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Comparative Effectiveness of Urea, Ammonium Nitrate, and Urea Ammonium Polyphosphate on Fescue Production

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COMPARATIVE EFFECTIVENESS OF UREA, AMMONIUM NITRATE, AND UREA AMMONIUM POLYPHOSPHATE ON FESCUE PRODUCTION

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Introduction

In the past, nitrogen (N) fertilizers used on grass pastures in Kentucky have largely been ammoniated phosphates in mixed fertilizers and ammonium nitrate. Due to the economic advantage of producing solid urea as opposed to ammonium nitrate, availability of urea is becoming greater and, in some areas, is the only source of solid nitrogen. If urea is not incorporated into the soil immediately after application, some of the nitrogen may be lost as ammonia gas. The loss is called volatilization. The amount of loss depends on a number of conditions. High soil and air temperatures and a moist soil which is undergoing drying are contributing factors to volatilization losses. Presence of organic residues on the soil surface and a high soil pH (6.5 or above) are also thought to increase the expected loss. Based on these conditions we would expect N losses from topdressed urea to be greater when applied to pastures than when applied to row crops and the rate might be different at different times during the season.

Most of the pasture fertilization research on which the present University of Kentucky recommendations were based resulted from the use of ammonium nitrate as the nitrogen source. Therefore, if urea is used, how much loss can be expected? How does the rate of loss change during the growing season? To test the potential for such losses, an experiment was established at Princeton in 1973 to compare the effectiveness of ammonium nitrate, urea, and urea ammonium polyphosphate as nitrogen fertilizers for fescue pastures. Comparisons were made between urea and ammonium nitrate every two weeks throughout the entire growing season to determine whether or not time of growing season had an effect.

Method

The experiment was carried out on a Tilsit silt loam soil, a moderately well to somewhat poorly drained fragipan soil. The site had been in Kentucky 31 fescue for at least 15 years. Results of soil tests by the University of Kentucky Soil Testing Laboratory in March of 1970 were: pH, 6.6; P, 94; K, 485; Ca, 2350; and Mg, 272 lbs. per acre. The experiment was laid out in a split-plot randomized complete block design. Nitrogen sources were topdressed on the plots in 1973, 1974, 1975 and 1977 at the rate of 70 lb/acre of actual N. Ammonium nitrate and urea were topdressed on their respective plots every two weeks from the first of April through September. There were separate plots for each time of application. Therefore, each plot was topdressed with N only once each year. Urea ammonium polyphosphate was topdressed on its respective

plots the first of every month from April through September in 1974, 1975, and 1977. All plots were fertilized with P_2O_5 and K_2O at the beginning of each season at the rate of 45 and 90 lb/acre, respectively. The plots were clipped to a 2 inch height just prior to topdressing and were harvested four weeks and ten weeks after treatment. Dry matter yields from the two harvests were combined for treatment comparisons since it was found that only a small effect of the added nitrogen is reflected in the second harvest. This indicates that the ten week period was long enough to allow for almost all of the added nitrogen to be utilized. Each harvest was oven-dried, weighed and sub-sampled. The sub-samples were analyzed for nitrogen by the Kjeldahl method.

Results

Table 1 compares dry matter production from use of urea and ammonium nitrate. Nitrate increased yields in all cases. Slightly over 16 pounds of dry matter was produced for each pound of N added as ammonium nitrate when averaged over the entire year. Each pound of N produced 24 pounds of dried fescue when applied in April and decreased throughout the growing season to a low of about 11 pounds when applied in August. There was no yield difference between urea and ammonium nitrate treatments for the first three application periods. After that, urea consistently produced less dry matter than ammonium nitrate although the differences for the last four application dates were not significantly different at the 10% level. Comparing total yields, urea produced an average of 86 percent of that receiving ammonium nitrate. On two dates, one in 1975 and one in 1977, production with urea was as little as 78 percent of that with ammonium nitrate. We can also compare the efficiency of these nitrogen sources in another way. If yields without nitrogen fertilizer are subtracted from those with nitrogen fertilizer, the difference is the production attributed to the added nitrogen (N response). When compared in this manner, the efficiency of urea was much lower than that of ammonium nitrate. As in the case of total yields, the first 3 dates of application were comparable. Subsequent nitrogen application dates resulted in urea producing an average of 72% as much fescue as ammonium nitrate.

Table 1. Effect of N application date (70 lb/acre) on yield of fescue using urea and ammonium nitrate over a four year period.

Application Date	Dry Matter Yield*			Urea/Am. Nitrate Yield Ratios	
	None	Ammonium Nitrate	Urea	Total Yield	N Response**
	lb/acre			%	
Early April	1998a	3592b	3531b	98	96
Mid April	1804a	3587b	3638b	101	103
Early May	1608a	2412b	2311b	96	87
Mid May	1328a	2613b	2271c	87	73
Early June	1479a	2511b	2188c	87	69
Mid June	1468a	2768b	2374c	86	70
Early July	1496a	2924b	2552c	87	74
Mid July	934a	1927b	1675b	87	75
Early August	786a	1683b	1406b	84	69
Mid August	741a	1438b	1287b	89	73
September	372a	1076b	852b	79	68

* Numbers followed by different letters at the same date of application are significantly different at the 10% level.

**Yield with N (minus) - yield with no N = yield due only to the addition of N.

Table 2 shows the total nitrogen uptake in both harvests. Less than half of the added nitrogen was accounted for in the plants except for one application date. In every case nitrogen uptake was greater from ammonium nitrate as compared with urea. This was true for the first three dates even though there was little difference in growth. However, the nitrogen uptake was significantly higher, at the 10% level, with ammonium nitrate than with urea at only two application dates. An estimate of the amount of fertilizer nitrogen taken up by the fescue was made by subtracting the nitrogen in the fescue when no N was added from that with N applied. When the estimated N uptake due to N additions was compared between urea and ammonium nitrate, the amount of N uptake from urea was much less than from ammonium nitrate. The range was from 91 to 59% and the average was only 77%.

Table 2. Effect of date of application of urea and ammonium nitrate (70 lb N/acre) on nitrogen uptake by fescue over a three year period.

Application Date	Nitrogen Uptake* None	Ammonium Nitrate	Urea	Fertilizer N Uptake** Urea/Am. Nitrate
	lb/acre			%
Early April	33.8a	63.1b	60.2b	91
Mid April	33.8a	72.3b	69.4b	90
Early May	42.7a	69.7b	65.0b	82
Mid May	29.4a	59.1b	52.4b	77
Early June	28.7a	51.0b	47.9b	86
Mid June	23.2a	54.2b	41.7c	59
Early July	15.4a	30.3b	28.8b	90
Mid July	16.7a	39.3b	32.1b	68
Early August	11.5a	35.1b	27.2c	66
Mid August	12.3a	24.8b	22.2b	79
September	8.0a	22.6b	18.0b	64

* Numbers followed by different letters at the same date of application are significantly different at the 10% level.

**Nitrogen uptake with added N (minus) - nitrogen uptake with no N = nitrogen uptake due to added N.

Table 3 shows fescue growth comparing ammonium nitrate, urea, and urea ammonium polyphosphate. This portion of the experiment was carried out to measure N loss from urea incorporated into another compound, such as urea ammonium polyphosphate. As in the first experiment, there was little yield difference in production among sources for the first three application dates. After this date, yields were higher with ammonium nitrate than with either of the other sources. Yields with ammonium nitrate were significantly higher for only one date when compared with the urea ammonium polyphosphate as the N source. Comparing urea and urea ammonium polyphosphate, fescue production was very similar. The magnitude and trends of the nitrogen uptake with urea ammonium polyphosphate (not shown) is very similar to that with urea found in the first experiment.

Summary and Conclusions

Based on 4 years of data from the Tilsit silt loam soil, it appears that the effectiveness of urea as a source of nitrogen for topdressing fescue pasture was found to be greatly dependent on time of application. The effect of time of application is closely related to a number of environmental conditions such as temperature and moisture content of the soil. When urea is applied early May or before, it appears to be as effective as ammonium nitrate. When applied after early May, the efficiency of urea

Table 3. Effect of date of application of urea, ammonium nitrate, and urea ammonium polyphosphate (70 lb N/acre) on yield of fescue over a three year period.

Application Date	Dry Matter Yield*				Yield Ratio Comparisons** With Amm. Nitrate	
	None	Ammonium Nitrate	Urea Amm. Polyphosphate	Urea	UAP	Urea
	lb/acre				%	
Early April	1741a	3371b	3282b	3407b	97	101
Early May	1303a	2154b	2015b	2044b	94	95
Early June	1600a	2635b	2404bc	2305c	91	88
Early July	1549a	3033b	2615c	2603c	86	86
Early August	978a	2013b	1824c	1677c	91	83
September	372a	986b	812b	802b	82	81

* Numbers followed by different letters at the same date of application are significantly different at the 10% level.

**Using total dry matter yield, UAP/Am. nitrate and Urea/Am. nitrate, ratios were calculated.

is reduced by about 14 percent as compared to ammonium nitrate. Considering only the forage produced by the added nitrogen, urea produced only 72% as much forage as ammonium nitrate. Based on estimates of N uptake from the added nitrogen applied after early May, urea was only 74% as effective as ammonium nitrate.

For urea to be an economic alternative to ammonium nitrate for topdressing pastures, the cost per pound of nitrogen from urea would have to be at least 15% cheaper and preferably 20 to 25% cheaper if applied after early May.

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