

Fertilizer Experiments With Pasture and Alfalfa

By E.C.DOLL and A.L.HATFIELD



Heavy nitrogen fertilization resulted in loss of clover in the plot on the right (Simpson County, 1958).

(Filing Code I-1)

**AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF KENTUCKY
LEXINGTON**

FERTILIZER EXPERIMENTS WITH PASTURE AND ALFALFA

(PROGRESS REPORT)

By E. C. Doll and A. L. Hatfield

A number of fertilizer experiments with alfalfa and pasture have been conducted from 1950 to 1957 at various locations throughout the state. A summary and brief discussion of the results are given in this report as an additional aid to county agents and other agricultural workers in making fertilizer recommendations. The data given here are intended only to supplement the general recommendations given in Misc. Pub. 10 and the soil test recommendations given in Misc. Pub. 13, and are not intended to supersede either of these publications.

Pasture Experiments

Greenville Soil Experiment Field: An experiment to determine the effects of nitrogen and potassium on the yield of a pasture composed of orchardgrass, tall fescue, and Ladino clover was started in 1954 and concluded in 1957. The soil was Tilsit silt loam, which is fairly representative of the upland soils in the Western Coalfield and the sandstone area on its borders. It is very low in phosphorus, and potassium usually becomes limiting after the soil is cropped for a short time. Three tons of limestone were applied prior to seeding. All fertilizers applied prior to seeding were broadcast and disked into the surface soil. Relatively heavy initial applications of potassium were compared with lighter, annual topdressings. The rates of potassium and yields obtained from 1954 to 1957 are given in Table 1. No nitrogen was applied to any treatments, and 200 pounds of P_2O_5 per acre were applied annually to all treatments.

Table 1 -- Effect of Potassium on Pasture Yields at Greenville

Lb K_2O per Acre		Yield (Cwt / A)				
Rate of Application	Total Applied	1954	1955	1956	1957	Total
0	-	12.7	27.2	28.6	44.0	112.5
Annual:						
50	200	19.6	39.5	42.6	61.2	163.0
100	400	24.8	50.0	53.2	63.6	191.6
200	800	26.1	50.0	54.9	75.0	205.9
Initial:						
200	200	25.0	45.3	45.9	55.3	171.4
400	400	27.1	51.4	48.3	54.5	181.2
L. S. D.	(0.05)	5.5	12.8	10.5	10.2	19.2

The results of the annual topdressing with potassium show a significant response for the first 50 pounds of K_2O , but no significant increase for 100 pounds as compared with 50 pounds. The total yields for the four years, however, show a significant increase in yield for the 100-pound rate.

The total yields obtained for the initial applications did not differ from those obtained when equal amounts of potash were applied in four annual applications. However, when 400 pounds of K_2O was applied initially the yields tended to drop off in the fourth year as compared with those when 100 pounds was applied annually.

Nitrogen comparisons, including rates and times of applications were also included.

Table 1 a -- Effect of Nitrogen on Pasture Yield at Greenville

Lb N per Acre		Yield per Acre (Cwt)		
March 1	June 15	1955	1956	1957
0	0	50.0	54.9	75.0
50	0	51.6	60.3	80.1
0	50	56.5	61.7	76.6
50	50	53.8	62.7	81.5
100	0	50.9	68.8	79.3
0	100	50.9	62.8	78.0

In no year was the response to nitrogen great enough to pay the cost of the fertilizer application. The yield trends during the year are not shown by the total annual yield; however, fertilizer nitrogen tended to increase yields early in the spring and to decrease yields in late summer and fall.

Simpson County: Two different mixtures which receive the same fertilizer treatments are included in an experiment located in Simpson county: one mixture (I) is composed of orchardgrass, tall fescue, Kentucky bluegrass, and white clover and the other (II) is composed of orchardgrass, tall fescue, and Ladino clover. No stand of white clover was obtained in mixture I, so it is composed entirely of grasses, but a good stand of Ladino clover was obtained initially in mixture II.

The soil type is Pembroke silt loam, which is a deep, well-drained, highly productive soil typical of the upland soils of the limestone section of the western Pennyroyal.

In this experiment, one treatment is included which receives no fertilizer, one which received an initial application, and one which receives an initial plus an annual maintenance application. The yields in 1956 and 1957 are given in Table 2.

Results with both mixtures show a marked response to fertilizer. In Mixture I, no clover was present, and nitrogen was limiting in all three treatments. In Mixture II, excellent clover stands were obtained, and an excellent response was obtained for the annual maintenance application in 1957.

Various rates and combinations of phosphorus and potassium were applied. All these treatments received an initial application of 20 pounds N and 20 pounds P_2O_5 per acre at seeding. The results obtained in 1956 and 1957 are given in Table 3.

Table 2. ---Yield of Pasture in Simpson County in 1956 and 1957

Lb N-P ₂ O ₅ -K ₂ O per Acre		Yield (Cwt / A)		
At Seeding	Annual Topdressing	1956	1957	Total
<u>Pasture Mixture I</u>				
0-0-0	0-0-0	15.5	24.8	40.3
20-120-60	0-0-0	47.6	28.0	75.6
20-120-60	0-30-60	48.2	26.9	75.1
<u>Pasture Mixture II</u>				
0-0-0	0-0-0	14.6	19.7	34.3
20-120-60	0-0-0	58.0	39.6	97.6
20-120-60	0-30-60	56.4	48.5	104.9

Table 3. -- Effect of Phosphorus and Potassium on Yield of Pasture Mixture II in Simpson County

Lb P ₂ O ₅ per Acre	Yield (Cwt / A)			
	Lb K ₂ O per Acre			
	60	120	240	480
<u>1956</u>				
30	36.2	35.8	35.4	-
60	35.6	38.9	42.6	-
120	37.9	47.9	42.4	-
240	-	-	40.5	42.4
<u>1957</u>				
30	30.8	24.5	27.9	-
60	31.3	29.5	34.6	-
120	38.1	39.7	37.4	-
240	-	-	33.0	49.2

No response was obtained for potassium in either year; although an apparent response was obtained in 1956, the differences were not large enough to be significant. However, the increase in yield due to phosphorus applications was highly significant in 1957. Applications of N and K₂O at 240 and 480-pound rates were top-dressed in 120-pound increments in early spring and immediately after successive cuttings until the proper amount had been applied.

With both mixtures, various rates of nitrogen were applied in combination with rates of phosphorus and potassium. (tables 4 and 5)

All treatments in tables 4 and 5 included 20 pounds of N and 20 pound of P₂O₅ at seeding, and the treatments given in the tables were topdressed in spring 1956 and 1957. When 240 pounds of N and K₂O were to be applied, the applications were split and 120 pounds of each applied in early spring and 120 pounds after the first cutting.

Table 4. -- Effect of Nitrogen on Yield of Mixture I in Simpson County

Lb N per Acre	Yield (Cwt / A)			Average
	Pounds P ₂ O ₅ - K ₂ O per Acre			
	30 - 60	60 - 120	120 - 240	
		<u>1956</u>		
0	27.5	34.6	33.1	31.7
30	38.5	42.9	41.1	40.8
60	39.5	41.8	49.8	43.7
120	45.7	52.3	52.0	50.0
240	55.2	64.9	61.9	60.7
		<u>1957</u>		
0	24.2	28.4	29.7	27.4
30	35.9	37.8	41.8	38.5
60	46.7	47.3	50.5	48.2
120	57.9	62.3	63.2	61.1
240	73.6	76.6	84.2	78.1

As stated above, this mixture is composed almost entirely of grass, since the white clover failed to give a stand. Consequently, all of the nitrogen must be derived from either fertilizer or soil organic matter. An excellent response was obtained for nitrogen in both 1956 and 1957, and the response was relatively greater in 1957.

Table 5. -- Effect of Nitrogen on Yield of Mixture II in Simpson County

Lb N per Acre	Yield (Cwt / A)			Average
	Pounds P ₂ O ₅ - K ₂ O per Acre			
	30 - 60	60 - 120	120 - 240	
		<u>1956</u>		
0	36.2	38.9	42.4	39.2
30	40.6	43.8	50.0	44.8
60	44.1	46.4	50.8	47.1
120	51.1	58.3	59.7	56.4
240	63.8	59.7	67.4	63.6
		<u>1957</u>		
0	30.8	29.5	37.4	32.6
30	21.8	29.2	38.4	29.8
60	22.9	27.8	37.2	29.3
120	27.1	28.9	35.0	30.3
240	44.1	51.3	59.4	51.6

A response to nitrogen was obtained in 1956, but none in 1957 except at the 240-pound rate. At rates of 120 and 240 pounds, all of the clover has been eliminated, and a substantial portion of the clover is gone at the 30 and 60-pound rates. In addition, on the 240-pound plots, the stand of grass is thin, and the plots are becoming weedy.

Through an error, no weights were obtained from the second cutting of mixture II in 1957. Therefore, a comparison of total yields of mixtures I and II cannot be made.

Garrard County: (The experiments in Garrard county were conducted by W. C. Templeton, Jr., T. H. Taylor, and W. N. McMakin). Two pasture fertility experiments were established in Garrard County, Kentucky in the spring of 1954 on soil tentatively classified as Trappist silt loam. This land was very low in available phosphorus and low to medium in available potash. The primary mixture used is Ky. 31 tall fescue-Ladino clover. A few plots of orchardgrass-Ladino clover are included. Rates of application of nitrogen, phosphorus and potassium are being tested as is time of application of nitrogen. Generally speaking, precipitation during the three growing seasons has been adequate though periods of mild drought occurred during late summer in 1956 and again in 1957. Response to the fertility treatments has been determined in terms of dry matter production and clover content of the herbage.

Phosphorus fertilization has been effective in increasing both forage yields and clover content. For example, 1955-56 average yields per acre and clover content were as follows for tall fescue-Ladino clover:

Table 6.

<u>P₂O₅/A, lb</u>	<u>Dry Matter/A, lb</u>	<u>Clover Content, %</u>
0	2,704	26
20	3,892	38
200	4,432	35

Little or no response to potash has been obtained in these experiments to date.

Plots which received commercial nitrogen during 1955 and 1956 had less clover at the beginning of the 1957 season than did similar plots which had not received nitrogen. By the end of the 1957 season some plots had virtually no clover. Three-year (1955-57) average production and clover content are listed for a few representative treatments of tall fescue-Ladino clover.

Total seasonal yields of tall fescue-Ladino clover and orchardgrass-Ladino clover have been virtually the same but fall production of the tall fescue-Ladino clover has been considerably higher than that of the orchardgrass-Ladino mixture.

Table 7. -- Average Seasonal Production and Clover Content of a Tall Fescue-Ladino Mixture When Fertilized with Different Rates of Fertilizer, 1955-57 Average.

Treatment No.	Treatment				Dry Matter per acre, pounds	Clover Content, per cent	
	March	N May	Aug.	P ₂ O ₅ March			K ₂ O March
1	0	0	0	0	0	3,449	32
2	30	0	0	20	30	4,784	35
3	0	30	0	20	30	4,826	31
4	0	0	30	20	30	4,994	38
5	60	0	0	20	30	4,730	27
6	0	60	0	20	30	4,967	30
7	0	0	60	20	30	4,949	37
8	0	0	0	200	150	6,151	43
9	120	0	0	200	150	6,212	17
10	0	120	0	200	150	6,586	29
11	0	0	120	200	150	6,529	34
12	40	40	40	200	150	6,863	25
13	240	0	0	200	150	6,458	12
14	80	80	80	200	150	7,382	13

Laurel County: An experiment was conducted in Laurel County from 1952 to 1954 on Tilsit silt loam. The soil is similar to that described on the Greenville Soil Experiment Field. A mixture of orchardgrass, tall fescue and Ladino clover was seeded in spring 1952.

Table 8. -- Yield of Pasture in Laurel County 1952-54

N - P ₂ O ₅ - K ₂ O* Lb/A	Yield (Cwt/A)		
	1952	1953	1954
50-0-50	11.9	36.4	32.7
50-250-50	16.9	53.0	47.7
0-250-50	10.8	51.4	44.3
50-250-0	16.2	50.0	40.2
L. S. D. (0.05)	3.3	5.4	8.5

*Nitrogen and potash topdressed annually, all phosphorus being applied at time of seeding.

An excellent response was obtained for phosphorus every year. Although no significant response was obtained for potassium, the yields when no potassium was applied were steadily decreasing with respect to the other treatments. These results are typical of those obtained on Tilsit silt loam, in which phosphorus is limiting at the beginning of cropping, and then potassium becomes limiting after a short time.

Alfalfa Experiments

Greenville Soil Experiment Field: An alfalfa experiment was conducted for a number of years on Tilsit silt loam at the Greenville Soil Experiment Field. Initial fertilizer applications were made and Atlantic alfalfa seeded in August, 1949. The fertilizers were again applied and the experiment reseeded in 1951. Fertilizer treatments were revised in 1955, and the experiment discontinued in 1956.

Table 9. -- Yield of Alfalfa at Greenville, 1950-56

1950-1954			1955-1956			
Initial Treatment*		Ave. Annual	Annual Treatment		Ave. Annual	
Lb/A		Yield	Lb/A		Yield	
P ₂ O ₅	K ₂ O	T/A	P ₂ O ₅	K ₂ O	T/A	
200	0	2.5	60	0	1.8	
200	100	3.2	60	33	2.7	
200	200	3.8	60	66	3.5	
200	300	4.2	60	133	4.1	
0	300	2.6	0	133	1.8	

*Applied in 1949 and 1951.

Yield increases were obtained for both phosphorus and potassium each year.

Experiment Station Farm, Lexington: An alfalfa experiment is located on a low-phosphate soil on the Agricultural Experiment Station Farm that was formerly classified as Hagerstown silt loam but has now been tentatively classified as Maury silt loam. This experiment included (1) sources of liming materials together with non-neutralizing sources of calcium and magnesium, (2) nitrogen, (3) boron, and (4) rates of phosphorus and potassium. The soil tested pH 6.5, low in P and very low in K. Yields obtained in 1957 are given below.

Table 10. -- Effect of Liming Materials on Alfalfa Yield at Lexington in 1957
(Two tons of calcitic limestone and equivalent rates of other materials were applied.)

Source of Lime*	Yield per Acre (Cwt)		Total
	May 28	July 15	
No Lime	28.4	24.8	53.2
Calcitic limestone	31.2	29.4	60.6
Dolomitic limestone	29.7	28.3	58.0
Calcium sulfate (gypsum)	31.9	25.2	57.1
Magnesium sulfate	28.6	24.1	52.7

*120 pounds of P₂O₅ and K₂O applied per acre to all plots.

Even though the soil tested pH 6.5, there was a slight response obtained for limestone in the second cutting. No differences between calcitic and dolomitic limestone were noted. Calcium sulfate and magnesium sulfate apparently had very little, if any, effect on yields.

Table 11. -- Effect of Nitrogen on Yield of Alfalfa at Lexington

Lb N per Acre*		Yield per Acre (Cwt)		Total
Early Spring	After 1st cut.	May 28	July 15	
0	0	31.2	29.4	60.6
50	0	29.7	28.0	57.7
0	50	31.2	30.5	61.7
50	50	30.7	32.6	63.3

*120 pounds per acre of P₂O₅ and K₂O applied to all plots.

No response was obtained for nitrogen at either time of application.

Table 12. -- Effect of Phosphorus and Potassium on Yield of Alfalfa at Lexington in 1957

Pounds per Acre		Yield per Acre (Cwt)		Total
P ₂ O ₅	K ₂ O	May 28	July 15	
0	120	24.5	19.4	43.9
30	120	27.1	22.2	49.3
60	120	27.9	24.5	52.4
120	120	28.3	26.5	54.8
60	0	21.9	20.1	42.0
60	60	27.7	23.1	50.8
60	120	27.9	24.5	52.4
60	240	28.6	24.4	53.0
60	480	28.5	23.9	52.4

These results would indicate that for best yields and maintenance of the stand; about 60 pounds of P₂O₅ and 120 pounds of K₂O would be needed.

Western Kentucky Substation: Atlantic alfalfa was seeded on Pembroke silt loam in September 1954. The soil is similar to that in the Simpson county pasture experiment. The potassium test was low at the beginning of the experiment.

Table 13. -- Effect of Potassium on Yield of Alfalfa at Western Kentucky Substation

Initial	Lb K ₂ O per Acre		Yield per Acre (Cwt)			Total
	Annual	Total	1955	1956	1957	
0	0	0	39.7	77.2	45.3	162.2
60	60	180	38.7	74.9	54.4	168.0
120	120	360	37.4	75.4	56.9	169.7
240	0	240	41.8	81.3	51.0	174.1
360	0	360	35.7	81.0	50.9	167.6

Even though the soil tested low in potassium, no response was obtained until the third year of the experiment. However, the stand of alfalfa is poor on plots to which no potassium has been applied; apparently potassium has affected the stand of alfalfa more than the yields.

Simpson County: Rates of nitrogen, phosphorus, and potassium are included in an experiment located on Pembroke silt loam, which is similar to the soil where the preceding experiment (Western Kentucky Substation) is located. A mixture of Atlantic alfalfa and orchardgrass was seeded in September, 1955. Fertilizers were applied at seeding and again topdressed in early spring, 1957.

Table 14. -- Effect of Phosphorus on Yield of Alfalfa in Simpson County

Lb P ₂ O ₅ per Acre*		Yield per Acre (Cwt)		
1955	1957	1956	1957	Total
0	0	34.9	37.2	72.1
50	50	38.0	54.0	92.0
100	100	41.6	58.2	99.8
200	200	43.8	58.4	102.2
100	25	46.4	55.0	101.4
150	0	43.9	56.9	100.8

*120 lbs. K₂O applied to all plots.

A marked response to phosphorus was obtained both years. Apparently, a heavy initial application was as effective, for the 2-Year period, as were the split applications.

Table 15. -- Effect of Potassium on Yield of Alfalfa in Simpson County

Lb K ₂ O per Acre*		Yield per Acre (Cwt)		
1955	1956	1956	1957	Total
0	0	38.6	53.2	91.8
60	60	38.6	53.1	91.7
120	120	38.4	53.7	92.1
180	180	39.5	55.7	95.2
240	240	40.0	56.0	96.0
240	0	41.6	53.9	95.5
480	0	38.5	55.0	93.5

*120 lbs. P₂O₅ per acre applied to all plots in 1955 and 1957.

No response was obtained for potassium in either year. These results are similar to those obtained for the first two years at the Western Kentucky Substation.

Table 16. -- Effect of Nitrogen on Yield of Alfalfa in Simpson County

Lb N per Acre*	Yield per Acre	
	1956	1957
0	38.4	53.7
30	40.6	58.3
60	40.7	61.0
120	39.9	62.7

*120 pounds per acre of P₂O₅ and K₂O applied to all plots.

No response was obtained in 1956, and the higher yields in 1957 were due mostly to increased growth of orchardgrass. The increased yields at the 30 and 60 pound rates were barely enough to pay for the fertilizer nitrogen. When the effect of nitrogen on alfalfa stand is considered, the use of fertilizer nitrogen would probably be detrimental.

Discussion of Results

In general, the results of these experiments substantiate the fertilizer recommendations given in Miscellaneous Publications 10 and 13.

Lime: Only one experiment reported here included a liming differential (Table 10). From the soil test for acidity (pH 6.5), a slight response to lime would have been expected, and results of the second cutting show a small, but consistent response. Results from the soil experiment fields have shown that proper liming is essential if legumes are to be grown successfully. The rate of application should always be determined by means of soil tests.

Phosphorus: Phosphorus comparisons were included in several experiments (Tables 2, 3, 6, 7, 8, 9, 12, and 14). A good stand of legumes cannot be obtained unless sufficient available phosphorus is present in the soil. Sufficient phosphorus should be applied at seeding to obtain a good stand, and then the phosphorus level can be maintained by periodic topdressing. Phosphorus fertilization is necessary on nearly all of the soils in Kentucky except for the high-phosphate soils of the Inner Bluegrass and certain of the overflow bottom soils.

Potassium: Potassium comparisons were included at every location (Tables 1, 3, 7, 8, 9, 12, 13, and 15). Excellent yield responses were obtained at Greenville and Lexington. At both of these locations, present recommendations made on the basis of soil tests would apparently have resulted in the most profitable rate of fertilization.

Very little response was obtained for potassium on Pembroke silt loam at either the Western Kentucky Substation or Simpson County (Tables 3, 13 and 15). At Princeton, in 1957, a slight response was apparently obtained (Table 13) and the stand was definitely better where potassium had been applied. These results are in agreement with other results obtained on this particular soil type. On the basis of these and other experimental results, potash applications equal to one-half to two-thirds of the present recommended rates would probably be sufficient for optimum production of alfalfa and pasture on the well-drained upland soils derived from limestone in the Western Pennyroyal (red clay soils).

Nitrogen: If a pasture mixture contains a substantial portion of clover, the results obtained in these experiments (Tables 1 a, 5, 7, and 8) indicate that little or no response can be expected for fertilizer nitrogen. However, if the pasture is mainly grass (Table 4), excellent responses can be expected. The data obtained with alfalfa (Tables 11 and 16) indicate that very little response can be expected. In general, these results indicate that nitrogen applications to legumes or mixtures containing a considerable proportion of legumes will not be profitable.