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Yield and vegetative and chemical composition of forage crops as affected by soil treatment.

John Lawrence Parsons
University of Massachusetts Amherst

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**FIVE COLLEGE
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Yield and Vegetative and Chemical Composition
of forage Crops as Affected by Soil Treatment

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YIELD AND VEGETATIVE AND CHEMICAL COMPOSITION
OF FORAGE CROPS AS AFFECTED BY SOIL TREATMENT

by

John L. Parsons R1935

Thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

University of Massachusetts
Amherst, Massachusetts

June, 1953

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INTRODUCTION

With the growing appreciation of the important purposes to be fulfilled by grasslands a more intensive use is being made of "improved pastures" for specific purposes. The old "permanent" pasture has graduated from the role of occupying the least fertile fields of the farm and is being considered on the same level as cultivated crops. An event accompanying this "graduation" is the disappearance of certain less desirable species such as Kentucky bluegrass, redtop, bent grass and wild white clover from the seed mixtures.

In general, these permanent pasture species were well adapted to the purpose they served. They are adapted to conditions of lowered fertility and continuous grazing and will persist under various extreme conditions of mismanagement. They are, however, less productive than the larger and more erect growing species, orchard grass, smooth brome grass, alfalfa and Ladino clover. Improved forage species can be expected to yield annually as much as three times the dry matter produced by a permanent pasture sod of bluegrass-white clover (17).

Many investigators (5,11,12,22) have shown the desirability of maintaining a proper mixture of grass and legume. Not only is a mixture of grass and legume higher yielding than single species but it provides a more palatable and

nutritious forage and improves seasonal distribution of pasture. Because of the careful management and high fertility required by these improved species, farmers in the Northeast have experienced great difficulty in maintaining stands. It is, therefore, of considerable economic importance to the farmer that management factors governing the grass-legume balance be studied.

It has been observed frequently that with time the quality of grass-legume mixtures degenerates because of the depletion of the legume and the dominance of the area by weedy grasses, such as bent grass, redtop, Kentucky bluegrass and quack grass. These are designated weedy grasses because they compete seriously with legumes, such as alfalfa and Ladino clover and desirable grasses such as smooth brome, orchard grass and timothy for K* (13) and under the climatic conditions of Massachusetts, these weedy grasses are dormant during July and August (20). Thus, except in the spring, they are low in production and palatability. This degeneration of desirable species is affected by several factors including light, moisture, and nutrient competition among species. In addition, management factors, such as frequency and height of clipping or grazing, are important.

Brown (6) found that Kentucky bluegrass will make considerable root growth at temperatures as low as 40° F. and will

* Conventional symbols for fertilizer elements are used throughout this paper.

make maximum growth at 60° F. Root growth declined however as the temperature rose above this level, practically ceasing when soil temperatures went above 80° F. This is characteristic of bluegrass even at high levels of fertility and soil moisture. Similar root growth measurements have been made on bent grass (21). High soil temperature accounts for the summer dormancy period of these grasses.

Establishment and particularly maintenance of improved pasture species involves problems of management which are much more exacting than those of permanent pastures. Fertility requirements of the improved pasture is high. The high yields obtained with such species as Ladino clover, alfalfa, smooth brome grass and orchard grass remove large quantities of plant nutrients. Adequate amounts of lime and fertilizer elements must be returned to most soils of the Northeast region in order to maintain maximum growth.

In the literature on grass-legume mixtures for the Northeast, much stress has been placed on climatic factors, such as light and moisture, and on certain management factors. Relatively little has been done to determine the influence of fertilizer elements on this association.

After several years of study, Brown (5) concluded that climatic factors were of less importance than fertility factors in maintaining grass-legume associations. In studying the ecological factors influencing pasture flora in the Northeast, Cooper (8) found that plant succession on pasture

soils was correlated with the level of soil fertility. He found that bluegrass and wild white clover were the first species to come in as the fertility level of a cropped soil was depleted. As depletion of fertility continued bent grasses came in as well and eventually sweet vernal, poverty grass and other weeds and finally trees ingressed on the land. Once soil fertility has reached this state of depletion all efforts to improve the crop by planting better species are to no avail unless soil fertility is increased.

Blaser (4) in working with grass-legume associations found a competition for potassium among the species. He found that grasses are better competitors for this element than the legumes. Potassium competition becomes more serious as the level of available K drops during the growing season (13). On most soils low in K supplying power, frequent liberal applications of K fertilizer are required to maintain satisfactory production throughout the growing season (12,17,19).

Many workers have found that grasses as well as legumes have a tendency to accumulate K in excess of their needs when K is applied in large amounts (2,12). Because of this luxury absorption and species competition, it is believed that frequent light applications of potash fertilizers throughout the growing season are necessary to maintain stands and production of desirable legumes and grasses. Much information is still needed relative to grazing management practices that will

maintain a desirable and balanced grass-legume stand in improved pastures.

Tesar (22) reported that the best treatment for production and for maintaining Ladino clover in a stand was by harvesting four times during the season to a height of 3 1/2 inches. Sprague (18) found that the time of first harvest in the spring is important in maintaining Ladino clover. He stated that the first cutting should be made when the height of the forage is 8 to 10 inches and subsequent clippings when 8 inches in height. He found a 2 inch height of cutting to be better than 3 inches.

Another fertility problem confronting the farmer and research worker concerns phosphorus. Soils of the humid region have the property of converting soluble phosphate into relatively insoluble iron and aluminum phosphates which are not readily available to plants. To the farmer a means of preventing this "fixation" is important. Salter (15) recommended banding a phosphate fertilizer to minimize fixation. The phosphorus is placed in concentrated bands 2-4 inches deep with a grain drill so that a minimum of the fertilizer particles will come in contact with the soil and hence less phosphorus will be subject to "fixation".

Because of phosphate fixation which prevents penetration of phosphate to root depth, it is thought that topdressing of pastures with superphosphate is inefficient. Many workers such as Duley (10) and Garber (12) have found that banding

of superphosphate with crops such as wheat is decidedly superior to broadcasting. Since it is very difficult to drill fertilizer into an established pasture sod, it would be necessary to make a single large application prior to seeding. This initial application would have to be large enough to supply the needs of the crop for the life of the seeding.

The purpose of this investigation was: (a) to determine the approximate P and K requirements of Ladino clover, bromegrass, orchard grass and timothy when grown in pure stands on a well drained loessial soil in Massachusetts, (b) to evaluate the use of frequent light applications of potash fertilizers in maintaining satisfactory stands of legumes in haylands and pastures and (c) to investigate the practicability of making liberal applications of phosphate fertilizer in bands at seeding time to supply the phosphorus needs of the crop for a period of 4 to 6 years.

CLIMATOLOGICAL DATA

Figure 1 gives the rainfall distribution during the growing seasons by 10 day periods from April 1949 through September 1952. Following the planting date on April 28, 1949 there was a 30 day period of above normal rainfall with even distribution. From about June 1 to the middle of July 1949 however there was an extended dry period. The adverse effect of this drought was apparent until early September but it did not prevent establishment of a good even stand with all crops. The nurse crop of oats was harvested June 20, 1949 to reduce competition for moisture. The harvest year 1950 was characteristic of many seasons in Massachusetts, with infrequent periods of high rainfall interspersed with dry periods of from 10 to 20 days or more. On the sandy soils of Massachusetts a dry period of this duration can seriously affect crop growth and vigor of stand. The fall of 1950 was very dry from the middle of September until November. The 1951 season was similar to 1950 but with more precipitation in the fall in October and November. The fall of 1951 was especially favorable for the growth of weedy grasses which normally grow best when it is cool and moist.

The precipitation in 1952 was equal to or above normal every month during the growing season. However, during the growing period preceding each cutting there was one period when moisture was deficient. Thus it may be seen that while the total annual rainfall may appear to be adequate for crop needs the "effective" rainfall can be far from adequate.

Figure 1. Distribution of rainfall for 1949, 1950, 1951 and 1952, by 10 day periods throughout the growing season. Horizontal lines indicate average normal rainfall assuming even distribution throughout month. The arrows show time of each cutting. Arrow (1949) indicates seeding date.

MATERIALS AND METHODS

Field studies were begun in 1949 on Ladino clover, smooth bromegrass, orchard grass and timothy. Each species was planted as a pure stand to determine the P and K requirements. A modified split plot design with four replications was employed using plots 15 feet by 20 feet (two replications of bromegrass). An area of 150 square feet was harvested with a power mower by clipping at a height of about 2 inches. Green weights were taken in the field and moisture samples were taken to determine the dry weight. This sample was used for chemical determinations. All yields are expressed on oven dry basis (zero moisture).

The experiment was conducted on Merrimac sandy loam soil. Merrimac sandy loam soil is typical of large areas of well drained loessial soils of Massachusetts (7). The Truog phosphorus test showed 40 pounds P_2O_5 per acre, and the exchangeable K_2O was 100 pounds per acre. The pH of the soil was approximately 5.0. Three tons of finely ground dolomitic limestone per acre were applied at seeding time, which raised the pH to 6.8. This area was used 15 to 20 years ago for potatoes and tobacco and a reserve of fixed phosphate probably accumulated during this period since there were 2100 pounds fixed P_2O_5 per acre as determined by the citric acid method (1). The original vegetation consisted of approximately 50% Agrostis sp., 20% Kentucky bluegrass, and variable amounts of sorrel (Rumex acetosella), hair-cap moss (Polytrichum commune), sweet vernal (Anthoxanthum odoratum), cinquefoil (Potentilla canadensis) and sedges (Carex sp.).

Fertility treatments.

Three phosphate (20% superphosphate) applications, supplying 50, 100 and 200 pounds P_2O_5 per acre, were applied before seeding in bands seven inches apart and three inches deep. A fourth series received 200 pounds P_2O_5 per acre drilled in at seeding time and an annual topdressing of 100 pounds P_2O_5 per acre after the first cutting. Annually each of these P_2O_5 treatments received 50 or 100 pounds K_2O per acre after each cutting as a topdressing. A fifth treatment was 50 pounds K_2O per acre six weeks before the first cutting plus 50 or 100 pounds K_2O per acre topdressed after each cutting and 200 pounds P_2O_5 per acre banded at seeding plus 100 pounds P_2O_5 per acre after the first cutting annually. A sixth series of plots did not receive annual potash topdressing but did receive 200 pounds P_2O_5 per acre banded at seeding time. A seventh series did not receive potash after seeding but received 50 pounds P_2O_5 per acre banded initially when seeded. On the low K plots 100 pounds K_2O per acre were applied at seeding time in 1949 and none was added after that time. Table 1 gives a summary of the treatments and treatment numbers.

Nitrogen as NH_4NO_3 was supplied to the grasses in the spring and after each cutting at a rate (30-50 pounds N per acre) believed to be adequate for optimum growth. Analysis showed the total N content of the plant material to be at a uniformly high level.

Table 1.--Fertilizer treatments. Pounds P_2O_5 and K_2O per acre. I = Initial application at seeding time. AEC = After each cutting. BFC = Before first cutting. Ann. = Annually.

Treatment No.	lbs. P_2O_5	lbs. K_2O *
1	100 (I)	50 AEC
2**	200 (I)	50 AEC
3**	50 (I)	50 AEC
4**	200 (I)	--
5**	50 (I)	--
6	200 (I) + 100 (Ann.)	50 AEC
7	200 (I) + 100 (Ann.)	50 BFC + 50 AEC

* All plots received 100 pounds K_2O when seeded. In 1950 the potash treatments were 100 lbs. AEC.

** Botanical studies were made on four treatments. These treatments comprise a factorial (2 X 2) with P and K.

The first cutting each year was made when orchard grass and brome grass were in an early bloom stage. Three harvests were obtained each year on brome grass, orchard grass and Ladino clover. The second and third cuttings were made when the grasses were eight to ten inches high and Ladino was six to eight inches high. Two cuttings were obtained from timothy; the first timothy cutting was made at late bloom stage and the second cutting in September.

The fertilizer applications of treatments, number 2, 3, 4 and 5 comprise a 2 X 2 factorial. Vegetative composition was determined on these plots by making counts of species. After the first year the principal weed associations becoming established in all plots were Kentucky bluegrass (Poa pratensis) and bent grass (Agrostis spp.)*. Other weed

* The bent grass association consisted chiefly of Agrostis stolonifera, A. alba, and A. tenuis.

species accounted for less than 1% of the total vegetation.

Analysis of variance was calculated on dry matter yield and percent composition of phosphorus, potassium, calcium and magnesium. "Least significant differences" referred to in the following discussion and tables were calculated using the Tukey method for making tests of significance between means.*

* As explained in letter to Professor Sargent Russell, Agricultural Economics Department, University of Massachusetts, from Professor Paul G. Hameyer, Statistical Laboratory, Iowa State College, Ames, Iowa.

Figure 2. This photograph, taken in 1950, shows the experimental area one year after seeding. The stakes in the foreground outline each plot on which observations were made and from which samples of forage were taken. The vegetation seen in the background is typical of that existing on the entire area for several years prior to the experiment. Aside from a few scattered shrubs the vegetation consisted chiefly of bentgrass (Agrostis spp.), Kentucky bluegrass (Poa pratensis) and variable amounts of sorrel (Rumex acetosella), hair-cap moss (Polytrichum commune), sweet vernal (Anthoxanthum odoratum), cinquefoil (Potentilla canadensis), and sedges (Carex spp.).

RESULTS AND DISCUSSION

Effects of Potassium

Herbage yields of Ladino clover and grasses during three crop years showed marked response to potassium applications. Split applications of 150 pounds K_2O per acre annually (50 pounds after each of 3 cuttings) on orchard grass, bromegrass and Ladino gave maximum yields of hay when phosphorus and other fertilizer elements were adequate (High K - Table 2). An additional 50 pounds K_2O per acre in the early spring did not produce further yield increase (Appendix).

The increased hay production due to the split applications of potash was highly significant. Ladino clover plot yields were increased 28% (average of two harvest years) as a result of the added potash; however, Ladino clover stands had failed on low potash plots by the third harvest season. Timothy, bromegrass and orchard grass yields (three-year average) were increased 35%, 42% and 78% respectively on high K treatments (Table 2). Only two cuttings of smooth bromegrass were made the first harvest year.

The efficiency with which the various crops removed the added potassium is shown in Table 2. These data show the ability of grass to remove more K than Ladino at low as well as at high K levels. Although assumed liberal amounts of fertilizer potash were applied to the grasses studied,

there was nearly complete removal of applied K (79 to 95%). This points up the fact that it is not possible to increase the reserves of soil K when producing large yields of the forage grasses smooth brome, orchard or timothy on this and similar soils. When adequate potassium is not supplied these crops will actually "mine" the soil of most of the available K as shown by the low K data (Table 2).

Table 2.--Total pounds of K₂O added and pounds K₂O removed per acre in three crop years. Hay yields (dry matter) in pounds per acre per year.

Crop	:Treat-: :ment*	K ₂ O		:% of K ₂ O :		Dry Matter	
		:Added	:Removed	:Recovered	:Average	:3 year	Total
Orchard	Low K	100	170	170	3531		10593
	High K	650	568	87	6267		18801
Brome	Low K	100	200	200	4714		14143
	High K	550	521	95	6682		20046
Timothy	Low K	100	184	184	5324		15971
	High K	450	354	79	7169		21506
Ladino 2-yr.Av.	Low K	100	112	112	2765		5531
	High K	500	212	42	3541		7083

* Low K = average of treatments 2 and 3. High K = average of treatments 4 and 5.

There was little or no yield response to potassium the first crop year because of the initially high level of available potassium in the soil (100 pounds K₂O available plus 100 pounds K₂O per acre applied at seeding time). This lack of response is frequently observed by Massachusetts farmers and often leads to the false belief that annual potash is

not needed. Although the hay yield the first year was not affected, there was a marked effect on potassium content in the plant. On the low K treatments an amount equal to 85 to 95% of the initial 100 pounds of applied K_2O was removed by the grasses in the first cutting the first year. In the first harvest season the K content of Ladino was reduced from 2.3% (first cut) to 1.5% (third cut) on low K plots. The accompanying reduction for the grasses was from 2.3% to 1.2% for orchard grass; 1.4 to 0.8% for timothy, and 1.7 to 1.3% for brome grass. This percentage wise reduction in potassium on the low K treatments was actually a forewarning of what was to occur to forage yields and vigor of the stand during the second and third crop years.

During the second crop year the percentage increase in forage yield from potash applied at the rate of 50 pounds K_2O per acre after each of 3 cuttings for orchard grass, brome grass and Ladino was 113%, 54% and 73% respectively, and for the third crop year, orchard grass and brome grass increased 180% and 102% respectively. Applying 50 pounds K_2O per acre after the first and second cuttings of timothy increased the yields 41% and 100% in the second and third years, respectively. Ladino on low potash plots was not harvested in the third year because of stand failure on low K plots.

Effects of Phosphorus

Timothy was the only crop that responded to increasing initial P rates above the lowest rate (50 pounds P_2O_5 per acre banded at seeding time). The influence of phosphorus rates on yield, phosphorus content of forage and phosphorus recovery by orchard grass is illustrated in Figure 3. Only data for orchard grass are shown graphically since other grasses (Table 3) are similar in phosphate response. The percent P in orchard grass and brome grass was increased by increasing increments of P. The dry matter increases produced by 500 pounds P_2O_5 (1 1/4 tons of 20% superphosphate) compared to 50 pounds P_2O_5 were 2253, 2486 and 2499 (3-year total), respectively, for orchard grass, brome grass and Ladino (Table 3). For timothy the hay yield between the highest and lowest P_2O_5 application was 3958 pounds per acre (3-year total), or a response of two tons of timothy hay from 1 1/4 tons of 20% superphosphate. There was an 11 to 18% increase in the percent of phosphorus in timothy produced by the annual application of this element. Accompanying increases of 14 to 31% for orchard grass, 15 to 28% for brome grass and 6 to 14% for Ladino clover were measured as a result of annual phosphate applications.

What is the explanation for the failure of orchard and brome grass to respond to initial applications of applied P_2O_5 ? These grasses on the average removed amounts of P_2O_5

equal to 180% of that applied on the lowest P_{2O_5} treatment, whereas Ladino clover which produced less dry matter utilized amounts equal to 113% of applied P_{2O_5} (Fig. 3 and Table 3). In view of the high P fixing capacity of this soil and the liberal use of fertilizer on this area 20-40 years ago, it is evident that under the system of management used with high N and K fertilization, orchard grass and bromegrass were able to utilize a certain amount of this fixed phosphorus (9). At the end of the third crop year, although there had been no decrease of hay production, there was a decrease in P content of the plant material on the low P treatment plots. Therefore, on this soil the initial application of 50 pounds available P_{2O_5} per acre may not be sufficient to supply the phosphorus requirements for high yields of timothy, orchard grass, and smooth brome for more than three years.

Figure 3. Effect of fertilizer P_2O_5 on orchard grass yield, P_2O_5 content and on relative uptake of P_2O_5 . Hay yield is expressed on the basis of 15% moisture.

Table 3.--P₂O₅ added, removed, % recovered and dry matter production by orchard grass, bromegrass, timothy and Ladino clover in three crop years.

Treat-:	P ₂ O ₅		% P in : Dry Matter		
ment	:lbs. Added:	lbs. Removed:	% Recovered:	Crop**:	lbs. per Acre
ORCHARD GRASS					
3	50	92.1	184	0.218	18399
1	100	109.7	110	.250	19200
2	200	104.2	52	.237	19203
6*	500	135.4	27	.286	20652
			LSD (5%)	.018	1338
BROMEGRASS					
3	50	87.3	175	0.192	19869
1	100	84.6	85	.210	17584
2	200	99.0	50	.214	20224
6	500	126.2	25	.246	22355
TIMOTHY					
3	50	68.1	136	0.147	20177
1	100	78.0	78	.157	21684
2	200	77.8	39	.149	22836
6	500	96.1	19	.174	24135
			LSD (5%)	.011	2262
LADINO					
3	50	56.4	113	0.255	9672
1	100	64.0	64	.256	10508
2	200	65.9	33	.274	10491
6	500	80.6	16	.290	12171
			LSD (5%)	.012	2016

* Treatment 6 received 200 pounds P₂O₅ initially and 100 pounds annually after the first cutting.

** Three year average.

Calcium and Magnesium

Table 4 includes a three year summary of the 2 X 2 P-K factorial and the interacting effects on Mg and Ca composition. Many workers have found that the sum of cationic equivalents in plants tends to be constant (2,8,14). Therefore any change in the content of one cation (K in this case) influences the content of the other cations. The effect of increased soil K on Ca and Mg in the plant is shown in Table 4 and is illustrated in Figure 4. The degree of Ca and Mg change is greater in Ladino and orchard grass than in bromegrass and timothy. This may be due to Ladino and orchard grass having a higher cationic equivalent level.

The change in cation composition at two levels of P is due in part to the soluble Ca added in the superphosphate (Fig. 5). There was no significant relationship between fertilizer phosphorus rate and magnesium content of the grasses (Fig. 5).

The percentage of Mg in orchard grass is about twice as great as in timothy or bromegrass. This may be due to differences in maturity at cutting time as well as to a high level of soluble or exchangeable Mg in the soil (3 tons dolomite per acre at seeding time). Stewart and Bear (19) found the percentage of Mg in orchard grass varied from 0.19 to 0.34 in several Northeastern states. Beeson (3) found that Mg in timothy cut at the full bloom stage varied

from 0.09% to 0.17%, but when cut at earlier stages of maturity Mg was as high as 0.34. The fluctuations in other elements according to fertilizer level and stage of cutting of timothy (3) are as follows: K from 2.89% to 0.79%; Ca from 1.02% to 0.04%; P from 0.62% to 0.08%. Thus the practice of cutting timothy at the full bloom stage or later as compared to earlier stages produces a lower quality of hay from the standpoint of mineral nutrient content. However, unless timothy is cut at the full bloom stage or later, stand survival is low on this type of soil.

Table 4.--Percent Mg (two year average) and percent Ca (three year average) as affected by P and K levels.

Treatment No.		4-5	2-3	3-5	2-4	LSD
		Low-K	High-K	Low-P	High-P	(5% level)
Ladino (2 year Avg.)	Mg	0.456	0.353	0.419	0.379	0.032
	Ca	1.220	1.103	1.109	1.198	0.110
Orchard Grass	Mg	0.361	0.271	0.297	0.317	0.023
	Ca	0.386	0.300	0.322	0.339	0.015
Bromegrass	Mg	0.199	0.144	0.161	0.175	
	Ca	0.329	0.256	0.278	0.294	
Timothy	Mg	0.169	0.151	0.160	0.158	n. s.
	Ca	0.309	0.288	0.290	0.303	n. s.

Figure 4. Percent Mg and Ca as affected by K. Three year averages for Ca and two year averages for Mg. (Ladino - two year averages in each case).

Figure 5. Percent Mg and Ca as affected by P. Three year averages for Ca and two year averages for Mg. (Ladino - two year averages in each case).

EFFECT OF POTASH AND PHOSPHATE FERTILIZATION ON
LONGEVITY OF PURE STANDS

Ladino Clover

Vegetative composition studies for 3 years show the importance of potash on maintaining Ladino stands (Fig. 6). The percent of clover in low potash plots (Treatment 4) during the first crop year did not change. This may be attributed to stimulated growth resulting from the initial application of 100 pounds K_2O per acre plus the available soil potassium. From October 1950 (end of first harvest year) to the spring of 1951, there was a large reduction from 90 to 45 percent in Ladino clover stands on the low potash plots. By the end of the 1951 season (second crop year) the Ladino clover on the low potash plots was less than 15% of the total vegetation and by the spring of 1952 (third crop year) Ladino comprised only six percent of the population. For the same periods on the high potash plots (Treatment 2) the Ladino decreased from over 90% in October (end of first crop year) to 81% in the spring of 1951. From the spring of 1951 to the fall of 1951 (second crop year) the decrease was from 81 to 69 percent Ladino clover. From October 1951 (end of second crop year) to the spring of 1952, the Ladino clover dropped from 69 to 30 percent.

Table 5.--Potash removed in first and second harvest year by Ladino clover at low and high levels of applied K_2O *. Pounds K_2O per acre.

Harvest Year	Low K_2O		High K_2O	
	Applied	Removed	Applied	Removed
First	0	67	200	102
Second	0	26	150	75

* All plots received 100 pounds K_2O when seeded.

From these observations the following conclusions may be made: (a) Ladino clover maintains itself well during the first crop year if adequately fertilized at seeding time, but the K content drops rapidly (2.3 to 1.5% K in 3 cuttings) and the Ladino clover plants "go out" after the readily available potassium has been depleted (Table 5); (b) on a low K fertility level the Ladino clover was low in K content and was unable to survive the winter with sufficient vigor to compete with the incoming bluegrass and bent grass and (c) on a high K fertility level (150-200 pounds K_2O per acre) Ladino clover stands were maintained without serious decline until the third year.

During the spring of 1952 a marked decrease in the stand of Ladino clover occurred on the highest potash plots. This decrease may be attributed to the rapid growth of the weedy grasses, bent grass and Kentucky bluegrass, during the cool spring months. It is thus evident that even with high potash fertilization the ingress and dominance by the weedy grasses cannot be entirely prevented if they are not completely eradicated before seeding the Ladino clover.

Figure 6. The percent of Ladino clover, Kentucky bluegrass and bent grass as influenced by K application. (Maintenance K treatment; Low = 0, High = 150 lbs. K_2O per acre annually).

* S = Spring, F = Fall.

Figure 7. The above photograph was taken before the second harvest of the third crop year. In the foreground Ladino clover still predominates as a result of adequate potassium application. In the background bent grass and Kentucky bluegrass have almost completely forced the Ladino out because of potassium competition at low levels of this element. Two years before this photograph was taken both plots were covered with virtually a pure stand of Ladino clover.

Timothy

The relationship between timothy and weedy grasses as affected by fertilization is illustrated in Figure 8. The influence of a low potash level on timothy stands the first crop year was similar to that on Ladino clover. Little or no reduction in percent timothy was observed on low K plots until after the first year, but from then on there was a rapid and continuous reduction. The percent K in timothy dropped from 1.4 in the first cutting to 0.8% K in the second cutting on the low K plots. When K as well as P was maintained at a high level the timothy stands persisted until the third season. At this time there was a marked reduction due principally to the increase in bent grasses after the first cutting in 1952.

Timothy produces very heavy forage yields in the first cutting, and very little second growth is produced. This characteristic of timothy is thought to be responsible in part for the relatively short life of the stand at high fertility levels. Certainly there is little competition offered by timothy to the weedy grasses during the summer and fall period subsequent to this large first cutting.

Timothy was the only crop in the botanical composition study showing a marked response to different phosphorus levels (Fig. 8). The principal factor in this case was the relatively poor stand obtained at the low P level (50 pounds P_2O_5 per acre). Although a 65% stand of timothy was

Figure 8. Percent of timothy, bent grass and Kentucky bluegrass. High P = 200 lbs. P_2O_5 per acre at seeding time. High K = 150 and Low K = 0 lbs. K_2O per acre annually. * S = Spring, F = Fall.

obtained the first year on low P, the subsequent rate of decline was similar to that at other P levels.

Orchard Grass and Bromegrass

The influence of potash on orchard grass and bromegrass was similar in this study; thus, only the data for orchard grass are illustrated (Fig.9). As with Ladino clover and timothy, no apparent effect of reduced K level was observed the first year on the yield and stand of orchard grass and bromegrass. The percent K dropped from 2.3 in the first cutting to 1.2 in the third for orchard grass and from 1.7 to 1.3 in the second cutting for bromegrass. The decline after the first season, however, was continuous but not so rapid as with Ladino and timothy. Low K level on orchard and bromegrass greatly reduced the percent stand during the third crop year. At high K levels (adequate P), orchard grass and bromegrass still accounted for more than 90% of the stands at the first cutting in the third year. Thus, these two grasses, orchard and smooth brome, are considered to be better competitors than timothy against weedy grasses. The rate of recovery and continuous nature of plant growth are certainly important factors in this competition. In contrast to timothy, orchard grass and bromegrass characteristically produce much more aftermath than timothy throughout the summer and fall and thus offer greater competition to weedy grasses for light and moisture as well as for plant

nutrients. At low K this is especially true of orchard grass and to a lesser extent of brome grass as shown by the percent of stand remaining at the end of the third crop year, (31% for orchard grass, 11% for brome grass and 3% for timothy).

At the high K level the percent orchard grass, brome grass and timothy remaining at the end of the third crop year was 92, 65, and 29 percent, respectively. Until the first cutting of the third crop year, orchard and brome stands were essentially the same, percentagewise. While fertility is a most important factor, it is evident that factors such as light and moisture competition are also important.

When adequate K was supplied, both orchard grass and smooth brome grass maintained good stands during the third year, and neither bent grass nor Kentucky bluegrass populations made important increases. This may account for the fact that both smooth brome grass and orchard grass are desirable companion grasses with Ladino clover. Orchard and brome grass may be beneficial to Ladino clover by reducing the establishment of the weedy grasses, bent grass, and Kentucky bluegrass, which are serious K competitors with Ladino clover (13).

Figure 9. Percent of orchard, bent grass and Kentucky bluegrass. High P = 200 lbs. P_2O_5 per acre at seeding time. High K = 150 and Low K = 0 lbs. K_2O per acre annually. * S = Spring, F = Fall.

) - Low K

) - Low K

Figure 10. This photograph was taken in August before the second harvest in the third crop year. It shows a lengthwise view of an orchard grass fertility series. The stunted growth and yellow-brown coloration of the low potash plots are easily distinguished.

Across the fence in the background is a typical "permanent" pasture of New England. The difference in mid-summer growth between this "unimproved" and poorly fertilized pasture and the "improved" well fertilized grasses is thus apparent.

SUMMARY AND CONCLUSIONS

A field experiment was begun in 1949 to study the phosphorus and potassium requirements of the forage crops, Ladino clover, orchard grass, smooth brome grass and timothy. Each species was planted as a pure stand. Potassium was applied in small increments (50 or 100 pounds K_2O per acre) after each cutting. Phosphate applications made annually were compared with large single phosphate applications applied at seeding time. Vegetative composition was determined on certain treatments to study the effect of P and K rates on species competition. The forage from each plot was weighed, sampled and analyzed for potassium, phosphorus, calcium and magnesium.

Herbage yields of all crops showed marked response to potassium applications after the first year. Second year increases in dry matter as a result of increasing K rates were 73%, 113%, 54% and 41% for Ladino, orchard grass, brome grass and timothy, respectively. Annual phosphorus applications failed to give significant increases of dry matter production in most crops. Timothy was the only crop that responded to increasing initial P rates above the lowest rate (50 pounds P_2O_5 per acre applied at seeding time). The efficiency of phosphorus removal expressed as percent of applied P_2O_5 was unusually high as compared to reported P removal by cultivated crops. The grasses on the average removed the equivalent of 165% of applied P_2O_5 (three

crop years) on the lowest P_2O_5 treatment, whereas Ladino clover which produced much less dry matter utilized an equivalent of 113% of applied P_2O_5 . It is evident that under the system of management used with high N and K fertilization, the grasses were able to utilize appreciable amounts of fixed phosphorus.

Competition for K between desirable forage species and undesirable weedy species has a pronounced influence on the longevity of the stand. By the spring of the third crop year, Ladino clover comprised less than five percent of the vegetation on low K plots. The remaining vegetation was predominately the weedy grasses, Kentucky bluegrass and bent grass. On the high K plots Ladino clover comprised 70% of the stand in the spring of the third year.

Practical Application of the Results Reported Herein.

During the second and third year of this experiment it became apparent that Kentucky bluegrass and bent grasses were serious weed pests under the conditions studied. It was also apparent that the ingress of these weedy grasses was due, in large part, to stolons and underground rootstocks which were present before seeding time. Both of these weed pests are perennials and they produce rhizomes or stolons which are very difficult if not impossible to destroy by ordinary cultural practices. Unless all portions of these weedy plants are killed before seeding, vigorous growing stands of Ladino clover will be unable to persist for more than two to three

years. Frequent potassium applications that keep the supply of this element high will aid in extending the life of a Ladino stand under these conditions but will not prevent the eventual dominance of weedy grasses.

Considering the efficiency with which improved forage grasses remove potassium from the soil, it is not possible to build up the reserves of this element in this soil. This factor, in addition to species competition and the absorption of luxury amounts of soluble K, points to the desirability of making split applications of K fertilizer. Two applications and preferably three (one after each of three cuttings) are desirable for the faster growing improved forage species, such as Ladino clover, orchard grass and smooth brome grass.

The high efficiency of phosphorus uptake must also be considered. The current program for a Grassland Agriculture will result in serious depletion of soil P reserves unless adequate amounts of fertilizer P are returned to the soil.

Although the percent P in the plant material increased with added annual increments of P, there was no significant yield response to P on most species above the lowest P rate. On this soil phosphate needs of the crop for 3 to 4 years were supplied by banding 50 to 100 pounds P_2O_5 per acre at seeding time. Surface broadcasting of phosphate fertilizer on perennial forage crops is a highly inefficient method of applying this element. Banding 100 pounds P_2O_5 per acre at seeding time produced high yields of dry matter and

maintained the soil reserves of phosphate. The application of 500 pounds P_2O_5 (200 at seeding time and 100 pounds per acre annually for 3 years) gave dry matter increases of 1 ton of Ladino, orchard and bromegrass and 2 tons of timothy per acre (3 year total). At current prices 500 pounds of P_2O_5 (1 1/4 tons of 20% superphosphate) would cost approximately \$50. The value of the dry matter increase for three years would be \$30 to \$60 per acre, assuming it was United States Grade Number 2 hay.

As stated before, on this and similar soils, the initial application of 100 pounds P_2O_5 per acre for the legumes and grasses studied appeared adequate for 3 to 4 years of production. Certainly where 100 pounds of P_2O_5 per acre were applied initially, one could not justify, economically, annual topdress applications of superphosphate.

A P P E N D I X

Dry matter, pounds per acre.

Cutting: Treat- ment	1 9 5 0			:	1 9 5 1			:	1 9 5 2		
	1-st	2-nd	3-rd	:	1-st	2-nd	3-rd	:	1-st	2-nd	3-rd
L A D I N O											
1	1872	1436	1009		1109	1143	685		1743	1511	--
2	1650	1447	909		1352	1122	775		1479	1757	--
3	1792	1503	819		1129	1050	618		1399	1362	--
4	1924	1398	664		741	628	247		--	--	--
5	1799	1409	370		843	769	270		--	--	--
6	1824	1625	1007		1868	1309	826		1713	1999	--
7	1841	1442	999		1798	1058	748		1930	1703	--
O R C H A R D G R A S S											
1	3403	1465	1967		3165	1740	954		2661	2118	1727
2	3221	1610	1869		3114	1716	1208		2692	2189	1584
3	3125	1515	1887		3164	1776	938		2380	2080	1534
4	3329	1102	1541		1455	1118	101		910	691	408
5	2759	1227	1216		1564	1204	131		1019	884	527
6	3251	1588	2040		3584	1826	1136		2763	2483	1981
7	3513	1510	2152		3581	1778	1142		3056	2253	1808
B R O M E G R A S S											
1	4053	1273	--		3942	1558	478		3452	1845	983
2	4262	1846	--		4366	1960	980		3665	1930	1215
3	4943	1753	--		4426	1864	836		3113	1858	1076
4	4998	1475	--		3459	1084	141		1667	714	557
5	4595	1468	--		3059	1124	534		1658	1011	743
6	4702	2006	--		4900	2104	1184		3864	2141	1454
7	4153	1588	--		4550	1952	771		3913	2121	1152
T I M O T H Y											
1	5118	2117	--		5652	2090	--		4883	1824	--
2	5488	2163	--		6370	2068	--		5070	1677	--
3	4911	1523	--		5146	2045	--		4847	1705	--
4	5652	1836	--		4888	821	--		2717	649	--
5	5487	1255	--		4683	670	--		2688	596	--
6	5488	2738	--		5850	2600	--		5422	2037	--
7	6015	2423	--		5922	2748	--		5616	2108	--

THREE-YEAR SUMMARY

Pounds of dry matter per acre.

Treat- ment	1 9 5 0	1 9 5 1	1 9 5 2	Total
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L A D I N O

1	4317	2937	3254	10508
2	4006	3249	3236	10491
3	4114	2797	2761	9672
4	3986	1616	-----	5602
5	3578	1882	-----	5460
6	4456	4003	3712	12171
7	4282	3604	3633	11519
Avg.	4105	2869	3319	10293

O R C H A R D G R A S S

1	6835	5859	6506	19200
2	6700	6038	6465	19203
3	6527	5878	5994	18399
4	5972	2674	2009	10655
5	5202	2899	2430	10531
6	6879	6546	7227	20652
7	7175	6501	7117	20793
Avg.	6470	5199	5392	17061

B R O M E G R A S S

1	5326	5978	6280	17584
2	6108	7306	6810	20224
3	6696	7126	6047	19869
4	6473	4584	2938	14095
5	6063	4717	3412	14192
6	6708	8188	7459	22355
7	5741	7273	7186	20200
Avg.	6159	6467	5733	18359

T I M O T H Y

1	7235	7742	6707	21684
2	7651	8438	6747	22836
3	6434	7191	6552	20177
4	7488	5709	3366	16563
5	6742	5353	3284	15379
6	8226	8450	7459	24135
7	8438	8670	7724	24832
Avg.	7459	7364	5977	20800

PERCENT POTASSIUM

Cutting: Treat- ment	1 9 5 0			:	1 9 5 1			:	1 9 5 2		
	1-st	2-nd	3-rd	:	1-st	2-nd	3-rd	:	1-st	2-nd	3-rd
L A D I N O											
1	2.35	2.40	2.63		2.04	2.64	2.78		2.02	2.07	--
2	2.06	2.36	2.77		1.94	2.78	2.79		1.73	2.40	--
3	2.71	2.55	2.78		2.10	2.78	2.89		2.02	2.12	--
4	2.01	1.40	1.50		1.38	1.55	1.22		--	--	--
5	2.29	1.41	1.48		1.60	1.58	1.26		--	--	--
6	2.05	2.45	2.73		1.70	2.64	2.73		1.71	2.06	--
7	3.24	2.86	2.97		2.40	2.91	3.11		2.25	2.27	--
O R C H A R D G R A S S											
1	2.54	3.48	3.28		1.75	2.55	2.68		2.24	2.65	2.16
2	2.47	3.35	3.17		1.58	2.36	2.80		2.17	2.72	2.36
3	2.62	3.57	3.34		1.77	2.48	2.82		2.34	2.67	2.26
4	2.28	1.38	1.17		0.85	0.55	0.77		0.88	0.68	0.61
5	2.17	1.50	1.20		1.01	0.74	0.85		1.03	0.75	0.62
6	2.19	3.14	3.12		1.37	2.19	2.57		2.12	2.53	2.09
7	3.36	3.71	3.42		1.99	2.65	2.74		2.71	2.86	2.18
B R O M E G R A S S											
1	1.90	2.92	--		2.26	2.87	2.89		2.45	2.40	1.97
2	1.65	2.61	--		2.07	2.75	3.32		1.60	2.38	2.46
3	1.83	2.63	--		1.97	2.61	3.45		1.95	2.49	2.38
4	1.37	1.25	--		0.90	0.66	0.66		0.88	0.65	0.53
5	1.73	1.31	--		1.20	0.85	1.33		1.19	0.77	0.70
6	1.51	2.44	--		1.81	2.52	3.09		1.90	2.20	2.11
7	2.43	3.03	--		2.44	2.96	3.07		2.50	2.60	2.44
T I M O T H Y											
1	1.44	1.23	--		1.28	1.21	--		1.37	1.31	--
2	1.31	1.16	--		1.21	1.17	--		1.29	1.31	--
3	1.76	1.42	--		1.49	1.29	--		1.47	1.21	--
4	1.38	0.75	--		0.68	0.67	--		0.77	0.58	--
5	1.32	0.79	--		0.84	0.73	--		0.74	0.62	--
6	1.35	1.14	--		1.27	1.10	--		1.29	1.20	--
7	1.87	1.27	--		1.62	1.19	--		1.52	1.40	--

Potassium uptake, pounds K per acre.

Cutting: Treat- ment	1 9 5 0			:	1 9 5 1			:	1 9 5 2		
	1-st	2-nd	3-rd	:	1-st	2-nd	3-rd	:	1-st	2-nd	3-rd
L A D I N O											
1	44.0	34.5	26.5		22.6	30.2	19.0		35.2	31.3	--
2	34.0	34.2	25.2		26.2	31.2	21.6		25.6	42.2	--
3	48.6	38.3	22.8		23.7	29.2	17.9		28.3	28.9	--
4	38.7	19.6	10.0		10.2	9.7	3.0		--	--	--
5	41.2	19.9	5.2		13.5	12.2	3.4		--	--	--
6	37.4	39.8	27.5		31.8	34.6	22.5		29.3	41.2	--
7	59.6	41.2	29.7		43.2	30.8	23.3		43.4	38.7	--
O R C H A R D G R A S S											
1	86.4	51.0	64.5		55.4	44.4	25.6		59.6	56.1	37.3
2	79.6	53.9	59.3		49.2	40.5	33.8		58.4	59.5	37.4
3	81.9	54.1	63.0		56.0	44.0	26.4		55.7	55.5	34.7
4	75.9	15.2	18.0		12.4	6.1	0.8		8.0	4.7	2.3
5	59.9	18.4	14.6		15.8	8.9	1.1		10.5	6.6	3.3
6	71.2	49.9	63.6		49.1	40.0	29.2		58.6	62.8	41.4
7	118.0	56.0	73.6		71.3	47.1	31.3		82.8	64.4	39.4
B R O M E G R A S S											
1	77.0	37.2	--		89.1	44.7	13.8		84.6	36.3	19.4
2	70.3	48.2	--		90.4	53.9	32.5		58.6	45.9	29.9
3	90.5	46.1	--		87.2	48.7	28.8		60.7	46.3	25.6
4	68.5	18.4	--		31.1	7.2	0.9		14.7	4.6	3.0
5	79.5	19.2	--		36.7	9.5	7.1		19.7	7.8	5.2
6	71.0	48.9	--		88.7	53.0	36.6		73.4	47.1	30.7
7	100.9	48.1	--		111.0	57.8	23.7		97.8	55.1	28.1
T I M O T H Y											
1	73.7	26.0	--		72.3	25.3	--		66.9	23.9	--
2	71.9	25.1	--		77.1	24.2	--		65.4	22.0	--
3	86.4	21.6	--		76.7	26.4	--		71.2	20.6	--
4	78.0	13.8	--		33.2	5.5	--		20.9	3.8	--
5	72.4	9.9	--		39.3	4.9	--		19.9	3.7	--
6	74.1	31.2	--		74.3	28.6	--		69.9	24.4	--
7	112.5	30.8	--		95.9	32.7	--		85.4	29.5	--

THREE-YEAR SUMMARY

Potash uptake, lbs. K per acre and percent K.

Treat- ment	1 9 5 0		1 9 5 1		1 9 5 2		Three-year Summary	
	lbs K	% K	lbs K	% K	lbs K	% K	lbs K	% K
L A D I N O								
1	105	2.43	72	2.45	67	2.06	244	2.32
2	93	2.32	79	2.43	68	2.10	240	2.29
3	110	2.67	71	2.54	57	2.06	238	2.46
4	68	1.70	23	1.42	--	--	91	1.62
5	66	1.84	29	1.54	--	--	95	1.74
6	105	2.36	89	2.22	70	1.89	264	2.17
7	131	3.06	97	2.69	82	2.26	310	2.69
O R C H A R D G R A S S								
1	202	2.96	125	2.13	153	2.35	480	2.50
2	193	2.88	123	2.04	155	2.40	471	2.45
3	199	3.05	126	2.14	146	2.43	471	2.56
4	109	1.82	19	0.71	15	0.75	143	1.34
5	93	1.79	26	0.90	20	0.82	139	1.32
6	185	2.69	118	1.80	163	2.26	466	2.26
7	248	3.46	150	2.31	187	2.63	585	2.81
B R O M E G R A S S								
1	114	2.14	148	2.48	140	2.23	402	2.29
2	118	1.93	177	2.42	134	1.97	429	2.12
3	137	2.04	165	2.32	133	2.20	435	2.19
4	87	1.34	39	0.83	22	0.75	148	1.05
5	99	1.63	53	1.12	33	0.97	185	1.30
6	120	1.79	178	2.17	151	2.02	449	2.01
7	149	2.59	192	2.64	181	2.52	522	2.58
T I M O T H Y								
1	100	1.38	97	1.25	91	1.36	288	1.33
2	97	1.27	101	1.20	87	1.29	285	1.25
3	108	1.68	103	1.43	92	1.40	303	1.50
4	92	1.23	39	0.68	25	0.74	156	0.94
5	82	1.22	44	0.82	24	0.73	150	0.97
6	105	1.28	103	1.22	94	1.26	302	1.25
7	143	1.69	129	1.49	115	1.49	387	1.56

PERCENT PHOSPHORUS

Cut- ting: Treat- ment	1 9 5 0			:	1 9 5 1			:	1 9 5 2		
	1-st	2-nd	3-rd	:	1-st	2-nd	3-rd	:	1-st	2-nd	3-rd

L A D I N O

1	0.296	0.273	0.267	0.253	0.295	0.276	0.212	0.267	--
2	.320	.280	.281	.246	.307	.277	.232	.260	--
3	.260	.263	.267	.236	.295	.257	.219	.255	--
4	.313	.280	.283	.281	.318	.287	--	--	--
5	.245	.260	.277	.255	.310	.297	--	--	--
6	.321	.305	.304	.247	.328	.298	.277	.263	--
7	.315	.297	.285	.243	.323	.301	.278	.266	--

O R C H A R D G R A S S

1	0.228	0.276	0.299	0.207	0.314	0.258	0.210	0.289	0.239
2	.207	.253	.272	.207	.298	.258	.200	.264	.246
3	.202	.228	.254	.181	.274	.248	.183	.244	.219
4	.230	.308	.314	.248	.324	.262	.288	.282	.269
5	.210	.269	.278	.218	.317	.253	.244	.267	.236
6	.211	.346	.342	.235	.386	.319	.243	.325	.298
7	.229	.325	.330	.233	.380	.319	.239	.319	.299

B R O M E G R A S S

1	0.223	0.286	--	0.174	0.287	0.311	0.145	0.213	0.260
2	.225	.280	--	.157	.249	.312	.157	.235	.279
3	.189	.270	--	.129	.234	.307	.147	.221	.252
4	.230	.352	--	.171	.328	.324	.247	.315	.293
5	.193	.323	--	.145	.287	.302	.178	.225	.279
6	.218	.320	--	.179	.282	.371	.242	.263	.299
7	.223	.303	--	.186	.294	.366	.225	.265	.213

T I M O T H Y

1	0.160	0.147	--	0.133	0.162	--	0.165	0.212	--
2	.153	.132	--	.135	.162	--	.146	.204	--
3	.152	.161	--	.128	.166	--	.133	.198	--
4	.158	.137	--	.150	.195	--	.198	.261	--
5	.140	.141	--	.145	.188	--	.173	.252	--
6	.147	.162	--	.165	.178	--	.184	.251	--
7	.164	.152	--	.148	.171	--	.188	.213	--

PHOSPHORUS UPTAKE, POUNDS P PER ACRE

1 9 5 0			:	1 9 5 1			:	1 9 5 2		
Cutting: 1-st 2-nd 3-rd			:	1-st 2-nd 3-rd			:	1-st 2-nd 3-rd		
Treat-										
ment										

L A D I N O

1	5.54	3.92	2.69	2.81	3.37	1.89	3.70	4.03	--
2	5.28	4.05	2.55	3.33	3.44	2.15	3.43	4.57	--
3	4.66	3.95	2.19	2.66	3.10	1.59	3.06	3.47	--
4	6.02	3.91	1.88	2.08	2.00	0.71	--	--	--
5	4.41	3.66	1.02	2.15	2.38	0.80	--	--	--
6	5.86	4.96	3.06	4.61	4.29	2.46	4.74	5.26	--
7	5.80	4.28	2.75	4.37	3.42	2.25	5.36	4.53	--

O R C H A R D G R A S S

1	7.76	4.04	5.88	6.55	5.46	2.46	5.59	6.12	4.13
2	6.67	4.07	5.08	6.45	5.11	3.12	5.38	5.79	3.90
3	6.31	3.45	4.79	5.73	4.87	2.33	4.36	5.07	3.36
4	7.66	3.39	4.84	3.61	3.62	0.26	2.62	1.95	1.10
5	5.79	3.30	3.38	3.41	3.82	0.33	2.49	2.36	1.24
6	6.86	5.49	6.98	8.42	7.05	3.62	6.71	8.07	5.90
7	8.04	4.91	7.10	8.34	6.76	3.64	7.30	7.19	5.41

B R O M E G R A S S

1	9.04	3.64	--	6.86	4.47	1.49	5.00	3.93	2.56
2	9.59	5.17	--	6.85	4.88	3.06	5.75	4.54	3.39
3	9.34	4.73	--	5.71	4.36	2.57	4.58	4.11	2.71
4	11.50	5.19	--	5.91	3.55	0.46	4.12	2.25	1.63
5	8.87	4.74	--	4.44	3.23	1.61	2.95	2.27	2.07
6	10.25	6.42	--	8.77	5.93	4.39	9.35	5.63	4.35
7	9.26	4.81	--	8.46	5.74	2.82	8.80	5.62	2.45

T I M O T H Y

1	8.19	3.11	--	7.52	3.38	--	8.06	3.87	--
2	8.40	2.86	--	8.60	3.35	--	7.40	3.42	--
3	7.46	2.45	--	6.59	3.39	--	6.45	3.38	--
4	8.93	2.52	--	7.33	1.60	--	5.38	1.69	--
5	7.68	1.77	--	6.79	1.26	--	4.65	1.50	--
6	8.07	4.44	--	9.65	4.63	--	9.98	5.11	--
7	9.86	3.68	--	8.76	4.70	--	10.63	4.49	--

THREE-YEAR SUMMARY

Phosphorus uptake, lbs. P per acre and percent P.

Treat- ment	1 9 5 0		1 9 5 1		1 9 5 2		Three-year Summary	
	lbs P	% P	lbs P	% P	lbs P	% P	lbs P	% P
L A D I N O								
1	12.2	0.283	8.1	0.276	7.7	0.237	28.0	0.266
2	11.9	.297	8.9	.274	8.0	.247	28.8	.274
3	10.8	.262	7.4	.264	6.5	.235	24.7	.255
4	11.8	.296	4.8	.297	--	--	16.6	.296
5	9.1	.254	5.3	.282	--	--	14.4	.264
6	13.9	.312	11.4	.285	10.0	.269	35.3	.290
7	12.8	.299	10.0	.277	9.9	.272	32.7	.284
O R C H A R D G R A S S								
1	17.7	0.259	14.5	0.247	15.8	0.243	48.0	0.250
2	15.8	.236	14.7	.243	15.1	.234	45.6	.237
3	14.5	.222	12.9	.219	12.8	.214	40.2	.218
4	15.9	.266	7.5	.280	5.7	.284	29.1	.273
5	12.5	.240	7.6	.262	6.1	.251	26.2	.249
6	19.3	.280	19.1	.292	20.7	.286	59.1	.286
7	20.1	.280	18.7	.288	19.9	.280	58.7	.282
B R O M E G R A S S								
1	12.7	0.238	12.8	0.214	11.5	0.183	37.0	0.210
2	14.8	.242	14.8	.202	13.7	.201	43.3	.214
3	14.1	.210	12.6	.177	11.4	.188	38.1	.192
4	16.7	.258	9.9	.211	8.0	.272	34.6	.245
5	13.6	.224	9.3	.197	7.3	.214	30.2	.213
6	16.7	.249	19.1	.233	19.3	.259	55.1	.246
7	14.1	.246	17.0	.234	16.9	.235	48.0	.238
T I M O T H Y								
1	11.3	0.156	10.9	0.141	11.9	0.177	34.1	0.157
2	11.3	.148	11.9	.141	10.8	.160	34.0	.149
3	9.9	.154	10.0	.139	9.8	.150	29.7	.147
4	11.4	.152	8.9	.156	7.1	.211	27.4	.165
5	9.4	.139	8.0	.149	6.2	.189	23.6	.153
6	12.5	.152	14.3	.169	15.1	.202	41.9	.174
7	13.5	.160	13.5	.156	15.1	.195	42.1	.170

PERCENT CALCIUM

Cutting: Treat- ment	1 9 5 0			:	1 9 5 1			:	1 9 5 2		
	1-st	2-nd	3-rd	:	1-st	2-nd	3-rd	:	1-st	2-nd	3-rd
L A D I N O											
1	1.41	1.04	0.84		0.99	0.90	0.75		0.75	0.61	--
2	1.53	1.08	.94		1.18	.96	.87		.88	.71	--
3	1.40	1.01	.84		1.00	.92	.80		.89	.69	--
4	1.57	1.24	.92		1.24	1.01	.79		--	--	--
5	1.65	1.13	.92		.92	.97	.70		--	--	--
6	1.49	1.17	.96		1.39	1.10	1.03		1.17	.90	--
7	1.18	1.06	.88		1.05	.93	.85		.88	.83	--
O R C H A R D G R A S S											
1	0.27	0.33	0.28		0.25	0.36	0.40		0.32	0.33	0.43
2	.27	.33	.31		.24	.37	.38		.31	.30	.39
3	.26	.29	.27		.24	.33	.38		.32	.28	.35
4	.29	.41	.36		.37	.48	.66		.52	.53	.63
5	.28	.39	.37		.32	.43	.59		.46	.49	.56
6	.30	.37	.32		.29	.43	.47		.38	.37	.45
7	.25	.35	.32		.26	.39	.44		.35	.37	.44
B R O M E G R A S S											
1	0.24	0.39	--		0.21	0.27	0.39		0.26	0.28	0.42
2	.22	.36	--		.23	.26	.37		.28	.27	.42
3	.21	.33	--		.17	.25	.35		.23	.25	.37
4	.23	.44	--		.26	.44	.60		.35	.50	.67
5	.22	.42	--		.27	.39	.54		.39	.45	.61
6	.25	.37	--		.21	.29	.39		.29	.29	.44
7	.20	.37	--		.18	.28	.40		.28	.27	.45
T I M O T H Y											
1	0.28	0.26	--		0.25	0.40	--		0.28	0.39	--
2	.28	.25	--		.24	.41	--		.27	.39	--
3	.27	.28	--		.24	.36	--		.28	.36	--
4	.25	.31	--		.26	.59	--		.37	.62	--
5	.25	.31	--		.26	.53	--		.33	.61	--
6	.27	.25	--		.27	.38	--		.31	.45	--
7	.25	.23	--		.25	.34	--		.28	.36	--

THREE-YEAR SUMMARY

Calcium uptake, pounds Ca per acre and percent of Ca.

Treat- ment	1 9 5 0		1 9 5 1		1 9 5 2		Three-year Summary	
	lbs Ca	% Ca	lbs Ca	% Ca	lbs Ca	% Ca	lbs Ca	% Ca
L A D I N O								
1	49.8	1.15	26.7	0.91	22.3	0.68	98.8	0.94
2	49.4	1.23	33.5	1.03	25.5	0.79	108.4	1.03
3	47.2	1.15	26.1	0.93	21.9	0.79	95.2	0.98
4	53.7	1.35	17.4	1.08	--	--	71.1	1.27
5	46.9	1.31	17.0	0.90	--	--	63.9	1.17
6	55.9	1.25	48.7	1.22	38.0	1.02	142.6	1.17
7	45.8	1.07	35.0	0.97	31.1	0.86	111.9	0.97
O R C H A R D G R A S S								
1	19.7	0.29	18.1	0.31	22.9	0.35	60.7	0.32
2	19.9	.30	18.3	.30	21.1	.33	59.3	.31
3	17.6	.27	17.0	.29	18.8	.31	53.4	.29
4	19.6	.33	11.3	.42	11.0	.55	41.9	.39
5	17.1	.33	10.8	.37	12.0	.49	39.9	.38
6	22.0	.32	23.7	.36	28.6	.40	74.3	.36
7	21.1	.29	21.5	.33	27.0	.38	69.6	.33
B R O M E G R A S S								
1	14.6	0.27	14.0	0.23	18.3	0.29	46.9	0.27
2	16.0	.26	18.7	.26	20.6	.30	55.3	.27
3	16.2	.24	15.3	.21	15.8	.26	47.3	.24
4	17.9	.28	14.5	.31	13.1	.44	45.5	.32
5	16.2	.27	15.8	.33	15.5	.45	47.5	.33
6	19.2	.29	20.9	.26	23.8	.32	63.9	.28
7	14.1	.24	16.9	.23	21.9	.30	52.9	.26
T I M O T H Y								
1	19.7	0.27	22.0	0.28	20.8	0.31	62.5	0.29
2	21.0	.27	25.7	.30	20.2	.30	66.9	.29
3	17.6	.27	19.7	.27	19.7	.30	57.0	.28
4	20.0	.27	18.4	.32	14.0	.42	52.4	.32
5	17.8	.26	15.9	.30	12.5	.38	46.2	.30
6	21.7	.26	26.7	.32	26.0	.35	74.4	.31
7	20.6	.24	24.3	.28	23.3	.30	68.2	.27

PERCENT MAGNESIUM

Cutting Treat- ment	1 9 5 0			1 9 5 1		
	1-st	2-nd	3-rd	1-st	2-nd	3-rd
L A D I N O						
1	0.332	0.342	0.388	0.390	0.431	0.387
2	.331	.332	.350	.344	.426	.381
3	.331	.318	.357	.333	.449	.351
4	.337	.391	.414	.470	.541	.529
5	.372	.418	.437	.425	.514	.508
6	.337	.300	.354	.378	.404	.327
7	.297	.275	.314	.301	.395	.355
O R C H A R D G R A S S						
1	0.230	0.304	0.358	0.208	0.356	0.358
2	.225	.303	.385	.178	.386	.364
3	.210	.280	.345	.169	.338	.371
4	.263	.408	.483	.336	.506	.560
5	.241	.388	.494	.287	.503	.531
6	.249	.279	.351	.199	.329	.304
7	.208	.298	.354	.181	.303	.335
B R O M E G R A S S						
1	0.145	0.209	--	0.130	0.226	0.293
2	.141	.161	--	.114	.199	.277
3	.091	.174	--	.109	.208	.280
4	.135	.310	--	.190	.370	.375
5	.133	.291	--	.163	.340	.365
6	.147	.162	--	.107	.175	.258
7	.100	.159	--	.098	.171	.264
T I M O T H Y						
1	0.120	0.184	--	0.120	0.262	--
2	.121	.166	--	.133	.260	--
3	.122	.210	--	.128	.245	--
4	.109	.231	--	.193	.344	--
5	.129	.232	--	.171	.351	--
6	.116	.140	--	.141	.227	--
7	.104	.148	--	.098	.182	--

TWO-YEAR SUMMARY

Magnesium uptake, pounds Mg per acre and percent Mg.

Treat- ment	1 9 5 0		1 9 5 1		Two-year Summary	
	lbs Mg	% Mg	lbs Mg	% Mg	lbs Mg	% Mg
L A D I N O						
1	15.0	0.35	11.8	0.40	26.8	0.37
2	13.4	.33	12.4	.38	25.8	.36
3	13.6	.33	10.6	.38	24.2	.35
4	14.7	.37	8.2	.51	22.9	.41
5	18.7	.52	8.9	.47	27.6	.51
6	14.6	.33	15.0	.37	29.6	.35
7	12.6	.29	12.2	.34	24.8	.31
O R C H A R D G R A S S						
1	19.3	0.28	16.3	0.28	35.6	0.28
2	19.3	.29	16.7	.28	36.0	.28
3	17.3	.26	14.9	.25	32.2	.26
4	20.7	.35	11.0	.41	31.7	.37
5	17.4	.33	11.3	.39	28.7	.35
6	19.7	.29	16.7	.26	36.4	.27
7	19.4	.27	15.8	.24	35.2	.26
B R O M E G R A S S						
1	8.5	0.16	9.9	0.16	18.4	0.16
2	9.0	.15	11.6	.16	20.6	.15
3	7.5	.11	11.0	.15	18.5	.13
4	11.3	.17	11.1	.24	22.4	.20
5	10.4	.17	10.8	.23	21.2	.20
6	10.2	.15	12.0	.15	22.2	.15
7	6.7	.12	9.7	.13	16.4	.13
T I M O T H Y						
1	10.0	0.14	12.2	0.16	22.2	0.15
2	10.2	.13	13.8	.16	24.0	.15
3	9.2	.14	11.6	.16	20.8	.15
4	10.4	.14	12.0	.21	22.4	.17
5	10.0	.15	10.3	.19	20.3	.17
6	10.2	.12	13.9	.16	24.1	.14
7	9.9	.12	10.9	.13	20.8	.12

Botanical Composition in Percent Crop, Percent
Kentucky Bluegrass and Percent Bent Grasses

		1 9 5 0			1 9 5 1			1 9 5 2				
Cutting:		1-st	2-nd	3-rd	:	1-st	2-nd	3-rd	:	1-st	2-nd	3-rd
Treat- ment												
		L A D I N O										
2	Crop	88	81	95		81	64	69		30	40	30
	Ky. Bl.	5	1	2		6	16	17		32	28	42
	Bent	7	18	3		13	20	14		38	32	28
3	Crop	89	90	89		67	50	54		31	44	30
	Ky. Bl.	3	tr	4		11	16	21		27	25	40
	Bent	8	10	7		22	34	25		42	31	30
4	Crop	88	80	89		46	30	14		6	6	4
	Ky. Bl.	7	7	5		20	19	24		30	38	60
	Bent	5	13	6		34	51	62		64	56	36
5	Crop	90	88	89		30	15	7		5	2	tr
	Ky. Bl.	5	2	6		19	15	23		37	32	65
	Bent	5	10	5		51	70	70		58	66	35
		O R C H A R D G R A S S										
2	Crop	90	93	98		98	99	100		97	100	92
	Ky. Bl.	5	2	1		2	1	tr		3	tr	6
	Bent	5	5	1		tr	tr	tr		tr	tr	2
3	Crop	90	85	97		97	100	100		86	100	94
	Ky. Bl.	3	1	1		2	tr	tr		7	tr	4
	Bent	7	14	2		1	tr	tr		7	tr	2
4	Crop	91	86	95		95	96	82		75	60	31
	Ky. Bl.	4	4	tr		3	2	11		20	31	49
	Bent	5	10	5		2	2	7		5	9	20
5	Crop	90	83	96		96	98	76		71	72	40
	Ky. Bl.	3	2	tr		4	1	15		21	19	43
	Bent	7	15	4		tr	1	9		8	9	17

Botanical Composition in Percent Crop, Percent
Kentucky Bluegrass and Percent Bent Grasses

1 9 5 0				1 9 5 1			1 9 5 2				
Cutting:	1-st	2-nd	3-rd	:	1-st	2-nd	3-rd	:	1-st	2-nd	3-rd
Treat-											
ment											
B R O M E G R A S S											
2	Crop	95	89	--	96	98	100		86	100	65
	Ky. Bl.	3	7	--	2	1	tr		14	tr	27
	Bent	2	4	--	2	1	tr		tr	tr	8
3	Crop	91	91	--	93	90	100		82	93	67
	Ky. Bl.	1	5	--	5	5	tr		8	2	28
	Bent	8	4	--	2	5	tr		10	5	5
4	Crop	90	88	--	93	80	64		46	25	11
	Ky. Bl.	4	6	--	5	15	18		32	55	70
	Bent	6	6	--	2	5	18		22	20	19
5	Crop	91	87	--	92	84	59		40	27	7
	Ky. Bl.	5	5	--	8	10	23		40	50	78
	Bent	4	8	--	tr	6	18		20	23	15
T I M O T H Y											
2	Crop	90	85	--	95	77	--		85	29	--
	Ky. Bl.	2	4	--	3	8	--		8	25	--
	Bent	8	11	--	2	15	--		7	46	--
3	Crop	65	45	--	62	46	--		53	15	--
	Ky. Bl.	5	5	--	3	11	--		11	29	--
	Bent	30	50	--	35	43	--		36	56	--
4	Crop	90	80	--	78	52	--		44	3	--
	Ky. Bl.	5	6	--	3	12	--		30	48	--
	Bent	5	14	--	19	36	--		26	49	--
5	Crop	73	52	--	73	40	--		50	5	--
	Ky. Bl.	5	8	--	7	14	--		30	45	--
	Bent	22	40	--	20	46	--		20	50	--

LITERATURE CITED

1. Bass, G. B. and Sieling, D. H. 1950 Method for Determining Relative Phosphate-Fixing Capacity of Acid Soils. Soil Sci. 69:269
2. Bear, F. E. and Prince, A. L. 1945 Cation-Equivalent Constancy in Alfalfa. Jour. Amer. Soc. Agron. 37:217
3. Beeson, K. C. 1941 The Mineral Composition of Crops With Particular Reference to the Soils in Which They Were Grown. U.S.D.A. Misc. Publ. No. 369
4. Blaser, R. E. and Brady, N. C. 1950 Nutrient Competition in Plant Associations. Agron. Jour. 42:128
5. Brown, B. A. 1939 Some Factors Affecting the Prevalence of White Clover in Grassland. Jour. Amer. Soc. Agron. 31:322
6. Brown, E. M. 1943 Seasonal Variations in the Growth and Chemical Composition of Kentucky Bluegrass. Mo. Agr. Exp. Sta. Res. Bul. 360
7. Colby, W. G., Light, M. A. and Bertinuson, T. A. 1953 The Influence of Wind-Blown Materials on the Soils of Massachusetts. Soil Sci. Soc. Amer. Proc. 17. (In Press)
8. Cooper, H. P., Wilson, J. K. and Barron, J. H. 1929 Ecological Factors Determining the Pasture Flora in the Northeast U. S. Jour. Amer. Soc. Agron. 21:607
9. Dalton, J. D., Russell, G. C. and Sieling, D. H. 1952 Effect of Organic Matter on Phosphate Availability. Soil Sci. 73:173
10. Duley, F. L. 1930 Methods of Applying Fertilizers to Wheat. Jour. Amer. Soc. Agron. 22:515
11. Fergus, E. N. 1935 The Place of Legumes in Pasture Production. Jour. Amer. Soc. Agron. 27:367
12. Garber, R. J., Myers, W. M. and Sprague, V. G. 1946 Pastures and Pasture Problems in Northeastern States. Penn. Agr. Expt. Sta. Bul. 485
13. Gray, B. C., Drake, M. and Colby, W. G. 1953 Potassium Competition in Grass-Legume Associations as a Function of Root Cation Exchange Capacity. Soil Sci. Soc. Amer. Proc. 17. (In Press)

14. Lucas, R. E. and Scarseth, G. D. 1947 Potassium, Calcium, and Magnesium Balance and Reciprocal Relationship in Plants. Jour. Amer. Soc. Agron. 39:887
15. Salter, R. M. 1938 Methods of Applying Fertilizers. 1938 Yearbook of Agriculture. 546
16. Sprague, H. B. 1933 Root Development of Perennial Grasses and Its Relation to Soil Conditions. Soil Sci. 36:189
17. Sprague, M. A. and Eby, C. 1948 Growing Ladino Clover in New Jersey. N. J. Agr. Expt. Sta. Bul. 736
18. Sprague, V. G. and Garber, R. J. 1950 Effect of Time and Height of Cutting and Nitrogen Fertilization on the Persistence of the Legume and Production of Orchard Grass-Ladino and Bromegrass-Ladino Associations. Agron. Jour. 42:586
19. Stewart, I. and Bear, F. E. 1951 Ladino Clover - Its Mineral Requirements and Chemical Composition. N. J. Agri. Expt. Sta. Bul. 759
20. Stuckey, I. H. 1941 Seasonal Growth of Grass Roots. Amer. Jour. Bot. 28:486
21. Stuckey, I. H. 1942 The Influence of Soil Temperature on the Development of Colonial Bentgrass. Plant Physiology 17:116
22. Tesar, M. B. and Ahlgren, H. L. 1950 Effect of Height and Frequency of Cutting on the Productivity and Survival of Ladino. Agron. Jour. 42:230

APPROVED BY

R. B. Livingston

Joseph E. Steckel

F. W. Southwail

J. Harold Smith

Mark Drake, Chairman

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