# THE EFFECT OF FERTILIZATION AND OVERSEEDING WITH LESPEDEZAS ON A NATIVE HAY MEADOW


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ON A NATIVE HAY MEADOW

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# INTRODUCTION

Forage from native grass meadows is important in Oklahoma agriculture. The 500,000 acres of wild hay cut in 1914 has been slowly reducing until now approximately 400,000 acres are in production (15)/1. Since acre yields are close to one ton per acre, this is sufficient forage to winter 15 per cent of the present number of cattle in the state. Ninety per cent of the native hay land is located in the eastern half of the state. Cattle numbers are increasing in this area and there will be future demand for more winter forage and for one with a higher protein content than is now found in prairie hay.

Prairie hay was considered an excellent forage for the working horse, however the mechanical age now makes it necessary to use the hay for cattle. Additional protein must supplement prairie hay for good cattle maintenance rations during the winter months. This forage will have to carry twice the protein content now present to eliminate the need for expensive additional protein concentrates for winter maintenance of cattle. It appears that 2,000 pounds of forage per acre, with a protein content of 4 to 5 per cent is a very low acre return for good level land with favorable moisture conditions. A study of increasing acre yields and quality of

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/1 Figures in parentheses refer to "Literature Cited", p. 28.

the forage on the 400,000 acres of meadow land in the state is worthwhile. Native grass hay yields per acre are practically the same now as in 1914 when the first records of this crop were reported in Oklahoma (15). Hay yields are closely associated with seasonal rainfall and seemingly not affected by the annual removal of the forage from the land.

Most of the native grass meadow soils are low in phosphorus and are acid in nature. Field crops on nearby soils respond to commercial fertilizers and lime applications, and it would be logical to believe that yields could be increased by the addition of appropriate plant food elements to the soil. However, it seems that native grasses in this region do not respond to commercial fertilizers sufficiently for them to be economical. The question of improving chemical composition of the hay by fertilizers is controversial.

Another possible method of improving quality of the forage, and perhaps the yield, is by the introduction of a legume into the meadows. Good pastures in this region have legumes in the sward. Fortunately, there is a large number of pasture legume species adapted to the region. It is more difficult to introduce a legume into a dense growth of grass that is allowed to grow almost to maturity before harvest. It would be easy to grow winter legumes in hay meadows but they mature before hay harvest time. The legume, by necessity, must start growth in early spring, grow with the grass and reach its maximum growth in July which is the proper time for harvesting the native grasses for hay. If the legume is an annual it should produce seed for volunteer reseeding the next year.

Several species of lespedeza adapted to this region may have the desired features necessary to improve the production from native grass hay land. The lespedezas are popular in eastern Oklahoma because of their value as a pasture and hay crop; their tolerance to low fertility and acid soils; their drought resistance, and their ability to reseed each year.

The objective of this experiment was to determine if it is possible and economical to improve the quantity and quality of forage on prairie hay meadow land by the addition of fertilizers and overseeding with lespedezas.

## REVIEW OF LITERATURE

Many tests show that it is not profitable to fertilize native grass meadows. A larger number of experiments on improvement of native ranges also indicate that there is some question concerning the economy of using commercial fertilizers. The climax species of native grasses may respond to nitrogen under certain conditions, both for quality and quantity improvement, and phosphorus may improve quality but the increased production is not usually sufficient to offset costs. Fertilizers have potential value in native ranges on depleted soils for reseeding or recovery of climax species.

Harper (6) studied the effect of fertilization and climatic conditions on yield and composition of prairie hay and found hay yields were closely associated with seasonal rainfall. Commercial nitrogen fertilizers increased yields of hay when moisture conditions were favorable. He concluded from 20 years study in central Oklahoma that commercial fertilizer applications on native hay meadows were not profitable.

Murphy (11) increased yields of prairie hay on the central cross timbers and central prairies of Oklahoma by using phosphorus and nitrogen fertilizers, however, large quantities of fertilizers were necessary to increase yields significantly and their cost were prohibitive.

Working on moist meadow soils of the sandhill region of Nebraska, Brouse (2) increased production with phosphorus and nitrogen fertilizers. Phosphorus encouraged the growth of legumes, but a combination of nitrogen and phosphorus produced the best hay yields. There is some doubt that the cost of fertilizers would offset the return from the increased production.

Range soils in the Rocky Mountains shows no important increase in native herbage by using a variety of fertilizers, according to Retzer (13).

McIlvain (10), at Woodward, Oklahoma, was unable to increase yields on native grasses with fertilizers, whereas many introduced grasses responded to nitrogen.

A 60 per cent increase in animal gains was reported by Elwell and Daniels (3) from grazing native grasses on virgin soils at Guthrie, Oklahoma by the use of nitrogen and phosphorus fertilizers.

Animal nutritionists agree that forage for livestock should have not less than 0.12 to 0.13 per cent phosphorus and 0.23 to 0.25 per cent calcium content. A large number of chemical analyses of native grasses indicate that the calcium content is above the prescribed minimum. On the other hand phosphorus is below desired standards many times, and this is especially true of grasses grown on phosphorus deficient soils. Heller and Savage (9) found phosphorus high in native grasses in western Oklahoma.

Soils low in phosphorus were found to produce prairie hay containing 0.05 to 0.06 per cent phosphorus by Murphy (11).

The addition of superphosphate increased phosphorus content to 0.08 and 0.09 per cent. Harper, Daniels and Murphy (8) pointed out that native grasses are lower in nitrogen, phosphorus and calcium content than common weeds.

Murphy/2, in an attempt to check the palatability of prairie hay fertilized with nitrogen and phosphorus, and in combination, found cattle made no choice between hay from unfertilized and nitrogen fertilized plots. All phosphorus treated areas produced many weeds that the cattle refused to eat, and less forage was consumed from the phosphorus plots than from the unfertilized plots. He changed the botanical composition of a meadow near Stillwater, Oklahoma in 3 years by annual applications of commercial fertilizers. Nitrogen alone did not increase weeds. Superphosphate alone encouraged some weed growth and with nitrogen encouraged greater weed growth. The unfertilized plots contained 14 per cent weeds; while yearly applications of 200 pounds of superphosphate per acre increased weeds to 17 per cent, and 350 pounds of 11-48-0 per acre per year increased weeds to 29 per cent.

Hall and Altona (4) found little change in botanical composition on native velds in the Union of South Africa after the addition of phosphorus for 15 years. Only slight changes have been observed where single applications of nitrogen were applied each season. Where 3 dressings of nitrogen per season (63 pounds N per acre) were made, the grass species

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/2 Unpublished data. Okla. Agr. Exp. Station making up the original cover nearly disappeared and lovegrass (Eragrostis spp.) and Bermuda grass (Cynodon spp.) cover the soil. The change was gradual where 63 pounds of nitrogen per acre were applied annually. The first change showed up in about 4 years and was completed in approximately 8 years. Heavier rates of nitrogen brought about a more rapid change from native grasses to lovegrass and Bermuda grass. Fortunately, native grasses are less desirable in South Africa than the invaders under high nitrogen fertilization.

In the Southern Great Plains area of the United States the loss of native climax grasses is usually replaced by inferior forage plants.

Harper (6) had to change the time of nitrogen application on a native meadow from March to May to avoid weedy annual winter grass growth. March treatments of nitrogen encouraged Bromus commutatus and the available nitrogen had been used by May and June when the native grasses made their greatest growth. In many seasons the moisture also was depleted. In a few years sufficient annual brome seed had been deposited in the soil to insure an abundant growth when nitrogen was available in the winter or early spring months. A change from March to May applications of nitrogen corrected the situation in a few years; the native grasses regained their former density and the annual grasses were of little consequence.

Except in rare instances, forage research men have found the best method of improving grass for hay and grazing is by growing a legume with the grass. Applications of fertilizers are aimed primarily for legume growth to improve the quality of forage and to produce nitrogen for grass growth.

Harper (7) stated:

> Legumes are the key to pasture and meadow improvement where climatic conditions are favorable for their growth.... Superphosphate increased the phosphorus content of the hay but did not increase yields.... The quantity of nitrogen, phosphorus and calcium removed from soil when prairie hay is harvested is low, as compared with legume crops.... The protein and mineral content of prairie hay can be improved in the southern part of the Prairie soil area by planting legumes such as Kobe or Korean lespedeza each year.... If a legume could be introduced into a native meadow by fertilization, the increase in the protein and mineral content of the hay might be worth more than the cost of the fertilizer even if total yields were not increased.

Many native range specialists question the practice of overseeding native grasses with legumes. The leading objections are that higher carrying capacity will cause overgrazing of the grasses, and that native grasses are able to maintain themselves without addition of nitrogen from the legumes provided the grasses are grazed properly. Many native pastures in Oklahoma are not established to lespedeza in those areas where lespedeza is adapted. In many of these pastures the native grasses have been destroyed before overseeding with a legume by overgrazing and when this condition exists there can be little just criticism of overseeding with legumes. In those areas where good native grasses have been maintained and are desired in the future the practice of planting legumes becomes controversial.

Uniform regional lespedeza tests[3] in Oklahoma from 1944

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[3] Unpublished data. U.S.D.A.

to 1950 indicate that while the early Korean strains are adapted to the eastern part of the state, Kobe is superior in the southeast. Climax is a large, late maturing variety that made good hay yields in all the tests.

Kobe lespedeza was recommended for southeast Oklahoma, Climax for northeast Oklahoma, and Korean throughout the lespedeza growing sections of Oklahoma by Harlan, Elder and Chessmore (5).

In a 4-year study by Briggs (1) on time of cutting native meadows it was found that July-cut hay contained greater total digestible nutrients per acre than June, August and September cuttings. The meadow, near Stillwater, Oklahoma, produced hay high in calcium and low in phosphorus. In only one year did the hay contain sufficient protein to maintain steers in a positive nitrogen balance, and that only for the June cutting.

Pieters (12) stated that good hay can be made from Sericea lespedeza but it must be cut early for best quality and palatability. Late cuttings increased weight but decreased quality. He found early cuttings to have 15 per cent or more crude protein, but cuttings made the middle of July contained only 10 per cent protein. Established stands of Sericea were highly competitive to associated plants and suppressed summer weeds, but could not suppress winter grasses and weeds.

## MATERIALS AND METHODS

This test was conducted on native grass hay meadow land in eastern Oklahoma occupied by the Connors State Agricultural College, Warner, Oklahoma, which is located 20 miles southeast of Muskogee. The soil and vegetation were representative of the typical native hay meadows found on the prairies of eastern Oklahoma. The soil in this meadow has been mapped as Parsons silt loam. A recent mechanical analysis indicated it is a very fine sandy loam.

Parsons soils are grayish-brown, becoming lighter in color as the soils dry out, especially in the lower portion of the top soil. The silt loam and very fine sandy loams in the top soils change rapidly at a depth of 12 to 18 inches into a claypan of dense yellow-brown clay. The soils absorb water slowly because of the heavy subsoil and are droughty. Although the land is nearly all level, water does not stand on the surface very long after rains. The soils do become soggy and wet during wet seasons, especially during the winter months. The surface and subsoils are acid in reaction and are low in organic matter, phosphorus and potassium. The particular surface soil in this meadow had a pH of 5.4, and contained 0.15 per cent total nitrogen, 6.4 pounds per acre of phosphorus soluble in 0.1 normal acetic acid, 32 pounds per acre of exchangeable potassium, and 1,040 pounds per acre of exchangeable calcium.

When this test was begun in the spring of 1950, the desirable native grasses in the experimental plots were a combination of Little bluestem (Andropogon scoparius), Big bluestem (Andropogon gerardi), Switchgrass (Panicum virgatum), and Indian grass (Sorghastrum nutans). Some of the undesirable plant species were Triple awn (Aristida spp.), Wild brome grass (Bromus commutatus), Six-weeks fescue (Festuca octoflora), Hairy sunflower (Helianthus mollis), Goldenrod (Solidago spp.), Blazing star (Liatris spp.), Blackeyed Susan (Rudbeckia spp.) and many others. The only native legume observed in the plots was a few plants of Sensitive briar (Schkankia spp.).

The experimental area was laid out in a randomized block, split plot design. The blocks could not be located adjacent to one another because of occasional mounds of soil 1 to 2 feet high and 40 to 50 feet across that are characteristic of many areas in eastern Oklahoma. Each of 4 blocks was divided into 6 plots measuring 32 by 45 feet. Plots in each block received the following fertilizer treatments:

Plot 1 - 150 pounds of superphosphate (20% $P_2O_5$) per acre.

Plot 2 - 100 pounds ammonium nitrate per acre.

Plot 3 - One ton agricultural limestone per acre.

Plot 4 - One ton agricultural limestone and 150 pounds superphosphate per acre.

Plot 5 - One ton agricultural limestone, 150 pounds superphosphate and 100 pounds ammonium nitrate per acre.

Plot 6 - No fertilizer treatment.

The superphosphate was broadcast each year in March by hand on the surface of the soil. Ammonium nitrate was broadcast in the latter part of May every year, and the limestone was broadcast in March, 1950.

Each plot in the blocks was subdivided into 5 plots, 9 feet by 32 feet. Four of these plots were planted to different species and strains of lespedeza while the fifth was not seeded. Early Korean (Lespedeza stipulacea), Climax (Lespedeza stipulacea), Kobe (Lespedeza striata) and Sericea (Lespedeza cuneata) were planted by broadcasting with a Gandy seeder in March, 1950 at the rate of 15 pounds per acre for the annual lespedezas, and 25 pounds per acre for the Sericea. The annual lespedezas were replanted in March, 1953 to insure a stand since seed was not produced during the drought of 1952.

Hay yields were taken on July 14, 1950, July 18, 1951, July 12, 1952 and July 8, 1953. Green weights were determined for each plot at the time of cutting. A 500 gram sample was secured from each plot and dried in an oven to determine dry matter per cent, from which total forage yields per acre were computed. In 1950 a composite sample was taken from each treatment for chemical analysis. For the other 3 years each sample on all plots was analyzed. Chemical analyses included nitrogen, phosphorus, potassium, calcium and magnesium. Calcium and magnesium analyses were not completed in 1953 in time for inclusion in this report.

In 1950 botanical composition was measured on some of the plots at time of harvest. In 1953 the vegetation from 2 replications of a number of treatments was hand separated and the percentages of desirable grasses, annual weedy grasses, legumes and broadleaf weeds in the samples were determined.

## DISCUSSION AND RESULTS

Weather conditions were unfavorable for good hay production during 3 of the 4 years this study was in progress. The high rainfall in June, 1951 (App. Table 7) increased yields above normal expectations. Although the yields of prairie meadows vary considerably from year to year due to rainfall, this difference is not as great as that found in the major cultivated crops grown in the state.

The unfertilized plots produced 1,552 pounds of dry hay per acre in 1953 (Table 1) despite 50 days of dry hot weather prior to harvest. Only 3 showers totalling one inch of precipitation occurred during this 50 day period. With the favorable rainfall in 1951 the hay yield was 2,275 pounds per acre. With early harvest of hay in July (8 to 18), June growth controlled to a large extent total production. While the rainfall data shown in Appendix Table 7 for June, 1952 indicate 3.86 inches for the month, actually this occurred before June 5. During the remainder of the growing season until the hay was cut on July 12 there was no rain and the temperature was very high and was accompanied by high winds.

Annual lespedeza was almost a complete failure over the entire state in 1952 and 1953 because of the June droughts. Some annual lespedeza growth was found in the phosphated plots in 1953 (Table 3). In 1952, annual lespedeza was a failure and should not be considered in the yields. Sericea made its best growth in 1952. During 1950 and 1951 favorable conditions existed for normal growth of annual lespedezas.

## Effect of Fertilizers on Yields

One hundred pounds of ammonium nitrate per acre did not increase hay yields every year. Under favorable growing conditions in 1951 nitrogen increased production 558 pounds per acre (Table 1). This increased production was not sufficient to pay for the cost of fertilizer even at the high prices paid for hay during the drought years of 1952 and 1953. A darker green color was imparted to the grasses and it always could be observed in the nitrogen plots unless it became extremely dry. At the time of harvest in 1952 and 1953 grasses on the nitrogen areas were brown and contained less moisture than on the unfertilized areas. Unfertilized plots in 1952 and 1953 contained between 45 and 50 per cent moisture but where nitrogen was added, the moisture in the forage was about 5 per cent less. Moisture content of the grass at harvest time in 1950 and 1951 ranged from 60 to 70 per cent and 40 to 50 per cent in 1952 and 1953.

Yield data (Table 1) indicate that phosphorus alone encouraged production to a small but uneconomical extent. The increased production can quite reasonably be attributed to the stimulation given weeds and annual grasses (Table 3). Unlike nitrogen the increase was uniform for all years and not in proportion to rainfall.

One ton of agricultural lime per acre, applied in March, 1950, did not affect hay production. It was impossible to determine any difference between unfertilized plots and limed areas at any time during the 4 years.

Although lime alone did not affect yields, slightly more forage was received from lime and superphosphate in combination than from phosphorus alone. Actually this combination, where legumes were not growing, produced a higher 4-year average than the nitrogen plots. Change in botanical composition in these plots may account for some of the increased production. Addition of lime to phosphorus did not encourage legume growth over phosphorus alone.

The use of nitrogen, phosphorus and lime in combination increased forage yields for the 4-year average from 1,823 pounds per acre in the unfertilized plots to 2,589 pounds per acre (Table 1). This treatment produced more vegetation than the others but unfortunately all the vegetation was not desirable for livestock (Table 3).

## Effect of Overseeding Lespedezas on Yields

A good stand of annual legumes emerged in all plots each year. On the unfertilized, nitrogen, and limed areas, legumes made insufficient growth to be considered, however, in 2 of the 4 years the annual lespedezas produced plenty of seed after harvest for volunteer reseeding the next year. Sericea lespedeza plants were observed in these treatments each year but never contributed much forage.

Phosphorus stimulated lespedeza growth, and under favorable moisture conditions in June the annuals were a factor in production. At this location, Kobe was superior to Korean and Climax. Korean and Climax were important in this study only in 1951. Kobe, adapted to acid soils and low fertility, increased forage yields the first year 455 pounds per acre where 150 pounds of superphosphate alone was used (Table 1). Observations indicated that lime applications encouraged Korean and Climax growth, but yield data did not reflect any difference.

Sericea did not become established sufficiently in 1950 to increase yields, but was equal to Kobe and Climax in 1951. In 1952 this perennial was able to withstand adverse moisture conditions in June. The Sericea, on phosphorus and the combination of phosphorus and lime plots, produced the most forage in 1952. It was not outstanding in 1953, but was far more prominent than the annuals. Quality of the Sericea hay was very low in 1952 and 1953 because it was cut about the middle of July after the stems had become woody and tannic acid had reached a high content. Another factor that will eliminate Sericea for consideration in prairie hay meadows is its strong competitive ability. It was easily observed in 1953 that the desirable native grasses were being crowded out by Sericea. All young grasses were gone and only the larger and older bunches were surviving.

Legumes were always present in the plots where nitrogen, phosphorus and lime were applied in combination, but they

Table 1.—The Effect of Four Years Fertilization and Overseeding with Lespedezas on the Yields from a Native Hay Meadow.

| Fertilizer treatment per acre | Lespedeza variety | Pounds per acre. Average of 4 replications. | | | | |
|---|---|---|---|---|---|---|
| | | 1950 | 1951 | 1952 | 1953 | Average |
| None | None | 1,750 | 2,278 | 1,712 | 1,552 | 1,823 |
| | Korean | 1,786 | 2,384 | 1,783 | 1,418 | 1,843 |
| | Climax | 1,811 | 2,410 | 1,992 | 1,418 | 1,908 |
| | Kobe | 1,860 | 2,414 | 1,848 | 1,377 | 1,875 |
| | Sericea | 1,630 | 2,585 | 1,879 | 1,449 | 1,886 |
| 150# Superphosphate[1] | None | 1,954 | 2,435 | 2,067 | 1,871 | 2,082 |
| | Korean | 1,967 | 2,859 | 2,028 | 1,849 | 2,176 |
| | Climax | 1,945 | 2,994 | 2,108 | 1,989 | 2,257 |
| | Kobe | 2,409 | 2,869 | 2,418 | 2,077 | 2,443 |
| | Sericea | 1,867 | 2,862 | 2,857 | 2,172 | 2,439 |
| 100# Ammonium nitrate[2] | None | 1,773 | 2,836 | 2,182 | 1,669 | 2,115 |
| | Korean | 1,736 | 2,784 | 2,164 | 1,879 | 2,141 |
| | Climax | 1,386 | 2,886 | 1,849 | 1,609 | 2,157 |
| | Kobe | 1,692 | 2,746 | 1,914 | 1,549 | 1,975 |
| | Sericea | 1,948 | 2,796 | 2,023 | 1,686 | 2,113 |
| 1 ton Lime[3] | None | 1,680 | 2,646 | 1,846 | 1,435 | 1,902 |
| | Korean | 1,649 | 2,203 | 1,727 | 1,405 | 1,746 |
| | Climax | 1,786 | 2,669 | 1,917 | 1,428 | 1,950 |
| | Kobe | 1,724 | 2,145 | 1,920 | 1,427 | 1,804 |
| | Sericea | 1,842 | 2,512 | 1,965 | 1,533 | 1,963 |
| 150# Superphosphate + 1 ton Lime | None | 2,309 | 3,258 | 2,074 | 1,874 | 2,379 |
| | Korean | 2,215 | 2,687 | 2,222 | 2,000 | 2,281 |
| | Climax | 2,010 | 2,943 | 2,129 | 2,066 | 2,287 |
| | Kobe | 2,446 | 3,244 | 2,493 | 2,202 | 2,599 |
| | Sericea | 1,966 | 2,552 | 2,937 | 2,219 | 2,419 |
| 150# Superphosphate + 1 ton Lime + 100# Ammonium nitrate | None | 2,259 | 3,342 | 2,500 | 2,254 | 2,589 |
| | Korean | 2,271 | 3,645 | 2,641 | 2,321 | 2,719 |
| | Climax | 2,247 | 3,612 | 2,770 | 2,344 | 2,743 |
| | Kobe | 2,153 | 3,389 | 2,591 | 2,269 | 2,601 |
| | Sericea | 2,203 | 3,457 | 2,656 | 2,149 | 2,616 |

[1] Superphosphate broadcast each year in March.

[2] Nitrogen broadcast each year in May.

[3] Lime broadcast in March, 1950.

were subdued by the rank growing vegetation and did not materially increase yields in any of the 4 years of the experiment.

## Chemical Content of the Prairie Hay

The untreated plots produced hay containing 0.8 to 0.9 per cent nitrogen (Table 2). This is considered very good for prairie hay and may be explained by the early cutting in mid-July. Nitrogen content varied from year to year and within treatments, but some of the treatments produced hay consistently higher in nitrogen throughout the 4 years.

Ammonium nitrate increased nitrogen content of the hay more than 10 per cent over unfertilized areas (Table 2). This increase plus 10 per cent gain in forage weight resulted in a 20 per cent gain in protein production in favor of nitrogen fertilization (App. Table 1).

Hay from the Kobe and Sericea plantings treated with phosphorus had an analysis of more than one per cent nitrogen for an average of the 4 years (Table 2). The legumes were not analyzed separately but seemed present in sufficient quantity to raise the protein production appreciably.

Kobe lespedeza, with 150 pounds superphosphate per acre annually, increased protein production 50 pounds per acre over untreated plots (App. Table 1). This combination appears to be the best possibility for improving prairie hay, but until methods of management are found to prevent the invasion of annual grasses and weeds it cannot be recommended.

None of the treatments raised the nitrogen content of the hay sufficiently to meet the minimum requirements for wintering cattle without feeding a protein supplement.

Prairie hay from eastern Oklahoma has always been low in phosphorus, and hay from the non-phosphorus treated plots in this study was very low in this element. The untreated plots produced hay with an analysis of approximately 0.06 per cent phosphorus, while 150 pounds of superphosphate per acre increased the content to about 0.10 per cent (Table 2). This amount of phosphorus in forage is still considered slightly below the minimum for livestock. Hence, while these data would indicate that phosphorus fertilization increases the phosphorus content of the native grass hay appreciably, such a treatment cannot be recommended solely for this purpose.

No explanation can be given for the high calcium content of the prairie hay in 1950 (App. Table 4). In 1951 and 1952 the results were lower but similar for each of the two years, and little difference could be detected between the treatments. The calcium content of the hay under all conditions was above minimum requirements for livestock feeding.

It appears from Appendix Tables 5 and 6 that the magnesium and the potassium content in prairie hay differs more from year to year, and within treatments, than from the different treatments.

Table 2.—A Summary of the Percentage of Nitrogen, Phosphorus, Calcium, Magnesium and Potassium in Hay as Influenced by Fertilization and Overseeding with Lespedezas.

| Fertilizer treatment per acre | Lespedeza variety | Percentage Composition | | | | |
|---|---|---|---|---|---|---|
| | | Nitrogen/1 | Phosphorus/1 | Calcium/2 | Magnesium/2 | Potassium/1 |
| None | None | .858 | .061 | .581 | .247 | .544 |
| | Korean | .851 | .060 | .572 | .251 | .511 |
| | Climax | .889 | .062 | .595 | .241 | .495 |
| | Kobe | .923 | .061 | .650 | .241 | .509 |
| | Sericea | .852 | .061 | .570 | .225 | .478 |
| 150# Superphosphate/3 | None | .862 | .107 | .626 | .267 | .469 |
| | Korean | .872 | .109 | .601 | .262 | .444 |
| | Climax | .892 | .116 | .647 | .250 | .412 |
| | Kobe | 1.011 | .121 | .649 | .293 | .385 |
| | Sericea | 1.080 | .118 | .624 | .271 | .418 |
| 100# Ammonium nitrate/4 | None | .988 | .062 | .603 | .277 | .518 |
| | Korean | .940 | .065 | .573 | .259 | .460 |
| | Climax | .948 | .069 | .558 | .246 | .475 |
| | Kobe | 1.025 | .073 | .652 | .278 | .432 |
| | Sericea | 1.031 | .058 | .548 | .238 | .468 |
| 1 ton Lime/5 | None | .815 | .058 | .584 | .251 | .472 |
| | Korean | .825 | .062 | .638 | .263 | .439 |
| | Climax | .861 | .059 | .634 | .242 | .468 |
| | Kobe | .884 | .063 | .665 | .237 | .450 |
| | Sericea | .869 | .064 | .645 | .252 | .493 |
| 150# Superphosphate + 1 ton Lime | None | .833 | .107 | .645 | .269 | .436 |
| | Korean | .890 | .113 | .689 | .266 | .465 |
| | Climax | .896 | .116 | .656 | .257 | .425 |
| | Kobe | .940 | .106 | .796 | .265 | .423 |
| | Sericea | 1.031 | .097 | .667 | .274 | .432 |
| 150# Superphosphate + 1 ton Lime + 100# Ammonium nitrate | None | .902 | .102 | .568 | .285 | .408 |
| | Korean | .839 | .108 | .569 | .279 | .402 |
| | Climax | .934 | .105 | .562 | .297 | .450 |
| | Kobe | 1.047 | .102 | .625 | .282 | .372 |
| | Sericea | 1.060 | .108 | .574 | .296 | .396 |

/1 4-year average.

/2 3-year average (1950, 1951, 1952).

/3 Superphosphate broadcast each year in March.

/4 Nitrogen broadcast each year in May.

/5 Lime broadcast in March, 1950.

## Botanical Composition Conditions in the Meadow

As a rule native hay meadows in Oklahoma change very little in botanical composition from year to year if they are cut each year in July. The drought conditions in 1952 and 1953 increased broadleaf weed growth appreciably in the meadows of the state. It was easy to detect this increase of weeds from 1950 to 1953 in the meadow adjacent to the experimental plots. Hand separation of the vegetation from the check plots in 1950 and again in 1953 at harvest time showed that the weeds had increased from 17 per cent of the total forage weight in 1950 to 24 per cent in 1953. This increase was not caused by the invasion of new species, but was due to decreased growth of grass and to increased vigor on the part of native weeds always associated with native grasses.

Treatments of 100 pounds of ammonium nitrate per acre in May for 4 years did not affect the weed population (Table 3). This was also true where lime was used alone at the rate of one ton per acre.

Some of the treatments imposed on the meadow encouraged invasion of many weedy species seldom found in native grass lands used for hay. Table 3 shows an increase of winter annual grasses on the phosphorus treated plots. These determinations were made in 1953 which was most favorable for winter grasses. The dry summer of 1952 did not produce any growth of grass after cutting in July. Rains in November and

December encouraged germination of winter annual grasses and the dry May and June in 1953 did not permit the summer growing climax grasses to compete with the established annuals. The heavy invasion of the winter annual grasses on some plots was astonishing, since the other plots and adjacent meadow land showed no trace of the same species. This might be explained by the build-up of seed stock on the plots after the experiment started. The winter annual grass species that appeared in this study are able to thrive when available plant food elements are carried over into the winter months. Observations made in June, 1954 indicated much less growth of annual grasses in the heavily infested plots of the preceding year.

The winter weedy annual grasses appeared on all phosphorus treated plots, with the greatest infestation where lime and nitrogen were used in combination with the phosphorus. This treatment produced more weedy winter annuals than native grasses in addition to more than 25 per cent weeds in 1953 (Table 3). At the time of harvest, July 8, the annuals had matured seed and the entire vegetation was completely dead and very dry. These plots had a high production record for the year and the protein content of the forage was favorable, but the hay would have had little sale value. It contained a high percentage of six-weeks fescue which made mowing very difficult.

Phosphorus alone, and with lime, increased the winter annual grasses appreciably on the legume plots. These grasses on the nearby non-legume but phosphorus treated plots (Table 3) may be the result of haying in preceding years which scattered the seed from the legume plots to non-legume areas.

Close observation of the plots in September, 1953 indicated that all heavily infested plots of winter annual grasses had decreased the density of native grasses, but had prevented all growth of summer annual plants. Triple awn grass was common on the non-phosphorus plots. After the July 8 cutting rains encouraged good summer growth and all the phosphorus treated plots produced a very good seed crop of native grasses although the plants were fewer in number.

All Sericea plots with phosphorus decreased the density of native grasses severely. The legume competed with the grasses and broad-leaved weeds increased in the plots. The annual legumes encouraged winter annual grasses in this test, but did not encourage annual weed growth.

Table 3.—The Botanical Composition in 1953 of a Native Hay Meadow after Four Years of Fertilization and Overseeding with Legumes.

| Fertilizer treatment per acre | Lespedeza variety | Percentage Composition/1 Climax grasses | Weeds | Annual grasses/2 | Lespedeza |
|---|---|---|---|---|---|
| None | Composite/3 | 75.8 | 24.2 | Trace | None |
| 150# Superphosphate/4 | None | 60.7 | 28.6 | 10.7 | None |
| | Korean | 64.6 | 14.7 | 24.8 | 0.8 |
| | Climax | 46.3 | 17.9 | 33.7 | 2.1 |
| | Kobe | 41.3 | 25.6 | 27.8 | 3.3 |
| | Sericea | 41.1 | 20.9 | 26.3 | 11.7 |
| 150# Superphosphate ≠ 1 ton Lime | None | 64.9 | 18.2 | 16.9 | None |
| | Korean | 47.2 | 25.3 | 23.6 | 3.9 |
| | Climax | 53.7 | 22.6 | 22.8 | 0.9 |
| | Kobe | 62.6 | 15.6 | 16.3 | 5.5 |
| | Sericea | 39.2 | 21.5 | 26.4 | 12.9 |
| 150# Superphosphate ≠ 1 ton Lime ≠ 100# Ammonium nitrate | None | 24.6 | 28.6 | 46.8 | None |
| | Korean | 51.7 | 21.8 | 26.5 | Trace |
| | Climax | 44.1 | 28.0 | 27.9 | Trace |
| | Kobe | 25.1 | 22.9 | 52.0 | Trace |
| | Sericea | 22.5 | 30.5 | 44.5 | 2.5 |
| 1 ton Lime/5 | Composite/3 | 76.8 | 23.2 | Trace | None |
| 100# Ammonium nitrate/6 | Composite/3 | 73.0 | 27.0 | Trace | None |

/1 Two replications were used in making each of these determinations except for the composite samples as indicated in footnote 3.

/2 Composed primarily of Hairy brome (Bromus commutatus) and six-weeks fescue (Festuca octoflora).

/3 Composite samples were taken because unfertilized, lime and nitrogen treatments did not produce lespedeza growth.

/4 Superphosphate broadcast each year in March.

/5 Lime broadcast in March, 1950.

/6 Nitrogen broadcast each year in May.

## SUMMARY

The effect of fertilizers and overseeding with lespedezas on a native hay meadow was studied for four years (1950-1953).

Nitrogen fertilizer increased hay yields only when good moisture conditions prevailed in June. When the month of June was dry the hay was brown, low in dry matter and the yield was similar to untreated areas. The protein content of the forage was increased each year by the nitrogen treatment, but no change occurred in botanical composition. Under favorable conditions commercial nitrogen fertilizer was not profitable as large gains are necessary to offset costs, since prairie hay has a low monetary value.

Phosphorus fertilization encouraged legume, weed and possibly annual grass growth. It raised the phosphorus content of the forage more than 60 per cent.

The addition of agricultural limestone to the meadow did not change any factors considered in the project.

A combination of nitrogen, phosphorus and lime increased yields of forage, but stimulated weed growth and the invasion of weedy annual grasses, and reduced the density of the desirable grasses.

The yield and protein production was increased when Sericea lespedeza was fertilized with phosphorus, but the poor quality of the hay and its strong competition with

native grasses eliminates this legume for consideration in overseeding native hay meadows.

Kobe was superior to the Korean strains of lespedeza primarily because it was better adapted to southeastern Oklahoma. The combination of phosphorus fertilization and overseeding with Kobe lespedeza showed the most promise for improving forage in the native meadow.

It is possible that native hay meadows could be improved by overseeding them with annual lespedeza, and by applying a lighter annual rate of superphosphate than was used in this experiment. The smaller quantity of superphosphate would probably reduce the invasion of undesirable plants, and at the same time supply sufficient phosphorus for the quantity of lespedeza that can be grown in competition with the native grasses.

It is believed the study has furnished specific information on some possible methods of improving production on meadow land and has contributed much needed information on the controversial subject of improving native pastures in Oklahoma by the use of commercial fertilizers and overseeding with legumes.

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# A P P E N D I X

# APPENDIX

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App. Table 1.—The Effect of Four Years Fertilization and Overseeding with Lespedezas on the Protein Production in a Native Hay Meadow.

| Fertilizer treatment per acre | Lespedeza variety | Pounds per acre. Average of 4 replications. | | | | |
|---|---|---|---|---|---|---|
| | | 1950 | 1951 | 1952 | 1953 | Average |
| None | None | 97.2 | 112.2 | 86.7 | 92.7 | 97.2 |
| | Korean | 103.7 | 110.4 | 84.3 | 83.5 | 95.5 |
| | Climax | 104.1 | 127.2 | 98.0 | 87.6 | 104.2 |
| | Kobe | 117.4 | 126.8 | 93.9 | 82.0 | 105.0 |
| | Sericea | 92.7 | 131.5 | 91.1 | 79.8 | 98.8 |
| 150# Superphosphate/1 | None | 115.0 | 125.2 | 87.5 | 116.5 | 111.1 |
| | Korean | 121.7 | 157.6 | 98.8 | 115.4 | 119.0 |
| | Climax | 125.2 | 162.4 | 93.5 | 106.8 | 122.0 |
| | Kobe | 183.6 | 180.2 | 117.9 | 131.4 | 153.3 |
| | Sericea | 112.0 | 201.9 | 178.9 | 137.4 | 158.6 |
| 100# Ammonium nitrate/2 | None | 119.7 | 158.7 | 117.4 | 108.8 | 126.1 |
| | Korean | 108.5 | 140.5 | 107.6 | 125.0 | 120.4 |
| | Climax | 114.3 | 159.4 | 107.9 | 104.9 | 121.6 |
| | Kobe | 119.4 | 157.2 | 108.7 | 112.8 | 124.5 |
| | Sericea | 122.9 | 144.5 | 120.9 | 134.3 | 130.6 |
| 1 ton Lime/3 | None | 99.4 | 125.4 | 78.4 | 82.6 | 96.5 |
| | Korean | 97.9 | 95.0 | 78.4 | 86.2 | 89.4 |
| | Climax | 101.6 | 163.8 | 89.1 | 89.9 | 111.1 |
| | Kobe | 106.7 | 109.8 | 85.5 | 86.3 | 97.1 |
| | Sericea | 118.6 | 121.6 | 87.0 | 94.4 | 105.4 |
| 150# Superphosphate + 1 ton Lime | None | 141.9 | 148.9 | 102.4 | 104.4 | 124.4 |
| | Korean | 137.1 | 161.4 | 105.8 | 106.2 | 127.4 |
| | Climax | 117.0 | 164.5 | 102.3 | 132.5 | 129.1 |
| | Kobe | 146.7 | 187.0 | 130.8 | 118.0 | 145.6 |
| | Sericea | 124.0 | 154.9 | 221.1 | 139.2 | 159.8 |
| 150# Superphosphate + 1 ton Lime + 100# Ammonium nitrate | None | 132.6 | 170.9 | 127.2 | 144.3 | 143.8 |
| | Korean | 129.2 | 171.9 | 131.9 | 129.7 | 140.7 |
| | Climax | 148.7 | 215.0 | 139.7 | 158.4 | 145.5 |
| | Kobe | 150.7 | 244.0 | 151.1 | 145.5 | 172.8 |
| | Sericea | 132.2 | 208.5 | 177.5 | 137.1 | 163.8 |

/1 Superphosphate broadcast each year in March.

/2 Nitrogen broadcast each year in May.

/3 Lime broadcast in March, 1950.

App. Table 2.—The Effect of Four Years Fertilization and Overseeding with Lespedezas on the Nitrogen Content of Hay from a Native Meadow.

| Fertilizer treatment per acre | Lespedeza variety | Nitrogen per cent. Average of 4 replications. 1950 | 1951 | 1952 | 1953 | Average |
|---|---|---|---|---|---|---|
| None | None | .89 | .789 | .812 | .940 | .858 |
| | Korean | .93 | .748 | .758 | .968 | .851 |
| | Climax | .92 | .845 | .786 | 1.008 | .889 |
| | Kobe | 1.01 | .894 | .818 | .970 | .923 |
| | Sericea | .91 | .841 | .773 | .883 | .852 |
| 150# Superphosphate/1 | None | .94 | .825 | .679 | 1.002 | .862 |
| | Korean | .99 | .887 | .678 | .923 | .872 |
| | Climax | 1.03 | .854 | .755 | .930 | .892 |
| | Kobe | 1.22 | 1.010 | .787 | 1.025 | 1.011 |
| | Sericea | .96 | 1.335 | 1.003 | .995 | 1.080 |
| 100# Ammonium nitrate/2 | None | 1.08 | .902 | .913 | 1.055 | .988 |
| | Korean | 1.00 | .838 | .797 | 1.125 | .940 |
| | Climax | .97 | .877 | .930 | 1.014 | .948 |
| | Kobe | 1.13 | .897 | .903 | 1.168 | 1.025 |
| | Sericea | 1.01 | .826 | .955 | 1.332 | 1.031 |
| 1 ton Lime/3 | None | .90 | .762 | .681 | .915 | .815 |
| | Korean | .95 | .650 | .739 | .960 | .825 |
| | Climax | .91 | .717 | .738 | 1.077 | .861 |
| | Kobe | .99 | .848 | .713 | .983 | .884 |
| | Sericea | 1.03 | .717 | .768 | .960 | .869 |
| 150# Superphosphate ≠ 1 ton Lime | None | .99 | .724 | .794 | .903 | .853 |
| | Korean | .99 | .925 | .765 | .880 | .890 |
| | Climax | .93 | .892 | .774 | .988 | .896 |
| | Kobe | .96 | 1.064 | .841 | .895 | .940 |
| | Sericea | 1.01 | .889 | 1.222 | 1.004 | 1.031 |
| 150# Superphosphate ≠ 1 ton Lime ≠ 100# Ammonium nitrate | None | .94 | .819 | .814 | 1.033 | .902 |
| | Korean | .91 | .753 | .800 | .893 | .839 |
| | Climax | 1.06 | .990 | .809 | 1.076 | .984 |
| | Kobe | 1.12 | 1.099 | .931 | 1.038 | 1.047 |
| | Sericea | .96 | .954 | 1.301 | 1.020 | 1.060 |

/1 Superphosphate broadcast each year in March.
/2 Nitrogen broadcast each year in May.
/3 Lime broadcast in March, 1950.

App. Table 3.—The Effect of Four Years Fertilization and Overseeding with Lespedezas on the Phosphorus Content of Hay from a Native Meadow.

| Fertilizer treatment per acre | Lespedeza variety | Phosphorus per cent. Average of 4 replications. 1950 | 1951 | 1952 | 1953 | Average |
|---|---|---|---|---|---|---|
| None | None | .077 | .053 | .058 | .056 | .061 |
| | Korean | .074 | .053 | .058 | .055 | .060 |
| | Climax | .076 | .053 | .058 | .061 | .062 |
| | Kobe | .071 | .053 | .060 | .062 | .061 |
| | Sericea | .075 | .053 | .060 | .058 | .061 |
| 150# Superphosphate/1 | None | .101 | .105 | .103 | .118 | .107 |
| | Korean | .105 | .103 | .108 | .121 | .109 |
| | Climax | .117 | .110 | .108 | .131 | .116 |
| | Kobe | .128 | .110 | .108 | .138 | .121 |
| | Sericea | .125 | .118 | .112 | .118 | .118 |
| 100# Ammonium nitrate/2 | None | .067 | .053 | .066 | .063 | .062 |
| | Korean | .074 | .050 | .060 | .076 | .065 |
| | Climax | .074 | .060 | .080 | .062 | .069 |
| | Kobe | .074 | .068 | .068 | .081 | .073 |
| | Sericea | .063 | .053 | .060 | .054 | .058 |
| 1 ton Lime/3 | None | .067 | .053 | .060 | .052 | .058 |
| | Korean | .069 | .058 | .060 | .061 | .062 |
| | Climax | .064 | .055 | .060 | .059 | .059 |
| | Kobe | .076 | .060 | .060 | .056 | .063 |
| | Sericea | .069 | .057 | .060 | .069 | .064 |
| 150# Superphosphate ≠ 1 ton Lime | None | .113 | .093 | .103 | .121 | .107 |
| | Korean | .101 | .108 | .118 | .127 | .113 |
| | Climax | .126 | .110 | .113 | .115 | .116 |
| | Kobe | .110 | .100 | .110 | .104 | .106 |
| | Sericea | .095 | .097 | .102 | .094 | .097 |
| 150# Superphosphate ≠ 1 ton Lime ≠ 100# Ammonium nitrate | None | .114 | .095 | .093 | .108 | .102 |
| | Korean | .104 | .090 | .099 | .139 | .108 |
| | Climax | .096 | .100 | .093 | .133 | .105 |
| | Kobe | .106 | .103 | .103 | .095 | .102 |
| | Sericea | .123 | .093 | .103 | .115 | .108 |

/1 Superphosphate broadcast each year in March.

/2 Nitrogen broadcast each year in May.

/3 Lime broadcast in March, 1950.

App. Table 4.--The Effect of Four Years Fertilization and Overseeding with Lespedezas on the Calcium Content of Hay from a Native Meadow.

| Fertilizer treatment per acre | Lespedeza variety | Calcium per cent. Average of 4 replications. | | | |
|---|---|---|---|---|---|
| | | 1950 | 1951 | 1952 | Average |
| None | None | .72 | .535 | .488 | .581 |
| | Korean | .72 | .478 | .518 | .572 |
| | Climax | .79 | .579 | .510 | .595 |
| | Kobe | .75 | .598 | .603 | .650 |
| | Sericea | .77 | .473 | .468 | .570 |
| 150# Superphosphate/1 | None | .93 | .480 | .468 | .626 |
| | Korean | .84 | .514 | .450 | .601 |
| | Climax | .88 | .547 | .518 | .647 |
| | Kobe | .88 | .545 | .523 | .649 |
| | Sericea | .70 | .580 | .593 | .624 |
| 100# Ammonium nitrate/2 | None | .84 | .435 | .533 | .603 |
| | Korean | .75 | .495 | .475 | .573 |
| | Climax | .72 | .465 | .488 | .558 |
| | Kobe | .93 | .470 | .555 | .652 |
| | Sericea | .72 | .445 | .478 | .548 |
| 1 ton Lime/3 | None | .68 | .500 | .573 | .584 |
| | Korean | .79 | .605 | .548 | .638 |
| | Climax | .81 | .553 | .540 | .634 |
| | Kobe | .86 | .563 | .573 | .665 |
| | Sericea | .77 | .530 | .635 | .645 |
| 150# Superphosphate ≠ 1 ton Lime | None | .79 | .588 | .508 | .645 |
| | Korean | 1.01 | .580 | .473 | .689 |
| | Climax | .88 | .636 | .453 | .656 |
| | Kobe | 1.22 | .626 | .543 | .796 |
| | Sericea | .77 | .640 | .592 | .667 |
| 150# Superphosphate ≠ 1 ton Lime ≠ 100# Ammonium nitrate | None | .77 | .488 | .445 | .568 |
| | Korean | .81 | .488 | .408 | .569 |
| | Climax | .79 | .480 | .415 | .562 |
| | Kobe | .90 | .525 | .450 | .625 |
| | Sericea | .59 | .578 | .553 | .574 |

/1 Superphosphate broadcast each year in March.

/2 Nitrogen broadcast each year in May.

/3 Lime broadcast in March, 1950.

App. Table 5.—The Effect of Four Years Fertilization and Overseeding with Lespedezas on the Magnesium Content of Hay from a Native Meadow.

| Fertilizer treatment per acre | Lespedeza variety | Magnesium per cent. Average of 4 replications. | | | |
|---|---|---|---|---|---|
| | | 1950 | 1951 | 1952 | Average |
| None | None | .276 | .228 | .238 | .247 |
| | Korean | .300 | .210 | .242 | .251 |
| | Climax | .262 | .228 | .234 | .241 |
| | Kobe | .248 | .212 | .263 | .241 |
| | Sericea | .262 | .178 | .235 | .225 |
| 150# Superphosphate/1 | None | .333 | .220 | .249 | .267 |
| | Korean | .265 | .257 | .264 | .262 |
| | Climax | .184 | .307 | .260 | .250 |
| | Kobe | .344 | .270 | .266 | .293 |
| | Sericea | .313 | .237 | .264 | .271 |
| 100# Ammonium nitrate/2 | None | .352 | .217 | .262 | .277 |
| | Korean | .321 | .218 | .244 | .259 |
| | Climax | .288 | .218 | .231 | .246 |
| | Kobe | .366 | .197 | .271 | .278 |
| | Sericea | .263 | .227 | .225 | .238 |
| 1 ton Lime/3 | None | .271 | .220 | .263 | .251 |
| | Korean | .296 | .262 | .232 | .263 |
| | Climax | .322 | .187 | .218 | .242 |
| | Kobe | .277 | .198 | .236 | .237 |
| | Sericea | .316 | .210 | .229 | .252 |
| 150# Superphosphate + 1 ton Lime | None | .336 | .212 | .258 | .269 |
| | Korean | .347 | .222 | .229 | .266 |
| | Climax | .272 | .265 | .235 | .257 |
| | Kobe | .294 | .240 | .261 | .265 |
| | Sericea | .297 | .260 | .266 | .274 |
| 150# Superphosphate + 1 ton Lime + 100# Am. nitrate | None | .300 | .302 | .252 | .285 |
| | Korean | .288 | .275 | .276 | .279 |
| | Climax | .367 | .255 | .269 | .297 |
| | Kobe | .291 | .292 | .262 | .282 |
| | Sericea | .349 | .270 | .268 | .296 |

/1 Superphosphate broadcast each year in March.

/2 Nitrogen broadcast each year in May.

/3 Lime broadcast in March, 1950.

App. Table 6.—The Effect of Four Years Fertilization and Overseeding with Lespedezas on the Potassium Content of Hay from a Native Meadow.

| Fertilizer treatment per acre | Lespedeza variety | Potassium per cent. Average of 4 replications. | | | | |
|---|---|---|---|---|---|---|
| | | 1950 | 1951 | 1952 | 1953 | Average |
| None | None | .59 | .414 | .373 | .800 | .544 |
| | Korean | .56 | .436 | .392 | .656 | .511 |
| | Climax | .57 | .418 | .392 | .600 | .495 |
| | Kobe | .58 | .387 | .385 | .687 | .509 |
| | Sericea | .55 | .367 | .392 | .605 | .478 |
| 150# Superphosphate/1 | None | .53 | .417 | .390 | .541 | .469 |
| | Korean | .49 | .415 | .359 | .512 | .444 |
| | Climax | .35 | .407 | .352 | .540 | .412 |
| | Kobe | .36 | .363 | .328 | .488 | .385 |
| | Sericea | .42 | .445 | .332 | .477 | .418 |
| 100# Ammonium nitrate/2 | None | .47 | .406 | .377 | .819 | .518 |
| | Korean | .49 | .399 | .366 | .586 | .460 |
| | Climax | .48 | .415 | .351 | .656 | .475 |
| | Kobe | .43 | .429 | .373 | .495 | .432 |
| | Sericea | .52 | .427 | .351 | .576 | .468 |
| 1 ton Lime/3 | None | .51 | .384 | .402 | .592 | .472 |
| | Korean | .48 | .400 | .389 | .490 | .439 |
| | Climax | .53 | .452 | .399 | .492 | .468 |
| | Kobe | .51 | .375 | .375 | .541 | .450 |
| | Sericea | .45 | .438 | .399 | .684 | .493 |
| 150# Superphosphate + 1 ton Lime | None | .47 | .433 | .355 | .485 | .436 |
| | Korean | .47 | .369 | .376 | .647 | .465 |
| | Climax | .47 | .352 | .367 | .512 | .425 |
| | Kobe | .44 | .388 | .342 | .523 | .423 |
| | Sericea | .50 | .361 | .319 | .548 | .432 |
| 150# Superphosphate + 1 ton Lime + 100# Ammonium nitrate | None | .45 | .382 | .314 | .488 | .408 |
| | Korean | .47 | .362 | .351 | .426 | .402 |
| | Climax | .46 | .392 | .351 | .597 | .450 |
| | Kobe | .45 | .370 | .294 | .374 | .372 |
| | Sericea | .44 | .354 | .304 | .488 | .396 |

/1 Superphosphate broadcast each year in March.

/2 Nitrogen broadcast each year in May.

/3 Lime broadcast in March, 1950.

App. Table 7.—Precipitation Data for Webbers Falls, Oklahoma[1]

| | Precipitation in inches | | | |
|---|---|---|---|---|
| Month | 1950 | 1951 | 1952 | 1953 |
| April | 2.96 | 2.80 | 7.90 | 6.39 |
| May | 7.93 | 2.83 | 4.56 | 3.88 |
| June | 1.00 | 8.34 | 3.86 | 1.09 |
| July | 8.45 | 1.76 | 1.96 | 4.94 |

[1] From the United States Department of Commerce, Weather Bureau "Climatological Data" 1950-1954. Webbers Falls, located 10 miles east, is the nearest official weather station to the meadow studied in this experiment.

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