Effects of Atrazine, 2,4-D and Fertilizer on Crude Protein Content of Oklahoma Tallgrass Prairie

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Abstract

Various combinations of atrazine, 2,4-D, and NPK fertilizer were applied initially in 1975 on a tallgrass prairie in good condition and again as a retreatment in 1976 on one-half of each treated area. Application of atrazine with fertilizer increased crude protein content, crude protein yield, and range condition during the summer. Differences in protein levels in dormant forage were not evident. Therefore the application of atrazine and fertilizer appears to be more feasible for summer grazing or production of high quality prairie hay than for yearlong or winter grazing.

Forage dry matter content, nutrient composition, and palatability of range plants are important factors affecting livestock performance. Early growth of range plants is generally more nutritious than material of older, more mature plants. However, grazing animals must often utilize more mature, less nutritious forage for maintenance and production in late summer, fall, and winter.

The protein content of many tallgrass prairie plants declines rapidly in summer (Powell et al. 1978) and often does not meet livestock maintenance requirements. Even when fertilized, the protein content and digestibility of tallgrass prairie forage often reach low levels by maturity (Rao et al. 1973).

Herbicides have been used to increase and maintain protein in grasses (Sneva 1967, Kay and Torell 1970). Nontoxic concentrations of atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine] increase nitrogen metabolism in many grasses (Kay 1971, Houston and van der Sluijs 1975), although the physiological processes are not fully understood (Dumford and Ebert 1976).

Livestock production could be increased or supplemental feed costs reduced by increasing the protein content of herbage throughout the growing season. Therefore, the objective of this study was to determine the effects of atrazine, 2,4-D, and fertilizer on the protein content of tallgrass vegetation in northcentral Oklahoma.

Study Area

The study area is 2.25 ha of loamy upland rangeland, 11 km north of Stillwater, Oklahoma. Elevation is about 280 m. Stillwater has a continental climate with average maximum observed

Editor's Note: The first two articles of this issue discuss Oklahoma rangeland and may be of special interest to those planning to attend the Annual Meeting of the Society for Range Management in Tulsa, February 8-13, 1981.

temperatures exceeding 40° C from June through September, and average minimum observed temperatures below -20° C from December through March (Fig. 1). Annual precipitation averages 820 ± 250 mm, and its distribution during the 210-day growing season is 21% (April-May), 28% (June-August), and 17% (September-October). Wind occurs most frequently in March and April and pan evaporation is more than 250 mm/mo in June, July, and August.

Topography is rolling with smooth areas confined to broad interstream divides (Gray and Galloway 1959). Slope of the land varies from 2 to 6% eastward. Soils are predominately fine-loamy, mixed, thermic, Udic Argiustoll. Range site is good condition loamy prairie that was moderately grazed by cows and calves or mowed for hay prior to the study. Major species in the study area include *Schizachyrium scoparium*, *Sorghastrum nutans*, *Panicum virgatum*, *Andropogon gerardi*, *Aristida oligantha*, *Panicum oligosanthos* (all varieties), *Ambrosia psilostachya*, and various members of the *Cyperaceae* referred to as *Carex*. (Waterfall 1972, includes unpublished updates by R.J. Tyrl, OSU herbarium curator).

Methods

A randomized block experimental design was used in 1975 with

Fig. 1. Longterm (81 years) average monthly precipitation (mm), absolute observed temperatures (°C), wind (km/day), and evaporation (mm/mo) for study area.

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three replications of eight treatments. Randomly selected 12 × 15-m plots were treated with foliar sprays of atrazine and 2,4-D [(2,4-dichlorophenoxy) acetic acid] on June 27, 1975, with a tractor-powered boom sprayer using 187 liters water/ha at 2.8 kg/cm² pressure. Fertilizer (N-P-K) was broadcast June 7 at the rate of 67-45-45 kg/ha. The eight treatments included (1) untreated, (2) 1.1 kg atrazine/ha, (3) 3.4 kg atrazine/ha, (4) 0.8 kg 2,4-D/ha, (5) fertilizer, (6) 2,4-D + atrazine, (7) 3.4 kg atrazine + fertilizer, and (8) 3.4 kg atrazine + 2,4-D + fertilizer.

Standing herbage weight was estimated by species in July, August, and November 1975 using modified weight-estimate (Pechanec and Pickord 1937) and double sampling (Wilm et al. 1944). Species production on six, 0.5-m² samples were estimated for each treatment in each replication. Two of the six samples were clipped at a 5-cm stubble height and dried at 60° C to a constant weight to determine the estimation correction factor and dry matter content. Soil samples were collected at 0–30 cm and 30–60 cm depths at each clipped sample site to determine soil water content gravimetrically (National Academy of Science 1962).

All standing vegetation was mowed to a 10-cm height with a rotary lawnmower in March 1976 and left on plots as ground litter. A split plot design was superimposed on the randomized block design in 1976. One-half of each plot received the same treatment as in 1975, while the other half remained untreated to measure residual effects. In 1976, fertilizer was broadcast May 10 and herbicides were applied as in 1975 on June 4. Herbage yields were estimated in June, July, August, and November to coincide with similar phenological growth stages in 1975. Four estimates per treatment area were recorded with one estimated sample clipped. Other sampling procedures were unchanged from 1975.

Forage samples were mixed by hammermilling and then ground with a Wiley Mill to pass through a 2-mm screen. The 1975 nitrogen analyses were by the micro-Kjeldahl and nitrogen analyzer procedures (OSU Soil and Water Testing Laboratory, Stillwater, Unpublished procedures) while 1976 analyses were by the macro-Kjeldahl procedure (AOAC 1970).

Data were analyzed using ANOVA procedure of the Statistical Analysis System (Barr and Goodnight 1972). Statistically significant differences among selected combinations of treatment means were determined using the least significant differences (LSD) from the analysis of variance. All differences discussed are based on LSD's at the 90% level of probability unless otherwise indicated.

Fig. 2. Study period average monthly precipitation (mm), absolute observed temperatures (C), wind (km/day), evaporation (mm/mo).

Results and Discussion

Weather

Drought conditions prevailed throughout most of the study period after a wet May 1975 (Fig. 2). An 8-week summer drought with very limited rainfall occurred in July and August 1975. Drought conditions continued into winter with no recharge of subsoil water. In 1976, only March and April precipitation was above average and no single rainfall event produced more than 25 mm precipitation. By the end of July 1976 available soil water was extremely low. Many of the plants were under plant water stress for the remainder of the growing season. In general, unfavorable growing conditions were due more to limited precipitation than to temperature or wind extremes.

First Year Treatment Effects

In June 1975 prior to treatments, herbage protein content was 9.9% and protein yield was about 130 kg/ha (Fig. 3). With above-average precipitation in May and June, plants were actively growing.

By July protein content decreased to 7.4% on untreated areas, but ranged from 8.5% to 11.5% on the treated areas. Protein levels on areas treated with either 1.1 or 3.4 kg of atrazine were about 1% higher than those in herbage on areas treated with 2,4-D. Protein levels were highest on areas treated with both atrazine and fertilizer, and about 1% higher on these areas than on areas where fertilizer alone or fertilizer and 2,4-D in combination were applied. Species composition varied sufficiently so that no one species or group of species was responsible for the differences in protein content.

There was less difference in protein yield than in protein content due to treatments. The higher rate of atrazine temporarily reduced herbage yields and negated the effect of higher protein content on protein yield. Areas receiving only fertilizer had much higher protein yields than other treated areas and about twice the protein yield as on untreated areas.

In August protein content in untreated herbage was unchanged from that in July; however protein levels on treated areas decreased 1.5 to 3.0%. August protein levels

Fig. 3. First year treatment effects on protein content (%) and protein yield (kg/ha, oven-dry) of herbage in 1975. (Content LSD₁₀: July—1.8; August—1.8; November—0.8. Yield LSD₁₀: July—70; August—80; November—45.)

were highest on areas receiving both atrazine and fertilizer and, as in July, lower than average on areas treated with 2,4-D.

Protein yields remained higher on all fertilized areas than on untreated areas or areas treated with only one herbicide. In general protein yields were as high or higher in August than in July because of the increased herbage yield. The relative increases in herbage yield were large enough to offset the decreases in protein content.

Protein content and herbage yield declined between late summer and early winter. Differences in both protein content and protein yield were relatively small after frost.

Residual Effects

In June 1976 the protein content in untreated herbage was about the same as that in untreated herbage in 1975; however, herbage and protein yields on treated areas were about 65% greater in 1976 than in 1975 (Fig. 4). Although May 1976 precipitation was only about 40% of average, 128 mm of rain in April 1976 and rest from grazing in 1975 may have caused the higher yields in June 1976. Tallgrasses and other warm-season perennial grasses were most abundant on treated areas, whereas early summer grasses and forbs were most abundant on untreated areas.

The high proportion of tallgrasses on areas treated with the higher rate of atrazine or with only fertilizer apparently caused lower protein content in herbage on these areas. Tallgrasses on these areas appeared to be in more advanced stage of growth than similar grasses on untreated areas or in areas treated with both atrazine and fertilizer in 1975.

But July and thereafter, there was little difference between protein contents or yields in herbage from any area. Protein contents decreased 2.5 to 4.0% between June and July on all areas. From July through November 1976 protein contents were relatively low on all areas and 1 to 2% lower than at comparable times in 1975 due to poor growing conditions in 1976.

Retreatment Effects

Herbicides were not applied until after the June 1-3, 1976, sampling whereas fertilizer was applied May 10, 1976. Therefore, June values in Figure 5 represent residual effects of herbicides and retreatment effects of fertilizer.

Fig. 4. Residual effects of treatments on protein content (%) and protein yield (kg/ha, oven-dry) of herbage in 1976. (Content LSD_{10} : June—1.4; July—0.7; August—1.2; November—1.1. Yield LSD_{10} : June—90; July—50; August—50; November—40.)

Fig. 5. Retreatment effects on protein content (%) and protein yield (kg/ha, oven-dry) of herbage in 1976. (Content LSD_{10} : June—2.5; July—1.0; August—1.4; November—1.2. Yield LSD_{10} : June—160; July—60; August—100; November—65.)

Protein contents and yields were much greater on all retreated areas than on untreated areas in early June (Fig. 5). Herbage treated with only fertilizer contained 16.2% protein while herbage treated with fertilizer plus residual herbicide treatments codes as (DNP, A3NP, A3DNP) (Fig. 5) contained 13.0 to 13.7% protein. Herbage on areas receiving only fertilizer was 38% forbs, twice the forb production of any of the other three fertilizer treatments that also included an herbicide. More than half the forb production on fertilizer-only areas was from *Ambrosia psilostachya*, a forb normally high in protein content throughout the growing season (Joe Blaine, OSU Range Science senior student, Unpublished data) but low in palatability. *Ambrosia psilostachya* was reduced by herbicides in 1975 and was absent from herbicide-treated areas in 1976.

Herbage protein was about 2% lower on all areas in July 1976 than on comparable areas in July 1975. Protein yields on fertilized (NPK, DNP, A3NP, A3DNP) areas however, were 1½ to 2 times greater in 1976 than in 1975. Protein contents and yields on herbicide-only areas (A1, A3, D) were no greater than those on untreated areas and were much lower than those on areas receiving fertilizer (NPK, DNP, A3NP, A3DNP).

Protein content was greatest in July and August on those areas receiving both atrazine and fertilizer even though herbage was predominately tallgrasses. The combination of atrazine and fertilizer therefore improved range condition (i.e., increased the proportion of tallgrasses) and maintained a relatively high protein content. In November crude protein content levels were relatively low on all areas and particularly low on areas treated with herbicides and not fertilizer.

Conclusions

The application of atrazine with fertilizer increased crude protein content of actively growing tallgrass prairie vegetation during two successive dry years. No residual effects on plant protein levels the year following treatment were evident. Fertilizer or atrazine alone increased herbage protein levels. The combination of atrazine plus fertilizer improved range condition and palatability of herbage by decreasing

undesirable species, such as *Aristida oligantha* and *Ambrosia psilostachya*, and by increasing desirable perennial grasses while protein levels remained consistently high. Atrazine alone increased the percentage of tallgrasses in herbage and this change apparently reduced dormant herbage protein levels. However, atrazine did appear to delay maturity of some tallgrass species in late summer.

Further study is necessary to determine long-term effects of repeated treatments of atrazine on tallgrass species. The maximum period of increased protein content appears to be short, but with proper use and management the opportunity for utilizing high quality forage appears available. Our results indicate the application of atrazine and fertilizer on tallgrass prairie will be more useful for hay production and summer cattle grazing than for yearlong or winter grazing. Protein yield was greatly increased the second year. If this increase can be maintained indefinitely with optimum rate and date of application of atrazine and fertilizer, this practice may provide a significant management and production alternative for ranchers.

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