FERTILITY INVESTIGATIONS

With a Ladino-Orchardgrass Mixture in Southeastern Virginia

1954-1961

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Research Report 88

Virginia Agricultural Experiment Station
Blacksburg, Virginia

August 1964

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SUMMARY

Phosphorus, potassium, and nitrogen fertility investigations with a ladino-orchardgrass mixture were conducted on Bertie fine sandy loam at Holland, Virginia from 1954 to 1961. Fertilization rates for establishment of the seeding varied from 0 to 15 lb. per acre of nitrogen, 0 to 400 lb. per acre of phosphate (P_2O_5) and 0 to 100 lb. per acre of potash (K_2O). Annual fertilization rates varied from 0 to 150 lb. per acre of nitrogen, 0 to 100 lb. per acre of phosphate and 0 to 300 lb. per acre of potash. Several combinations among the ranges encompassed by these rates were applied. The principal results of this study are summarized in the following statements:

1. Average yields of approximately 4 tons per acre of forage, including weeds, were obtained from the highest rate of nitrogen (150 lb. per acre). The 50-lb. per acre rate of nitrogen in February or June produced about 1/4 ton more hay than the August 50-lb. application or the best no-nitrogen treatment. The highest yield of hay without nitrogen fertilization was 3.2 tons per acre. Significantly lower yields of hay were obtained from the unfertilized plots than from plots fertilized with potash or potash and phosphate.

2. Yields of first cutting hay were nearly double those of any other cutting; yields of third cutting hay were lowest.

3. The 150-lb. rate of nitrogen and to some extent the February 50-lb. rate markedly decreased the average percentage of ladino and increased the average percentage of orchardgrass in the clippings. Generally, the relative proportion of ladino was higher in forage fertilized with phosphorus and/or potassium than in that not fertilized.

4. In August 1959, average stands of both ladino and orchardgrass were lowest under the 150-lb. rate of nitrogen and next lowest on plots not fertilized with phosphorus. The highest stands of ladino and well above average stands of orchardgrass occurred on plots fertilized with 50 lb. of nitrogen each February.

5. The percentage of protein in ladino and orchardgrass was not influenced appreciably by any of the fertilizer treatments. However, the total production of protein by ladino and orchardgrass was highest for the February 50-lb. nitrogen treatment, but only slightly higher than some of the no-nitrogen treatments. If "weed" forage is included, the highest yields of protein were obtained from the 150-lb. rate of nitrogen. Nitrogen fertilization did not increase protein production so long as good stands of ladino persisted.

6. The percent of phosphorus, calcium, or magnesium in ladino and orchardgrass did not vary appreciably among the different fertility treatments. On the other hand, the potassium content of ladino was increased considerably by potassium fertilization.

7. Available soil phosphorus (Truog) levels in 1959 were still nearly similar among the various fertility treatments. However, there were somewhat lower amounts in plots which received heavy applications of potash

and less than 300 lb. per acre of phosphate during the previous 6-year period. By 1959, exchangeable soil potassium contents to a depth of at least 24" were markedly lower in plots fertilized at a rate of 50 lb. or less of potash, annually. Much of the potassium applied readily leached to the 18" to 24" depth and probably deeper. No such evidence was obtained regarding phosphorus. It is estimated that in terms of rapid soil analyses, establishment and/or maintenance of a high available phosphorus and a medium available potassium level was necessary for continued production of high yields of good quality forage on Bertie soils. The minimum rate of fertilization required to do this was approximately 400 lb. per acre of phosphate, all at establishment or divided annually, and 200 lb. per acre of potash, annually. Also, higher rates of both nutrients may be needed when nitrogen is applied.

8. Simple correlation studies indicated that although both ladino and orchardgrass stands in August 1959 were significantly (1% level) related to average hay yields (1956 to 1959), maintenance of the ladino stands was of greater relative importance for high yields, at least when no more than 50 lb. per acre of nitrogen is applied annually.

9. Relatively few significant correlations were obtained between plant data and available soil phosphorus data. On the other hand, soil potassium contents were quite closely correlated with that in both ladino and orchardgrass.

Fertility Investigations With a Ladino-Orchardgrass Mixture in Southeastern Virginia, 1954-1961

D. L. Hallock and R. E. Blaser[1]

Sharp increases in the number of livestock on southeastern Virginia farms necessitates emphasis on efficient pasture practices. Heretofore, little pasture fertility research had been conducted in the Tidewater area of Virginia. Furthermore, since soil and climatic factors which affect pasture fertilization practices differ in various parts of Virginia, research data obtained elsewhere frequently is not applicable to southeastern Virginia, thus necessitating local investigations.

The objectives of this investigation were to determine the relative amounts of phosphate and potash, as well as the time and method of their application, necessary to establish and maintain high yields of good quality pasture forage. Also studied was the effect of nitrogen fertilization, in addition to phosphate and potash amendments, on total yields, seasonal yields, and chemical and botanical composition of the forage.

METHODS AND MATERIALS

This experiment was conducted on Bertie fine sandy loam located at the Tidewater Research Station, Holland, Virginia. Bertie soils are somewhat poorly drained, with heavy sandy clay loam to sandy loam subsoils usually underlain by sandy substrata. The study was initiated in the fall of 1953 and concluded after the 1961 crop. The plots were 10' by 30' and were arranged in a randomized block design replicated 4 times. Dolomitic limestone at a rate of 1 ton per acre was broadcast uniformly on the soil, which was initially about pH 5.5. All fertilizer applied for establishment (Table 2) was broadcast by hand well ahead of seeding. Both the lime and fertilizer were incorporated into the soil surface by disking in a lengthwise direction through the previously plowed plots. A mixture of 8 lb. of orchardgrass and 2 lb. of inoculated ladino clover per acre was seeded over the area in September 1953 using a Brillion-type seeder. Very good stands were obtained. An attempt to reseed the site in September 1959 was unsuccessful because of dry weather. However, stands were successfully reestablished in February 1960, but no yield data were taken during that year. In preparation for the September 1959 reseeding, the plots were plowed and 1 ton per acre of lime broadcast uniformly and disked in as previously described. The fertilization program followed in 1953 for the original establishment of the forages was not repeated in 1959 or 1960; however, the regular maintenance fertilizer treatments were continued. In all cases during this experiment, 20% superphosphate, muriate of potash, and ammonium nitrate were the sources of phosphorus, potassium, and nitrogen.

The herbage was harvested 4 times annually. Cutting height was approximately 2". Yields were estimated from the weight of forage in a narrow (36" to 40")

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swath cut lengthwise through the middle of each plot. Samples of fresh hay from all plots were dried at 70°C and the content of dry matter determined for adjustment of yields. The botanical composition of the forage from each plot was estimated visually before the first and third cuttings, and by species separations of several pinch samples drawn at random from the second and fourth cuttings. These separates were dried at 70°C, weighed, and ground in a Christy Mill. Representative samples of the ground tissue were stored in tightly closed glass bottles for chemical analysis. The content of phosphorus in these samples was determined by vanadomolybdophosphoric colorimetry, the content of potassium, calcium, and magnesium was determined by flame photometry following dilute nitric acid dissolution of dry ashed tissue. Nitrogen contents were estimated by a micro-Kjeldahl method.

The stands of orchardgrass and ladino in each plot were estimated in August 1959. A frame 1 yard square divided into square foot sections was placed to best represent the average plant distribution and the number of shoots of each forage counted.

Prior to the annual maintenance fertilizer applications in February, the soil in each plot was sampled at depths of 0" to 1", 1" to 3", and 3" to 6". In August 1959, a special group of soil samples were taken by 6-inch increments to a depth of 24". These samples were analyzed for pH (1 to 1 soil-water ratio), contents of dilute-acid soluble phosphorus (Truog method), and exchangeable calcium, magnesium, and potassium (1.0 N neutral ammonium acetate at a 1 to 10 soil-water ratio). The amounts of cations in the soil extracts were determined by flame photometry. All soil samples were allowed to air dry before pulverization to pass a 2 mm. sieve.

Most of the soil and plant data obtained in the special 1959 sampling, and the regular 1956 and 1959 results from individual plots rather than treatment means, were included in simple correlation analyses. To reduce possible confounding of the results, data from plots regularly fertilized with nitrogen (treatments 17, 18, 19, and 20) were omitted in the correlation studies involving the regular soil and plant data. Only data from plots fertilized at the high nitrogen rate were omitted from the correlation studies using the special August 1959 plant and soil samples. Also, ordinary analysis of variance statistics were computed for all yield as well as certain other plant data.

RESULTS AND DISCUSSION

1. Weather-1954 to 1961

Mean air temperatures and total precipitation by months for 1954 to 1959 and 1961, as recorded at the Tidewater Research Station, are given in Table 1. These data are official U. S. Weather Bureau observations. The departures of these monthly means from normal (1933 to 1962 mean) are also given.

June and December 1955; January, February, March, and December 1958; and January 1961 generally were unusually cold, being 5 or more degrees below normal. May, November, and December 1954; January and November 1955; January 1956; January and October 1957; June and September 1958; January 1959; and April and May 1961 were also relatively cold, being from 2.5 to 5 degrees below normal. The coldest year was 1958 (-2.6°) followed by 1961 and 1955.

Table 1. Mean air temperatures and total precipitation by months for 1954 to 1959 and 1961, Tidewater Research Station, Holland, Virginia.

Month	Type of data	Mean* temperature - °F							Precipitation - inches						
		1954	1955	1956	1957	1958	1959	1961	1954	1955	1956	1957	1958	1959	1961
January	Mean	39.1	36.4	36.5	38.1	34.4	37.6	34.4	6.29	1.53	2.60	3.50	4.61	1.68	3.41
	Departure**	-1.5	-4.2	-4.1	-2.5	-6.2	-3.0	-6.2	+2.70	-2.06	-0.99	-0.09	+1.02	-1.91	-0.18
February	Mean	45.3	39.9	45.3	44.3	35.5	42.6	43.8	2.35	3.25	5.88	5.43	3.91	2.41	4.44
	Departure	+3.3	-2.1	+3.3	+2.3	-6.5	+0.6	+1.8	-1.33	-0.43	+2.20	+1.75	+0.23	-1.27	+0.76
March	Mean	48.5	52.4	47.0	47.4	43.5	48.6	52.0	3.80	3.56	3.35	4.47	3.88	3.50	3.25
	Departure	-0.8	+3.1	-2.3	-1.9	-5.8	-0.7	+2.7	+0.23	-0.01	-0.22	+0.90	+0.31	-0.07	-0.32
April	Mean	61.9	61.6	55.9	61.5	57.7	59.2	53.6	2.39	3.21	4.60	1.87	5.07	5.66	2.59
	Departure	+4.1	+3.8	-1.9	+3.7	-0.1	+1.4	-4.2	-0.94	-0.12	+1.27	-1.46	+1.74	+2.33	-0.74
May	Mean	62.9	67.6	65.4	67.2	66.4	69.2	64.2	5.93	2.23	2.93	2.77	6.31	1.16	8.38
	Departure	-4.2	+0.5	-1.7	+0.1	-0.7	+2.1	-2.9	+2.26	-1.44	-0.74	-0.90	+2.64	-2.51	+4.71
June	Mean	74.5	69.7	75.6	76.2	70.7	73.9	72.5	1.04	5.31	1.93	3.42	4.77	3.62	10.61
	Departure	+0.3	-5.1	+0.8	+1.4	-4.1	-0.9	-2.3	-3.58	+0.69	-2.69	-1.20	+0.15	-1.00	+5.99
July	Mean	77.1	80.1	77.9	77.1	80.0	77.9	77.8	4.34	3.55	5.90	2.27	3.00	10.55	3.42
	Departure	-0.3	+2.7	+0.5	-0.3	+2.6	+0.5	+0.4	-1.95	-2.74	-0.39	-4.02	-3.29	+4.26	-2.87
August	Mean	77.0	79.5	75.1	74.7	76.7	78.3	77.0	6.01	13.42	6.15	5.32	6.35	1.64	7.32
	Departure	+0.6	+3.1	-1.3	-1.7	+0.3	+1.9	+0.6	-0.50	+6.91	-0.36	-1.19	-0.16	-4.87	+0.81
September	Mean	72.7	71.7	69.6	73.6	68.5	71.8	74.2	1.58	10.34	5.70	4.21	0.21	1.92	4.09
	Departure	+1.6	+0.6	+1.5	+2.5	-2.6	+0.7	+3.1	-2.67	+6.09	+1.45	-0.04	-4.04	-2.33	-0.16
October	Mean	63.4	60.9	62.6	55.8	59.3	63.2	59.6	2.85	2.86	7.23	4.53	3.49	12.72	5.55
	Departure	+2.7	+0.2	+1.9	-4.9	-1.4	+2.5	-1.1	-0.26	-0.25	+4.12	+1.42	+0.38	+9.61	+2.44
November	Mean	47.8	48.0	49.4	51.3	54.0	50.8	52.5	2.57	2.62	1.46	6.13	1.71	2.68	2.32
	Departure	-3.2	-3.0	-1.6	+0.3	+3.0	-0.2	+1.5	-0.72	-0.67	-1.83	+2.84	-1.58	-0.61	-0.97
December	Mean	38.4	35.6	50.2	44.8	34.5	43.7	40.8	2.81	2.14	3.98	5.33	3.88	2.87	3.59
	Departure	-3.2	-6.0	+8.6	+3.2	-7.1	+2.1	-0.8	-0.11	-0.78	+1.06	+2.41	+0.96	-0.05	+0.67
Year	Mean	59.1	58.6	59.2	59.3	56.7	59.7	58.5	41.96	53.94	51.71	49.25	47.19	50.41	58.97
	Departure	-0.2	-0.7	-0.1	0.0	-2.6	+0.4	-0.8	-6.94	+5.04	+2.81	+0.35	-1.71	+1.51	+10.07

* Average of daily maximum and minimum monthly means.
** Departure = difference between that for the month in a particular year and the 30-year mean.

On the other hand, only December 1956 was at least 5 degrees (+8.6°) warmer than normal. The mean temperatures of February, April, and October 1954; March, April, July, and August 1955; February 1956; April, September, and December 1957; July and November 1958; October 1959; and March and September 1961 were from 2.5 to 5 degrees above normal. Only in 1959 was the annual mean temperature above normal, and then by less than one degree.

Exceptionally high amounts of rainfall (+4 or more inches) were noted for August and September 1955; October 1956; July and October 1959; and May and June 1961. Surpluses of 2" to 4" over normal occurred during January and May 1954; February 1956; November and December 1957; May 1958; April 1959; and October 1961. The total precipitation for 1955 was 5" and for 1961, 10" above the 1933-62 mean.

Abnormally low amounts of rainfall (-4") were received in July 1957, September 1958, and August 1959. Precipitation during June and September 1954; January and July 1955; January and June 1956; July 1958; May and September 1959; and July 1961 was from 2" to 4" under average. Nearly a 7" deficit was recorded for 1954. Generally, subnormal precipitation during the winter months does not create a serious problem, but prolonged dry spells in hot weather are often detrimental to ladino-orchardgrass swards. Prolonged periods of subnormal rainfall during June through September occurred in 1954 (-8.7"), 1956 (-3.4"), 1957 (-6.4"), 1958 (-7.3") and during May and June 1959 (-3.5"). This might have influenced longevity of the stands in this study.

II. Yields of Forage

The mean yields of ladino-orchardgrass hay obtained from the various treatments are given in Table 2 for each year 1954 to 1959 and 1961. The data indicate that approximately 4 tons of dry forage can be produced annually from a ladino-orchardgrass mixture with a good fertilization program. Such yields were obtained when 150 lb. per acre of nitrogen were applied (3 equal increments - February, June and August) in conjunction with ample phosphorus and potassium. However, the forage from these plots usually contained more weeds in the middle and late summer cuttings during the last 2 or 3 years of the investigations. The average annual yields were about 1/2 ton per acre higher when 150 rather than 50 lb. per acre of nitrogen were applied either in June or February. On the other hand, application of nitrogen at the lower rate in August did not increase yields over the no-nitrogen plots with similar phosphorus and potassium fertilization. These differences are significant at the 5% level for the 7-year period. No yield response was obtained from the application of 15 lb. per acre of nitrogen at establishment of the forage. This does not preclude a possible need for such fertilization on lighter soils lower in residual nitrogen.

The mean (7-year) annual yields of forage were 600 lb. per acre higher (significant at 5% level) on plots fertilized with 200 lb. of potash (no phosphorus) annually than on unfertilized plots. When ample phosphorus was applied, yields were statistically similar (5% level) at all levels of potash (K_2O) from 50 to 300 lb. per acre, annually. It appears that application of phosphorus increased potassium availability. However, there were no treatments in this study to show forage response to phosphorus without potassium fertilization. During the latter years of the study, average yields were higher at rates of potassium above the minimum. For instance, yields in 1959 and 1961 were approximately 1,000 to 1,300 lb. per acre higher on the plots which received the 300-lb. rate than on those fertilized with the 50-lb. rate of potash. The probable cause of this apparent

Table 2. Mean yields of ladino-orchardgrass hay grown under various rates and times of application of N, P, and K on Bertie fine sandy loam, 1954 to 1959 and 1961.

	Treatments* (Lbs./A.)						Pounds per acre hay at 12% moisture									
	N✝		P_2O_5		K_2O											
No.	Est.	Mtn.	Est.	Mtn.	Est.	Mtn.	1954	1955	1956	1957	1958	1959	1961	Total	Mean §	
1	15	0	0	0	0	0	7355	5265	6400	4555	4765	3320	3965	35,625	5090	f
2	15	0	0	0	100	200**	6865	5205	6625	5855	5710	4180	5405	39,845	5690	e
3	15	0	400	0	100	200**	7130	5430	7180	6520	5525	5146	5315	42,246	6035	cde
4	15	0	200	100	100	200**	7015	5965	6660	6700	4905	4750	5885	41,880	5980	cde
5	15	0	200	50	100	200**	7295	6025	6805	5980	6040	5010	5145	42,300	6040	cde
6	15	0	200	0	100	200**	7525	6545	6535	6140	6065	5375	5550	43,735	6250	cde
7	15	0	100	100	100	200**	7360	6085	6990	6150	5700	4545	5145	41,975	5995	cde
8	15	0	100	50	100	200**	7110	5760	7145	6890	5910	4960	5600	43,375	6195	cde
9	15	0	50	50	100	200**	6920	5350	6625	6090	5680	3820	5120	39,605	5660	e
10	15	0	0	100✝	100	200**	7115	6110	7130	7090	5515	6150	6315	45,425	6490	c
11	15	0	200	100	50	200**	7085	5660	6475	6670	5600	4980	6340	42,810	6115	cde
12	15	0	200	100	50	50	7055	5845	7090	6570	5690	4420	4730	41,400	5915	cde
13	15	0	200	100	100	100	7515	6140	6695	6455	6055	5390	5275	43,525	6220	cde
14	15	0	200	100	100	200	6975	5675	6550	6050	5820	4240	5660	40,970	5855	de
15	15	0	200	100	100	300‡	7085	5780	7300	6610	6620	5710	5720	44,825	6405	cd
16	0	0	200	100	100	200**	7185	5880	6750	6740	5580	4125	5930	42,190	6025	cde
17	15	50J	200	100	100	200**	7090	6565	7325	7525	8130	6350	6715	49,700	7100	b
18	15	50A	200	100	100	200**	7425	6395	7055	7190	6080	5640	5580	45,365	6480	c
19	15	50F	200	100	100	200**	7515	6930	7485	7325	6835	5895	7025	49,010	7000	b
20	15	150‡	200	100	100	200**	7225	8340	9180	7980	8500	9070	7725	58,020	8290	a

* Est. = applied at establishment only, Mtn. = applied annually beginning in February 1955, J = June, A = August, F = February.

✝ Maintenance fertilizer applications were started in 1954.

‡ One-third applied in February, 1/3 in June, 1/3 in August.

** One-half applied in February, 1/2 in June.

§ Significant (5% level) differences among 6-year means according to Duncan's Multiple Range Test.

increase in response with time was the gradual decline from the relatively high fertility level of the plot area initially. (See soil chemical study section).

The phosphate (P_2O_5) treatments (nos. 2 to 10) varied from none to 700 lb. per acre applied in various manners over the 7-year period. All plots in this group were fertilized with 200 lb. per acre of potassium, annually. Treatment 10, which included 100 lb. per acre of phosphate topdressed on the forage annually, beginning before the first harvest season but none when the test was seeded, produced significantly (5% level) more forage than the 0 phosphorus plots. Treatment 10 also significantly outyielded plots on which 50 lb. of phosphate were applied at establishment plus a similar amount annually, beginning with the second year. No other significant differences in yield were found among the various rates of phosphorus fertilization. With only one exception (treatment 9) the average yields of forage were increased at least 300 lb. per acre by phosphorus fertilization. This lack of yield response in treatment 9 appears irregular, since the second highest yield (without nitrogen) was obtained from the application of only 200 lb. of phosphate, all at establishment (treatment 6). Furthermore, 150 lb. per acre less phosphate was applied in treatment 6 than in treatment 9. The results from treatments 8 and 10 preclude explanation of this anomaly based on time of phosphorus application (establishment or maintenance). For the 7-year period, yields from treatment 6 average 560 lb. per acre higher than from the 0 phosphorus plots. Equal amounts of potassium were applied in both cases. Thus, under conditions similar to this study, a rate of phosphorus fertilization approximating treatment 6 appears most feasible.

It is apparent that some yield response was obtained to each of the 3 nutrients - phosphorus, potassium, and nitrogen. However, the most profitable rates of phosphorus and potassium are difficult to ascertain from the data in Table 2. Consider, for example, the approximate return from phosphorus and potassium in treatment 10, which produced the highest average yields without nitrogen. If the potassium and phosphorus cost 6¢ and 23¢ per pound, respectively, and hay is valued at $35 per ton, the average return from these nutrients for the 7-year period is $63 per acre above their cost. However, at similar prices the average return for each of the last 2 years of the study was $20 per acre above fertilizer cost. Nevertheless, even with similar fertilization, yields from treatments 4, 7, 11, and 16 are sufficiently lower than from treatment 10, so that the rates of potassium and phosphorus fertilization in these treatments may not be quite profitable. Thus, slightly lower levels probably should be recommended.

Application of 50 lb. per acre of nitrogen in February or June produced an annual average yield increase worth approximately $4 to $5, net, per acre. On the other hand, 150 lb. per acre of nitrogen (treatment 20) returned nearly $15 per acre net, annually, more than plots not fertilized with nitrogen. However, it is questionable that the quality of the forage was comparable at the various levels of nitrogen fertilization because of a reduction in the proportion of ladino (see botanical composition section). Also, in view of the lack of forage yield response to nitrogen applications in August, elimination of that part of treatment 20 might be practical.

The forage yields for the 7-year period, by cuttings, are presented in Table 3. Cool season forages normally follow a production pattern similar to that indicated by these data. Yields in the first cutting were nearly double those of any other cutting. Second and fourth cutting yields were quite similar

Table 3. Mean yields of ladino-orchardgrass hay by cuttings on Bertie fine sandy loam for the period 1954 to 1959 and 1961.

	Treatments* (Lbs./A.)						Pounds per acre of hay at 12% moisture				
	N†		P_2O_5		K_2O		April-May	May-June	June-July	Aug.-Sept.	Mean
No.	Est.	Mtn.	Est.	Mtn.	Est.	Mtn.	cutting	cutting	cutting	cutting	(annual)
1	15	0	0	0	0	0	1715	1110	975	1280	5080
2	15	0	0	0	100	200**	1930	1210	1150	1405	5740
3	15	0	400	0	100	200**	2195	1330	1170	1430	6125
4	15	0	200	100	100	200**	2170	1280	1170	1365	5985
5	15	0	200	50	100	200**	2150	1310	1120	1465	6045
6	15	0	200	0	100	200**	2225	1410	1175	1445	6255
7	15	0	100	100	100	200**	2130	1275	1130	1445	5980
8	15	0	100	50	100	200**	2195	1345	1200	1455	6195
9	15	0	50	50	100	200**	1970	1240	1100	1345	5655
10	15	0	0	100†	100	200**	2515	1410	1150	1420	6495
11	15	0	200	100	50	200**	2265	1260	1145	1435	6105
12	15	0	200	100	50	50	2085	1320	1105	1405	5915
13	15	0	200	100	100	100	2335	1405	1150	1335	6225
14	15	0	200	100	100	200	2115	1230	1105	1435	5885
15	15	0	200	100	100	300‡	2360	1355	1210	1460	6385
16	0	0	200	100	100	200**	2170	1330	1150	1380	6030
17	15	50J	200	100	100	200**	1980	1295	1950	1785	7010
18	15	50A	200	100	100	200**	2315	1370	1115	1685	6485
19	15	50F	200	100	100	200**	3230	1390	1105	1280	7005
20	15	150‡	200	100	100	200**	3095	1080	2190	1920	8285

* Est. = applied at establishment, Mtn. = applied annually beginning in February 1955, J = June, A = August, F = February.

† Maintenance fertilizer applications were started in 1954.

‡ One-third applied in February, 1/3 in June, and 1/3 in August.

** One-half applied in February, 1/2 in June.

and generally slightly higher than third cutting yields, except for certain nitrogen treatments. Applications of 50 lb. of nitrogen in early June increased third and fourth cutting yields, whereas that applied in February was ineffective on these cuttings. However, the February application increased first cutting yields considerably. The same amount of nitrogen applied in August increased fourth cutting yields slightly. Yields of all cuttings except the second were increased by the 150 lb. rate of nitrogen. Also, these treatments influenced the botanical composition of the 4 cuttings.

III. Botanical Composition and Stand Studies

The average estimated percentages of ladino and orchardgrass in first cutting forage for 1954 to 1959 are given in Table 4. Data for 1961 were not included here because they represent a new seeding. Fertilization did not influence the relative proportion of these 2 species greatly, except at the high rate of nitrogen. Application of 150 lb. per acre of nitrogen, annually, markedly decreased the average percentage of ladino and slightly increased the average percentage of orchardgrass. Also, the effect of the 50 lb. nitrogen application in February was similar but far less drastic. Generally, the relative proportion of ladino was higher in forage fertilized with phosphorus and/or potassium than in that not fertilized.

In general, the percentages of ladino and orchardgrass by weight in second cutting hay correspond closely with those for the first cutting. The proportion of ladino in the hay was significantly (5% level) lower at the high rate of N than for the other treatments. That for the February nitrogen (50 lb.) treatment was next lowest, although not significantly. Conversely, the relative content of orchardgrass was significantly higher for these 2 nitrogen treatments. Note that weed encroachment (ladino + orchardgrass = about 100%) in second cutting hay was lowest in plots fertilized at the 50 lb. rate of nitrogen in February. Under the 150 lb. rate of nitrogen, forage contained only 10% undesirable species. The highest average percentage of ladino in hay produced over the 6-year period occurred on plots fertilized with only 200 lb. per acre of phosphate when the stand was established but none for maintenance (treatment 6), plus ample potash but no nitrogen. No reasonable explanation can be offered for this inferred depressional effect of higher rates of phosphate fertilization. Since this mean percentage of ladino is not significantly higher than the means of any other treatments without nitrogen, the difference may be chance variation.

In general, the proportion of desired species was approximately 10% to 15% lower in third cutting hay than in the previous cutting. Again, there is little difference among the treatment effects, except nitrogen. In this cutting, application of nitrogen in June decreased the percentage of ladino but did not alter the content of orchardgrass. The effect of the February 50 lb. nitrogen treatment on the proportion of ladino and orchardgrass, noted for the 2 previous cuttings, was not observed. Also, the relative proportion of orchardgrass in this cutting was not increased by the 150 lb. rate of nitrogen.

The average contents of orchardgrass and ladino were lower in the fourth cutting (Table 4) than in any of the others. Since these are cool season species, it is probable that hot summer weather (Table 1) depressed growth more during this harvest period than others. Although the mean differences are small, the fertility treatments significantly influenced the proportion of ladino and

Table 4. Average percentages of ladino and orchardgrass in 4 cuttings of hay grown on Bertie fine sandy loam, 1954 to 1959. (Species separations were made on the second and fourth cuttings only).

	Treatments* (Lbs./A.)						Cuttings							
	N†		P_2O_5		K_2O		Ladino clover				Orchardgrass			
No.	Est.	Mtn.	Est.	Mtn.	Est.	Mtn.	First	Second	Third	Fourth	First	Second	Third	Fourth
1	15	0	0	0	0	0	44	41 ab§	36	19 abcd	45	53 bc	38	25 bcd
2	15	0	0	0	100	200**	51	45 ab	33	17 abcd	40	45 c	37	21 d
3	15	0	400	0	100	200**	55	47 ab	39	21 abc	39	50 c	43	29 abc
4	15	0	200	100	100	200**	52	43 ab	37	19 abcd	41	51 bc	40	23 cd
5	15	0	200	50	100	200**	52	45 ab	36	17 abcd	42	47 c	41	27 bcd
6	15	0	200	0	100	200**	58	53 a	42	23 a	39	44 c	41	28 abcd
7	15	0	100	100	100	200**	52	46 ab	35	18 abcd	42	51 bc	40	28 abcd
8	15	0	100	50	100	200**	52	47 ab	37	18 abcd	43	51 bc	41	35 a
9	15	0	50	50	100	200**	50	43 ab	34	20 abc	43	49 c	40	26 bcd
10	15	0	0	100†	100	200**	47	44 ab	37	19 abc	49	53 bc	44	32 ab
11	15	0	200	100	50	200**	50	43 ab	36	16 bcd	40	51 bc	40	29 abcd
12	15	0	200	100	50	50	53	43 ab	36	19 abcd	40	52 bc	42	30 abc
13	15	0	200	100	100	100	54	48 ab	41	23 a	41	51 bc	42	26 bcd
14	15	0	200	100	100	200	50	43 ab	34	17 abcd	43	52 bc	41	27 bcd
15	15	0	200	100	100	300‡	51	48 ab	38	17 abcd	44	49 bc	42	30 abc
16	0	0	200	100	100	200**	49	42 ab	37	18 abcd	44	48 c	39	28 abcd
17	15	50J	200	100	100	200**	46	42 ab	25	12 e	42	48 c	42	28 abcd
18	15	50A	200	100	100	200**	45	45 ab	35	15 de	48	51 bc	39	31 abc
19	15	50F	200	100	100	200**	42	37 b	36	19 abc	53	63 a	44	27 bcd
20	15	150‡	200	100	100	200**	25	27 c	18	14 e	60	63 a	41	24 bcd

* Est.= applied at establishment, Mtn.= applied annually beginning in February 1955, J = June, A = August, F = February.

† Maintenance fertilizer applications were started in 1954.

‡ One-third applied in February, 1/3 in June, and 1/3 in August.

** One-half applied in February, 1/2 in June.

§ Significant (5% level) differences among 6-year means according to Duncan's Multiple Range Test.

orchardgrass. The 150 lb., the June 50 lb., and to some extent the August 50 lb. applications of nitrogen reduced the relative content of ladino in the clippings. The highest average percentage of ladino occurred in treatments 6 and 13, and of orchardgrass in treatment 8. However, these results do not seem to be directly related to the fertility treatments. No particular treatment appeared to reduce appreciably the relative content of orchardgrass in this cutting. Yet, it did appear that potash without phosphate fertilization may have reduced the percentage of orchardgrass slightly.

Although annual data are not given, some mention should be made of the low content of ladino in the fourth cuttings beginning with 1957. Data given in Table 1 show that rainfall during the period April through August was 8.95" below normal. This dry weather certainly must have been a major cause for the poor growth of ladino and to a lesser extent of orchardgrass. Ladino did recover and produce well in the spring of 1958 and 1959 but not in July and August of these years. During both 1958 and 1959 the fourth cutting was plagued by drouths at certain times, but of much less severity than in 1957.

Six years after seeding, in August 1959, stands of ladino and orchardgrass were estimated. The results of this survey are recorded in Table 5. Apparently, there was so much variability among replications that the rather large differences among treatment means were not significant (5% level) for either crop. Nevertheless, definite tendencies are indicated and should be mentioned. Average stands of both ladino and orchardgrass were lowest under the 150 lb. rate of nitrogen and next lowest on the plots not fertilized with phosphorus. The highest average stands of ladino occurred on plots fertilized with 50 lb. of nitrogen in February. Also, orchardgrass stands on these plots were well above the test average. These results are of particular interest because they define the optimum time of application for nitrogen relative to the best maintenance of ladino stands. Furthermore, grazing animals would probably clip the ladino leaves from the short shoots which the mower missed in July and August, and thus the proportion of clover in their diet might be higher than indicated in the species separation data.

An important question not answered by these botanical composition and stand data is whether or not the reduced quality of the forage, resulting from less ladino on plots fertilized with 150 lb. per acre of nitrogen, is offset by increased yields. This question is considered in Section IV. It may be reasonable to postulate that annual nitrogen applications of about 75 lb. in February, 25 lb. in June, and none in August would be optimum for maximum feeding value per acre. Any good nitrogen fertilization program necessitates proper levels of other nutrients.

IV. Forage Chemical Composition Studies

Samples of ladino and orchardgrass from the second and fourth cuttings for most of the years 1954 to 1959 and 1961 were analyzed for contents of nitrogen, phosphorus, potassium, calcium, and magnesium. Species samples for these determinations were obtained from the botanical separations. The results of these determinations on ladino are presented in Table 6 and those on orchardgrass in Table 7.

There were no consistent differences among the 5-year treatment means for either species in the percentages of protein in the second cutting. Year to year

Table 5. Sixth-year stands of ladino clover and orchardgrass grown under several fertility systems on Bertie fine sandy loam, August 1959.

	Treatments* (Lbs./A.)						Number of shoots per square yard (4 replications)									
	N†		P_2O_5		K_2O		Ladino clover					Orchardgrass				
No.	Est.	Mtn.	Est.	Mtn.	Est.	Mtn.	1	2	3	4	Ave.	1	2	3	4	Ave.
1	15	0	0	0	0	0	158	11	1	60	57	81	2	1	23	26
2	15	0	0	0	100	200**	23	10	42	101	44	12	3	7	75	24
3	15	0	400	0	100	200**	240	88	220	33	145	59	58	54	17	47
4	15	0	200	100	100	200**	276	22	16	183	124	73	4	13	54	36
5	15	0	200	50	100	200**	153	32	131	18	84	109	6	49	8	43
6	15	0	200	0	100	200**	45	242	275	189	188	18	55	48	109	58
7	15	0	100	100	100	200**	123	90	15	26	64	99	41	4	9	38
8	15	0	100	50	100	200**	413	27	146	232	205	136	11	66	50	66
9	15	0	50	50	100	200**	31	239	32	29	83	11	147	28	3	47
10	15	0	0	100†	100	200**	60	95	375	292	206	40	96	62	23	55
11	15	0	200	100	50	200**	158	10	297	154	155	59	1	29	85	44
12	15	0	200	100	50	50	27	44	285	7	152	53	48	92	21	54
13	15	0	200	100	100	100	84	118	144	136	121	58	57	94	27	59
14	15	0	200	100	100	200	7	327	137	17	122	4	32	87	1	31
15	15	0	200	100	100	300‡	75	161	97	51	96	29	12	85	10	34
16	0	0	200	100	100	200**	298	49	19	174	135	69	7	8	60	36
17	15	50J	200	100	100	200**	86	28	4	130	62	25	18	13	70	32
18	15	50A	200	100	100	200**	12	65	185	45	77	40	30	59	8	34
19	15	50F	200	100	100	200**	285	80	389	155	227	21	44	61	82	52
20	15	150‡	200	100	100	200**	10	1	47	36	23	11	1	16	5	8

* Est. = applied at establishment, Mtn. = applied beginning in February 1955, J = June, A = August, F = February.

† Maintenance fertilizer applications were started in 1954.

‡ One-third applied in February, 1/3 in June, 1/3 in August.

** One-half applied in February, 1/2 in June.

variability accounts for most of the differences which did occur. In orchardgrass, the protein content diminished with the age of the stand; that in the new 1961 seeding was low also. Nitrogen did not increase the protein content of ladino or orchardgrass, appreciably, as might be expected. In fact, the total production of protein by the desired species in this cutting was slightly lower on all plots fertilized with nitrogen than on some of the other plots. This reduction in protein production resulted largely because orchardgrass, which contained less protein, made up a larger proportion of the hay where yield responses to nitrogen occurred. Thus, the relative proportion of protein from each of these species was changed considerably by the rate and by the time of nitrogen application. However, this slight depression in protein production by the second cutting under these nitrogen treatments was more than counterbalanced by the much higher production from these species in the first cutting.

In general, the percentages of crude protein in the fourth cutting do not have any marked relationship to the fertility treatments. The protein content in orchardgrass grown on the check plots in 1961 was slightly lower than for the fertilized plots. Also, orchardgrass fertilized with 50 lb. of nitrogen in August contained the highest average (4-year) percentage of protein, although the difference was small (Table 7). The average protein contents of fourth cutting orchardgrass were somewhat higher than for the second cutting. A similar tendency was shown by ladino, but not as clearly (Table 6). Total production of protein by the desired species in this cutting was highest from the August nitrogen application and lowest from the February application. The differences were quite small and not appreciably greater than from certain treatments exclusive of nitrogen.

The average total production of protein, annually, under the 4 treatments with nitrogen fertilization and one without (Treatment 6) was estimated by making certain assumptions. The protein contents of second and fourth cutting ladino and orchardgrass were used to calculate protein production of the first and third cutting, respectively. In each case the protein contents of the "weed" forage were assumed to be similar to orchardgrass. The no-nitrogen treatment 6, which produced hay that contained the highest average percentage of ladino for the 4 cuttings, was selected for comparison with the above treatments. Also, the total yield of hay from treatment 6 was third highest among the no-nitrogen treatments.

The total production of protein by ladino and orchardgrass was highest for the February 50-lb. nitrogen treatment (1,205 lb.) but only slightly higher than treatment 6 (1,185 lb.) without nitrogen. Protein yields were 1,120, 1,055 and 1,030 lb. per acre for the 150-lb. and August and June 50-lb. nitrogen treatments, respectively. When weeds were included, the 150-lb. rate produced the highest yield of protein (1,565 lb.) and the August 50-lb. rate the lowest (1,320 lb.). The June and February nitrogen treatments produced 1,425 and 1,410 lb. of protein, respectively. Treatment 6 was next to the lowest in protein production, with 1,375 lb. per acre.

These results bring out an important point. Nitrogen fertilization at rates and times of application, similar to those in this study, did not increase protein production and its use may not be economical so long as good stands of ladino persist. However, when ladino stands diminish, an early spring application probably would be most feasible. As pointed out previously (Table 5), ladino stands remained thicker under the February 50-lb. application than for

Table 6. Average percentages of crude protein, phosphorus, potassium, calcium, and magnesium in the ladino separates of second and fourth cutting hay grown on Bertie fine sandy loam, 1954 to 1956, 1959, and 1961. (Protein determined only in 1954 to 1956, 1959, and 1961).

	Treatments* (Lbs./A.)						Percentage in forage cuttings									
	N†		P_2O_5		K_2O		Protein		Phosphorus		Potassium		Calcium		Magnesium	
No.	Est.	Mtn.	Est.	Mtn.	Est.	Mtn.	2nd	4th	2nd	4th	2nd	4th	2nd	4th	2nd	4th
1	15	0	0	0	0	0	26.2	23.7	0.35	0.34	2.08	2.06	1.41	0.99	0.50	0.51
2	15	0	0	0	100	200**	25.6	24.5	0.33	0.35	3.44	3.53	1.05	0.86	0.41	0.45
3	15	0	400	0	100	200**	25.3	23.8	0.34	0.37	3.75	3.05	1.22	1.00	0.43	0.45
4	15	0	200	100	100	200**	25.6	24.5	0.34	0.36	3.35	3.31	1.18	1.12	0.41	0.44
5	15	0	200	50	100	200**	25.1	25.1	0.34	0.35	3.38	3.48	1.23	1.01	0.42	0.43
6	15	0	200	0	100	200**	26.5	25.7	0.36	0.37	3.53	3.50	1.48	0.95	0.43	0.46
7	15	0	100	100	100	200**	26.5	26.0	0.36	0.37	3.33	3.16	1.23	0.99	0.41	0.45
8	15	0	100	50	100	200**	26.2	24.0	0.33	0.35	3.18	3.36	1.21	0.97	0.42	0.44
9	15	0	50	50	100	200**	26.0	24.2	0.35	0.36	3.33	3.22	1.19	0.98	0.42	0.48
10	15	0	0	100†	100	200**	25.6	26.2	0.34	0.37	3.12	3.11	1.21	1.03	0.42	0.44
11	15	0	200	100	50	200**	27.0	23.2	0.36	0.36	3.14	3.26	1.25	1.08	0.41	0.44
12	15	0	200	100	50	50	26.1	25.0	0.37	0.38	2.54	2.13	1.36	1.13	0.49	0.48
13	15	0	200	100	100	100	26.3	24.4	0.35	0.38	2.88	2.40	1.33	1.20	0.44	0.51
14	15	0	200	100	100	200	25.6	24.2	0.35	0.36	3.42	3.00	1.25	0.95	0.41	0.45
15	15	0	200	100	100	300‡	26.0	25.3	0.34	0.36	3.76	3.61	1.15	0.96	0.40	0.43
16	0	0	200	100	100	200**	25.8	25.7	0.34	0.37	3.26	3.08	1.24	1.11	0.40	0.43
17	15	50J	200	100	100	200**	25.2	24.4	0.35	0.35	3.28	2.93	1.24	0.93	0.42	0.42
18	15	50A	200	100	100	200**	25.5	23.8	0.34	0.37	3.36	3.46	1.12	0.94	0.40	0.46
19	15	50F	200	100	100	200**	25.8	22.9	0.35	0.37	3.28	2.92	1.19	1.05	0.39	0.45
20	15	150‡	200	100	100	200**	25.2	24.5	0.37	0.39	3.21	3.43	1.13	0.98	0.41	0.42

* Est. = applied at establishment, Mtn. = applied annually beginning in February 1955, J = June, A = August, F = February.

† Maintenance fertilizer applications were started in 1954.

‡ One-third applied in February, 1/3 in June, 1/3 in August.

** One-half applied in February, 1/2 in June.

Table 7. Average percentages of crude protein, phosphorus, potassium, calcium, and magnesium in the orchardgrass separates of second and fourth cutting hay grown on Bertie fine sandy loam, 1954 to 1959 and 1961. (Protein determined only in 1954 to 1956, 1959, and 1961).

	Treatments* (Lbs./A.)						Percentage in forage cuttings									
	N†		P_2O_5		K_2O		Protein		Phosphorus		Potassium		Calcium		Magnesium	
No.	Est.	Mtn.	Est.	Mtn.	Est.	Mtn.	2nd	4th	2nd	4th	2nd	4th	2nd	4th	2nd	4th
1	15	0	0	0	0	0	16.8	18.2	0.50	0.44	3.23	2.91	0.27	0.28	0.33	0.37
2	15	0	0	0	100	200**	15.0	18.9	0.47	0.43	3.90	3.98	0.23	0.20	0.25	0.28
3	15	0	400	0	100	200**	16.4	18.2	0.48	0.42	3.89	3.78	0.27	0.25	0.25	0.27
4	15	0	200	100	100	200**	15.9	17.8	0.51	0.46	3.94	3.81	0.26	0.24	0.26	0.27
5	15	0	200	50	100	200**	15.9	18.3	0.53	0.40	3.98	3.63	0.26	0.23	0.27	0.26
6	15	0	200	0	100	200**	17.6	19.1	0.51	0.43	3.98	3.95	0.24	0.21	0.27	0.27
7	15	0	100	100	100	200**	16.2	19.2	0.50	0.43	3.88	3.62	0.25	0.24	0.25	0.27
8	15	0	100	50	100	200**	16.1	18.0	0.50	0.46	3.99	4.02	0.27	0.24	0.27	0.29
9	15	0	50	50	100	200**	16.1	18.9	0.51	0.42	4.06	3.68	0.26	0.22	0.27	0.29
10	15	0	0	100†	100	200**	15.8	18.5	0.51	0.48	3.89	4.00	0.29	0.30	0.26	0.30
11	15	0	200	100	50	200**	15.6	19.0	0.52	0.40	3.87	3.97	0.26	0.26	0.26	0.23
12	15	0	200	100	50	50	16.9	18.8	0.54	0.51	3.71	3.11	0.29	0.26	0.30	0.29
13	15	0	200	100	100	100	15.7	18.7	0.53	0.54	3.89	3.60	0.27	0.27	0.26	0.30
14	15	0	200	100	100	200	16.1	18.7	0.52	0.48	4.02	3.83	0.26	0.27	0.25	0.28
15	15	0	200	100	100	300‡	16.0	18.2	0.54	0.48	4.02	3.98	0.26	0.23	0.25	0.26
16	0	0	200	100	100	200**	15.6	18.3	0.51	0.45	3.89	3.88	0.26	0.23	0.27	0.26
17	15	50J	200	100	100	200**	16.3	19.3	0.49	0.46	3.88	4.00	0.25	0.23	0.24	0.28
18	15	50A	200	100	100	200**	16.1	19.7	0.49	0.49	3.86	4.24	0.26	0.23	0.24	0.28
19	15	50F	200	100	100	200**	16.2	19.0	0.51	0.42	4.01	3.72	0.28	0.23	0.26	0.28
20	15	150‡	200	100	100	200**	17.4	18.5	0.46	0.43	3.90	4.31	0.26	0.22	0.26	0.26

* Est. = applied at establishment, Mtn. = applied annually beginning in February 1955, J = June, A = August, F = February.

† Maintenance fertilizer applications were started in 1954.

‡ One-third applied in February, 1/3 in June, 1/3 in August.

** One-half applied in February, 1/2 in June.

any of the other nitrogen treatments. If highest production of dry matter is desired and/or maximum protein production with orchardgrass or other grasses when ladino stands are poor, then nitrogen fertilization certainly would be profitable.

Fertility treatment differences did not affect the phosphorus content of the hay appreciably throughout the study. Since the phosphorus content of the forage from the check plots was similar to that in highly fertilized forages, even for the last year of the study, soil phosphorus availability without fertilization was apparently not severely limiting. However, total uptake of phosphorus was lower on the check plots because of lower yields.

In contrast to phosphorus, the contents of potassium in ladino particularly (Table 6), but also in orchardgrass, responded considerably to treatment differences. The hay from the check plots contained the lowest percentage of potassium, and that from the 300-lb. rate of potassium fertilization the highest. Potassium contents of ladino fertilized at the intermediate rates also varied in direct relation to the rate of potassium application. These relationships are similar for both cuttings.

The calcium contents of the second and fourth cuttings of ladino and orchardgrass are quite similar for all fertility treatments. Second cutting ladino is slightly higher in calcium than fourth cutting; that in the 2 cuttings of orchardgrass is comparable. Similarly, the percentages of magnesium differed little among treatment means, except that magnesium contents of both species were higher when not fertilized. This effect is probably related to the lower potassium content of unfertilized forage.

The general lack of variability in certain nutrient contents of these forage species, with large differences in fertilization rates, indicated a high level of residual availability of these elements in this soil during this study.

V. Soil Chemical Studies

In the next 2 tables, data obtained by various soil chemical analyses are presented for 1955 and 1959. The 1955 data refer only to the top 6" of soil. The 1959 data refer to analysis of both the surface and subsoil to a depth of 24". Soils were sampled in February 1955 and in August 1959.

The available phosphorus levels (Table 8) did not vary greatly with treatments which supplied none to 700 lb. per acre of phosphate (P_2O_5) during the 6-year period. However, the amount of phosphorus in the top 24" of soil fertilized with considerable potash and less than 400 lb. per acre of phosphate during this period is somewhat below that of the others. This effect is particularly apparent by comparison of treatments 1 and 2, no fertilization versus potash fertilization only. There is little if any evidence in these data showing downward movement of phosphate beyond the first sampling increment. Apparently, most of the applied phosphorus in excess of plant removal must have changed to forms not readily detectable by the extractant utilized, since it is unlikely that it all leached deeper than 24". On the other hand, the level of available phosphorus in the surface layer at least, in 1955 and 1959, were quite similar even on the check plots. Thus, sufficient phosphorus from a residual source was converted into available form to maintain its level nearly equivalent to that in the highly fertilized plots.

Table 8. Contents of 0.002N H_2SO_4 (Truog) phosphorus and exchangeable potassium in the soil at 4 depths under ladino-orchardgrass sod on Bertie fine sandy loam, 1955 and 1959.

Treat- ment no.	Total applied 1953-1959: (Lb./A.)* N†	P_2O_5	K_2O	Soil phosphorus 1955 0-6"	Soil phosphorus 1959 0-6"	7-12"	13-18"	19-24"	Total	Soil potassium 1955 0-6"	Soil potassium 1959 0-6"	7-12"	13-18"	19-24"	Total
1	15	0	0	80	98	75	28	23	224	80	55	40	55	60	210
2	15	0	1100	100	90	24	26	20	160	130	270	175	130	90	665
3	15	400†	1100	135	104	58	24	12	198	110	260	165	115	90	630
4	15	700	1100	115	130	71	54	40	295	100	205	130	105	70	510
5	15	450	1100	120	110	54	40	22	226	115	230	115	100	85	530
6	15	200†	1100	100	103	59	19	12	193	125	305	185	105	90	685
7	15	600	1100	100	130	74	41	12	257	130	205	120	80	90	495
8	15	350	1100	105	110	66	32	29	237	100	285	145	95	105	630
9	15	300	1100	90	100	37	22	19	178	125	380	205	155	120	860
10	15	600	1100	110	109	59	31	25	224	110	220	155	95	75	545
11	15	700	1050	100	108	83	45	26	261	70	290	180	125	105	700
12	15	700	300	135	116	66	32	22	236	70	55	50	50	45	200
13	15	700	600	70	115	63	32	18	228	75	110	80	65	45	300
14	15	700	1100	75	104	62	29	28	223	60	300	170	130	85	685
15	15	700	1500**	130	145	48	48	24	265	150	400	240	185	130	955
16	0	700	1100	100	107	51	27	20	205	110	195	110	85	95	485
17	315J	700	1100	135	135	51	28	40	254	115	245	135	100	105	585
18	315A	700	1100	90	100	82	38	38	258	130	175	110	100	95	480
19	315F	700	1100	115	112	61	36	6	215	100	165	120	60	65	410
20	900**	700	1100	105	121	59	29	22	231	130	150	90	80	85	405

* Mostly applied in 1 or 2 annual applications unless otherwise indicated. J = June, A = August, F = February.

† Applied for establishment in 1953 (includes all 15-lb. N applications, not other N).

** One-third applied in February, 1/3 in June, 1/3 in August.

In contrast to the soil phosphorus data, exchangeable soil potassium levels (Table 8) were influenced considerably by potassium fertilization. The potassium content of the 0" to 6" layer by 1959 varied from 55 to 400 lb. per acre as the amount of potash (K_2O) applied over the 6-year period increased from 0 to 1,400 lb. That in the other 3 layers was distributed in a similar pattern. Considerable movement of topdressed potassium into lower layers is indicated. The difference in the 18" to 24" layer was approximately 50 versus 130 lb. of exchangeable potassium per acre for the 2 extremes, respectively. Soil potassium contents in all layers in plots fertilized at the 300 lb. rate (6 years - treatment 12) were equivalent to the check plots.

Approximately 1,050 lb. of potash were removed in the hay harvested on the check plots during the 6-year period. Hence, even more is needed on the fertilized plots because of higher yields and increased potassium contents in the hay. It appears that under highly efficient conditions the 200-lb. annual rate is the minimum amount necessary to replace that removed in 3 tons per acre of hay. The data show that at this rate soil potassium levels remained quite high in all soil layers. However, there appeared to be some buildup at a rate of 100 lb. per acre of potash, annually, as indicated by the 1955 versus 1959 data for treatment 13. The 0" to 6", 7" to 12", 13" to 18", and 19" to 24" layers contained about 250, 160, 120, and 100 lb. per acre of exchangeable potassium, respectively, in 1959. Under similar potassium fertilization, but when 50 lb. per acre of nitrogen was applied either in February or June, the soil potassium levels were somewhat lower. At the 150 lb. rate of nitrogen, these levels were down to 150, 90, 80, and 85 lb., respectively, in the 4 layers. Increased yields as well as higher potassium contents in the orchardgrass fraction, which were favored somewhat by nitrogen fertilization, caused removal of more soil potassium. This is reflected in the data for all 4 depths. Plots which received 100 lb. per acre of potash annually (treatment 13) contained only 110, 80, 65, and 45 lb. of exchangeable soil potassium by 1959.

It is difficult, if possible from the data presented, to predict accurately the optimum soil phosphorus and potassium levels which should be maintained. A level of approximately 100 lb. per acre of both available phosphorus (Truog) and exchangeable potassium or their equivalent is given as a reasonable estimate. In terms of rapid soil analyses, this means maintenance of a high available phosphorus and medium available potassium level is probably most feasible.

Soil pH and contents of exchangeable calcium and magnesium for the surface layer in 1955 and for all 4 soil depths in 1959 are recorded in Table 9. These data show that the soil to a depth of 24", at least, was well supplied with available calcium and magnesium in spite of the rather low pH levels below the plow layer. Also, over the 6-year period, the pH of the surface soil had become somewhat below that considered desirable for ladino, having declined approximately 0.6 to 0.8 pH units. Another application of lime during this period probably would have been warranted. Although the data are not given in these tables, the 0" to 6" layer initially was limed to pH 6.0.

VI. Simple Correlation Studies

A. Regular 1956 and 1959 Soil and Plant Data

Simple correlation statistics were calculated using certain data obtained from the regular 1956 and 1959 soil and plant samples. The soil samples were

Table 9. Soil pH and contents of exchangeable soil calcium and magnesium at 4 depths under ladino-orchardgrass sod on Bertie fine sandy loam, 1955 and 1959.

	Soil pH					Soil calcium						Soil magnesium					
	1955	1959				1955	1959					1955	1959				
Trt. no.	0-6"	0-6"	7-12"	13-18"	19-24"	0-6"	0-6"	7-12"	13-18"	19-24"	Total	0-6"	0-6"	7-12"	13-18"	19-24"	Total
1	5.7	5.4	5.1	4.8	4.5	1100	1405	655	410	315	2785	270	275	160	100	65	600
2	5.6	5.3	4.7	4.6	4.6	1045	1020	405	280	245	1950	225	190	100	65	70	425
3	5.8	5.1	4.9	4.5	4.5	1425	1150	720	375	315	2560	265	140	120	80	70	410
4	5.7	5.2	4.8	4.5	4.5	1075	1240	645	385	360	2630	225	145	120	80	80	425
5	5.8	5.2	5.0	4.7	4.5	1195	1320	680	401	320	2720	255	185	150	100	80	515
6	5.7	5.2	4.9	4.4	4.5	1295	1440	645	345	305	2735	260	245	150	90	80	565
7	5.8	5.3	5.0	4.6	4.5	1235	1440	655	390	320	2805	280	180	160	85	70	495
8	5.7	5.1	4.9	4.4	4.5	1210	1390	675	385	365	2815	260	170	130	100	85	485
9	5.6	5.2	4.9	4.6	4.6	1060	1175	590	400	295	2460	235	155	125	100	70	450
10	5.7	5.2	4.9	4.5	4.6	1360	1565	825	405	345	3140	315	185	150	90	80	505
11	5.7	5.3	4.8	4.6	4.5	1130	1235	655	375	310	2575	245	165	130	75	70	440
12	5.7	5.4	5.0	4.6	4.4	1335	1435	785	445	315	2980	290	245	155	85	95	580
13	5.7	5.3	5.0	4.8	4.5	1360	1510	765	380	280	2935	300	190	150	75	70	485
14	5.7	5.4	5.0	4.7	4.5	1080	1355	705	455	355	2870	245	170	140	105	85	500
15	5.7	5.3	4.7	4.7	4.5	1180	1375	605	455	315	2750	230	150	105	100	65	420
16	5.7	5.1	4.9	4.6	4.5	1205	1365	750	385	365	2865	245	175	140	100	80	495
17	5.6	5.3	4.9	4.8	4.7	1160	1605	620	400	480	3105	250	230	170	90	95	585
18	5.7	5.4	5.0	4.7	4.6	1190	1425	725	435	350	2935	255	230	170	105	75	580
19	5.7	5.1	4.9	4.6	4.6	1280	1560	650	390	320	2920	260	185	130	95	65	475
20	5.8	5.4	5.1	4.9	4.8	1205	1340	655	420	320	2735	250	215	125	90	60	490

those obtained in February from the 0" to 1", 1" to 3", and 3" to 6" layers. Correlation coefficients were determined for 167 comparable relationships where similar data for both years were available. Fourteen were significant (5% level or higher) both years, 11 were significant in 1956 only, and 43 in 1959 only. In some cases, comparable data were not obtained both years. Most of these relationships involved 1956 data, of which 39 were significant at the 5% level or higher. In all, approximately 500 relationships were correlated and 111 of the coefficients were significant.

Soil pH was correlated with 26 variables, but significant relationships were found only for 1956 data. In 3 cases it was positively related to the calcium and magnesium content of the hay. Also, soil pH was positively related to the percentage of orchardgrass and to the percentage of phosphorus in ladino in fourth cutting hay.

The contents of available soil phosphorus in the 0" to 1", 1" to 3", and 3" to 6" layers were each correlated with 21 variables for 1956 and about half as many for 1959. Seventeen significant relationships were found. Of perticular interest among these is the highly significant inverse relationship between soil phosphorus in the 0" to 1" layer and the content of ladino and orchardgrass in the hay in 1956. A similar correlation did not exist for the other 2 soil layers. Other significant relationships were noted between soil phosphorus and the content of phosphorus in orchardgrass particularly, and in ladino when the amount of phosphorus in the 3" to 6" layer was considered. Also, the percentage of magnesium in both second cutting ladino and orchardgrass in 1959, but not 1956, was inversely related to the level of phosphorus in the 0" to 1" layer.

The correlations between the content of exchangeable soil potassium and the 21 plant variables were generally more significant, as well as more consistent, for both years than for the other soil factors. Forty-four relationships were significant, with many coefficients much larger than the minimum requirement. Soil potassium in all 3 layers seemed to be inversely related to the contents of phosphorus in ladino and of calcium and magnesium in both ladino and orchardgrass. On the other hand, the amount of soil potassium was closely and positively related to its percentage in the hay.

The contents of calcium in the 0" to 1" and 3" to 6" soil layers were quite closely related to the yields of hay both years. In some instances, soil calcium was significantly correlated with the percentage of ladino and occasionally orchardgrass in the hay, but these relationships varied with years.

Significant correlations involving the content of exchangeable soil magnesium were limited mostly to 1959 data. Soil magnesium levels in the 0" to 1" and 1" to 3" layers were directly related to the percentage of magnesium in the hay. Orchardgrass content of the hay was directly related to the content of magnesium in all 3 soil layers, but ladino was related only to that in the 1" to 3" and 3" to 6" layers. Also, the magnesium content of these 2 lower layers was directly related to the yield of hay in 1959.

The following positive relationships were significant[1] both in 1956 and 1959. The correlation coefficients are listed for 1956 and 1959, respectively.

1/*Significant at the 5% level, **Significant at the 1% level.

1. PP2M soil P in 1" to 3" layer vs. % P in 2nd cut orchardgrass (0.271*, 0.326*).
2. PP2M soil Ca in 0" to 1" layer vs. yield of hay (0.227*, 0.354**).
3. PP2M soil Ca in 3" to 6" layer vs. yield of hay (0.356**, 0.330**).
4. PP2M soil Ca in 0" to 6" layer vs. yield of hay (0.305**, 0.491**).
5. PP2M soil K in 0" to 1" layer vs. % K in 2nd cut ladino (0.630**, 0.507**).
6. PP2M soil K in 0" to 1" layer vs. % K in 2nd cut orchardgrass (0.242*, 0.316**).
7. PP2M soil K in 1" to 3" layer vs. % K in 2nd cut ladino (0.564**, 0.595**).
8. PP2M soil K in 3" to 6" layer vs. % K in 2nd cut ladino (0.405**, 0.474**).
9. PP2M soil K in 0" to 6" layer vs. % K in 2nd cut ladino (0.610**, 0.632**).

The following positive relationships were significant only in 1956, but data were available both years.

1. Soil pH of 0" to 6" layer vs. % Ca in 2nd cut ladino (0.260*).
2. Soil pH of 0" to 6" layer vs. % Ca in 2nd cut orchardgrass (0.330*).
3. Soil pH of 0" to 6" layer vs. % Mg in 2nd cut ladino (0.227*).
4. PP2M soil P in 0" to 1" layer vs. % P in 2nd cut orchardgrass (0.267*).
5. PP2M soil P in 3" to 6" layer vs. % P in 2nd cut ladino (0.252*).
6. PP2M soil P in 3" to 6" layer vs. % P in 2nd cut orchardgrass (0.323**).
7. PP2M soil P in 0" to 6" layer vs. % P in 2nd cut orchardgrass (0.314**).
8. PP2M soil Ca in 0" to 1" layer vs. % P in 2nd cut ladino (0.292**).

The following positive relationships were significant only in 1959, but data were available both years.

1. PP2M soil P in 0" to 6" layer vs. % Ca in 2nd cut ladino (0.232*).
2. PP2M soil Ca in 0" to 1" layer vs. % ladino in 2nd cut hay (0.297**).
3. PP2M soil Ca in 0" to 1" layer vs. % orchardgrass in 2nd cut hay (0.330**).
4. PP2M soil Ca in 0" to 1" layer vs. % P in 2nd cut orchardgrass (0.252*).
5. PP2M soil Ca in 0" to 1" layer vs. % Ca in 2nd cut ladino (0.260*).
6. PP2M soil Ca in 0" to 1" layer vs. % Mg in 2nd cut ladino (0.223*).
7. PP2M soil Ca in 3" to 6" layer vs. % ladino in 2nd cut hay (0.246*).
8. PP2M soil Ca in 0" to 6" layer vs. % ladino in 2nd cut hay (0.413**).
9. PP2M soil Ca in 0" to 6" layer vs. % orchardgrass 2nd cut hay (0.275*).
10. PP2M soil Mg in 0" to 1" layer vs. % orchardgrass 2nd cut hay (0.301**).
11. PP2M soil Mg in 0" to 1" layer vs. % Mg in 2nd cut ladino (0.483**).
12. PP2M soil Mg in 0" to 1" layer vs. % Mg in 2nd cut orchardgrass (0.407**).
13. PP2M soil Mg in 3" to 6" layer vs. yield of hay (0.394**).
14. PP2M soil Mg in 3" to 6" layer vs. % ladino in 2nd cut hay (0.359**).
15. PP2M soil Mg in 3" to 6" layer vs. % orchardgrass 2nd cut hay (0.223*).
16. PP2M soil Mg in 0" to 6" layer vs. yield of hay (0.301**).
17. PP2M soil Mg in 0" to 6" layer vs. % ladino in 2nd cut hay (0.321**).
18. PP2M soil Mg in 0" to 6" layer vs. % orchardgrass in 2nd cut hay (0.321**).
19. PP2M soil Mg in 0" to 6" layer vs. % Mg in 2nd cut ladino (0.444**).
20. PP2M soil Mg in 0" to 6" layer vs. % Mg in 2nd cut orchardgrass (0.268*).
21. PP2M soil K in 1" to 3" layer vs. % K in 2nd cut orchardgrass (0.244*).
22. PP2M soil K in 0" to 6" layer vs. % K in 2nd cut orchardgrass (0.327**).

The following negative relationships were significant for both years. The correlation coefficients are listed for 1956 and 1959, respectively.

1. PP2M soil K in 0" to 1" layer vs. % Ca in 2nd cut ladino (0.313**, -0.304**).
2. PP2M soil K in 1" to 3" layer vs. % P in 2nd cut ladino (-0.250*, -0.258*).
3. PP2M soil K in 1" to 3" layer vs. % Mg in 2nd cut orchardgrass (-0.231*, -0.341**).
4. PP2M soil K in 0" to 6" layer vs. % P in 2nd cut ladino (-0.223*, -0.303**).
5. PP2M soil K in 0" to 6" layer vs. % Ca in 2nd cut ladino (-0.235*, -0.303**).

The following negative relationships were significant only in 1956, but data were available both years.

1. PP2M soil P in 0" to 1" layer vs. % ladino in 2nd cut hay (-0.317**).
2. PP2M soil P in 0" to 1" layer vs. % orchardgrass in 2nd cut hay (-0.302**).
3. PP2M soil P in 0" to 6" layer vs. % ladino in 2nd cut hay (-0.232*).

The following negative relationships were significant only in 1959, but data were available both years.

1. PP2M soil P in 0" to 1" layer vs. % Mg in 2nd cut ladino (-0.244*).
2. PP2M soil P in 0" to 1" layer vs. % Mg in 2nd cut orchardgrass (-0.368**).
3. PP2M soil P in 0" to 6" layer vs. % Mg in 2nd cut orchardgrass (-0.276*).
4. PP2M soil Mg in 0" to 1" layer vs. % K in 2nd cut ladino (-0.463**).
5. PP2M soil Mg in 0" to 1" layer vs. % K in 2nd cut orchardgrass (-0.314**).
6. PP2M soil Mg in 0" to 6" layer vs. % K in 2nd cut ladino (-0.276*).
7. PP2M soil K in 0" to 1" layer vs. % P in 2nd cut ladino (-0.254*).
8. PP2M soil K in 0" to 1" layer vs. % P in 2nd cut orchardgrass (-0.299**).
9. PP2M soil K in 0" to 1" layer vs. % Ca in 2nd cut orchardgrass (-0.226*).
10. PP2M soil K in 0" to 1" layer vs. % Mg in 2nd cut orchardgrass (-0.403**).
11. PP2M soil K in 0" to 1" layer vs. % Mg in 2nd cut ladino (-0.480**).
12. PP2M soil K in 1" to 3" layer vs. % Ca in 2nd cut ladino (-0.240**).
13. PP2M soil K in 1" to 3" layer vs. % Mg in 2nd cut ladino (-0.495**).
14. PP2M soil K in 3" to 6" layer vs. % orchardgrass in 2nd cut hay (-0.276*).
15. PP2M soil K in 3" to 6" layer vs. % P in 2nd cut ladino (-0.242*).
16. PP2M soil K in 3" to 6" layer vs. % Mg in 2nd cut ladino (-0.382**).
17. PP2M soil K in 3" to 6" layer vs. % Mg in 2nd cut orchardgrass (-0.320**).
18. PP2M soil K in 0" to 6" layer vs. % orchardgrass in 2nd cut hay (-0.223*).
19. PP2M soil K in 0" to 6" layer vs. % Ca in 2nd cut orchardgrass (-0.261*).
20. PP2M soil K in 0" to 6" layer vs. % Mg in 2nd cut ladino (-0.510**).
21. PP2M soil K in 0" to 6" layer vs. % Mg in 2nd cut orchardgrass (-0.433**).

The following additional relationships were significant, but data were available for only one of the years in each case.

Positive correlations with 1956 data

1. Soil pH of 0" to 6" layer vs. % orchardgrass in 4th cut hay (0.264*).
2. Soil pH of 0" to 6" layer vs. % P in 4th cut ladino (0.234*).
3. PP2M soil Ca in 0" to 1" layer vs. % ladino in 4th cut hay (0.309*).

4. PP2M soil Ca in 0" to 1" layer vs. % orchardgrass in 4th cut hay (0.223*).
5. PP2M soil Ca in 0" to 1" layer vs. % P in 4th cut ladino (0.311**).
6. PP2M soil Ca in 0" to 1" layer vs. % Ca in 4th cut orchardgrass (0.253*).
7. PP2M soil Ca in 1" to 3" layer vs. % ladino in 4th cut hay (0.324**).
8. PP2M soil Ca in 3" to 6" layer vs. % ladino in 4th cut hay (0.279*).
9. PP2M soil Ca in 3" to 6" layer vs. % Ca in 4th cut orchardgrass (0.337**).
10. PP2M soil Ca in 3" to 6" layer vs. % Mg in 4th cut ladino (0.326**).
11. PP2M soil Ca in 3" to 6" layer vs. % Mg in 4th cut orchardgrass (0.294**).
12. PP2M soil Ca in 0" to 6" layer vs. % ladino in 4th cut hay (0.387**).
13. PP2M soil Ca in 0" to 6" layer vs. % orchardgrass in 4th cut hay (0.273*).
14. PP2M soil Ca in 0" to 6" layer vs. % P in 4th cut ladino (0.236*).
15. PP2M soil Ca in 0" to 6" layer vs. % Ca in 4th cut orchardgrass (0.302**).
16. PP2M soil Ca in 0" to 6" layer vs. % Mg in 4th cut ladino (.223*).
17. PP2M soil Ca in 0" to 6" layer vs. % Mg in 4th cut orchardgrass (0.280*).
18. PP2M soil Mg in 3" to 6" layer vs. % Mg in 4th ladino (0.280*).
19. PP2M soil Mg in 0" to 6" layer vs. % orchardgrass in 4th cut hay (0.240*).
20. PP2M soil K in 0" to 1" layer vs. % K in 4th cut ladino (0.718**).
21. PP2M soil K in 0" to 1" layer vs. % K in 4th cut orchardgrass (0.578**).
22. PP2M soil K in 1" to 3" layer vs. % K in 4th cut ladino (0.636**).
23. PP2M soil K in 1" to 3" layer vs. % K in 4th cut orchardgrass (0.531**).
24. PP2M soil K in 3" to 6" layer vs. % K in 4th cut ladino (0.357**).
25. PP2M soil K in 3" to 6" layer vs. % K in 4th cut orchardgrass (0.349**).
26. PP2M soil K in 0" to 6" layer vs. % K in 4th cut orchardgrass (0.560*).
27. PP2M soil K in 0" to 6" layer vs. % K in 4th cut ladino (0.678**).

Positive correlations with 1959 data

1. PP2M soil Mg 1" to 3" layer vs. yield of hay (0.277*).
2. PP2M soil Mg 1" to 3" layer vs. % ladino in 2nd cut hay (0.354**).
3. PP2M soil Mg 1" to 3" layer vs. % orchardgrass 2nd cut hay (0.236*).
4. PP2M soil Mg 1" to 3" layer vs. % Mg in 2nd cut ladino (.389**).
5. PP2M soil Mg 1" to 3" layer vs. % Mg in 2nd cut orchardgrass (0.297*).

Negative correlations with 1956 data

1. PP2M soil Ca in 3" to 6" layer vs. % P in 4th cut orchardgrass (-0.254*).
2. PP2M soil K in 0" to 1" layer vs. % Ca in 4th cut ladino (-0.230*).
3. PP2M soil K in 0" to 1" layer vs. % Ca in 4th cut orchardgrass (-0.369**).
4. PP2M soil K in 0" to 1" layer vs. % Mg in 4th cut orchardgrass (-0.410**).
5. PP2M soil K in 1" to 3" layer vs. % Ca in 4th cut ladino (-0.220*).
6. PP2M soil K in 1" to 3" layer vs. % Ca in 4th cut orchardgrass (-0.386**).
7. PP2M soil K in 1" to 3" layer vs. % Mg in 4th cut orchardgrass (-0.359**).
8. PP2M soil K in 3" to 6" layer vs. % Ca in 4th cut orchardgrass (-0.370**).
9. PP2M soil K in 3" to 6" layer vs. % Mg in 4th cut orchardgrass (-0.256*).
10. PP2M soil K in 0" to 6" layer vs. % Ca in 4th cut ladino (-0.229*).
11. PP2M soil K in 0" to 6" layer vs. % Ca in 4th cut orchardgrass (-0.398**).
12. PP2M soil K in 0" to 6" layer vs. % Mg in 4th cut orchardgrass (-0.388**).

B. Special Soil and Plant Data from the August 1959 Sampling

Simple correlations coefficients were calculated for certain combinations among the following data, obtained from special soil and plant samples taken in

August 1959. Individual plot data were used in these correlations also:

1. Mean yield of dry hay for the period 1956 to 1959.
2. Stands of ladino and orchardgrass.
3. Soil pH of 0" to 6", 6" to 12", 12" to 18", and 18" to 24" layers.
4. Amount of available soil phosphorus (Truog) in the same layers and the total of the 4 layers (0" to 24").
5. Amount of exchangeable soil magnesium and potassium in the 0" to 6", 6" to 12" and 0" to 24" layers.

The significant relationships obtained with these data differ from the previous group in that yields of hay were significantly related to the content of soil phosphorus. They are similar in that no close relationship between hay yields and contents of soil potassium were found. Also, in both groups of correlations the content of soil magnesium was significantly related to hay yields and stands or proportion of orchardgrass in the hay.

Both ladino and orchardgrass stands were highly correlated with the average yields for 1956 to 1959. The correlation between yields and ladino stands was much closer than with orchardgrass stands. Hence, maintenance of ladino stands was apparently of greater relative importance for higher yields than maintenance of orchardgrass stands, at least under the conditions of this experiment and excluding the 150 lb. rate of nitrogen fertilization.

A highly significant relationship was obtained between stands of ladino and orchardgrass. In general, this indicates that treatment variables in this experiment affected the durability of both species somewhat similarly. However, these variables did not affect the populations of both species to the same extent in all cases. Soil pH of the 0" to 6" layer was significantly (5% level) correlated with ladino but not orchardgrass stands. Orchardgrass but not ladino stands were significantly related to soil magnesium contents.

The correlation coefficient between soil pH of the 4 soil layers and stands of both species were all negative, although only that for ladino was significant. This seems contrary to expectation, particularly for ladino, since less-acid soils are generally more favorable for most leguminous forages. Perhaps this apparent irregularity results from the lack of wide variability in soil pH of the plots.

Evidence of the relative leachability of soil phosphorus, magnesium, and potassium is demonstrated by certain of these correlations. No significant correlations were found between the soil phosphorus contents of different layers; similar relationships for soil magnesium and potassium were very closely correlated. A significant inverse relationship between contents of soil magnesium and potassium was also found.

The absence of close correlation between yields of hay and contents of available soil phosphorus and potassium appears anomalous, in view of yield response to fertilization. A study of the plot data included in these correlations reveals that occasional low yields were obtained from certain well-fertilized plots. Consequently, soil analyses indicated high levels of these nutrients in low-yielding plots. It is believed that this type of variability caused the generally poor correlations obtained.

The following relationships were significant at the 1% level: (correlation coefficients given).

Positive correlations

1. Yield of hay vs. ladino stands (0.456**).
2. Yield of hay vs. orchardgrass stands (0.297**).
3. Orchardgrass stands vs. ladino stands (0.589**).
4. Orchardgrass stands vs. lb./A. soil Mg in 0" to 6" layer (0.304*).
5. Orchardgrass stands vs. lb./A. soil Mg in 6" to 12" layer (0.320**).
6. Orchardgrass stands vs. lb./A. soil Mg in 0" to 24" layer (0.338**).
7. Soil pH in 0" to 6" layer vs. soil pH in 6" to 12" layer (0.397**).
8. Lb./A. soil Mg in 0" to 6" layer vs. lb./A. soil Mg in 6" to 12" layer (0.739**).
9. Lb./A. soil Mg in 0" to 6" layer vs. lb./A. soil Mg in 0" to 24" layer (0.917**).
10. Lb./A. soil Mg in 6" to 12" layer vs. lb./A. soil Mg in 0" to 24" layer (0.905**).
11. Lb./A. soil K in 0" to 6" layer vs. lb./A. soil K in 6" to 12" layer (0.867**).
12. Lb./A. soil K in 0" to 6" layer vs. lb./A. soil K in 0" to 24" layer (0.968**).
13. Lb./A. soil K in 6" to 12" layer vs. lb./A. soil K in 0" to 24" layer (0.929**).

Negative correlations

1. Lb./A. soil Mg in 0" to 6" layer vs. lb./A. soil K in 0" to 6" layer (-0.329**).
2. Lb./A. soil Mg in 0" to 6" layer vs. lb./A. soil K in 6" to 12" layer (-0.384**).
3. Lb./A. soil Mg in 0" to 6" layer vs. lb./A. soil K in 0" to 24" layer (-0.390**).
4. Lb./A. soil Mg in 0" to 24" layer vs. lb./A. soil K in 6" to 12" layer (-309**).
5. Lb./A. soil Mg in 0" to 24" layer vs. lb./A. soil K in 0" to 24" layer (-341**).

The following relationships were significant at the 5% level:

Positive correlations

1. Yield of hay vs. lb./A. soil P in 0" to 6" layer (0.259*).
2. Yield of hay vs. lb./A. soil P in 0" to 24" layer (0.229*).
3. Yield of hay vs. lb./A. soil Mg in 0" to 24" layer (0.257*).

Negative correlations

1. Ladino stands vs. soil pH of 0" to 6" layer (-0.229*).
2. Lb./A. soil Mg in 6" to 12" layer vs. lb./A. soil K in 0" to 6" layer (-0225*).
3. Lb./A. soil Mg in 6" to 12" layer vs. lb./A. soil K in 6" to 12" layer (-0.225*).
4. Lb./A. soil Mg in 6" to 12" layer vs. lb./A. soil K in 0" to 24" layer (-0.274*).
5. Lb./A. soil Mg in 0" to 24" layer vs. lb./A. soil K in 0" to 6" layer (-0.290*).