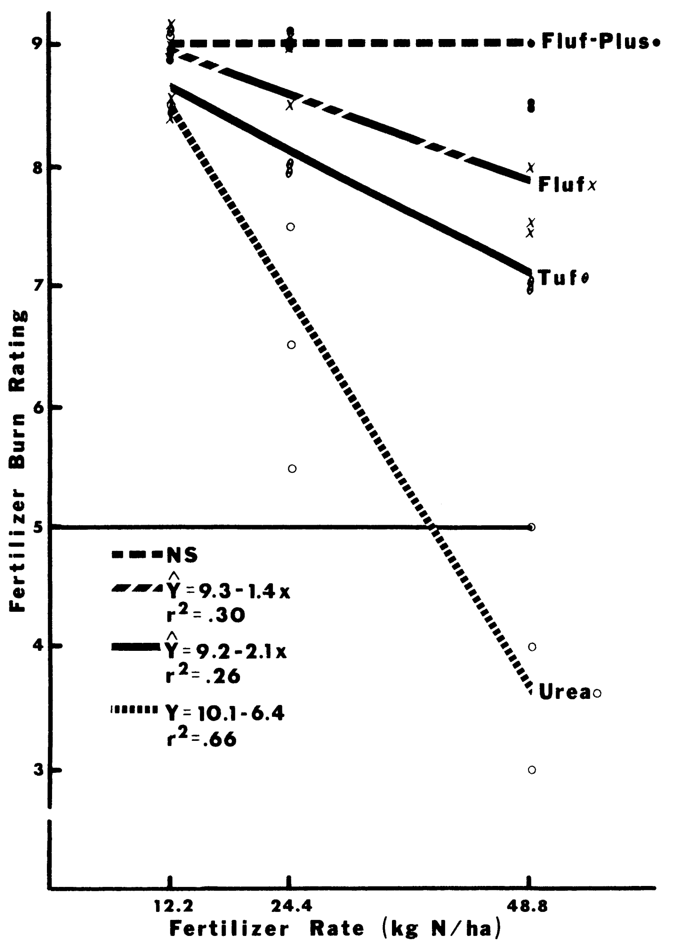

Fig. 2. Fertilizer burn of Kentucky bluegrass in response to the application of liquid N solutions observed 4 days after treatment. Treatments were applied in June and July, 1982, and July, 1983. A comparison of Fluf-Plus, Fluf, Tuf, and urea. Means of 3 replications are presented for each application date. Damage ratings less than 5.0 were considered unacceptable.

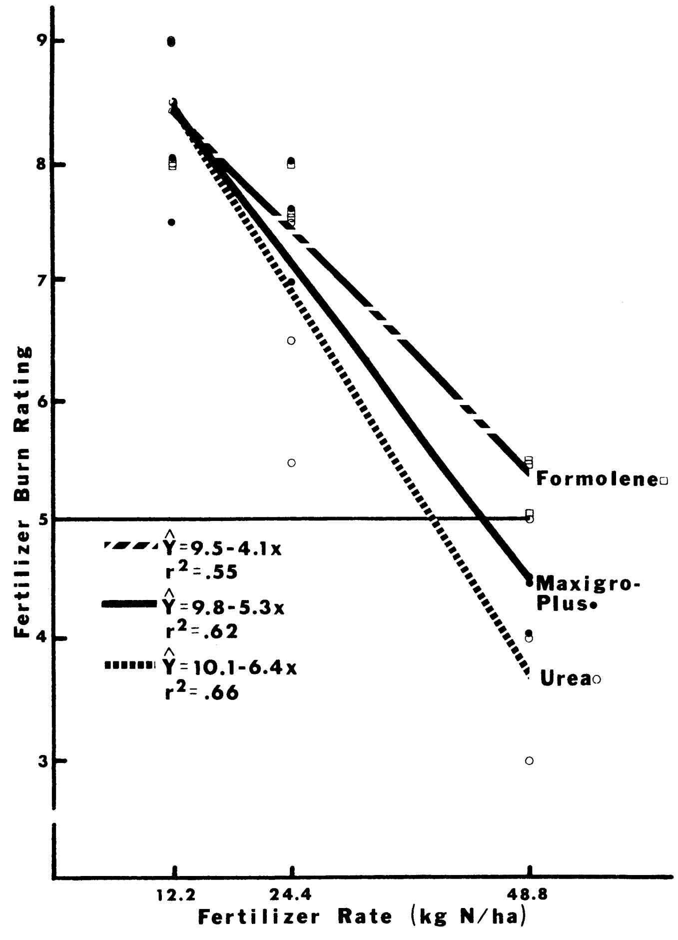

Fig. 3. Fertilizer burn of Kentucky bluegrass in response to the application of liquid N solutions observed 4 days after treatment. Treatments were applied in June and July, 1982, and July, 1983. A comparison of Formolene, Maxigro-Plus, and urea. Means of 3 replications are presented for each application date. Damage ratings less than 5.0 were considered unacceptable.

and urea are available commercially. The materials were applied with the Spreader King liquid fertilizer applicator that was developed and produced by the Britt Tech Corporation of Britt, Iowa (Fig. 1.). The Spreader King was designed to apply concentrated liquid fertilizers through a gravity-fed spinning-disk attachment.

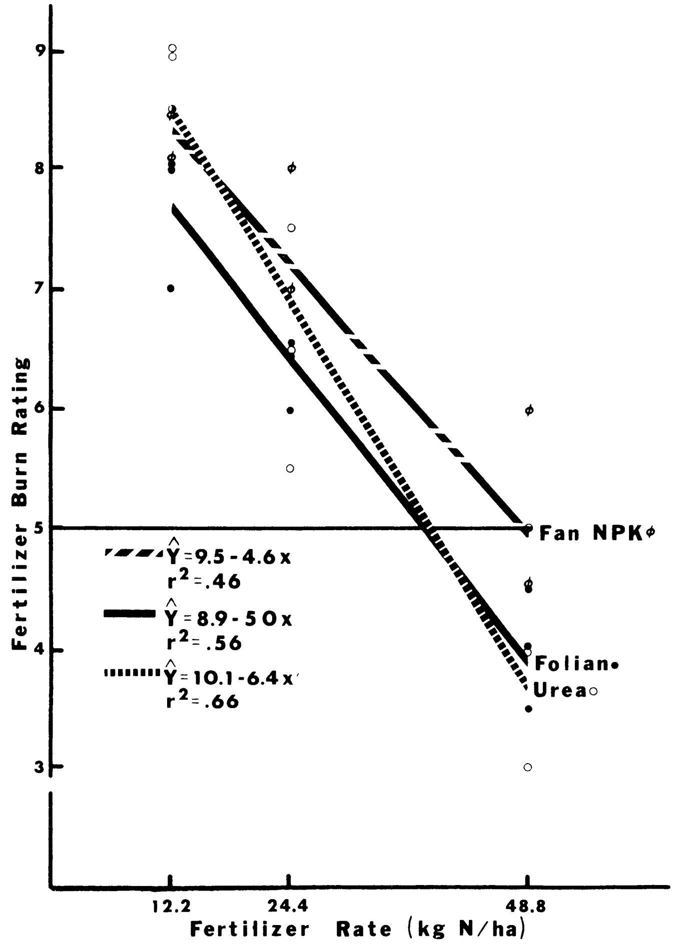

Fig. 4. Fertilizer burn of Kentucky bluegrass in response to the application of liquid N solutions observed 4 days after treatment. Treatments were applied in June and July, 1982, and July, 1983. A comparison of Fan NPK, Folian, and urea. Means of 3 replications are presented for each application date. Damage ratings less than 5.0 were considered unacceptable.

Table 2. The analysis of variance and single degree of freedom contrasts for linear regression lines. Treatments were applied June and July, 1982, and July, 1983.

Source of variation	df	Mean squares
Experiment	2	2.71
Fertilizer	7	28.24**
Rate	2	129.51**
Fertilizer × rate	14	6.30**
Methylene ureas vs. urea	1	84.38**
Fluf vs. Tuf	1	2.80
Fluf-Plus vs. Tuf	1	9.45*
Formolene vs. urea	1	7.78*
Formolene vs. Methylene ureas	1	34.08**
Folian vs. urea	1	1.67
Fan NPK vs. urea	1	2.60
Error	197	1.22

*,**Significant at 5% (*) or 1% (**) level.

Treatments were applied to a Kentucky bluegrass (*Poa pratensis* L. 'Adelphi', 'Aquila', 'Glade', and 'Parade') blend that was established in Aug. of 1981, on an Aquic Hapludoll fine-loamy mixed 'Nicollet' soil with a pH of 7.5, 10 ppm P, and 90 ppm K. Treatments included 12.2, 24.4, and 48.8 kg N/ha applied to 1.2 m × 3.1 m plots, separated by 0.6 m borders. Fluf, Fluf-Plus, Tuf, and Formolene were diluted 1:1 (v/v) with water to facilitate flow through the Spreader King. Urea was applied as a 17% solution, and the others were applied without dilution. Treatments were not irrigated for 24 hr after application. Treatments were applied at midday on 28 June and 26 July, 1982, and 22 July, 1983. The temperature and relative humidity on application dates were 27°C and 60%, 31° and 54%, and 36° and 39%, respectively. The study was arranged in a randomized complete block with 25 treatments replicated 3 times. Tuf and Fan NPK were not available when the 1983 application was made.

Turfgrass foliar burn was estimated visually for several days following treatment. Damage was rated in increments of 0.5 on a scale of 1 to 9 with 1 = browned turf, 5 = acceptable (no more than 30% leaf blade browned), and 9 = no visible burn. Data for the 4th day after fertilizer application for each date are reported.

Data from June and July, 1982, and July, 1983, were combined and analyzed to measure the variability among application dates. No significant differences were found among dates ($P > 0.01$), and the data were combined for further analysis. An analysis of variance was performed using single degree of freedom contrasts to determine if differences existed among N sources. Regression analyses were performed on each material to investigate the effect of fertilizer rate.

Results and Discussion

The methylene ureas (Fluf, Fluf-Plus, and Tuf) exhibited less potential for foliar burn than did urea, and the degree of burn caused by these materials remained at an acceptable level, even at 48.8 kg N/ha (Table 2, Fig. 2). Fluf and Fluf-Plus behaved similarly, with both causing only minimal burn even at 48.8 kg N/ha (Table 2, Fig. 2). Fluf-Plus contains more longer-chained methylene ureas than Fluf, but is reported by the manufacturer to have N release characteristics similar to Fluf. Tuf burned more than Fluf-Plus, but not more than Fluf (Table 2, Fig. 2). The relatively low coefficient of determination (R^2) values listed in Fig. 2 are due to increased variability from combining the repeated experiments for analysis.

Formolene caused less foliar burn damage than urea (Table 2), especially at the 48.8 kg N/ha rate (Fig. 3). Formolene contains no water-insoluble N and is composed of 50% urea and 50% methylol urea (9). Maxigro-Plus produced foliar burn similar to Formolene and urea at 12.2 and 24.4 kg N/ha, but, unlike Formolene, produced an unacceptable injury at 48.8 kg N/ha (Fig. 3). Maxigro-Plus is 75% Formolene and 25% urea liquor.

No differences in foliar burn were noted between Folian and urea, or urea and Fan NPK (Table 2, Fig. 4). Folian is a complete fertilizer containing urea as the N source. Fan NPK contains N as free urea and alkyldiene ureas, with no water-insoluble N.

The feasibility of applying concentrated liquid fertilizers to turfgrass was found to be limited by N source and rate. Distribution of the methylene ureas was a problem, since the suspended particles tended to clog the sprayer system, and these materials left a white residue on treated grasses which was not removed until the area was watered or mowed. Yet, their very low burn potential, when applied as concentrated solutions, would indicate potential for use in equipment designed to apply low volume of liquid materials to turfgrass areas.

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Increasing Returns from Roses with Root-zone Warming

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Abstract. **Three rose cultivars, Ilona, Mercedes, Sonia, on *Rosa multiflora* rootstock were grown in a nutrient film technique (NFT) system for 2 years, with root-zone warming (RZW) to 25°C compared with ambient temperature roots. In the 1st season the night air temperatures were 18°, 12°, and no heating (9°); in the 2nd season, 18°, 14°, and 10°. Harvested flowers were graded according to stem length. In the 1st winter seasons RZW increased the proportion of long stemmed roses and increased the total yield, especially in 'Ilona'. In the 2nd winter season, RZW again increased the proportion of long stemmed roses in 'Ilona' but increased the total number of blooms more in the other cultivars. The effects of RZW persisted into the summer period. Prevailing wholesale prices were used to calculate probable gross returns based on yields. Since RZW tended to give longer stemmed roses and more blooms than did ambient conditions, this treatment enhanced returns more than that of the increased air temperature treatments. RZW increased probable returns over the ambient for 'Ilona', 'Mercedes', and 'Sonia' by 49%, 69%, and 78%, respectively.**

Recent developments in soilless cultivation techniques, such as NFT (2), or rockwool systems (4) enable control of the root environment, including nutrition, water, temperature, and aeration, more easily than in soil. Yet, few have attempted to assess the value of manipulating the root environment of roses in such systems. Roses (in soil) were considered unresponsive to RZW, having root temperature optimum cited as 18°C (9). Recently, however, the number of blooms was increased by root-zone warming to 25°(1).

The aims of this study were to determine if roses in soilless culture with RZW increased yield or value of the crop, and if RZW would reduce the energy requirement of greenhouse cut roses.

Materials and Methods

This study was conducted at Griffith, latitude 34°S, an area with good winter light (total horizontal solar radiation around 7 MJ m^{-2} day^{-1}), and warm to hot summers. The experiments were conducted in a 9 m span modern glasshouse divided into 3 sections. Each section was a separate night temperature treatment (see below). In each section were 4 benches running north to south, each carrying 2 NFT channels with a 45 liter plastic tank of nutrient to each bench. A thermostatically controlled heater maintained nutrient solutions at 25°C in the RZW treatment channels while the ambient root-zone treatment solutions were unheated.

Each root temperature treatment was replicated twice (i.e., 2 blocks each containing 2 treatments), but since it was not possible to duplicate night temperature treatments, statistical comparisons of night temperature effects are not strictly valid. The design was a split plot, and the chief interest was in the interaction between root temperature and air temperature. The analysis gave an error estimate for testing night temperature effects, but this value was really an estimate of within plot variance and may underestimate the between plot error appropriate for testing these effects. Analyses were carried out separately on each cultivar in each year.

The nutrient solution described by Cooper was used in the 1st season. The conductivity and pH of the solution were mea-

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