# N, P, and K Fertilization of Tall Fescue (*Festuca arundinacea* Schreb.) Overseeded Range in Eastern Oklahoma

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## Abstract

**A native hay meadow in northeastern Oklahoma was overseeded with tall fescue (*Festuca arundinacea* Schreb.) and fertilized for 6 years with N in August and February to encourage tall fescue growth in late fall and early spring, thus extending the green forage season. The effect of P and K fertilizer on forage yield and plant nutrient concentration was determined. Cool-season N fertilization (112 kg/ha) nearly doubled tall fescue yield and increased forage nitrogen concentration without altering warm-season grass production. Additions of P (15, 29 kg/ha) and K (28, 112 kg/ha) increased cool-season forage yield marginally and increased fertilizer N recovery but had no desirable effect on forage N, P, and K content. Tall grass decreaser species were dominant at the end of the study. Available soil P increased with P fertilization and available soil K increased with K fertilization.**


Native grassland and tame pastures dominated by warm-season perennial grasses are sometimes overseeded with a cool season grass such as tall fescue (*Festuca arundinacea* Schreb.) to extend the green forage season. In the eastern one-third of Oklahoma, where rainfall conditions are favorable, spring forage production has been greatly increased after overseeding. With adequate moisture, tall fescue also produces forage in the fall which can be used for winter grazing, thus extending the green feed season into both spring and winter. However, adequate forage production by tall fescue depends on application of fertilizers, particularly nitrogen (Hallock et al. 1973, Fuller et al. 1971, Wilkinson and Mays 1979). Timing of fertilization is critical since companion warm-season species use available water and nutrients in summer.

Many studies have been conducted on the monoculture of tall fescue and the optimal rate of annual N application appears to be around 224 kg/ha (Alexander and McCloud 1962; Balasko 1977; Hallock et al. 1965, 1973; Hojjati et al. 1977). In eastern Oklahoma, where poor quality of range forage from November to May is a problem, optimum yield from fall growth of tall fescue occurs with approximately 67 kg N/ha (Fuller et al. 1971) and will provide winter forage for about 25 cows/ha. Additional N application of 45 kg/ha in January insures adequate spring growth to maintain the same stocking rate through May (Rommann and McMurphy, 1979). It is possible to produce more spring forage with greater N application, but the limiting factor for determining stocking rate for tall fescue is winter forage availability. Therefore, in eastern Oklahoma the optimal rate of annual N application is around 112 kg/ha.

Maximal N use efficiency depends on adequate soil P and K (Fuller et al. 1971) and fertilizer studies on tall fescue, perennial ryegrass (*Lolium perenne* L.), and orchardgrass (*Dactylis glomerata* L.) indicate that added N fertilizer increases P and K uptake (Mortensen et al. 1964, Duell 1965, Hunt 1973, 1974). Dry matter yields are usually higher after additions of P and K than yields with N fertilization alone (Duell 1960, Mortensen et al. 1964, Ludwick and Rumburg 1976).

Previous studies (Elder and Murphy 1958, Huffine and Elder 1960, Gay and Dwyer 1964) on fertilizer application to eastern Oklahoma rangelands have shown marginal benefits in terms of warm-season forage production. Furthermore, increases in undesirable forbs and annual grasses often resulted from fertilization of native grass.

Because many eastern Oklahoma soils are low in available P and K, this study was designed to apply N fertilizer at a rate to achieve optimal and uniform winter and spring tall fescue yield (112 kg/ha/hr); and then to vary application of P and K so that we might determine the effects of fertilizer P and K on the yield and quality of forage produced by N fertilized native hay meadow overseeded with tall fescue.

## Materials and Methods

Field plots were established during February, 1975, in a native tallgrass hay meadow overseeded with tall fescue near Wynona, Okla. Big bluestem *(Andropogon gerardii),* Indiangrass *(Sorghastrum nutans),* and little bluestem *(Schizachyrium scoparium)* made up more than 60% of the foliar cover at the end of the study. Soil was a Wynona silty clay loam (fine-silty, mixed, thermic Cumulic Haplaquolls) which tested deficient in P and K.

Nitrogen was applied at an annual rate of 112 kg/ha as ammonium nitrate (34-0-0) on 36 plots, each measuring 3×6 m. The N was applied twice a year, 45 kg/ha in February and 67 kg/ha in August, for 6 years (1975-80). Phosphorous and K treatments were applied in a 3×3 factorial arrangement with 4 replications in a randomized block. Three levels of P (0, 15, and 29 kg/ha) and 3 levels of K (0, 28, 112) were evaluated using concentrated superphosphate (0-46-0) and muriate of potash (0-0-60) as sources. The P and K were applied in February and August, 1975, and thereafter in August every year. Four check plots (3×6 m) with no added N, P, or K were included.

Herbage yield was estimated by mowing a 1×6-m quadrat at 50 mm height in each of the plots, after which all the plots were mowed and the forage removed. Herbage was clipped annually in late May or early June to estimate tall fescue yield (oven-dried) and in August to estimate yield (oven-dried) of native grasses. Fall yield of tall fescue was estimated in 1975 and 1977 with a December harvest. Dried herbage samples were evaluated for N (Kjeldahl), P (perchloric acid digestion-ammonium vanadate) and K (atomic absorption spectrophotometer) content.

Soil samples (0–15 cm depth) were taken from each plot at the beginning and conclusion of the study. Available P was extracted with the Bray-P1 extractant using a 20:1 solution to soil ratio. Exchangeable K was determined on an atomic absorption spectrophotometer. Soil pH was determined on a 1:1 soil to water paste.

Analysis of variance was performed on the data as collected by year and as pooled over years. Treatment means were compared using Fisher's Protected Least Significant Difference method as outlined by Chew (1977). In a separate analysis of variance the data from check plots were omitted to test for main effects of P and K

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Journal article 4579 of the Oklahoma Agricutural Experiment Station, Stillwater 74078.

Manuscript accepted April 5, 1985.

**Table 1. Mean herbage yield and nutrient concentration of spring harvested tall fescue (1975-80) and August harvested native grasses (1975-1979) following, N, P and K fertilizer treatments.**

| Fertilizer rate (kg/ha) | | | Tall Fescue | | | | Native Grasses | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| N | P | K | Yield (kg/ha) | N (%) | P (%) | K (%) | Yield (kg/ha) | N (%) | P (%) | K (%) |
| 0 | 0 | 0 | 1600 a[1] | 1.30 a | 0.15 c | 1.26 a | 2400 a | 1.03 a | 0.12 c | 0.80 a |
| 112 | 0 | 0 | 3000 b | 1.54 c | 0.13 b | 1.21 a | 2600 a | 1.14 a | 0.10 ab | 0.79 a |
| 112 | 0 | 28 | 2900 b | 1.48 bc | 0.11 a | 1.26 a | 2700 a | 1.07 a | 0.09 a | 0.79 a |
| 112 | 0 | 112 | 3300 bc | 1.54 c | 0.12 ab | 1.63 c | 2600 a | 1.08 a | 0.11 bc | 1.17 c |
| 112 | 15 | 0 | 3700 d | 1.33 ab | 0.16 cd | 1.21 a | 2500 a | 1.11 a | 0.14 d | 0.80 a |
| 112 | 15 | 28 | 3500 cd | 1.38 ab | 0.17 cd | 1.37 b | 2300 a | 1.18 a | 0.14 d | 0.92 b |
| 112 | 15 | 112 | 3900 de | 1.43 b | 0.18 d | 1.69 c | 2700 a | 1.13 a | 0.14 d | 1.09 c |
| 112 | 29 | 0 | 3600 cd | 1.40 b | 0.20 e | 1.18 a | 2600 a | 1.14 a | 0.16 e | 0.83 a |
| 112 | 29 | 28 | 3900 de | 1.36 ab | 0.20 e | 1.23 a | 2500 a | 1.10 a | 0.18 f | 0.85 ab |
| 112 | 29 | 112 | 4200 e | 1.37 ab | 0.21 e | 1.68 c | 2700 a | 1.18 a | 0.17 ef | 1.10 c |

[1]Means in a column followed by the same letter are not significantly different ($P<.05$).

and the PK interaction. Differences were considered significant at $P<0.05$.

## Results

### Dry Matter Yield

Nitrogen fertilization at an annual rate of 112 kg/ha increased spring yield of tall fescue from an average of 1,600 kg/ha to 3,000 kg/ha (Table 1). Average yield was further increased by P and K fertilization, the highest rates of P and K resulting in the highest yields (Table 1). Analysis of variance detected no significant PK interaction during any of the 6 years but the main effects of P and K fertilization pooled over years were significantly different between the 0, 15, and 29 kg/ha P rates and between the 0 and 112 kg/ha rates of K. Phosphorous fertilization increased spring yields of tall fescue starting in 1976 and increased yields each year through 1980. Herbage yield was increased by K fertilization in only 2 years, 1977 and 1978.

Dry matter yields of the native grasses on check plots varied annually from a low of 1,600 kg/ha in 1977 to 3,700 kg/ha in 1979. None of the fertilizer treatments significantly increased native grass herbage production (Table 1).

Fall herbage production by tall fescue was not dependable. In December, 1975 and 1977, after more than average rainfall in August–September, standing crop was sufficient to harvest (Table 2). Nitrogen fertilization had a significant effect in 1977 when yield increased from 1,400 kg/ha to 2,500 kg/ha. P and K treatments had no significant effects on herbage production in either 1975 or 1977.

**Table 2. Tall fescue herbage yield harvested in December, 1975 and 1977, following N, P and K fertilizer treatments.**

| Fertilizer Rate (kg/ha) | | | December Yield (kg/ha) | |
|---|---|---|---|---|
| N | P | K | 1975 | 1977 |
| 0 | 0 | 0 | 500 a[2] | 1400 a |
| 112[1] | 0 | 0 | 1000 a | 2500 b |
| 112 | 0 | 28 | 900 a | 2300 b |
| 112 | 0 | 112 | 800 a | 3000 c |
| 112 | 15 | 0 | 1000 a | 2800 bc |
| 112 | 15 | 28 | 700 a | 2600 bc |
| 112 | 15 | 112 | 800 a | 2900 bc |
| 112 | 29 | 0 | 800 a | 3400 c |
| 112 | 29 | 28 | 1000 a | 3000 bc |
| 112 | 29 | 112 | 1000 a | 3100 c |

[1]N fertilization was 67 kg/ha in August and 45 kg/ha in February.
[2]Means in a column followed by the same letter are not significantly different ($P<0.05$).

### Nutrient Concentration-Tall Fescue

Nitrogen fertilization significantly increased plant nitrogen content from 1.3 to 1.5% (Table 1). The nitrogen concentration of fertilized herbage was significantly lower in plots with P additions than in plots without added P. Nitrogen concentration was unaffected by added K, and no significant PK interactions were detected in any of the 6 years. Phosphorous concentration was significantly higher with each increment of P fertilization, and K concentration was significantly higher with increasing K fertilization.

### Nutrient Concentration—Native Grasses

Nitrogen fertilization did not increase N content of the native grass herbage, nor were there any significant P or K interactions with N. Compared to the control, herbage P concentration was significantly higher with each increment of P fertilization.

### Fertilizer N Recovery

Recovery of fertilizer N is a function yield and N concentration. Thus, the native grass which had no differences in yield or N concentration had no significant differences due to treatments in N recovery (data not shown). Recovery of N fertilizer by tall fescue was increased by P and K fertilization with the highest rates of P and K resulting in greatest recovery (Table 3). Maximum recovery of N was 41% by tall fescue forage and 47% by all forage harvested (tall fescue plus native grass). The total quantity of N fertilizer applied during the study was 605 kg/ha.

**Table 3. Recovery of fertilizer N (605 kg/ha) by tall fescue and all forage (1975-1980).[1]**

| Fertilizer Rate (kg/ha) | | % Recovery | |
|---|---|---|---|
| P | K | Tall fescue | All forage |
| 0 | 0 | 29 ab[2] | 33 ab |
| 0 | 28 | 26 a | 30 a |
| 0 | 112 | 35 cd | 39 cd |
| 15 | 0 | 32 bc | 35 bc |
| 15 | 28 | 29 ab | 31 ab |
| 15 | 112 | 38 de | 43 de |
| 29 | 0 | 34 cd | 38 cd |
| 29 | 0 | 34 cd | 39 cd |
| 29 | 112 | 41 e | 47 e |

[1]$\% \text{ N recovery} = \frac{\text{N(kg/ha) in fert. forage} - \text{N(kg/ha) in unfert. forage}}{\text{N (k/ha) fertilizer applied}} \times 100$
[2]Means followed by the same letter are not significantly different ($P<0.05$).

### Soil Tests

Mean soil pH was 5.7 at the beginning and end of the study, and was unaffected by any fertilizer treatment. Nitrogen fertilizer had no measurable effect on available soil P or soil K. Annual application of P fertilizer resulted in a significant increase in available soil P (Table 4) but had no effect on pH or available soil K. Applications of K fertilizer resulted in a significant increase in available soil K but had no effect on pH or available soil P.

**Table 4. Mean soil test values (kg/ha) from 0-15 cm depth at the beginning (Feb. 1975) and end (Nov. 1980) of the study.**

| Annual Fertilizer rate (kg/ha) | Feb. 1975 | Nov. 1980 |
|---|---|---|
| | Available Soil P | |
| 0 P | 11 a[1] | 22 a |
| 15 P | 10 a | 33 b |
| 29 P | 11 a | 60 c |
| | Available Soil K | |
| 0 K | 217 a | 174 a |
| 28 K | 217 a | 216 b |
| 112 K | 220 a | 283 c |

[1]Means in a column within an element (P or K) followed by the same letter are not significantly different ($P<0.05$).

## Discussion

Application of N fertilization in August and February, which coincides with the growth cycle of tall fescue, nearly doubled cool-season herbage yield. The N fertilizer was apparently utilized by tall fescue with no residual for native grass summer production because the added N had no effect on August native grass yield nor its crude protein content. Phosphorus, at a moderate application rate (15 kg/ha), enhanced tall fescue yield by about 20% in this situation where N was added, but soil tested P-deficient. Increases in yield attributable to K were minimal at all treatment levels.

While grazing animals may select a higher quality diet than we were able to sample, bulk forage quality was not improved by additions of P and K. Regardless of soil amendments and increases in P and K concentrations associated with treatment additions of P and K, the sampled forage was always deficient in P and sufficient in K when compared to NRC dietary standards for a lactating beef cow. Nitrogen fertilization alone resulted in the largest improvement in forage nutrient content. Phosphorus and K fertilization diminished N concentration from that achieved by N fertilization alone, possibly a dilution effect caused by greater forage production with the same amount of available N.

Tall fescue production in fall was an unreliable forage resource. The long-term mean August–September precipitation for the area is 15.7 cm. Fall yield was measurable only in the 2 years when precipitation during August–September was greater than average.

The recovery of N fertilizer in this study (41 or 47%) was less than expected. A tall fescue monoculture in Oklahoma recovered at least 60% of the N applied at rates up to 358 kg N/ha (Elder and Tucker 1964). Whitehead (1970) reported that cool-season grasses normally have 55 to 70% recovery of N fertilizer depending on management and species. However, recovery of N fertilizer by a native hay meadow in Oklahoma averaged only 33% (McMurphy 1970), and other native grass studies in the Southern Great Plains have experienced lower recovery rates (Drawe and Box 1969, Harper 1967). Authors of previous studies have explained lower than expected N recovery to be a result of N incorporation into roots rather than shoots (Black and Wight 1979, Power 1972). Another possible explanation in tall grass prairie is that a high root turnover rate [life expectancy of 4 years (Kucera et al. 1967)] makes available a high C:N (carbon:nitrogen) ratio food source for soil microorganisms. Soil microorganisms may utilize fertilizer N, thus immobilizing it for plant uptake.

This tall fescue-native grass system was evaluated using mowing to determine forage yield and further evaluation with grazing should proceed with caution. The high palatability of native tall grass species in May would probably insure heavy grazing use of the native grasses. It is expected that summer deferment may be quite important to preservation of native grass vigor and stand maintenance.

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