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The Effect of Fertilization and Overseeding With Lespedezas on A Native Hay Meadow

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INTRODUCTION

Native grasses cut from 380,000 acres of meadow land in Oklahoma furnish sufficient forage to winter 15 percent of its present number of cattle (7).[1] Ninety percent of the native hay land is located in the eastern half of the state. The average yield of one ton of hay per acre, with a protein content of four to five percent, appears very low for good level land with favorable moisture conditions.

Most of the native grass meadow soils are low in phosphorus and are acid in nature. On nearby soils, field crops respond favorably to commercial fertilizers and lime applications. It is possible to introduce a large number of adapted legumes into improved pastures in this region.

The study reported herein was designed to determine whether it is possible and economical to improve the quantity and quality of forage on prairie hay meadow land by adding fertilizers and overseeding with lespedeza.

PREVIOUS WORK IN OKLAHOMA

A large number of experiments on improvement of native grass meadows and ranges indicate that there is some question concerning the economy of using commercial fertilizers. In most long-time tests on climax species, commercial fertilizer applications have changed the botanical composition. After 20 years of study, Harper (3) concluded that commercial fertilizers were not profitable in central Oklahoma. In this study nitrogen fertilizers increased yields when moisture conditions were favorable.

Murphy (6) increased yields of prairie hay on central cross timbers and central prairies of Oklahoma by using phosphorus and nitrogen fertilizers. However, large quantities of fertilizers were necessary for significant gains, making costs prohibitive.

In western Oklahoma, McIlvain (5) was unable to increase yields on native grasses with fertilizers, whereas many introduced grasses responded to nitrogen.

A 60 percent increase in animal gains was reported by Elwell and Daniels (2) from grazing native grasses on virgin soils at Guthrie,

[1] Figures in parentheses refer to "Literature Cited," p.

Oklahoma, by use of nitrogen and phosphorus fertilizers.

Harper (3) changed the time of nitrogen application on a native grass meadow from March to May to avoid weedy annual winter grass growth.

The botanical composition of a native grass meadow was changed with annual applications of commercial fertilizers by Murphy.[1] Superphosphate encouraged weed growth. Nitrogen applied at the proper time did not increase weeds; but when phosphate was applied with the nitrogen, weed infestation was greater than on areas receiving phosphate alone.

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.

Harper (4) states 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.

In a four-year study by Briggs et al. (1) on time of cutting native meadows near Stillwater, it was found that July-cut hay contained greater total digestible nutrients per acre than June, August and September cuttings.

PROCEDURE

This test was conducted on native grass hay meadow land located 20 miles southeast of Muskogee, Oklahoma. The soil and vegetation were representative of typical native hay meadows found on the prairies of eastern Oklahoma. The soil is mapped as Parsons silt loam.

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 blue-stem *(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 *(Schrankia spp.)*.

The experimental area was laid out in a randomized block, split plot design. The blocks could not be located adjacent to one another

[1] Unpublished data. Okla. Agr. Exp. Station

because of occasional mounds of soil one to two feet high and 40 to 50 feet across that are characteristic of many areas in eastern Oklahoma. Each of four blocks was divided into six 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.

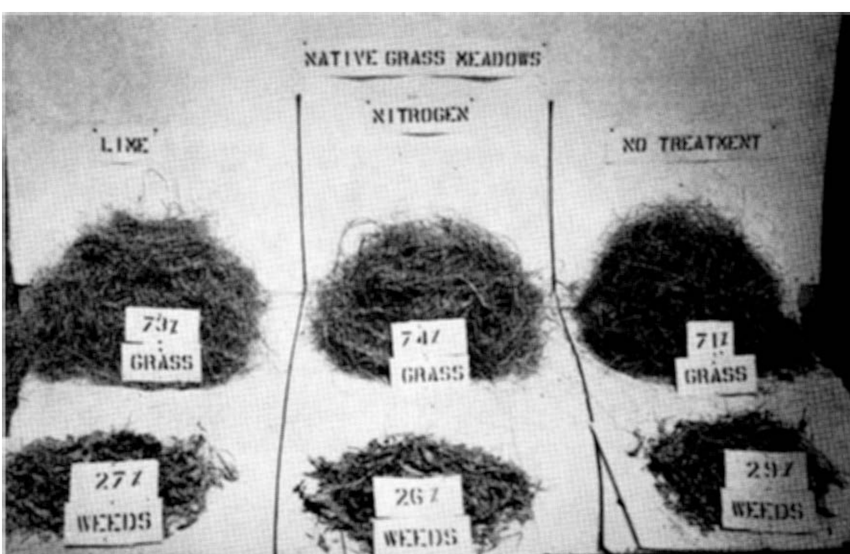
Plot 4—One ton agricultural limestone and 150 pounds superphosphate per acre.

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 five plots, nine 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.



(1) Lime and nitrogen applied at the proper time does not affect the composition. The period of this experimental application was four years.

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 percentage, 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 three years a sample from each plot was analyzed. Chemical analyses included nitrogen, phosphorus, potassium, calcium, and magnesium. Calcium and magnesium analyses were not completed in 1953.

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

Fertilizer treatment per acre	Lespedeza variety	Hay Yield (Pounds per acre. Average of four replications.) 1950	1951	1952	1953	Average
None	None	1,749	2,278	1,712	1,565	1,826
	Korean	1,786	2,398	1,782	1,418	1,846
	Climax	1,811	2,415	1,992	1,418	1,909
	Kobe	1,861	2,314	1,848	1,377	1,850
	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	2,749	2,027	1,849	2,148
	Climax	1,954	2,994	2,108	1,989	2,261
	Kobe	2,409	2,869	2,418	2,077	2,443
	Sericea	1,867	2,862	2,858	2,172	2,439
100# Ammonium nitrate[2]	None	1,773	2,836	2,097	1,669	2,094
	Korean	1,736	2,783	2,164	1,879	2,141
	Climax	1,886	2,886	1,849	1,607	2,057
	Kobe	1,693	2,746	1,914	1,549	1,975
	Sericea	1,948	2,795	2,023	1,686	2,113
1 ton Lime[3]	None	1,680	2,672	1,846	1,435	1,908
	Korean	1,649	2,395	1,726	1,405	1,794
	Climax	1,786	2,669	1,917	1,428	1,950
	Kobe	1,724	2,064	1,920	1,427	1,784
	Sericea	1,842	2,513	1,965	1,533	1,963
150# Superphosphate+ 1 ton Lime	None	2,309	3,258	2,074	1,883	2,381
	Korean	2,216	2,937	2,222	2,000	2,344
	Climax	2,010	2,943	2,129	2,066	2,287
	Kobe	2,446	3,240	2,493	2,202	2,595
	Sericea	1,865	2,552	2,937	2,219	2,393
150# Superphosphate+ 1 ton Lime+ 100# Ammonium nitrate	None	2,259	3,324	2,500	2,254	2,589
	Korean	2,272	3,645	2,641	2,321	2,720
	Climax	2,247	3,496	2,770	2,344	2,714
	Kobe	2,153	3,389	2,590	2,269	2,600
	Sericea	2,203	3,479	2,656	2,150	2,622

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

In 1950 botanical composition was measured on some of the plots at time of harvest. In 1953 the vegetation from two 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 best hay production in three of the four years this study was in progress. The high rainfall in June, 1951 (Table 6) increased yields above normal expectations. Annual lespedezas were almost a complete failure in 1952 and 1953 because of the June droughts. Sericea made its best growth in 1952 because it took two years for the perennial legume to become established.

Effect of Fertilizers on Yields.

One hundred pounds of ammonium nitrate per acre did not increase hay yields significantly for any of the four years (see five percent multiple range test, Table 2). This is true also where one ton of lime per acre alone was used. If the gain of 500 pounds of hay per acre (Table I) for 1951 in favor of nitrogen treatment over check plots is accepted, the gain would not be sufficient to pay the cost of fertilizer and application. A darker green color was imported to the grasses and it could be observed in the nitrogen plots unless it became extremely dry. At harvest time in 1952 and 1953, grasses on the nitrogen areas were brown and contained less moisture than clippings from unfertilized areas.

Phosphate alone increased hay production significantly three of the four years (Table 2). The increased production quite reasonably can be attributed to increased legume growth (Table I) and the stimulation given weeds and annual grasses.

Although lime alone did not affect yields, slightly more forage was received from lime and superphosphate in combination than from phosphate alone. Addition of lime to phosphorus did not encourage lespedeza growth over the phosphate alone.

The use of nitrogen, phosphorus and lime in combination increased forage yields significantly at the five percent level of probability for all four years (Table 2). This treatment produced more vegetation than the others, but the botanical composition was so radically changed by the fourth year that much of the vegetation was not desirable for livestock.

Effect of Overseeding Lespedeza on Yields.

A good stand of annual lespedeza emerged in all plots each year. Legumes made insufficient growth to be considered on the unfertilized plots and on plots where nitrogen and lime were used alone. Table 2 shows that where production from all treatments was added together, only serecia lespedeza increased yields significantly one year and the annual lespedezas did not affect production. However, Table I indicates considerable increase for Kobe lespedeza in 1950 and for all the annual lespedezas in 1951 where the 150 pound rate of 0-20-0 per acre was used.

Sericea, on phosphated plots, produced good gains in 1952 and 1953; but the quality of the hay was low because it was cut after the stems had become woody and a high tannic acid content was reached. 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.

Legumes were always present in plots where nitrogen, phosphorus and lime were applied in combination but they were subdued by the rank-growing vegetation and did not materially increase yields in any of the four years of the experiment.

Chemical Content of the Prairie Hay.

All fertilizer treatments, except lime alone, increased total protein production in the hay over the check plots for all years that

Table 2.—Average[1] Hay Production for Various Treatments, by Years[2]

1950 Treatment	1950 Avg.	1951 Treatment	1951 Avg.	1952 Treatment	1952 Avg.	1953 Treatment	1953 Avg.
Fertilizer Treatments†							
Lime	1736	None	2414	None	1843	None	1443
None	1767	Lime	2435	Lime	1875	Lime	1446
33-0-0	1807	0-30-0	2802	33-0-0	2026	33-0-0	1678
0-30-0	2028	33-0-0	2809	0-30-0	2293	0-30-0	1992
0-30-0 Lime	2189	0-30-0 Lime	2937	0-30-0 Lime	2371	0-30-0 Lime	2074
33-30-0 Lime	2227	33-30-0 Lime	3489	33-30-0 Lime	2612	33-30-0 Lime	2268
Lespedeza Varieties††							
Ser.	1909	Kor.	2760	None	2061	None	1775
Kor.	1927	Kobe	2794	Kor.	2094	Clx.	1809
Clx.	1947	None	2799	Clx.	2127	Kor.	1812
None	1954	Ser.	2801	Kobe	2197	Kobe	1817
Kobe	2047	Clx.	2919	Ser.	2386	Ser.	1835

[1] Averages of four replications.
[2] Averages covered by same line do not differ significantly at 5% level.

statistical analyses were run (Table 4). Also, all varieties of lespedeza, except Korean, increased protein production significantly. Gains in protein production are due to an increase in nitrogen content of the hay in treated plots (Table 3) and to a small gain in total hay production that was not always significant.

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

Table 3.—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.

analysis of approximately 0.06 percent phosphorus, while 150 pounds of superphosphate per acre increased the content to about 0.10 percent (Table 3). 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 3). 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 Table 3 that the magnesium and the potassium contents in prairie hay differs more from year to year, and within treatments, than from the different treatments.

Table 4.—Average[1] Protein Production for Various Treatments, by Years[2]

1951 Treatment	1951 Avg.	1952 Treatment	1952 Avg.	1953 Treatment	1953 Avg.
Fertilizer Treatments					
Lime	115	Lime	83	None	85
None	121	None	90	Lime	87
33-0-0	151	33-0-0	112	33-0-0	118
0-30-0	165	0-30-0	115	0-30-0 Lime	120
0-30-0 Lime	165	0-30-0 Lime	132	0-30-0	121
33-30-0 Lime	199	33-30-0 Lime	145	33-30-0 Lime	143
Lespedeza Varieties					
Kor.	139	Kor.	99	Kor.	
None	140	None	101	None	
Clx.	159	Clx.	106	Kobe	
Ser.	159	Kobe	114	Clx.	
Kobe	167	Ser.	145	Ser.	

1 Averages of four replications.
2 Averages covered by same line do not differ significantly at 5% level.

TRENDS IN BOTANICAL COMPOSITION

As a rule, native hay meadows in Oklahoma change very little in botanical composition from year to year if they are cut each 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 percent of the total forage weight in 1950 to 24 percent 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.

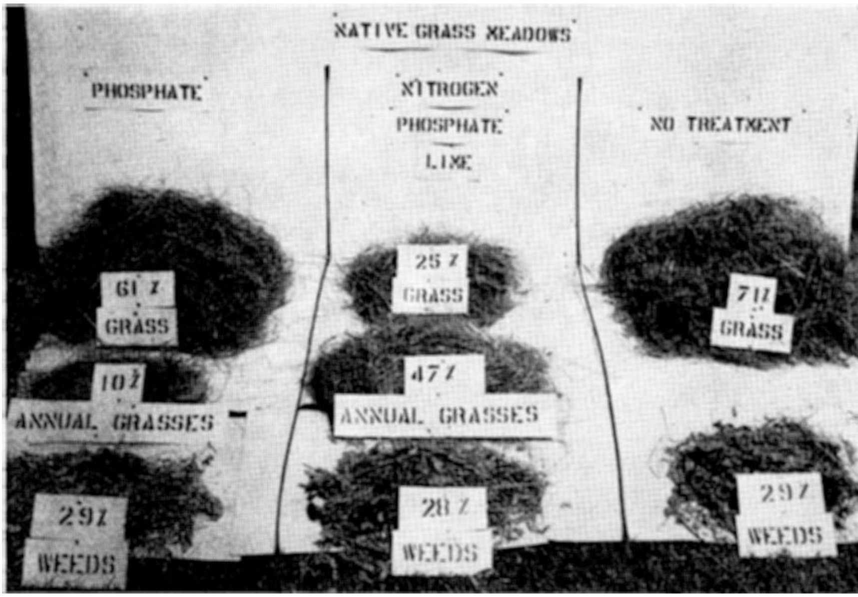
Treatments of 100 pounds of ammonium nitrate per acre in May for four years did not affect the weed population (Table 5). This was also true where lime was used alone at the rate of one ton per acre.

Some of the treatments imposed on the meadow encouraged invasion of many weedy species seldom found in native grass lands used

Table 5.—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]	75.3	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	4.45	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 (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.



(2) When phosphate was added by its self the composition changed only slightly, but when nitrogen, phosphate and lime were all used the composition was greatly changed. The period of experimental application was four years.

for hay. Table 5 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. 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.

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 percent weeds in 1953 (Table 5). 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 5) 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 6.—Precipitation Data for Webbers Falls, Oklahoma[1]

Month	Precipitation in inches			
	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 experment.

SUMMARY

The effect of fertilizers and overseeding with lespedezas on a native hay meadow growing on Parsons silt loam near Muskogee 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 has was brown and low in moisture 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; 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 percent.

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

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.

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