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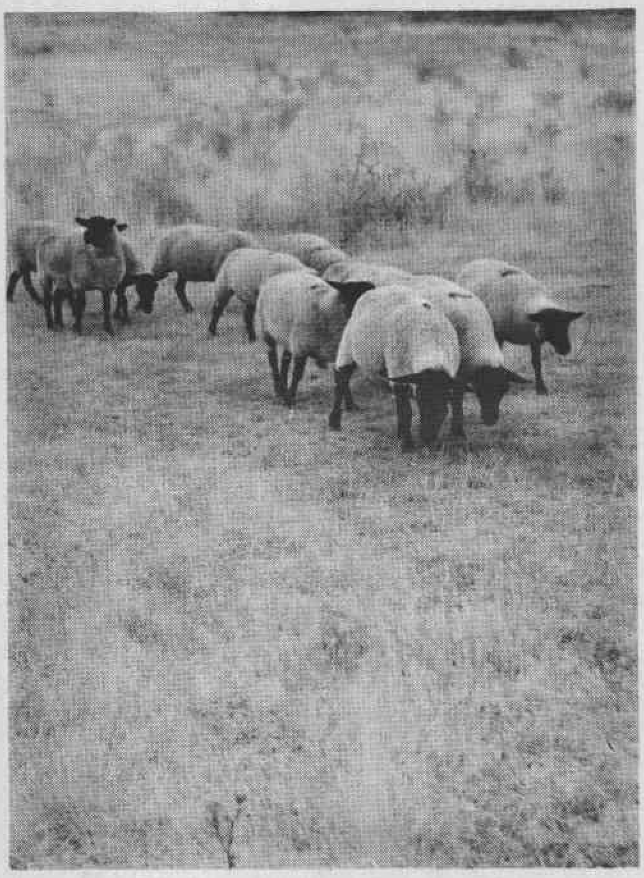
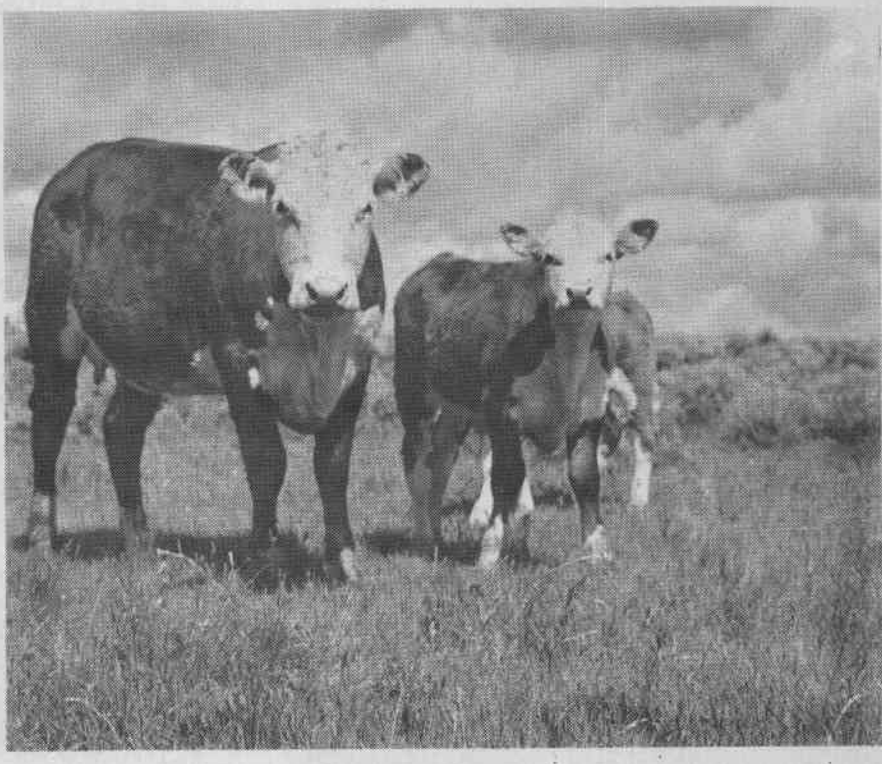


Range Studies No. 1

Fertilizer Treatments on Tall Fescue

D. W. Hedrick



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Fertilizer Treatments on Tall Fescue

D. W. Hedrick*

Western Oregon receives a surplus of rainfall during fall, winter, and early spring months. Temperature and soil fertility are the principal factors limiting growth during this period. If livestock producers are to take full advantage of the forage potential of this area, it is necessary for them to supply plant nutrients for maximum growth.

Various workers have reported beneficial effects of fertilizing pasture forage. Brown and Munsell (1933), (1943), and Swift, _et al_. (1948) found unfertilized plots produced a higher percentage of dry matter; legumes were benefited primarily by lime and superphosphate; mineral nitrogen was not as effective as legumes in producing quantity and quality yields; and fertilized forage generally had higher feed value than did check area forage in early spring. Most of this experimental work, however, has been undertaken in the Middle West which has different growing conditions and species than the Pacific Northwest.

Limited work has been done on dryland pastures in the west; Dickey, _et al_. (1940); Bentley and Talbot (1951); Hoglund, _et al_. (1952); and Bentley and Green (1953). These workers report favorable yield increases after applications of nitrogen, phosphorus, and sulfur-bearing fertilizers on annual ranges.

Dickey and co-workers reported nitrogen as giving big increases in hay production as well as seven week advances in the stage of range readiness. Bentley and Talbot stated that in their studies sulfur-bearing fertilizers increased native annual legumes on granitic soils in the California foothills. This change in species composition resulted in improved yields, higher

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quality summer feed, and better winter forage growth. A recent progress report on range fertilization in California by Martin and Berry (1954) indicates encouraging results from five, short-term grazing tests. Their nitrogen and nitrogen-phosphorus treatments resulted in earlier feed; and meat production per acre was increased from nearly two to over four times by fertilization.

Klages and Stark (1949), working on improved forage grasses in Idaho, report that grasses have a high nitrogen requirement and the addition of nitrogen had a more consistent effect on seed than on hay production.

There are a few reports on optimum amounts of fertilizer materials to use on dryland pastures. Rates of 50 to 100 pounds of nitrogen have been generally considered more profitable than higher rates.

According to Chapman, et al. (1949), reporting on a lysimeter study of nitrogen gains and losses under various systems of covercropping and fertilization in California, the nitrogen requirement of sudan grass is 125 pounds per acre. These workers further state that this requirement was fully met through nitrogen fixation by legume cover crops. In their opinion, high level nitrogen fertilization is wasteful — excesses may be lost by gaseous volatilization, leaching, and luxury consumption by plants. They conclude that greatest nitrogen economy will be achieved when nitrogen is maintained at the lowest possible point consistent with satisfactory crop performance.

Various demonstrations have indicated favorable responses to nitrogen, lime, phosphate, and sulfur on nonirrigated soils of western Oregon but little work has been done with potassium and all combinations of these elements. Neither has there been any great effort made to use nitrogen fertilizer to increase off season production or lengthen the green feed period.

This work was undertaken to: improve the basis for further pasture fertilization work in dryland areas in western Oregon; and to study the response of fall, and early spring, grass pasture to nitrogen fertilizer on two soil types.

Experimental Methods

Three separate experiments were conducted to test the response of some western Oregon, nonirrigated pastures to fertilizer treatments. Experiments 1 and 3 were conducted on Amity silty clay loam which is a typical valley soil in this area. Experiment 2 was conducted on a well-drained, clay loam typical of hill land, where the soil series has been tentatively designated as Dixonville. Much of the area occupied by these well-drained hill lands is unimproved, whereas nearly all of the valley soil is either cultivated or improved pasture.

A mixture of seven grasses and legumes had been seeded where experiments 1 and 3 were conducted. The area had been fertilized with 100 pounds of treble superphosphate and 50 pounds of ammonium sulfate in October 1944.

Of the seeded species, only Alta fescue (*Festuca arundinacea*) was abundant at the time of treatment. In addition, two species, orchard-grass (*Dactylis glomerata*) and burnet (*Sanguisorba minor*), which were probably introduced as impurities in the original seeding, were common. Several resident annuals, soft chess (*Bromus mollis*), foxtail fescue (*Festuca myuros*), hop clover (*Trifolium procumbens*), and annual lotus (*Lotus americanus*) were found on the area. Velvet grass (*Holcus lanatus*) is an undesirable perennial grass present that commonly invades seedings of improved species. Plantain (*Plantago lanceolata*) is an abundant, broadleaf weed.

This area was grazed by sheep from 1945 until 1950. In March 1947, birdsfoot trefoil (Lotus corniculatus) was seeded in the stubble but didn't become established except for an occasional plant. During the 1950 grazing season the area was fenced and protected from grazing. Mature forage was clipped in late summer and removed before the experiment was laid out.

Experiment 1 consisted of a 3 x 2 x 2 x 2 x 2 factorial design — with 0, 200, and 300 pounds per acre of N; none and 500 pounds per acre of P_2O_5; none and 240 pounds per acre of K_2O; none and 72 pounds per acre of sulfur; and none and 3 3/4 tons per acre of limestone — in four replicates. Nitrogen was applied as ammonium nitrate, phosphorus as treble superphosphate, potassium as muriate of potash, sulfur as gypsum, and calcium as limestone.

Plots 5 by 15 feet in size were laid out in blocks 60 feet square (figure 1). All fertilizer applications were broadcast in October 1950 except for nitrogen, one-fourth of which was applied in the fall and three-fourths in late February 1951.

The first harvest was made June 3 and 4, 1951, with the grasses in hay stage. Sample strips about ten feet long and 1.7 feet wide were harvested from each plot with the Scythette. The green forage was weighed and moisture samples were taken to obtain air-dry weights. D. W. Cooper, a graduate student in range management, obtained the 1951 plot yields from this experiment. Dr. J. R. Li, professor of Statistics at Oregon State College, designed the experiment and analyzed the 1951 data. Subsequent residual harvests were made on June 3, 1952, and May 27, 1953, at approximately the same stage of maturity.

Experiment 2 was started in 1951 to test effects of nitrogen fertilizer in increasing fall and early spring production from a well-drained hill pasture.

Plant cover was similar to that reported in experiment 1 except that the weedy perennials, velvetgrass and plantain, were not abundant here. An existing trial, where manure treatments were being tested, was used. A split-plot experiment was set up with manure as main plots and nitrogen as sub-plots. Main plots were 0.4 acre and sub-plots 0.1 acre in area.

Treatments were started in the fall of 1951 to test effects of application times of nitrogen on December, April, and June yields of grass forage, principally Alta fescue, on well-drained hill soil. These treatments were as follows: 33 pounds of nitrogen in October plus 33 pounds in March, 66 pounds of N in October, and 66 pounds of N in March. Ammonium nitrate was used as a nitrogen source (figures 3 and 4).

Experiment 3 was established near experiment 1 in the fall of 1952 to obtain additional information on effects of various rates and times of nitrogen fertilizer application. Soil and plant cover were similar to those described for experiment 1. Objectives of this 2 x 3 x 2 x 3 factorial were to test effects of: nitrogen fertilizer source, rates of application, dates of application, and harvest times on seasonal yields.

Treatments were as follows: two hitrogen sources (ammonium sulfate and ammonium nitrate); three rates (33, 66, and 99 pounds of N); two application dates (September and February); and harvest in December-June, April-June, and June. Plot size and arrangement of the design were similar to those used in the first experiment (figure 2). Fertilizer applications were made in fall of 1952, spring and fall of 1953, and spring of 1954. Harvests to obtain seasonal response of fertilizers were made in December, April, and early June. All plots were harvested

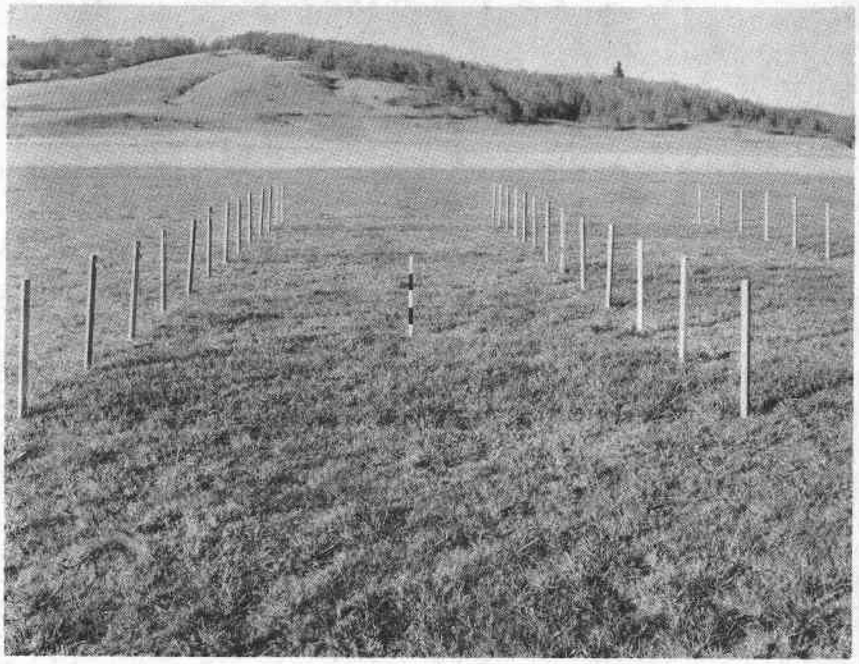

Figure 1. General view of area where experiments 1 and 3 were conducted. Photo taken in December 1951 shows results of fall application of nitrogen in experiment 1.

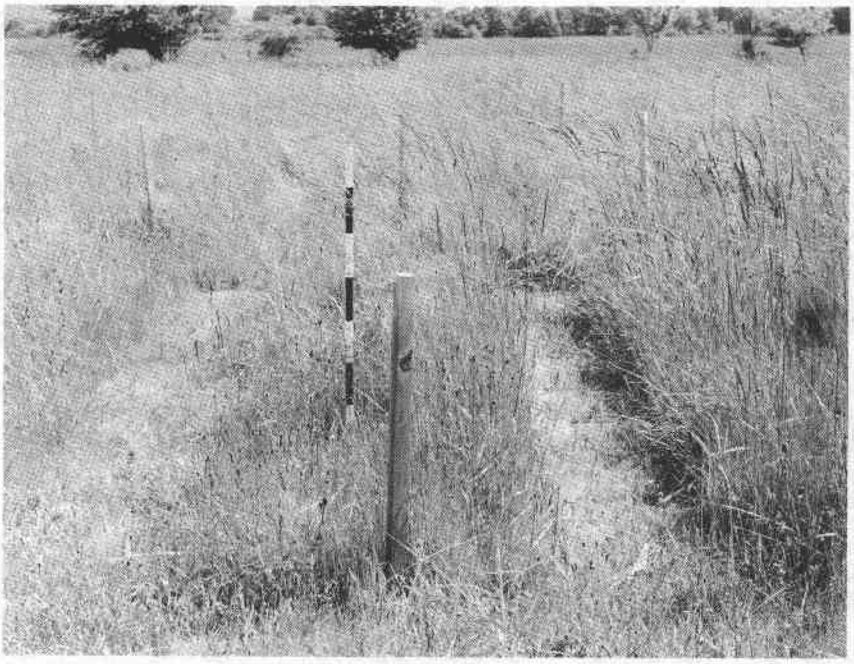

Figure 2. Results from fall nitrogen applied as NH_4NO_3 in October 1952 for experiment 2. Plot on left received 33 lbs. N compared to 99 lbs. for plot on right. Photo taken after late spring harvest, June 1953.

Figure 3. Shows uniform early spring grazing by sheep on plots manured and fertilized with 100 lbs. of NH_4NO_3 (33 lbs. N) per acre in fall, 1951. Photo taken March 28, 1952, in well-drained hill soil of experiment 2. Ungrazed forage yields obtained from exclosure.

Figure 4. Patchy sheep grazing on experiment 2 where plots were fertilized with fall nitrogen but no manure had been applied. Photo taken same time as figure 3.

in June 1953, but regrowth from December and April cuttings was not measured until June 1954. Chemical analyses of forage were obtained on clippings made in April and June of 1953, and in June of 1954. These analyses were made in the Animal Nutrition Laboratory at Oregon State College under the direction of Dr. J. E. Oldfield.

Precipitation and mean temperatures for 1950-51, 1951-52, 1952-53, and 1953-54 are presented in figures 5 and 6 for a weather station at the site of experiment 2.

Results of soil tests run by the Soils Testing Laboratory at Oregon State College on samples taken from 0- to 6-inch depths on the experimental areas are as follows:

Expt.	Soil Series	pH	Organic Matter	Nitrogen	Phosphorus	Potassium	Calcium
			percent	percent	ppm	ppm	ppm
1, 3	Valley land-- Amity silty clay loam --	5.7	3.4	0.19	12	308	4200
2	Well-drained hill land-- Soil series unknown ----	5.3	3.8	0.16	2.5	120	1180

Experimental Results and Discussion

Experiment 1. -- The analyses of yield data variance over a 3-year period from 1951 through 1953 are summarized in table 1. On this dryland pasture where grass predominated, nitrogen gave the greatest response. In the third year, phosphorus was the only element showing a residual effect. Significant interactions with sulfur were observed the first year for phosphorus and lime. No significant interactions of phosphorus and lime with sulfur were observed in 1952 and 1953.

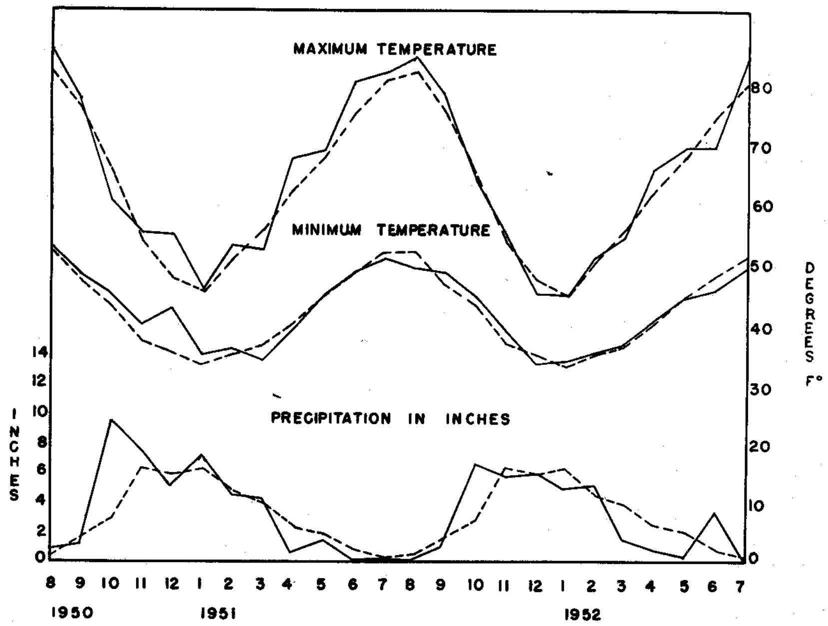

Figure 5. Precipitation and mean temperature by months shown as solid lines for 1950-51 and 1951-52. Broken lines indicate 60-year averages. Records taken at station on experimental area.

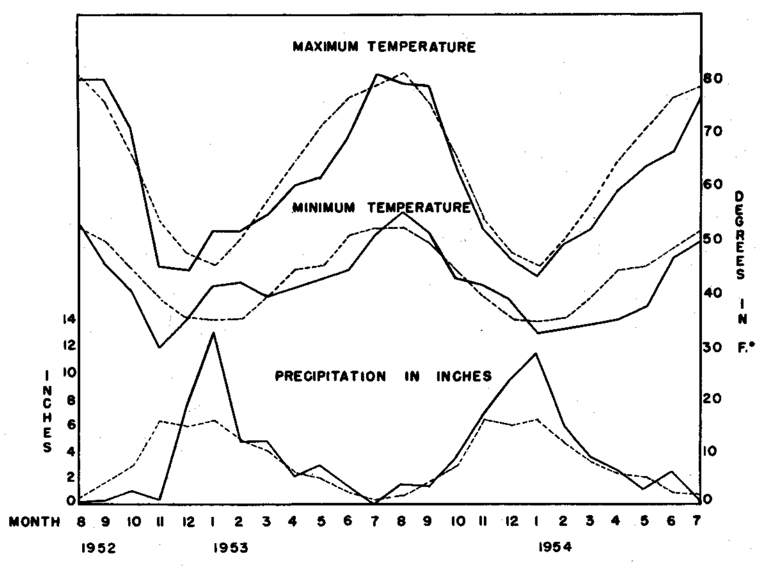

Figure 6. Precipitation and mean temperatures by months shown as solid lines for 1952-53 and 1953-54. Broken lines indicate 60-year averages. Records taken at station on experimental area.

Mean yields from the three elements, in tons per acre, are given in table 2. These data indicate that no practical advantage is realized from raising the nitrogen level from 200 to 300 pounds of N per acre. The residual effect of nitrogen fertilization was only about one-half as great in 1952 as compared to the first year response in 1951. No carry-over effect was observed for nitrogen in the third year.

table 1. Summary of analyses of variance of fertilizer yields over a 3-year period, 1951 through 1953, on Amity silty clay loam.

Source of variation	Degrees of freedom	Mean squares 1951	1952	1953
Replication	3	1.20**	108,715.81**	13,732.94*
N	2	101.66**	1,733,607.57**	10,404.68
P	1	1.13**	193,611.50**	24,053.13*
K	1	0.01	21,231.04	190.01
S	1	0.04	2,530.25	3,562.13
L	1	1.49**	114,709.63**	6,428.76
NP	2	0.17	20,790.85	4,902.54
NK	2	0.17	6,242.08	10,274.35
NS	2	0.03	7,653.01	3,419.76
NL	2	0.05	7,949.79	4,306.41
PK	1	0.00+	206.26	577.54
PS	1	0.51*	20.68	7,190.76
PL	1	0.05	2,798.38	16,706.67
KS	1	0.10	1,698.14	
KL	1	0.00+	740.26	
SL	1	1.00**	360.26	
Combined higher order interactions	27	None significant		
Error	141	0.11	8,861.07	5,124.54
Total	191			

*Significance at 05 level.
**Significance at 01 level.

Perhaps the most striking result from experiment 1 is the lowered production in 1952 on all plots, with and without nitrogen fertilization (table 2). In 1951 the plots were harvested to a 1-inch stubble height which apparently upset the normal physiology of the plants. Cutting was probably made before root and stem base storage of food reserves had taken place. This resulted in lowered plant vigor the subsequent year. To partially overcome this difficulty in later years, the stubble height in 1952 was raised from a 1- to a 2-inch level. Height-weight studies of Alta fescue made in this area indicate that about 10% of the weight of a 40-inch plant is found in the next to the last inch segment. Even if this adjustment for different stubble heights is made, the second year yield was reduced materially by lowered plant vigor. A further decline, but not so marked, occurring between 1952 and 1953 may have resulted from lowered vigor after continuous clipping, or simply a year difference.

Table 2. Mean yields in tons showing effects from nitrogen, phosphorus, and lime for a 3-year period.

Mean yields in dry weights for different nitrogen levels

Nitrogen per acre	Dry weight per acre		
	1951	1952	1953
Pounds	Tons	Tons	Tons
None - - - - - - - - - -	1.81*	0.94	0.77
200 - - - - - - - - - -	4.29	1.47	0.83
300 - - - - - - - - - -	4.50	1.75	0.81
LSD's (05) - - - - - - -	0.14	0.08	0.06

Mean yields in dry weights for phosphorus and lime

P_2O_5 per acre	1951		1952		1953	
Pounds	None	4 tons L	None	4 tons L	None	4 tons L
None - - - -	3.31**	3.56	1.19	1.36	.74	.81
500 - - - -	3.54	3.71	1.42	1.52	.84	.82
LSD's (05) - - - - - - - -	.16		.08		.07	

*Each mean based on 64 plots.
**Each mean based on 48 plots.

Samples of the first year yields from experiment 1 were taken from each plot and composited by replications. These were analyzed for crude protein content by the Department of Agricultural Chemistry under the direction of Dr. J. R. Haag. A summary of these analyses according to the level of nitrogen is as follows:

Levels of nitrogen fertilizer N per Acre pounds	Crude protein percent
None	6.32 $\pm$ .09
200	7.83 $\pm$ .08
300	8.50 $\pm$ .10

When these percentages are multiplied by herbage yields and the resulting pounds of protein per acre further reduced to pounds of nitrogen by multiplying by 16%, a recovery of 35% of the fertilizer nitrogen for the 200 pound rate is obtained. This is further increased by an additional approximate 6% the second year. The rate of recovery for the 300 pound rate is much lower. These figures are lower than ones recently reported by Wagner (1954), but much higher than those reported by Chamblee, et al. (1953) for grass and legume mixtures.

Experiment 2. -- Yields from this split-plot design are summarized in table 3.

table 3. Herbage yields from nitrogen-manure plots on a well-drained hill soil.

Date of harvest treatment	Herbage yields					
	December		April		June*	
	Manure	No Manure	Manure	No Manure	Manure	No Manure
	Tons/Acre		Tons/Acre		Tons/Acre	
Check ------------	0.21	0.21	0.46	0.58	0.95	0.69
33#N in fall 33#N in spring ---	0.52	0.60	1.52	1.33	1.57	1.26
66#N in fall -----	0.55	0.55	1.11	0.98	1.05	1.12
66#N in spring ---	--	--	0.93	0.64	1.40	1.08
LSD (05) -------------	.20		.49		.55	

*June yields represent total production from October 1951.

Yield increases from all treatments were significant with the exception of manure. Soil variability, especially in depth, within replications was so great that more samples were needed to attach significance to differences from application of manure on June cuttings. June yields were probably reduced by the dry, warm weather in April and May. (See figure 5 for climatic data.)

These results indicate that 33 pounds of nitrogen per acre was as satisfactory as heavier rates for fall growth. Fall application of nitrogen doubled the yield of herbage in December. Split applications of nitrogen (fall and spring) were superior to comparable rates applied at one time in either fall or spring. Manuring in late summer knocked down the old growth and promoted more even grazing by sheep in early spring (figures 3 and 4).

Experiment 3. -- Table 4 contains a summary of yields obtained from the nitrogen fertilizer factorial. The variance analyses of these yields are summarized in tables 5 and 6. Increases in yields from rate and date of application of nitrogen were significant at the 1% level. Differences in yields caused by source of nitrogen were not significant except in early spring yields. For example, in both April harvests there was a significant source and date interaction. This differential response of nitrate and sulfate was caused by the comparatively higher April yield from fall applied nitrate (table 4). There appears to be a carry-over effect of spring applied sulfate from 1953 to 1954 since the response of spring applications in the 1954 harvest was greater than for the fall applications.

Response to rate of nitrogen applied was nearly linear for sulfate over a 2-year period, but decreased between the 66- and the 99-pound rates for nitrate (table 4). This effect is further noted in the combined analysis (table 6) which indicates a significant interaction of source and rate,

Table 4. Summary of yields of air-dry herbage for 1953-54 with fall and spring application of nitrogen from two sources at three rates.

		Date of Harvest*										
		1953						1954				
		April		June		December		April		June		
Source	Rate	F	S	F	S	F	S	F	S	F	S	Means
		Lbs/acre		Lbs/acre		Lbs/acre		Lbs/acre		Lbs/acre		
	33	360	190	1,270	1,910	90	60	220	460	1,460	1,880	790
NH_4NO_3	66	540	310	2,520	3,000	120	110	700	410	2,490	2,940	1,310
	99	790	290	3,310	3,470	110	110	950	540	3,100	3,670	1,630
Means		560	260	2,360	2,790	110	100	620	440	2,350	2,830	1,230
	33	240	300	1,350	2,450	90	80	250	330	1,500	1,730	830
NH_4SO_4	66	360	280	2,540	3,230	100	90	400	510	2,490	2,580	1,260
	99	540	350	3,480	3,770	120	100	620	890	2,940	3,610	1,640
Means		380	310	2,460	3,150	100	90	430	580	2,310	2,640	1,240

*April yields represent total growth since the previous June.
December yields represent total growth since the previous June.
June yields represent total growth for the year.

Table 5. Separate analyses of variance of nitrogen fertilizer factorial by harvest dates.

Source of variation	DF	Mean squares				
		1953			1954	
		April	June	December	April	June
Replication	3	4,566.35*	9,546.91	12.95	6,895.61*	13,180.11
Source S	1	2,067.19	24,435.18	15.75	1,083.00	6,371.02
Rate R	2	8,076.40**	504,302.77**	152.66**	30,493.09**	460,979.02**
Date of app. D	1	16,762.69**	151,537.68**	81.38*	1.34	79,625.52**
S x R	2	478.94	1,417.57	31.76	441.00	636.26
S x D	1	6,188.02*	8,295.03	5.01	10,041.33*	2,745.19
R x D	2	3,347.32	16,780.57	15.94	3,170.58	5,582.51
S x R x D	2	268.27	1,112.02	13.67	7,668.68*	2,124.47
Error	33	1,345.87	9,845.53	14.20	1,974.44	5,759.47
Total	47					

*Significance at 05 level.
**Significance at 01 level.

Table 6. Analysis of yields obtained in June 1954 on nitrogen fertilizer factorial (includes regrowth on December and April harvests).

Source of variation	DF	Mean Squares
Replication	3	61,585.60**
Treatment	35	101,787.40**
Source (S)	1	3,495.77
Rate (R)	2	1,329,978.30**
Date of appl. (D)	1	482,967.09**
Time of harvest (H)	2	52,732.82**
S x R	2	26,480.02*
S x D	1	3.20
S x H	2	5,686.08
R x D	2	21,440.68
R x H	4	4,326.56
D x H	2	22,766.94
S x R x D	2	5,906.85
S x R x H	4	7,496.19
S x D X H	2	8,992.78
R x D x H	4	9,067.53
S x R x D x H	4	11,140.77
Error	105	7,594.99
Total	143	

*Significance at 05 level.
**Significance at 01 level.

and suggests the greater value of ammonium sulfate at rates exceeding 66 pounds of N per acre.(table 7).

On Amity soil, which is wet and rather poorly drained in winter, yields are in favor of spring applications. In contrast, well-drained hill lands responded favorably to fall applications (table 3). This response is particularly important for winter and early spring production.

Table 7. Yield data for June 1954, showing effects of application date of nitrogen, harvest time, nitrogen source, rate, and source by rate interaction on air-dry herbage yields.

Time of harvest	Date of application of N Fall	Spring	Harvest means
	Lbs/acre	Lbs/acre	Lbs/acre
December + June	1790	2610	2200
April + June	2120	2630	2380
June only	2330	2740	2530
Date means	2080	2660	

LSD_{05} Harvest means = 180
LSD_{05} Date means = 150

Source of nitrogen	Nitrogen* 33 lbs/acre	66 lbs/acre	99 lbs/acre	S means
	Lbs/acre	Lbs/acre	Lbs/acre	
NH_4NO_3	1620	2500	3060	2390
NH_4SO_4	1390	2360	3280	2350
R means	1510	2430	3170	

LSD_{05} R means = 180
LSD_{05} S means = 150

*Although a zero rate was not included in the factorial, check yields from nearby plots were approximately 800 pounds per acre.

Yields from plots harvested only once in June were greater than those harvested in December plus April and June (table 7). However, if one checks crude protein content of the forage, as summarized in table 8, it appears

Table 8. Effect of treatments in experiment 3 on crude protein content of herbage samples in April and June harvests.

Treatments	Time of harvest 1953 April	1953 June	1954 June
	Crude protein Percent	Percent	Percent
Source			
NO_3	13.26 ± .14	7.69 ± .03	6.48 ± .02
SO_4	13.51 ± .16	7.65 ± .04	6.42 ± .03
Rates Lbs/acre			
33	10.83 ± .27	7.61 ± .04	6.35 ± .02
66	13.53 ± .18	7.54 ± .05	6.41 ± .03
99	15.82 ± .23	7.87 ± .07	6.59 ± .05
Date of Application			
Fall	10.96 ± .06	7.36 ± .03	6.34 ± .02
Spring	15.82 ± .13	7.99 ± .04	6.57 ± .02
Harvest Date			
December + June			6.33 ± .02
April + June			6.79 ± .03
June only			6.23 ± .03

that the total pounds of protein per acre would be greater from two harvests — the first in April and the second in June. The analyses of protein content show significant effects of application date and nitrogen rate. Spring applications of nitrogen raised the crude protein content appreciably in April but this difference nearly disappeared by June. With these comparatively low rates of N, there is much less difference due to rate than was recorded with 200 and 300 pounds of nitrogen per acre in 1951.

The greatest influence on crude protein in 1954 was brought about by harvest dates. Regrowth from plots harvested in April was significantly higher in crude protein than from plots harvested in December plus June or in June alone. This improved quality of regrowth forage indicates the need for more than one harvest date on these pastures to supply the largest amount of total digestible nutrients per acre.

Because of the advantage that legumes generally show in comparison with fertilizer nitrogen (Brown and Munsell, 1943; Chamblee, *et al*., 1953; Wagner, 1954), it is believed that additional studies need to be conducted with legume-grass mixtures on these soils. In such a study it will be particularly important to consider interactions between grazing management and fertilizer practices. Results of this work should facilitate better understanding of reasons for legumes' failure or success in mixtures, under varying degrees of fertilization and pasture use. Such a study is in progress, with the predominant forage species being orchardgrass, burnet, and subclover (*Trifolium subterranean*).

Summary and Conclusions

A brief review of literature indicates that more information is needed on the response of nonirrigated pastures in western Oregon to fertilizer treatments. Three experiments were used to study fertilizer responses. Yields from a factorial experiment with three levels of nitrogen, and two levels each of phosphorus, potassium, sulfur, and lime, were obtained over a 3-year period. A single, heavy application of all fertilizers except nitrogen, one-fourth of which was applied in the fall and three-fourths in the spring, was made on Amity silty clay loam. The herbage cover was chiefly grass, established in 1944 and now principally composed of Alta fescue and orchardgrass with some burnet, annual grasses, and annual legumes.

Two additional experiments were undertaken with nitrogen fertilizer in testing rate, application date, and source effects on yields in December, April, and June on both hill and valley soils with similar plant cover.

Results in terms of yield and crude protein content of harvested forage may be summarized as follows:

1. Nitrogen gave the greatest response of the five fertilizers used.
2. Residual effects of nitrogen, phosphorus, and lime are not large under high rates of fertilization on Amity soil with a predominately grass cover.
3. Heavy rates of nitrogen produced significant increases in the forage's crude protein content the first year following application.
4. Nitrogen fertilizer on well-drained hill soils can be used to effectively increase yields of winter and early spring herbage. Split applications of nitrogen in fall and early spring were superior to equivalent rates in fall or spring alone.
5. Fall applications of ammonium nitrate were more effective than sulfate for increasing April yields on Amity soil. In contrast, sulfate gave a greater response in June yields, particularly when applied in the spring at the 99-pound rate. Otherwise, nitrogen source was not important.
6. Nearly linear responses were obtained at rates from 33 to 99 pounds of nitrogen. Total herbage production was greater from spring applications than fall, on Amity soil.
7. Crude protein in the April herbage was increased markedly by both fall and spring applications of nitrogen. No appreciable effects at rates less than 99 pounds were observed in June yields.
8. The greatest increase in crude protein content of forage harvested in June occurred on plots first harvested in April. This fact suggests improved quality of regrowth needs to be considered along with total herbage production in order to arrive at the best fertilization and management practices for these grass pastures.

9. More work is needed on the relative performance of grass versus legume-grass mixtures in this area. Emphasis needs to be placed on the relative roles that fertilizer and grazing management play in maintaining a suitable grass-legume mixture under nonirrigated conditions.

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