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A Pasture Which Could Be Much Improved by Means of Liming and Top-dressing with Fertilizer

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SUMMARY AND CONCLUSIONS

Pasture improvement experiments were conducted on the Live Stock and the Dairy farms of the West Virginia Agricultural Experiment Station situated near Morgantown. The soil is typical in its topography of much pasture land in the state. The land was considered too steep for reestablishing the pasture by plowing. The only cultivation given was disking on some of the plots.

Top dressings of manure alone, manure and superphosphate, superphosphate alone, and nitrate of soda alone were applied both in combination with and without lime. Three different seed mixtures were compared. The value of cultivating with a disk harrow was tested. A number of plots were left without treatment to serve as checks.

Each plot was divided into a grazed and an ungrazed half. Yields were obtained on the ungrazed half and estimates on the percentage of various classes of pasture plants and weeds were made on both the grazed and ungrazed half of each plot every year.

A combination of manure and superphosphate, together with lime, produced the best results on both farms. A seed mixture was used with this treatment, and the plots were disked. This combination produced the highest yields, and the greatest improvement was noted in the kinds of pasture grasses thriving on such plots. Without lime the treatment was not nearly as effective as with lime.

Manure and lime proved to be the treatment next best to the combination of manure, superphosphate, and lime in effectiveness of improving the pasture. Without lime the response was much less.

Superphosphate with lime produced a decided increase in yield and quality. Superphosphate alone without lime was much less effective.

When lime was applied alone without any fertilizer treatment only small increases in yield resulted. The quality of pasture was, however, improved considerably by the treatment.

An application of nitrate of soda together with lime resulted in some increase in yield, but not as great as lime with superphosphate alone. Without lime the nitrate had little effect on either the yield or quality of the pasture.

Very little difference was observed between the 3 seed mixtures used, either in quantity of grass produced or quality of the pasture sod.

An application of superphosphate and lime without seeding or disking increased the yields and improved the quality of the pasture sod. The better pasture plants developed, and the weeds and poorer grasses decreased.

Disking alone without other treatments had very little effect on pasture.

Seeding alone without other treatment was of no value.

The cattle showed a very marked preference for certain plots where improved pasture grasses were increasing.

As a result of these experiments it is recommended that pastures of this type be top dressed with lime and superphosphate. In most cases a simple seed mixture probably should be added and the land, if not too rough, may be disked or harrowed. If manure is available a top dressing of this may also be expected to net a good return when applied to such pastures. When in doubt as to the advisability of using either lime or fertilizer on a pasture, a small area of the pasture should be used for a preliminary trial. The treatment of the remainder of the pasture should be based on this test.

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by T. E. ODLAND, C. V. WILSON,
H. O. HENDERSON, and E. P. DEATRICK*†

THE PASTURE crop in West Virginia is the most important crop in the state and at the same time the one on which the least study has been made. A number of pasture demonstrations have been carried on in different parts of the state but until recently there have been few attempts to get an actual measure of the increase in quantity and quality of pasture grasses resulting from various treatments. The reason for such meager information in this state as well as in most other states lies largely in the difficulties involved in conducting pasture investigations.

If the experiments include grazing and the measurement of increase in either meat or milk production, it is desirable to have several animals on each plot, and large plots are, therefore, required. If a number of treatments are compared on such plots, the area becomes large and the cost is likely to be prohibitive.

Another method employed in pasture investigations is to use plots similar to those used in field experiments. Instead of grazing the plots, the yields and values of the treatments are determined by cutting and weighing the grass. Although this method is the more convenient of the two, it is subject to the objection that the conditions of the experiment are not the same as they would have been under actual grazing.

In the experiments described in this bulletin an attempt was made to combine the two methods by grazing one-half of each plot, and cutting the other half for the yield determinations. Although it was not possible to make yield determinations on the grazed parts of the plots, a comparison was made each year by estimating the percentage of the various plants on the grazed and ungrazed halves of each plot.

A pasture survey[1] of 245 farms in West Virginia made a few years ago showed that on the average it required approximately four acres to carry a cow through the pasture season and a little more for a 3-year-old steer. It was estimated that a properly managed pasture in the area should support an animal on every two acres. The survey indicated that the pastures were not as productive

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†Mr. Odland resigned February, 1929.

[1]W. Va. Agri. Exp. Sta. Bul. 177.

as they had been some years ago and were becoming less productive. The farmers interviewed were all of the opinion that the pastures were rapidly deteriorating, but little agreement was evident as to the best remedy or the chief causes for the poor condition. A previous experiment at this Station[2], in which sheep were used to measure the value of different treatments, indicated that little improvement may be expected from an application of lime alone, but that lime in combination with either superphosphate or complete fertilizer results in marked improvement.

Recent experiments by the Pennsylvania Station[3] showed the greatest growth of bluegrass where complete fertilizer and lime were applied, and their use appeared to be profitable. The calculated return from an acre in good bluegrass pasture exceeded that from an acre of the crops of a regular 4-year rotation. Experiments at Cornell University[4] indicate that the greatest need of pastures in that state is lime and superphosphate.

TYPES OF PASTURE

Pastures may generally be classed as temporary, rotation, or permanent. In a temporary pasture, land is sown to some crop or combination of crops to provide a supplementary pasture for part of the season. In a rotation pasture, land in a regular rotation of crops is seeded and used for pasture for from one to several years. A permanent pasture is used for pasture for a greater number of years without plowing or reseeding. Permanent pastures may be grouped into 3 classes as to methods for treatment: (1) those that can be plowed and then re-established; (2) those too steep or rough to make plowing and reseeding practical but which may be improved by top-dressing with fertilizer and lime; and (3) those on poor, hilly lands more suitable for timber production than pasture.

The experiments of the Pennsylvania Station indicate that the best method of improving pastures of the first class is to plow, lime, and fertilize them, just as would be done with land for any other crop in a regular rotation. The largest proportion of pasture land in West Virginia probably belongs to the second class, land that is too steep and rolling to make plowing and reseeding practical. The experiments reported in this bulletin were conducted on land of this type.

PLAN OF THE EXPERIMENTS

The pasture experiments described in this bulletin were planned to obtain further information on the improvement of permanent pastures of the type that is too steep to plow. Because of the limited land available it was necessary to select treatments that would answer the more important questions relating to pasture improvement.

[2]W. Va. Agr. Exp. Sta. Bul. 177.
[3]Penna. Agr. Exp. Sta. Bul. 195.
[4]Cornell University Memoir 104.

Two series of plots were provided. One series consisting of 44 tenth-acre plots was laid out in 1922 on the Live Stock farm of the University near Morgantown. The other series, a duplicate of the first, was located about a half-mile away on the Dairy farm, and was begun in 1923. Both areas are rather steep and typical of much of the pasture land in the state. The pasture on the Dairy farm was in a little better state of fertility, as shown by the yields of grass obtained. The soil on both farms is classified as Dekalb clay loam. Acidity tests showed a lime requirement of about two tons of limestone per acre.

FIGURE 1.—Pastures like this should not be plowed, because of danger of soil erosion. They can often be much improved without plowing

The treatments consisted of manure, manure and superphosphate, superphosphate, and nitrate of soda. A limed strip extended across all plots so that for each treatment there was a limed half as well as an unlimed half. In addition to the fertilizer and lime treatments 3 seed mixtures were compared, and disking was contrasted to no-cultivation.

As shown in Figures 2 and 3, each experiment consisted of 4 series of plots, each 33 by 132 feet. Each treatment was replicated 3 times. Two plots in each series were left untreated for checks. The yield reported in each case is the average of the 4 plots for each year. Four-foot alleys separated the plots and a 16-foot roadway separated the various series. A strip 4 rods wide was limed* lengthwise through the middle of each series and across all the plots. Thus

*The lime used in this experiment was furnished by the Security Cement and Lime Co., now the North American Cement Corporation, Hagerstown, Md.

half of each plot was limed and half was not limed. A fence extended through the middle of each series so that half of each plot could be kept ungrazed. The yields were obtained by cutting the grass on the ungrazed halves.

The fertilizing materials were applied at the following rates per acre: manure, 8 tons, superphosphate, 300 pounds, and nitrate of soda, 100 pounds. Hydrated lime was applied at the rate of 1½ tons per acre—the equivalent of two tons of ground limestone. The fertilizers and manure were to be applied every third year, and the lime treatments every sixth year. The initial superphosphate and lime treatments were applied on the Live Stock farm in the fall of 1922, the manure during the following winter, and the nitrate of soda the following spring. The initial treatments on the Dairy farm were made in the fall of 1923 and spring of 1924. A second application of manure and fertilizer was made on the Live Stock farm in the spring of 1926 and on the Dairy farm in the spring of 1927. Yields are for 6 years on the Live Stock farm plots and for 5 years on the Dairy farm plots.

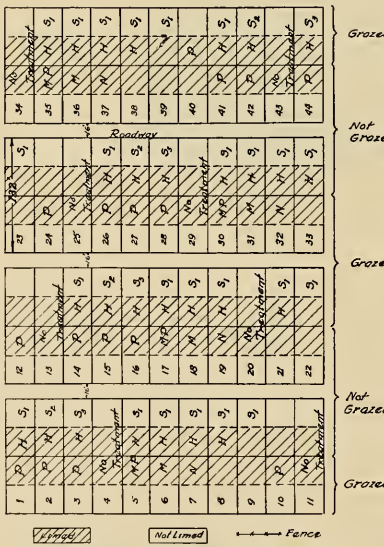

FIGURE 2.—Plan of pasture plots on the Live Stock farm. Each plot is 132 feet long and 33 feet wide. A 4-foot alley separates adjoining plots

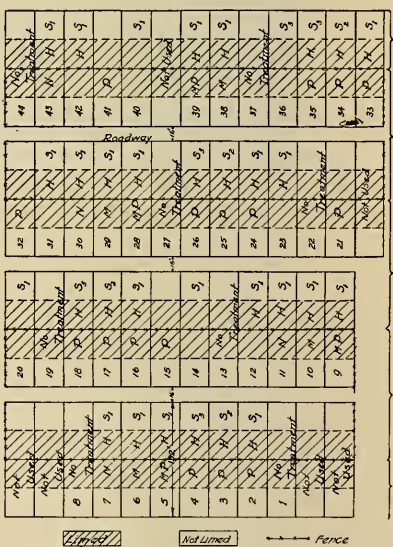

FIGURE 3.—Plan of pasture plots on the Dairy farm. Plots are 33x132 feet with a 4-foot alley separating adjoining plots

Seed Mixtures and Applications per Acre

Three different seed mixtures were sown. Seed mixture No. 1 was used as the standard on a number of plots subjected to various treatments. Mixtures No. 2 and 3 were sown separately on a plot in each series for comparison with Mixture No. 1. The following mixtures were used:

Seed Mixture No. 1

Timothy	4 lbs. per acre
Kentucky bluegrass	8 lbs. per acre
Alsike clover	3 lbs. per acre
White clover	1 lb. per acre

Seed Mixture No. 2

Timothy	4 lbs. per acre
Kentucky bluegrass	8 lbs. per acre
Orchard grass	4 lbs. per acre
Red clover	5 lbs. per acre
White clover	1 lb. per acre

Seed Mixture No. 3

Timothy	4 lbs. per acre
Kentucky bluegrass	4 lbs. per acre
Canada bluegrass	4 lbs. per acre
Orchard grass	2 lbs. per acre
Red top	2 lbs. per acre
Meadow fescue	2 lbs. per acre
Tall oat grass	4 lbs. per acre
Alsike clover	2 lbs. per acre
Sweet clvoer	3 lbs. per acre
White clover	1 lb. per acre
Japan clover	3 lbs. per acre

Mixture No. 2 differs from mixture No. 1 in that medium red clover is substituted for alsike, and orchard grass is added. Mixture No. 3 contained seven species of grasses and four of clovers in order that the degree of their establishment could be determined. The seed mixtures were applied soon after the initial lime and fertilizer applications. The plots so designated in the plan were harrowed once with a disk harrow after seeding. The timothy and alsike or timothy and medium-red clover in the mixtures were employed to produce a growth while the Kentucky bluegrass and white clover were becoming established.

The ungrazed half of the plots was cut with a mowing machine twice a year and the yields were obtained by weight. A small sample was taken for moisture determination at the time of weighing in the field. The dry weights given in the tables were computed from the field weights by using the moisture determinations of these samples. To determine the equivalent value of yields in hay of average moisture content, the yields as given should be increased by about 15 percent.

In order to study the effect of the treatments on the different varieties of plants, an area one yard square was staked off in the center of each quarter of a plot. There was thus a square in the limed and unlimed parts of the grazed and ungrazed halves of each plot. At the beginning of each experiment, and in each succeeding year at approximately the same time of season, a careful estimate was made of the percentage of each kind of grass and other plants which made up the growth on each of these square yard areas.

TABLE 1.—*Yields in Pounds per Acre (Dry Weight) from Pasture Plots Located on the Live Stock Farm in 1923 to 1928*

Fertilizer Treatment	Lime Treatment	Seed Mixture No.	Culture	Yield in Pounds per Acre (Dry Weight)						Average 1923-28
				1923	1924	1925	1926	1927	1928	
Manure and Superphosphate..	Limed	1	Harrow	532	2673	962	1579	1442	1531	1453
Manure and Superphosphate..	Not Limed ...	1	Harrow	307	1083	449	930	1066	1013	808
Manure	Limed	1	Harrow	500	1742	848	1335	1389	1395	1201
Manure	Not Limed ...	1	Harrow	287	853	357	705	965	997	694
Superphosphate..	Limed	1	Harrow	465	1703	743	1146	1222	1353	1105
Superphosphate..	Not Limed ...	1	Harrow	302	1185	497	777	948	1013	787
Superphosphate..	Limed	2	Harrow	550	1720	692	1097	1076	1189	1054
Superphosphate..	Not Limed ...	2	Harrow	300	950	497	804	899	864	719
Superphosphate..	Limed	3	Harrow	508	1750	809	1159	1121	1438	1131
Superphosphate..	Not Limed ...	3	Harrow	332	1302	656	955	1163	1209	936
Superphosphate..	Limed	0	None	494	1051	582	1110	1194	1386	969
Superphosphate..	Not Limed ...	0	None	306	823	420	630	790	868	639
Nitrate of soda...	Limed	1	Harrow	423	1154	646	1172	1042	1120	926
Nitrate of soda...	Not Limed ...	1	Harrow	254	637	394	737	710	687	570
No fertilizer	Limed	1	Harrow	385	1134	647	836	971	1027	833
No fertilizer	Not Limed ...	1	Harrow	259	870	426	574	858	780	628
No fertilizer	Limed	1	None	403	1056	541	889	943	901	789
No fertilizer	Not Limed ...	1	None	245	547	322	376	575	574	440
No fertilizer	Limed	0	None	429	879	482	826	856	968	740
No fertilizer	Not Limed ...	0	None	251	654	339	447	669	652	502

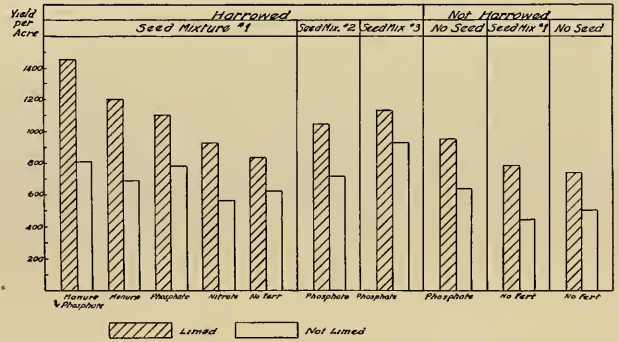

FIGURE 4. — Average yields 1923-28 in pounds per acre (dry weight) from pasture plots located on the Live Stock farm

Classification of Pasture Plants

The plants occurring on the plots were grouped into 3 classes. In the first group, designated as "native grasses," were included poverty grass (*Danthonia spicata*), brome sedge (*Andropogon furcatus*), sedges, and similar grasses or grass-like plants of little value as pasture plants. Poverty grass made up by far the largest proportion of all native grasses, especially on the Live Stock farm, where at the beginning of the experiment many plots were almost entirely covered by it.

The second group was designated as "pasture grasses and legumes." This included bluegrass, red-top, the clovers, and other pasture grasses and legumes of recognized economic importance. At the end of the 1928 season the pasture grasses in the better plots consisted almost entirely of Kentucky bluegrass and white clover. The third group, designated as "weed," embraced all plants not included in the first two classes. The percentage of the square yard area which was bare of plants also was estimated.

The condition found in the staked square yard may be taken as representative of the quarter of the plot on which it was located. Although certain irregularities occurred in these readings, it was felt that they gave a fairly trustworthy criterion of what changes were taking place in the vegetation under the different treatments.

Experimental Results Obtained on the Live Stock Farm

The yields obtained on the Live Stock farm with the various treatments used are indicated in Table 1, which shows that the most marked pasture improvement resulted from an application of lime and 8 tons of manure per acre, reinforced with 300 pounds of superphosphate. The average yield for the 6-year period was 1,453 pounds per acre as compared with 1,201 pounds where manure and lime were used without superphosphate. These plots were harrowed, and Seed mixture No. 1 was used. On the unlimed parts the yields were 808 and 694 pounds per acre respectively. This contrast shows very strikingly the necessity of liming as well as fertilizing. The yields for the various treatments are shown in Figure 4.

Superphosphate alone was used on 4 series of plots both with and without liming. On 3 series of plots 3 grass mixtures were used, while on the fourth no seed was applied. Seed mixture No. 1 was used on the superphosphate plot, the manure-superphosphate plot, the manure plot, and the nitrate plot, all of which were disked and otherwise treated alike for comparative purposes. On the limed half of the superphosphate plot the yield was 1,105 pounds per acre, or a little less than on the plot receiving manure and lime. On the unlimed half the superphosphate plot yielded 787 pounds as compared with 694 pounds for the manured plot. From these results it would seem that, under the conditions of the experiment, superphosphate is as effective as manure, or as manure and phosphate when lime is not added, and nearly as effective as manure when lime is added.

Comparison of Seed Mixtures

When the 3 seed mixtures on the limed part of the superphosphate plots are compared it is seen that Mixture No. 3 yielded an average of 1,131 pounds per acre; Mixture No. 1, 1,105 pounds; and Mixture No. 2, 1,054 pounds. Although Mixture No. 3, the one with the 11 different kinds of seeds, yielded a little more than the other two mixtures, the difference is not large enough to be significant. On the unlimed halves of these superphosphate plots, Mixture No. 3 yielded 936 pounds per acre; Mixture No. 1, 787 pounds; and Mixture No. 2, 719 pounds. More difference in favor of Mixture No. 3 appears here than on the limed halves.

FIGURE 5.—Effect of manure, superphosphate, and lime on pasture plots on the Live Stock farm in 1924. The plot on the left of A—B had no fertilizer applied, while the one on the right received manure and superphosphate. The half of each plot next to the fence and below the division line C—D was limed, while above the line no lime was applied. Note the heavy growth of clover on the limed half of the plot receiving manure and superphosphate

If the yields of the superphosphate plots where seed mixtures were used are compared with unseeded superphosphate plots, it is found that where no seed was used the average yield was 969 pounds on the limed half and 639 pounds on the unlimed half. With Mixture No. 2, the lowest yielding of the 3 mixtures, the yields were 1,054 and 719 pounds respectively on the limed and unlimed halves. This seed mixture yielded only small returns. In many cases pasture grasses and legumes will come in when the proper lime and fertilizer treatments are made. There was some Kentucky bluegrass and white clover on these plots at the beginning of the experiment. When lime and superphosphate were applied these pasture plants were enabled to make good growth and replace some of the undesirable weeds and grasses.

On the plots where no fertilizer or seed was applied the yields were 740 pounds on the limed half, and 502 pounds on the unlimed

half. This indicates that lime alone, although effecting some improvement in the pasture, is not sufficient. The average yield for a superphosphate application alone was 639 pounds per acre. Apparently, if either treatment were to be used alone on this type of pasture, the lime treatment should be chosen. Th combination of lime and superphosphate, however, is the most effective and the most economical.

An application of 100 pounds of nitrate of soda resulted in a yield of 926 pounds on the limed half of the plot, and 570 pounds on the unlimed half, or 137 pounds more on the limed part, and 130 pounds more on the unlimed part, than on the plots where no fertilizer was used. Although the nitrate application was effective in producing some improvement it was not as efficient as manure or superphosphate under the conditions of the experiment.

Effect of Various Treatments on Growth of Pasture Grasses

In considering the yields per acre due to these various treatments it is necessary also to take into consideration the kinds of grasses growing on these plots. Some of the plots bearing the most marked improvement, as recorded for the last year of the experiment, yielded as high as 80 percent tame grasses, consisting chiefly of Kentucky bluegrass, whereas some of the poorer plots yielded less than ten percent of tame grasses. Kentucky bluegrass is worth many times more, pound for pound, than such grasses as Danthonia and brome sedge. Thus the actual value of a treatment is not indicated by the increase in yield only.

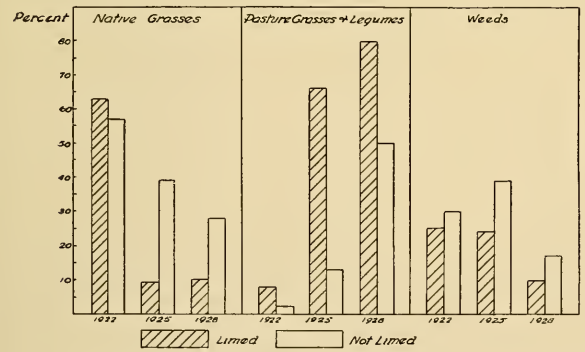

FIGURE 6.—Percentage of native grasses, pasture grasses and legumes, and weeds on the limed and unlimed halves of pasture plots on the Live Stock farm in 1922, 1925, and 1928. Not grazed. Fertilizer treatment: manure and superphosphate

The amounts of the various kinds of grasses and weeds on the plots receiving the treatments are estimated by individual years in Tables 13 and 14 (see pages 16 and 17). Table 2 presents a summary of the figures for the Live Stock farm, including an average of the yields from all superphosphate treatments, as well as of the yields from all untreated plots. Differences between these plots were not considered large enough to warrant separate figures in this summary table. For convenience the grazed and ungrazed parts of the same plot are shown in adjoining columns.

TABLE 2.—*Percentage of Native Grasses, Pasture Grasses, Weeds, and Vacant Space on Grazed and Ungrazed Plots on the Live Stock Farm in* 1922, 1925, *and* 1928

Fertilizer Treatment	Grazing	Percent of Various Plants and Vacant Space											
		Native Grasses			Pasture Grasses and Legumes			Weeds			Vacant		
		1922	1925	1928	1922	1925	1928	1922	1925	1928	1922	1925	1928
LIMED													
Manure and superphosphate	Grazed	49	24	9	8	54	84	33	19	7	10	3	0
Manure and superphosphate	Not grazed	63	9	10	8	66	80	25	24	10	4	1	0
Manure	Grazed	40	35	15	22	42	76	31	21	9	7	2	0
Manure	Not grazed	51	18	10	18	52	77	29	30	13	2	0	0
Superphosphate	Grazed	51	40	38	12	39	51	31	19	8	5	3	2
Superphosphate	Not grazed	42	20	37	22	61	51	30	18	9	6	1	2
Nitrate of soda	Grazed	34	36	57	26	36	34	36	26	9	4	2	0
Nitrate of soda	Not grazed	41	30	63	30	39	20	23	30	16	6	1	1
No fertilizer	Grazed	46	50	55	23	29	31	27	19	10	4	2	3
No fertilizer	Not grazed	58	41	65	12	30	20	24	29	13	5	2	2
NOT LIMED													
Manure and superphosphate	Grazed	45	41	24	18	26	66	30	31	10	7	2	0
Manure and superphosphate	Not grazed	57	39	28	2	13	50	30	39	17	11	9	5
Manure	Grazed	51	43	28	15	26	62	29	29	10	5	2	0
Manure	Not grazed	53	31	44	8	14	40	32	52	16	7	3	0
Superphosphate	Grazed	51	51	53	9	14	32	33	33	13	6	3	2
Superphosphate	Not grazed	44	43	56	14	21	22	36	35	19	6	1	3
Nitrate of soda	Grazed	55	62	80	18	11	7	24	24	12	3	3	1
Nitrate of soda	Not grazed	54	55	79	13	6	2	26	35	14	7	4	5
No fertilizer	Grazed	45	57	60	19	31	24	31	24	15	5	2	1
No fertilizer	Not grazed	56	60	74	10	4	3	28	31	18	5	5	5

Table 2 also shows a very marked improvement in the kind of plants found in the pasture in the case of some of the treatments. Where manure, superphosphate, and lime were applied the native grasses decreased on the grazed half from 49 percent in 1922 to 9 percent in 1928, the pasture grasses and legumes increased from 8 to 84 percent, and weeds decreased from 33 to 7 percent. Vacant space decreased from 10 percent in 1922 to none in 1928.

On the ungrazed halves the decrease in native grasses and weeds and the increase in pasture grasses and legumes corresponded to that on the grazed halves. This treatment therefore approximately trebled the yield as compared with the untreated plots. Furthermore, the material harvested consisted of highly nutritious grasses and clovers, while in the untreated plots the material harvested had a very low nutritive value. The relative percentages of the various plants on the ungrazed half of the manure and superphosphate plots are shown in Figure 6.

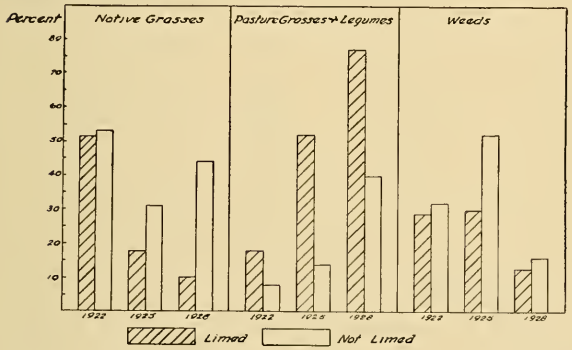

FIGURE 7. — Percentage of native grasses, pasture grasses and legumes, and weeds on the limed and unlimed halves of pasture plots on the Live Stock farm in 1922, 1925, and 1928. Not grazed. Fertilizer treatment: manure

On the unlimed part of these plots there is also a decrease of native grasses and an increase in pasture grasses, but the improvement is not as marked as where lime also was applied.

Where manure alone was applied with lime the native grasses decreased from 40 to 15 percent on the grazed half and from 51 to 10 percent on the ungrazed half. The pasture grasses and legumes increased from 22 to 76 percent on the grazed half and from 18 to 77 percent on the ungrazed half. Here again we see a very marked increase in the better pasture grasses where manure and lime were applied. The relative percentages for the manured plots on the ungrazed half are shown in Figure 7.

The unlimed part of these plots, like those where manure and superphosphate were applied, shows less improvement than where lime was applied.

An application of superphosphate with and without various seed mixtures resulted in a decrease of native grasses of from 51 to 38 percent on the grazed half and from 42 to 37 percent on the ungrazed half. The pasture grasses were increased from 12 and 22 percent respectively in 1922 to 51 percent in 1928 on the grazed and ungrazed

halves. The amount of weeds also was decreased. The results are shown for the ungrazed half in Figure 8.

On the unlimed half little change was noted in the percentage of native grasses, but some increase was noticed in the amount of pasture grasses and legumes. The application of 100 pounds of nitrate of soda once in 3 years did not materially decrease the native grasses nor increase the percentage of pasture grasses and legumes. As a matter of fact, in 1928 the average estimated percentage of native grasses was greater than in 1922. There was some increase in improved grasses on the limed portion, but not enough to be considered of much value. The results are shown in Figure 9.

TABLE 3.—*Average Yields per Acre (Dry Weight) and Percentage of Native and Pasture Grasses in* 1928 *on Pasture Plots on Live Stock Farm in* 1923 *to* 1928

Fertilizer Treatment	Lime Treatment	Average Yield in Pounds per Acre (Dry Weight)	Percent in 1928	
			Native Grasses	Pasture Grasses and Legumes
Manure and Superphosphate	Limed	1453	10	80
Manure and Superphosphate	Not limed	808	28	50
Manure	Limed	1201	10	77
Manure	Not limed	694	44	40
Superphosphate	Limed	1065	37	51
Superphosphate	Not limed	770	56	22
Nitrate of soda	Limed	926	63	20
Nitrate of soda	Not limed	570	79	2
No fertilizer	Limed	775	65	20
No fertilizer	Not limed	518	74	3

On the plots where no fertilizer was applied the results, expressed in terms of the percentage of the various kinds of grasses and weeds, are similar to results where nitrate was applied. Lime alone produced little change in the percentage of native grasses and yielded only a relatively small increase in the percentage of tame grasses. The results obtained are shown in Figure 10.

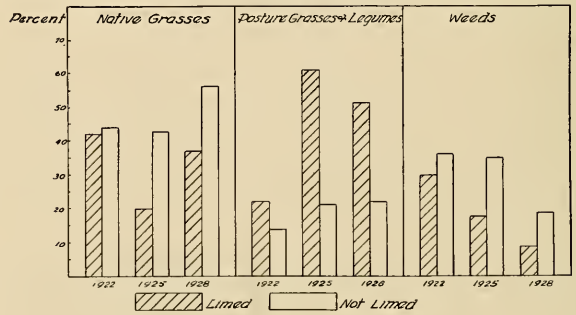

FIGURE 8. — Percentage of native grasses, pasture grasses and legumes, and weeds on the limed and unlimed halves of pasture plots on the Live Stock farm in 1922, 1925, and 1928. Not grazed. Fertilizer treatment: superphosphate

In Table 3 the average yields of the ungrazed halves of the plots are presented together with the estimated stands of native and pasture grasses. The same grouping of plots has been used as for Table 2. Table 3 shows that the range of yields extends from an average of 518 pounds per acre, with no treatment, to 1,453 pounds

per acre where manure, acid phosphate, and lime were applied. In the first case only 3 percent of the vegetation was made up of improved pasture grasses and legumes, while in the other case 80 percent was in improved pasture grasses and legumes. The plots bearing a high percentage of pasture grasses and legumes consisted almost entirely of Kentucky bluegrass and white clover in the last two years of the experiment. Medium-red and alsike clover were very prominent on the limed halves of the fertilized plots the first two years. After that these clovers rapidly disappeared, and bluegrass and white clover took their place. Only a few scattering plants of alsike or medium-red clover were found on the unlimed portion of any of the plots at any time.

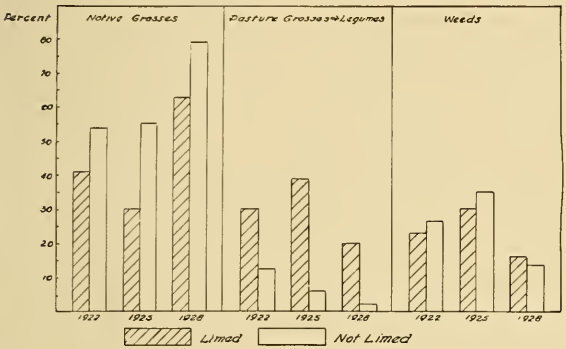

FIGURE 9. — Percentage of native grasses, pasture grasses and legumes, and weeds on the limed and unlimed halves of pasture plots on the Live Stock farm in 1922, 1925, and 1928. Not grazed. Fertilizer treatment: nitrate of soda

Effect of Seeding

Table 1 shows that little difference in yield resulted from the various mixtures used. Table 13 also indicates that the various mixtures had little effect upon the percentage of the various kinds of plants.

Where Mixture No. 1 was used the alsike clover made a very vigorous growth on the limed parts of the fertilized plots during the first two years. Practically no alsike plants were found outside the limed areas. The timothy also was quite generally in evidence on the limed and treated plots. During the last two years Kentucky bluegrass and white clover were the predominant plants on the limed and fertilized areas. The seed application, where the plots were neither limed nor fertilized, gave no improvement in the composition of the grasses.

The results obtained with Mixture No. 2, in which orchard grass was added and red clover was substituted for alsike, were very similar to those obtained with Mixture No. 1. The clover was very much in evidence on the limed and fertilized plots the first two years. After that it gave way to Kentucky bluegrass and white clover. The orchard grass, only a small part of the total crop in any year, appeared early in the spring. There was more of it than any of the other seeded grasses on the unlimed parts of the different plots.

TABLE 13.—*Estimated Percentage of Native Grasses, Pasture Grasses and Legumes, Weeds, and Vacant Space on Grazed and Ungrazed Halves of Pasture Plots on the Live Stock Farm, 1922 to 1928*

Fertilizer Treatment	Lime Treatment	Seed Mixture No.	Culture	Estimated Percent Stand																										
				Native Grasses							Pasture Grasses and Legumes							Weeds							Vacant						
				1922	1923	1924	1925	1926	1927	1928	1922	1923	1924	1925	1926	1927	1928	1922	1923	1924	1925	1926	1927	1928	1922	1923	1924	1925	1926	1927	1928
GRAZED																														
Manure and superphosphate ..	Limed	1	H	49	50	22	24	11	22	9	8	18	58	54	74	66	84	33	25	18	19	11	10	7	10	7	2	3	4	2	0
Manure and superphosphate ..	Not limed	1	H	45	45	40	41	32	29	24	18	32	30	26	49	62	66	30	19	26	31	16	8	10	7	4	4	2	3	1	0
Manure	Limed	1	H	40	32	32	35	19	14	15	22	35	45	42	66	74	76	31	28	22	21	13	11	9	7	5	1	2	2	1	0
Manure	Not limed	1	H	51	47	44	43	46	28	28	15	25	30	26	34	55	62	29	19	20	29	17	15	10	5	9	6	2	3	2	0
Superphosphate..	Limed	1	H	59	46	33	34	41	29	37	9	26	47	50	48	56	53	27	23	18	12	8	12	8	5	5	2	4	3	3	2
Superphosphate..	Not limed	1	H	54	53	45	61	67	53	56	2	8	18	5	8	28	26	37	31	31	30	20	15	15	7	8	6	4	5	4	3
Superphosphate..	Limed	2	H	47	35	29	51	51	27	39	13	20	34	24	31	58	51	33	36	33	23	12	11	8	7	9	4	2	6	4	2
Superphosphate..	Not limed	2	H	58	53	54	56	69	62	54	13	22	11	10	10	23	34	24	17	30	32	18	14	11	5	8	5	2	3	1	1
Superphosphate..	Limed	3	H	49	45	13	21	24	21	34	26	29	66	52	59	68	56	21	22	20	23	14	10	9	4	4	1	4	3	1	1
Superphosphate..	Not limed	3	H	51	46	29	33	40	48	45	22	26	46	34	31	35	43	22	21	22	31	23	14	12	5	7	3	2	6	3	0
Superphosphate..	Limed	0	None	50	50	45	52	36	44	43	2	13	32	29	48	38	45	42	34	21	17	12	14	8	6	3	2	2	4	4	4
Superphosphate..	Not limed	0	None	43	54	45	52	59	66	58	1	1	3	5	6	9	24	48	39	47	38	26	20	14	8	6	5	5	9	5	4
Nitrate of soda ..	Limed	1	H	34	31	38	36	36	60	57	26	27	21	36	46	20	34	36	34	38	26	13	19	9	4	8	3	2	5	1	0
Nitrate of soda ..	Not limed	1	H	55	54	54	62	69	78	80	18	16	18	11	11	10	7	24	24	25	24	16	11	12	3	6	3	3	4	1	1
None	Limed	1	H	30	32	40	37	30	32	41	39	39	28	39	49	43	48	27	26	31	23	16	19	10	4	3	1	1	5	6	1
None	Not limed	1	H	44	47	38	51	64	62	63	15	13	10	12	10	8	22	38	34	50	36	21	26	15	3	6	2	1	5	4	0
None	Limed	1	None	44	51	46	50	56	49	55	17	14	25	29	25	29	26	35	30	26	19	12	13	14	4	5	3	2	7	9	5
None	Not limed	1	None	45	47	52	53	59	68	65	18	19	15	22	12	14	19	30	29	31	24	20	14	14	7	5	2	1	9	4	2
None	Limed	0	None	55	57	53	57	61	61	63	17	18	24	23	21	24	24	24	21	20	17	14	12	9	4	4	3	3	4	3	4
None	Not limed	0	None	45	53	54	63	62	62	56	23	17	13	16	20	20	28	28	23	27	18	14	15	15	4	7	6	3	4	3	1
NOT GRAZED																														
Manure and superphosphate ..	Limed	1	H	63	42	13	9	3	4	10	8	16	65	66	86	84	80	25	33	21	24	10	12	10	4	9	1	1	1	0	0
Manure and superphosphate ..	Not limed	1	H	57	56	35	39	21	20	28	2	6	24	13	52	57	50	30	29	34	39	20	18	17	11	9	7	9	7	5	5
Manure	Limed	1	H	51	47	36	18	10	6	10	18	19	37	52	75	74	77	29	29	25	30	15	20	13	2	5	2	0	0	0	0
Manure	Not limed	1	H	53	45	37	31	29	41	44	8	13	27	14	43	35	40	32	31	32	52	25	23	16	7	11	4	3	3	1	0
Superphosphate..	Limed	1	H	41	41	15	16	23	21	38	21	29	66	69	65	69	49	30	26	15	14	11	9	11	8	4	4	1	1	1	2
Superphosphate..	Not limed	1	H	39	46	31	22	43	41	56	15	5	27	28	15	31	21	41	43	41	48	41	28	20	5	6	1	2	1	0	3
Superphosphate..	Limed	2	H	40	42	22	34	17	24	34	25	28	56	54	68	59	50	28	25	21	11	14	15	11	7	5	1	1	1	2	5
Superphosphate..	Not limed	2	H	47	45	38	49	67	58	65	7	11	31	22	7	15	15	40	36	29	28	23	21	13	6	8	2	1	3	6	7
Superphosphate..	Limed	3	H	40	37	16	13	23	25	41	24	30	62	71	65	63	48	31	27	21	16	11	10	9	5	6	1	0	1	2	2
Superphosphate..	Not limed	3	H	38	37	21	42	46	50	48	18	21	49	26	26	28	29	36	35	28	31	25	21	22	8	7	2	1	3	1	1
Superphosphate..	Limed	0	None	49	53	28	19	25	44	35	17	18	47	49	48	36	58	30	26	24	30	24	20	7	4	3	1	2	3	0	0
Superphosphate..	Not limed	0	None	54	61	55	57	59	54	56	13	12	18	10	22	24	22	28	25	25	33	17	20	20	5	2	2	0	2	2	2
Nitrate of soda ..	Limed	1	H	41	44	38	30	50	51	63	30	21	40	39	32	25	20	23	28	20	30	15	21	16	6	7	2	1	3	3	1
Nitrate of soda ..	Not limed	1	H	54	56	51	55	63	68	79	13	5	9	6	4	1	2	26	34	36	35	26	21	14	7	5	4	4	7	10	5
None	Limed	1	H	51	60	34	39	50	47	65	23	16	44	35	34	30	21	22	19	20	22	14	20	13	4	5	2	4	2	3	1
None	Not limed	1	H	54	62	57	58	66	59	69	17	12	9	8	6	9	4	24	21	29	30	24	26	21	5	5	5	4	4	6	6
None	Limed	1	None	65	62	42	38	60	59	69	9	15	38	32	20	18	16	22	22	19	28	19	21	12	4	1	1	2	1	2	3
None	Not limed	1	None	69	64	70	69	73	74	77	5	5	6	3	2	3	2	18	21	17	23	16	15	15	8	10	7	5	9	8	6
None	Limed	0	None	59	59	54	44	56	62	63	8	13	25	21	19	17	23	27	25	19	33	23	17	12	6	3	2	2	2	4	2
None	Not limed	0	None	51	57	59	56	66	65	75	9	6	3	3	4	8	3	36	31	34	36	24	22	18	4	6	4	5	6	5	4

TABLE 14.—*Estimated Percentage of Native Grasses, Pasture Grasses and Legumes, Weeds, and Vacant Space on Pasture Plots on the Dairy Farm, 1923 to 1928*

Fertilizer Treatment	Lime Treatment	Seed Mixture No.	Culture	Estimated Percent Stand																			
				Native Grasses						Pasture Grasses and Legumes						Weeds						Vacant					
				1923	1924	1925	1926	1927	1928	1923	1924	1925	1926	1927	1928	1923	1924	1925	1926	1927	1928	1923	1924	1925	1926	1927	1928
GRAZED																											
Manure and superphosphate ..	Limed	1	H	34	28	14	9	12	5	10	36	63	70	74	87	51	34	22	19	14	8	5	2	1	2	0	0
Manure and superphosphate ..	Not limed	1	H	34	27	27	34	34	36	26	43	35	44	55	53	34	28	36	20	11	11	6	2	2	2	0	0
Manure	Limed	1	H	49	24	20	14	21	9	3	46	45	61	63	81	41	30	34	23	15	10	7	0	1	2	1	0
Manure	Not limed	1	H	42	33	28	29	26	34	14	18	36	30	55	55	39	45	34	36	18	11	5	4	2	5	1	0
Superphosphate..	Limed	1	H	27	22	16	19	24	12	10	37	52	52	63	81	52	36	29	23	9	6	11	5	3	6	4	1
Superphosphate..	Not limed	1	H	40	22	28	34	54	56	13	20	28	30	27	31	41	52	41	31	18	12	6	6	3	5	1	1
Superphosphate..	Limed	2	H	46	28	18	17	26	24	9	31	60	55	64	66	41	35	20	23	9	8	4	6	2	5	1	2
Superphosphate..	Not limed	2	H	28	28	26	36	36	26	9	28	21	25	31	39	54	40	52	34	30	31	9	4	1	5	3	4
Superphosphate..	Limed	3	H	37	21	10	18	16	14	6	44	64	65	70	75	50	32	25	15	10	9	7	3	1	2	4	2
Superphosphate..	Not limed	3	H	12	6	21	18	27	19	24	24	30	32	37	42	59	67	48	46	34	36	5	3	1	4	2	3
Superphosphate..	Limed	0	None	30	32	22	21	22	16	3	24	48	51	54	73	59	34	29	25	20	11	8	10	1	3	4	0
Superphosphate..	Not limed	0	None	42	33	43	46	50	64	3	8	6	6	10	16	50	56	50	44	36	16	5	3	1	4	4	4
Nitrate of soda ..	Limed	1	H	46	33	40	34	36	48	2	17	16	22	49	36	47	46	41	38	12	15	5	4	3	6	3	1
Nitrate of soda ..	Not limed	1	H	55	45	34	36	39	52	5	14	14	14	23	21	35	37	48	43	34	26	5	4	4	7	4	1
None	Limed	1	H	42	37	36	24	35	37	1	16	28	38	40	46	46	39	32	30	18	12	11	8	4	8	7	5
None	Not limed	1	H	18	36	36	50	66	69	2	17	3	4	8	10	70	41	59	41	25	21	10	6	2	5	1	0
None	Limed	1	None	50	35	30	39	36	39	5	25	38	26	39	46	39	36	26	26	14	8	6	4	6	9	11	7
None	Not limed	1	None	33	23	23	37	37	46	0	7	3	3	4	6	60	67	73	57	54	45	7	3	1	3	5	3
None	Limed	0	None	44	35	33	34	34	28	4	16	24	32	47	56	46	43	41	30	15	13	6	6	2	4	4	3
None	Not limed	0	None	35	34	39	37	53	55	14	17	14	17	21	22	44	42	42	40	21	18	7	7	5	6	5	5
NOT GRAZED																											
Manure and superphosphate ..	Limed	1	H	33	22	7	11	17	9	17	48	56	61	71	84	47	30	36	25	12	7	3	0	1	3	0	0
Manure and superphosphate ..	Not limed	1	H	45	34	38	50	57	54	12	30	32	26	29	37	36	33	30	21	14	9	7	3	0	3	0	0
Manure	Limed	1	H	46	41	11	16	11	16	3	21	55	57	75	70	42	37	34	26	13	13	9	1	0	1	1	1
Manure	Not limed	1	H	39	31	21	36	54	46	6	29	44	36	35	40	49	39	34	28	11	14	6	1	1	0	0	0
Superphosphate..	Limed	1	H	32	36	14	20	25	19	11	27	50	52	56	69	51	36	36	28	18	12	6	1	0	0	1	0
Superphosphate..	Not limed	1	H	39	32	30	51	75	75	9	12	15	14	6	14	44	52	51	33	16	11	8	4	4	2	3	0
Superphosphate..	Limed	2	H	41	30	6	21	13	22	11	45	71	54	75	69	39	22	23	22	12	9	9	3	0	3	0	0
Superphosphate..	Not limed	2	H	35	32	26	53	70	76	8	22	24	10	7	9	49	39	49	32	20	14	8	7	1	5	3	1
Superphosphate..	Limed	3	H	31	37	9	13	40	23	6	29	54	48	45	67	51	32	37	35	14	9	12	2	0	4	1	1
Superphosphate..	Not limed	3	H	40	27	34	39	48	64	8	22	20	24	36	21	46	50	45	34	15	14	6	1	1	3	1	1
Superphosphate..	Limed	0	None	32	36	13	21	26	19	3	36	54	48	59	72	58	28	32	30	14	9	7	0	1	1	1	0
Superphosphate..	Not limed	0	None	43	42	33	50	72	65	4	14	20	13	9	23	48	44	47	36	18	11	5	0	0	1	1	1
Nitrate of soda ..	Limed	1	H	47	29	20	40	49	44	5	30	56	34	39	43	44	39	24	24	11	11	4	2	0	2	1	2
Nitrate of soda ..	Not limed	1	H	41	36	33	56	62	74	5	8	10	6	8	6	50	52	56	34	28	16	4	4	1	4	2	4
None	Limed	1	H	44	37	30	42	61	58	8	26	37	34	25	31	39	33	31	21	13	10	9	4	2	3	1	1
None	Not limed	1	H	44	30	46	60	80	84	7	8	8	6	4	5	43	56	44	30	15	10	6	6	2	4	1	1
None	Limed	1	None	24	33	24	39	62	45	4	15	34	24	10	28	62	51	42	36	28	26	10	1	0	1	0	1
None	Not limed	1	None	42	41	48	46	70	78	3	4	3	3	1	3	49	50	44	42	24	15	6	5	5	9	5	4
None	Limed	0	None	34	34	25	36	45	45	10	22	34	26	35	44	50	42	40	37	20	11	6	2	1	1	0	0
None	Not limed	0	None	44	51	59	66	80	75	4	8	6	5	4	13	44	40	34	27	15	11	8	1	1	2	1	1

Because of its early appearance in the spring and its ability to thrive on poor soils it appears to be desirable for a pasture mixture.

The complex mixture designated as No. 3 did not produce any prominent plants not included in Mixtures 1 and 2. Sweet clover sown in this mixture did not produce very many plants even on the limed and fertilized plots. To obtain a good stand of sweet clover

TABLE 4.—*Average Yields per Acre on Seeded and Unseeded Pasture Plots on the Live Stock Farm in* 1923 *to* 1928

Fertilizer Treatment	Lime Treatment	Average Yields 1923-28	
		Seeded	Not Seeded
Superphosphate	Limed	1097	969
Superphosphate	Not limed	814	639
No fertilizer	Limed	811	740
No fertilizer	Not limed	534	502

the land probably should have been disked several times, and much more seed used. No very good stands of Japan clover were obtained on any of the plots; at the end of the experiment there were practically no plants of this legume. Later experiments conducted on the Agronomy farm indicate that Korean lespedeza is much more likely to reseed itself under the conditions of the present experiment than the common Japan clover which was used. Meadow fescue and tall oat grass did not become established to any extent in any of the plots. They were found on both the limed and unlimed parts of the plots, but more thickly on the limed parts. Red top and Canada bluegrass were found quite generally on the plots bearing this mixture—more thickly on the limed portion of the plots.

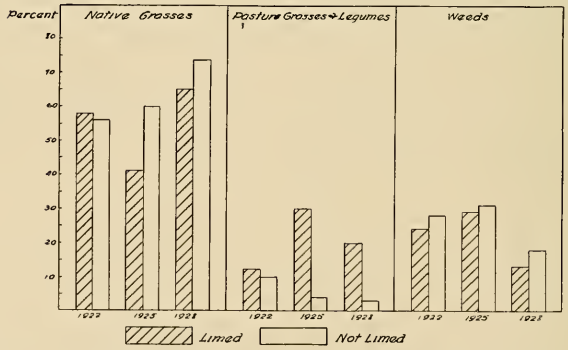

FIGURE 10.—Percentage of native grasses, pasture grasses and legumes, and weeds on the limed and unlimed halves of pasture plots on the Live Stock farm in 1922, 1925, and 1928. Not grazed. Fertilizer treatment: none

In Table 4 the yields of the seeded plots are compared with the yields of unseeded plots. Comparisons are made between plots receiving the same treatments, with the exception of the seeding. Table 4 shows that, where seed was applied together with superphosphate, the average yield was 1,097 pounds per acre, while on the unseeded plots the average yield was 969 pounds. On the unlimed part the yields were 814 and 639 pounds, respectively. Some increase was

obtained from seeding, but the increase was not large, whether or not lime was used. Table 13 also indicates that at the end of the experiment there was as high a percentage of pasture grasses and legumes in the unseeded as in the seeded plots. Apparently there were enough plants of bluegrass present in these plots at the beginning of the experiment to develop and form a good pasture sod when the proper fertilizer and lime treatments were made.

TABLE 5.—*Average Yields per Acre on Cultivated and Uncultivated Pasture Plots on the Live Stock Farm in* 1923 *to* 1928

Fertilizer Treatment	Lime Treatment	Average Yields 1923-28	
		Cultivated	Not cultivated
No fertilizer	Limed	833	789
No fertilizer	Not limed	628	440

On the unfertilized plots the average yield on the limed half was 811 pounds per acre when seeded, and 740 pounds when not seeded. On the unlimed halves the yields were 534 and 502 pounds on the seeded and unseeded plots, respectively. The difference is so small as to be of no significance in either case. To reseed a pasture of this type with any kind of mixture without applying both lime and some kind of fertilizer is to waste time and effort.

Effect of Cultivation

A comparison between a series of plots disked after seeding and a series where the seed was applied without subsequent disking is also afforded by this experiment. The only plots where this comparison can be made, however, are those where no fertilizer was applied. This perhaps is not a fair test for cultivation but it was the best that could be devised with the area available. The results are shown in Table 5. On the limed half the cultivated part yielded 833 pounds per acre, and the uncultivated half, 789 pounds. The yields on the unlimed parts were 628 and 440 pounds respectively.

TABLE 6.—*Average Yields per Acre for the Years* 1923 *to* 1928 *and Grand Average Yield on the Seeded Pasture Plots on the Live Stock Farm, Where Phosphate Was Used with and without an Application of Lime*

Fertilizer Treatment	Lime Treatment	Yields in Pounds per Acre						Average 1923-28
		1923	1924	1925	1926	1927	1928	
Superphosphate	Limed	508	1724	748	1134	1140	1329	1097
Superphosphate	Not limed	311	1146	550	845	1003	1029	814

Although cultivation resulted in a small increase in yields, it was so small that it seems safe to state that one may well afford to lime and fertilize a pasture of this type even if it is not possible to go over it with a disk or springtooth harrow. The most important factors are lime and fertilizer. The Virginia Station[5] also found very little benefit from cultural treatments of bluegrass pastures.

[5]Virginia Agr. Exp. Sta. Bul. No. 204.

Yearly Variation in Pasture Yields

Table 6 represents a combination of all seeded superphosphate plots, to show the yearly variation in yields. The lowest yields were obtained in 1923, a rather dry year, with weather unfavorable for the growth of pasture grasses. The following year (1924), characterized by a cold, late spring with much rain, showed a yield of more than 3 times that of the first year. The clovers produced their maximum yield in 1924. The following year showed a sharp decrease in yield, followed in succeeding years by a gradual increase, due largely to the gradual increase in the amount of Kentucky bluegrass.

Grazing vs. Mowing a Pasture

That grazing has a different effect upon pasture grasses and other plants in general than cutting for hay is usually accepted. This experiment was planned so that it might be possible to study the comparative influence of grazing and of cutting the grass twice a year. The comparison was made by careful estimate each year of the percentage of the various classes of plants on the square yard area, staked off on both the grazed and ungrazed halves of each plot. The results obtained as given in Table 13 show (see page 00), as far as could be determined, little difference in the character of the vegetation between the grazed and the ungrazed parts. The results are shown in Figures 11 to 15. It would seem from this that cutting the plots twice a year and weighing the cut material gives a fairly accurate measure of what might be expected from various treatments under actual pasturing conditions, if the kinds of grasses making up the harvested material are also taken into consideration.

On the grazed half of the plots a very marked difference could be noted in the preference of the cattle for certain plots. Where the better pasture grasses predominated the plots were much more closely grazed than where weeds and native grasses made up the bulk. The boundary of certain plots could easily be traced in many instances from the difference in amount of grazing.

EXPERIMENTAL RESULTS OBTAINED ON THE DAIRY FARM

The yields obtained with the various treatments on the Dairy Farm are shown in Table 7. As was the case on the Live Stock Farm, the application of a combination of manure and superphosphate together with lime resulted in the most marked improvement in the pasture. The average yield for this combination during the 5-year period was 2,388 pounds per acre. Not only was the yield the greatest, but the percentage of pasture grasses and legumes was higher on these plots than under any other treatment. This is shown in the accompanying tables and graphs. Where manure only was applied with lime the average yield was 2,027 pounds per acre, or about 300 pounds per acre less than where superphosphate was added to the manure. On the unlimed parts the yields were 1,787 and 1,753

TABLE 7.—*Yields in Pounds per Acre (Dry Weight) from Pasture Plots Located on the Dairy Farm in 1924 to 1928*

Fertilizer Treatment	Lime Treatment	Seed Mixture No.	Culture	Yield in Pounds per Acre (Dry Weight)					Averages 1924-28
				1924	1925	1926	1927	1928	
Manure and superphosphate	Limed	1	Harrow	2549	1933	1484	2947	3026	2388
Manure and superphosphate	Not limed	1	Harrow	1861	1012	908	2463	2691	1787
Manure	Limed	1	Harrow	2380	1401	1064	2525	2764	2027
Manure	Not limed	1	Harrow	2128	978	881	2233	2544	1753
Superphosphate	Limed	1	Harrow	1825	1327	1152	1904	2391	1720
Superphosphate	Not limed	1	Harrow	1193	569	447	1271	1579	1012
Superphosphate	Limed	2	Harrow	1918	2894	1316	1829	2155	2022
Superphosphate	Not limed	2	Harrow	1126	854	588	1272	1542	1076
Superphosphate	Limed	3	Harrow	1869	1354	1098	1830	2204	1671
Superphosphate	Not limed	3	Harrow	1154	596	587	1319	1576	1046
Superphosphate	Limed	0	None	1677	1106	1066	1784	2151	1557
Superphosphate	Not limed	0	None	1094	525	566	1338	1582	1031
Nitrate of soda	Limed	1	Harrow	1579	839	907	1928	1717	1396
Nitrate of soda	Not limed	1	Harrow	1194	464	473	1457	1377	993
No fertilizer	Limed	1	Harrow	1384	865	841	1430	1847	1273
No fertilizer	Not limed	1	Harrow	912	346	507	1125	1441	866
No fertilizer	Limed	1	None	1072	602	673	1262	1377	997
No fertilizer	Not limed	1	None	853	344	445	986	1037	733
No fertilizer	Limed	0	None	1287	775	741	1462	1819	1217
No fertilizer	Not limed	0	None	1088	439	509	1203	1317	911

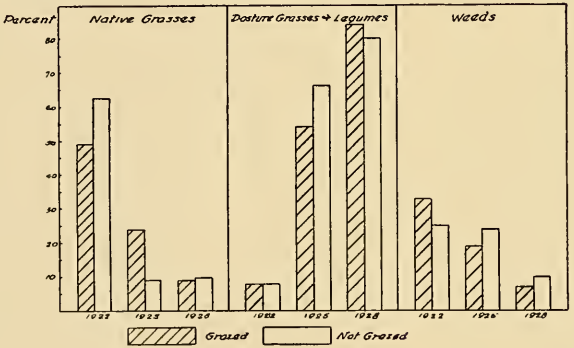

FIGURE 11.—Percentage of native grasses, pasture grasses and legumes, and weeds on the grazed and ungrazed halves of pasture plots on the Live Stock farm in 1922, 1925, and 1928. Limed. Fertilizer treatment: manure and superphosphate

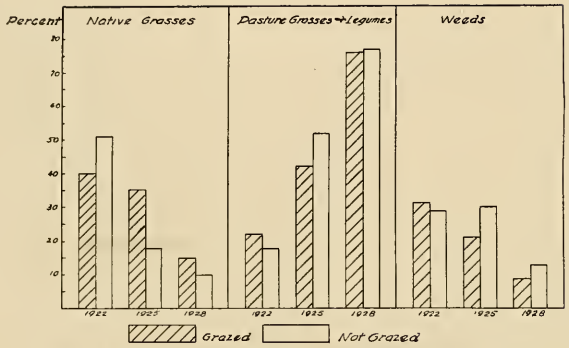

FIGURE 12.—Percentage of native grasses, pasture grasses and legumes, and weeds on the grazed and ungrazed halves of pasture plots on the Live Stock farm in 1922, 1925, and 1928. Limed. Fertilizer treatment: manure

FIGURE 14.—Percentage of native grasses, pasture grasses and legumes, and weeds on the grazed and ungrazed halves of pasture plots on the Live Stock farm in 1922, 1925, and 1928. Limed. Fertilizer treatment: nitrate of soda

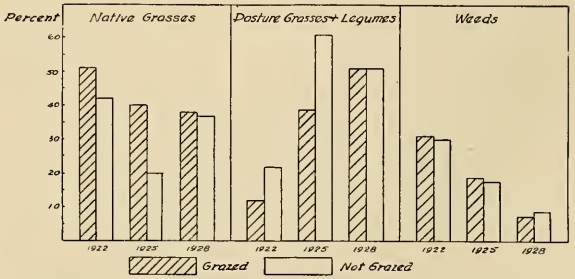

FIGURE 13.—Percentage of native grasses, pasture grasses and legumes, and weeds on the grazed and ungrazed halves of pasture plots on the Live Stock farm in 1922, 1925, and 1928. Limed. Fertilizer treatment: superphosphate

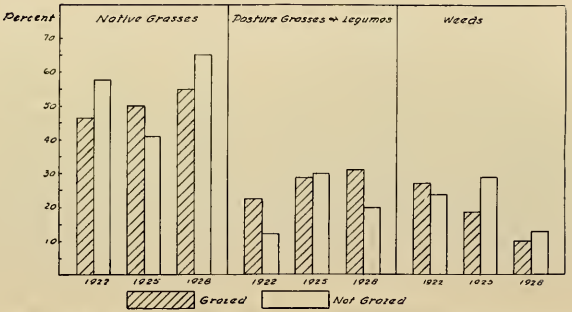

FIGURE 15.—Percentage of native grasses, pasture grasses and legumes, and weeds on the grazed and ungrazed halves of pasture plots on the Live Stock farm in 1922, 1925, and 1928. Limed. Fertilizer treatment: none

pounds per acre for the manure-and-superphosphate and the manure-alone plots, respectively. Without the lime the addition of phosphate to the manure apparently had no appreciable effect on yield.

The average yields on the Dairy farm were considerably higher than those on the Live Stock farm, where the soil apparently was in a lower state of fertility. This probably accounts for some of the cases wherein the response to certain of the treatments was not the same on the two farms. In general, however, the results on the two farms agree very closely.

On the 3 series of plots where the 3 different grass mixtures were used the yields on the limed half were 1,720 pounds with Mixture No. 1, 2,022 pounds with Mixture No. 2, and 1,671 pounds with Mixture No. 3. On the unlimed halves the yields were 1,012, 1,076, and 1,046 pounds per acre for the same respective mixtures. Mixture No. 2 produced the highest average yield for the 5-year period, due chiefly to the heavy crop of red clover on these plots in 1925. The season was exceptionally favorable for red clover, and high yields were obtained. If this one year were omitted the average yields for all 3 mixtures would be very nearly the same. On the unlimed parts the average yields are approximately the same for all mixtures. Except for the one season, therefore, there was little difference in yields with the various mixtures either on the limed or unlimed parts of the plots on the Dairy Farm. This agrees with results obtained on the Live Stock farm. A simple mixture therefore is to be preferred over a more complicated and expensive one.

The series of plots where superphosphate alone and Seed Mixture No. 1 were used can be compared with the series where manure only was applied, since these two series are alike except for fertilizer treatment. The manure alone with lime yieled an average of 2,027 pounds per acre, while superphosphate alone with lime yielded 1,720 pounds. On the unlimed parts the yields were 1,753 and 1,012 pounds, respectively, for the manure and superphosphate plots. On these plots, therefore, manure alone, whether used with or without lime, was more effective than superphosphate in increasing the yields of pasture grasses.

When the series of plots where superphosphate was added, but no seed applied, is compared with the plots where both seed and superphosphate were applied, a small increase in yield is seen on the limed part when seed is applied, but no significant difference is noted where no lime was used. Where no seed was used the yields were 1,557 pounds and 1,031 pounds on the limed and unlimed parts, respectively. With Seed Mixture No. 1 the average yields were 1,720 pounds on the limed half and 1,012 pounds on the unlimed half. As on the Live Stock farm, some bluegrass and other pasture grasses were present when the experiment was started, and where the right fertilizer treatment was applied together with lime, these grasses developed and a good sod was formed even though no seed was applied.

TABLE 8.—*Percentage of Native Grasses, Pasture Grasses, Weeds, and Vacant Space on Grazed and Ungrazed Plots on the Dairy Farm in* 1923, 1925, *and* 1928

Fertilizer Treatment	Grazing	Percent of Various Plants and Vacant Space											
		Native Grasses			Pasture Grasses and Legumes			Weeds			Vacant		
		1923	1925	1928	1923	1925	1928	1923	1925	1928	1923	1925	1928
LIMED													
Manure and superphosphate	Grazed	34	14	5	10	63	87	51	22	8	5	1	0
Manure and superphosphate	Not grazed	33	7	9	17	56	84	47	36	7	3	1	0
Manure	Grazed	49	20	9	3	45	81	41	34	10	7	1	0
Manure	Not grazed	46	11	16	3	55	70	42	34	13	9	0	1
Superphosphate	Grazed	35	16	17	7	56	74	50	26	8	8	2	1
Superphosphate	Not grazed	34	10	21	8	57	69	50	32	10	8	0	0
Nitrate of soda	Grazed	46	40	48	2	16	36	47	41	15	5	3	1
Nitrate of soda	Not grazed	47	20	44	5	56	43	44	24	11	4	0	2
No fertilizer	Grazed	45	33	33	3	31	51	44	35	11	7	4	5
No fertilizer	Not grazed	26	26	48	8	35	37	50	38	16	8	1	1
NOT LIMED													
Manure and superphosphate	Grazed	34	27	36	26	35	53	34	36	11	6	2	0
Manure and superphosphate	Not grazed	45	38	54	12	32	37	36	30	9	7	0	0
Manure	Grazed	42	28	34	14	36	55	39	34	11	5	2	0
Manure	Not grazed	39	21	46	6	44	40	49	34	14	6	1	0
Superphosphate	Grazed	30	30	41	12	21	41	51	48	24	6	1	3
Superphosphate	Not grazed	39	31	70	7	20	17	47	48	12	7	1	1
Nitrate of soda	Grazed	55	34	52	5	14	21	35	48	26	5	4	1
Nitrate of soda	Not grazed	41	33	74	5	10	6	50	56	16	4	1	4
No fertilizer	Grazed	30	36	56	7	9	15	54	56	25	8	2	3
No fertilizer	Not grazed	44	53	78	4	6	9	44	39	12	7	2	2

The application of 100 pounds of nitrate of soda every third year together with seed produced an average yield of 1,396 pounds on the limed half and 993 pounds on the unlimed half. This shows some increase over the plots receiving no fertilizer, but less than where superphosphate was used. As would be expected, the greatest improvement from the use of nitrate resulted in the year the application was made. If nitrate of soda is used for top dressing it probably should be applied every spring for best results.

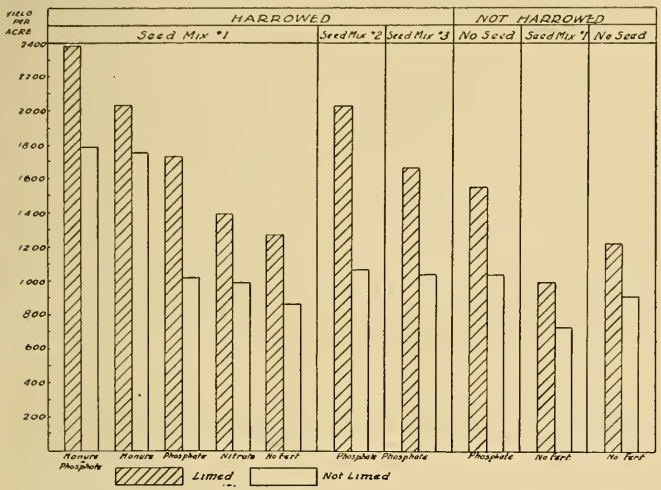

FIGURE 16.—Average yield 1924-28 in pounds per acre (dry weight) from pasture plots located on the Dairy farm

The plots which received no fertilizer, seed, or cultural treatments yielded an average of 1,217 pounds per acre where lime was applied and 911 pounds where no lime was used. As on the Live Stock farm, the use of lime alone resulted in considerable improvement in the pasture, but the best results were obtained when both lime and fertilizer were applied.

The average yields of the various treatments are shown in Figure 16.

Effect of Various Treatments on Growth of Different Pasture Grasses

The percentages of the various kinds of grasses and weeds for each year and for the various treatments are estimated in Table 14 (See page 00). Table 8 presents a summary of Table 14. The plots are grouped as in the summary table for the Live Stock farm.

Results on the Dairy farm were very similar to those obtained on the Live Stock farm. The stand on the former contained a slightly higher percentage of pasture grasses and legumes at the conclusion of the experiment. The greatest improvement in the pasture plants was made where lime, superphosphate, and manure were applied. On the grazed half of the plot the native grasses decreased from 34 percent in 1923 to 5 percent in 1928, and the pasture grasses and legumes increased from 10 percent in 1923 to 87 percent in 1928. The pasture grasses and legumes referred to consisted almost en-

tirely of Kentucky bluegrass and white clover at the end of the experiment in 1928. The native grass consisted chiefly of poverty grass (*Danthonia spicata*).

TABLE 9.—*Average Yields per Acre (Dry Weight) of Pasture Plots on the Dairy Farm in 1924 to 1928 and Percentage of Native and Pasture Grasses in 1928*

Fertilizer Treatment	Lime Treatment	Average Yield in Pounds per Acre (Dry Weight)	Percent in 1928	
			Native Grasses	Pasture Grasses and Legumes
Manure and Superphosphate	Limed	2388	9	84
Manure and Superphosphate	Not limed	1787	54	37
Manure	Limed	2027	16	70
Manure	Not limed	1753	46	40
Superphosphate	Limed	1742	21	69
Superphosphate	Not limed	1041	70	17
Nitrate of soda	Limed	1396	44	43
Nitrate of soda	Not limed	993	74	6
No fertilizer	Limed	1176	48	37
No fertilizer	Not limed	855	78	9

The effect of the manure and superphosphate treatments on the various classes of pasture plants is shown in Figure 17.

On the unlimed halves the increase in improved grasses and legumes was much less than on the limed parts, and no decrease was noted in the amount of native grasses.

The plot receiving manure alone produced the next greatest increase in the amount of pasture grasses and legumes, and decrease in native grasses and in weeds. The stand of pasture grasses and legumes increased from an average of 3 percent in 1923 to 81 percent on the grazed half in 1928 and to 70 percent on the ungrazed half. The stand of native grasses decreased from 49 to 46 percent on the grazed and ungrazed halves in 1923 to 9 and 16 percent, respectively, in 1928. These results are shown in Figure 18.

FIGURE 17. — Percentage of native grasses, pasture grasses and legumes, and weeds on the limed and unlimed halves of pasture plots on the Dairy farm in 1923, 1925, and 1928. Not grazed. Fertilizer treatment: manure and superphosphate

The application of superphosphate and lime also resulted in a striking improvement in the composition of the pasture grasses, as shown in Figure 19.

The application of nitrate of soda alone did not result in much

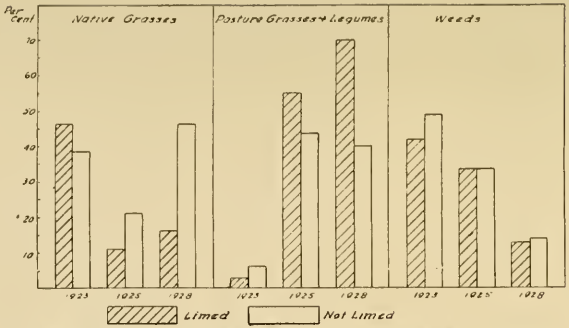

FIGURE 18.—Percentage of native grasses, pasture grasses and legumes, and weeds on the limed and unlimed halves of pasture plots on the Dairy Farm in 1923, 1925, and 1928. Not grazed. Fertilizer treatment: manure

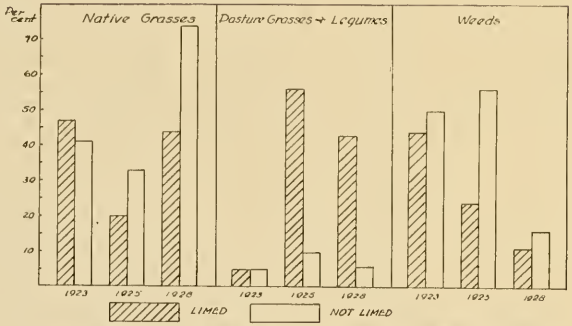

FIGURE 20.—Percentage of native grasses, pasture grasses and legumes, and weeds on the limed and unlimed halves of pasture plots on the Dairy farm in 1923, 1925, and 1928. Not grazed. Fertilizer treatment: nitrate of soda

FIGURE 19.—Percentage of native grasses, pasture grasses and legumes, and weeds on the limed and unlimed halves of pasture plots on the Dairy farm in 1923, 1925, and 1928. Not grazed. Fertilizer treatment: superphosphate

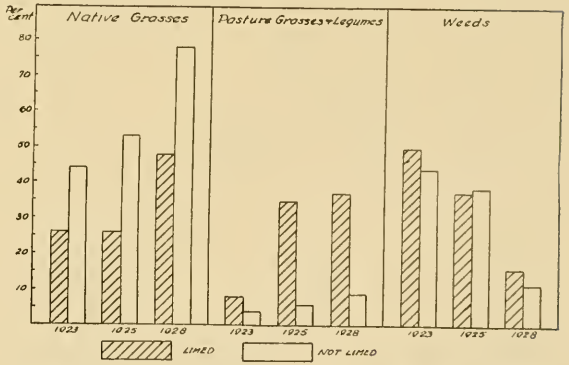

FIGURE 21.—Percentage of native grasses, pasture grasses and legumes, and weeds on the limed and unlimed halves of pasture plots on the Dairy farm in 1923, 1925, and 1928. Not grazed. Fertilizer treatment: none

change in the percentage of the various classes of plants either on the grazed or ungrazed parts. When nitrate was used with lime the percentage of pasture grasses and legumes was increased, but the increase was less than that obtained with superphosphate. Figure 20 shows the results.

TABLE 10.—*Average Yields per Acre on Seeded and Unseeded Pasture Plots on the Dairy Farm in* 1924 *to* 1928

Fertilizer Treatment	Lime Treatment	Average Yield 1924-28	
		Seeded	Not Seeded
Superphosphate	Limed	1804	1557
Superphosphate	Not limed	1045	1031
No fertilizer	Limed	1135	1217
No fertilizer	Not limed	800	911

The results obtained on the plots which received no fertilizer were similar to those where nitrate of soda only was applied. There was some increase in the percentage of pasture grasses and legumes on the limed half of these plots, but no great improvement resulted. The results are shown in Figure 21.

FIGURE 22. — Percentage of native grasses, pasture grasses and legumes, and weeds on the grazed and ungrazed halves of pasture plots on the Dairy farm in 1923, 1925, and 1928. Limed. Fertilizer treatment: manure and superphosphate

The average yields obtained from the various treatments on the Dairy farm and the percentages of native grasses and of pasture grasses are brought together in Table 9. The percentages of the different grasses are derived from the ungrazed half of each plot. Here, as was true on the Live Stock farm, the application of fertilizer and lime produced a striking increase in valuable pasture grasses. The application of superphosphate, manure, and lime increased the yield of valuable pasture grasses almost 3 times over the no-treatment plots, while the percentage of tame grasses, chiefly Kentucky bluegrass, increased from 9 to 84 percent. The improvement in the quality of the pasture obviously was greater in value than the yield alone would indicate.

Effect of Seeding.

The results obtained with the various seeding mixtures on the Dairy farm were very similar to those on the Live Stock farm. At the end of a period of years no advantage either in yield or composition of the pasture was obtained from using a complex seed mixture as compared to a more simple mixture. Where Mixture No. 2 was used a heavy growth of medium-red clover was obtained for one year on the limed and fertilized plots. This probably was due largely to the very favorable season for red clover.

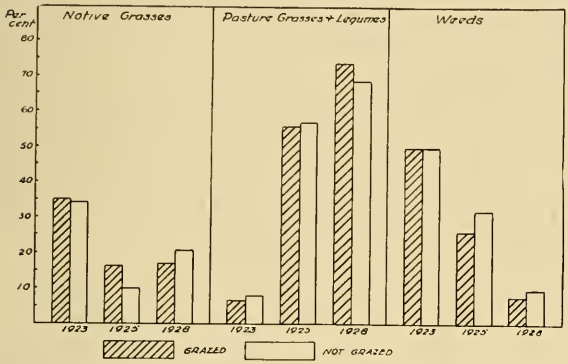

FIGURE 23. — Percentage of native grasses, pasture grasses and legumes, and weeds on the grazed and ungrazed halves of pasture plots on the Dairy farm in 1923, 1925, and 1928. Limed. Fertilizer treatment: superphosphate

In Table 10 several plots which received seed are compared with plots where no seed was applied. As may be seen from this table, increased yields were obtained from seeding on the lime-and-superphosphate plots. The average yields were 1,804 and 1,557 pounds per acre, respectively, on the seeded and unseeded halves. There was practically no difference in yield on the unlimed halves. No increase in yield resulted from seeding on either the limed or unlimed parts of the unfertilized plots. As will be seen in Table 14, seeding did not increase the percentage of pasture grasses and legumes. As was true on the other farm, the stand of bluegrass and white clover at the beginning of the experiment was sufficient eventually to replace the more undesirable native grasses and weeds when fertilizer and lime were applied.

TABLE 11.—*Average Yields per Acre on Cultivated and Uncultivated Pasture Plots on the Dairy Farm in* 1924 *to* 1928

Fertilizer Treatment	Lime Treatment	Average Yields 1924-28	
		Cultivated	Not Cultivated
No fertilizer	Limed	1273	997
No fertilizer	Not limed	866	733

Effect of Cultivation.

In Table 11 the yields on a series of plots which were cultivated by means of a disk harrow are compared with a similar uncultivated

series. As was true on the Live Stock farm, seeding and cultivation alone resulted in only a small increase in yield on both the limed and unlimed parts of the plots.

TABLE 12.—*Yields per Acre for the Years* 1924 *to* 1928 *and Average Yields on the Pasture Plots on the Dairy Farm, Where Phosphate Was Used with and without an Application of Lime*

Fertilizer Treatment	Lime Treatment	Yields in Pounds per Acre					Average 1924-28
		1924	1925	1926	1927	1928	
Superphosphate..	Limed	1871	1858	1189	1854	2250	1804
Superphosphate..	Not limed	1158	673	541	1287	1566	1045

Yearly Variation in Pasture Yields

In Table 12 are shown the average yearly yields of all plots receiving superphosphate only. Here as on the other farm good yields were obtained in the first years of the experiment, when the clover made up a large bulk of the crop on the limed parts of the plots. This was followed by a lower yield in 1926 and then by a gradual increase as the bluegrass was developing.

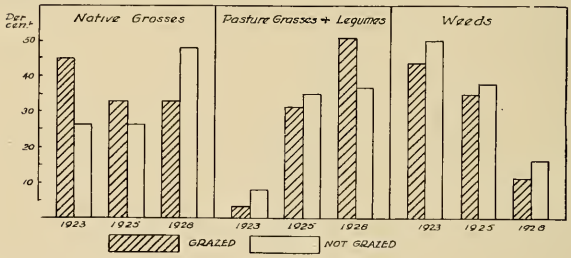

FIGURE 24. — Percentage of native grasses, pasture grasses and legumes, and weeds on the grazed and ungrazed halves of pasture plots on the Dairy farm in 1923, 1925, and 1928. Limed. Fertilizer treatment: none

Grazing vs. Mowing a Pasture

The results obtained on the grazed and ungrazed halves of the plots on the Dairy farm are shown in Table 14. The results of several treatments are also shown in Figures 22 to 24. As was true on the Live Stock farm, there was little difference in the various classes of plants on the grazed and ungrazed halves of the plots. Cutting the plots twice a year had about the same effect as moderate grazing.

DISCUSSION OF RESULTS

Certain of the treatments used indicate the possibilities of improving pastures. The soil involved in this investigation was a Dekalb clay loam. It was in a low state of fertility, too steep to make practicable the reestablishing of the pasture by plowing. The soil possessed, however, sufficient fertility to make improvement practicable. The soil on the Dairy farm was in a little better state of fertility than the soil on the Live Stock farm, as shown by the yields obtained. The effects of the various treatments and combinations of treatments

are very similar on the two farms, except that yields were higher on the Dairy farm.

On both farms the most striking improvement in the pasture resulted from an application of lime with a combination of manure and superphosphate. A seed mixture was applied with this treatment, and the plots were disked after the seeding. Manure alone or phosphate alone was not as effective as a combination of the two. On most farms in the state not enough manure is produced to warrant a general application on the pastures. The question, then, is whether one should apply either lime alone, superphosphate alone, or both. A complete commercial fertilizer was not included in these experiments; yet it is possible that on many farms a complete fertilizer together with lime may be the most profitable. An earlier experiment at this Station[6] indicated that an application of superphosphate and lime would give as good results as an application of complete fertilizer and lime. Before making a general application of fertilizer or lime on a pasture it is recommended that a preliminary trial be made on a small area as outlined in Circular 47 of this Station.

The application of lime, superphosphate, and Seed mixture No. 1 over a 6-year period cost approximately $18 per acre, exclusive of labor (an annual cost of $3 per acre). Where manure was applied in addition, the cost per acre was considerably more, and the exact amount would vary under different conditions. Considering the increased yields and the improvement in the quality of the pasture as shown in these experiments, it may be stated conservatively that where lime, superphosphate, and seed were applied, the carrying capacity was at least 3 times as great as before treatment. Where manure was applied in addition the improvement was still more striking. From the results obtained in these experiments it would seem that money invested in lime, superphosphate, and seed for pastures of this type will bring a very good return on the investment. For each dollar invested, the lime probably yielded the greatest return, and the seed the least. On both farms there seem to have been enough good pasture grasses so that where lime and fertilizer were applied, these grasses developed and a good sod was formed even where no seed was applied. If any of the treatments are to be left out, the cultivation and seed application are the first that should be omitted.

The application of nitrate of soda alone, when applied once every 3 years, although effecting some improvement of pasture when used in combination with lime, does not produce the results obtained by using superphosphate in combination with lime. On some pastures a combination of superphosphate with nitrate of soda, or a complete fertilizer when used with lime, probably will prove the most profitable treatment.

The experiments show conclusively that scattering seed over a

[6]W. Va. Agr. Exp. Sta. Bul. 177.

pasture of this type without other treatment is useless. In the pasture survey made in this state a few years ago[7], 98 percent of the farmers interviewed suggested reseeding the pasture as a means of improving it. Only a few more than one-half of these men suggested liming in addition, and less than one in 10 suggested applying fertilizers. A pasture must be considered as a piece of land producing a crop, just as much as any piece of land under cultivation.

Like seeding, disking a pasture without other treatment cannot be expected to produce any benefits. Good results may be obtained if lime and superphosphate are applied, and if cultivation is omitted entirely, particularly where topography of pasture makes cultivation difficult. If some bluegrass and white clover are present, seeding may also be omitted. The main consideration is to reduce the soil acidity by liming and then to supply fertilizer for the plants to utilize in their growth. Where a seed mixture is used, a simple mixture will probably be as effective as a more complicated one.

Although no experiments on the amount of grazing were included in these tests, attention should be called to the fact that best results cannot be expected from a pasture if it is kept too closely grazed, especially in the early part of the season. Cattle should be kept off the pasture until the grass has had opportunity to get a good start in the spring. After the grass has become well established there is less danger from damage to pasture by overgrazing.

[7]W. Va. Agr. Exp. Sta. Bul. 177.