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THE INFLUENCE OF LIME AND PHOSPHORUS ON THE GROWTH OF ALSIKE CLOVER AND TIMOTHY ON TWO ACID SOILS

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by

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The purpose of this thesis was to determine the influence of lime and phosphorus on the growth of alsike clover and timothy on two acid soils,- one good and one poor acid soil. The influence of liming and of liming in varying amounts these acid loving, or, at least, acid tolerating crops was the particular problem.

Some work along this line has been done by other stations,-

The Cornell station[1] found that one plot with manure alone yielded 2811 pounds alsike; another plot with manure and lime yielded 4999 pounds alsike.

Cornell further states[2],-"Lime had no influence upon the growth of timothy, but in other experiments on this same type of soil has shown a marked effect upon the growth of alfalfa."

The Wisconsin Experiment Station reports[3]- "It is not understood why wood ashes should have a more marked effect than lime when supplemented with both potash and phorphorus on this soil." This work was done on a peat soil at Phillips, Wisconsin. The crops were barley, timothy and alsike clover.

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1 Cornell Agr. Exp. Sta. Bul 264 p. 354
2 Cornell Agr. Exp. Sta. Bul 232 p. 32-46
3 Wisconsin Agr. Exp. Sta. Report XX p.30

The Pennsylvania Experiment Station's results using clover and timothy were[1], "An application of 4000 pounds of lime to supplement 12000 pounds of barnyard manure increased the yield. Lime alone compared with the plots receiving no fertilizer reduced the yield, while ground limestone and plaster each gave a slight increase."

The Massachusetts Experiment Station states[2], "Lime produced a marked result in increasing the proportion of timothy in a mixture of timothy, red top, and clover".

The West Virginia Station reports[3], that with clover as the crop lime and manure produced 6800 pounds; manure alone produced 7075 pounds. This soil contained only .043% phosphorus and phosphorus was probably a limiting factor.

The Rhode Island Station states[4], "Upon limed grass section 80% of the crop seemed to be timothy while upon the unlimed one there was about 10% timothy, the grass being chiefly red top". Liming increases[5] the relative amounts of timothy and the total weight of hay crops. Timothy and clover give way to red top on acid soils.

The Tennessee Station reports[6], 1800 pounds burned lime per acre were applied and the results were obtained in the seven years following the liming. On an upland red friable soil the

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1 Penn. Agr. Exp. Sta. Rept. 1902, p. 191-267
2 Mass. Agr. Exp. Sta. Rept. 1903, p. 110-149
3 W. Va. Agr. Exp. Sta. Bul. 99, p. 206
4 R.I. Agr. Exp. Sta. Bul. 49, 1898
5 R.I. Agr. Exp. Sta. Rept., 1897
6 Tenn. Agr. Exp. Sta. Bul. 97

limed plots of alsike and orchard grass gave 100% better growth than the unlimed. On a fertile and durable fine sandy loam bottom land limed plots of alsike and orchard grass gave 20% better growth than the unlimed. On the same upland soil limed plots of alsike and tall oat grass gave 60% better growth than the unlimed and on the lowland soil gave 30% better growth than the unlimed. As a result the Tennessee experimenters concluded that on upland soils experiments show alsike clover a practical failure without liming and that timothy is moderately helped. As regards lime they put alsike in the same class with alfalfa, red clover, and white clover.

The soils for this thesis experiment were obtained from the townships of Center and Magnolia, Rock County, Wisconsin. One soil was taken from the George Fenn cornfield at the foot of a large hill and bordering a marsh which was fairly well drained. The corn on this field was very good in the season of 1914. The soil was a brownish gray silt loam. As near as could be found the main crop on this piece of soil had always been corn. The other soil was taken from near the top of a hill on the Maria Chase farm a mile from the other field. The corn on this field was poor. This soil was also a brownish gray silt loam containing a little more clay than the other soil. The order of rotation on this piece of land has been corn, oats, seeding to red clover, and meadow two years. The tenant said it was the poorest piece of land on the farm. Both soils were found to be equally acid by Truog's method. The calcium carbonate requirements to neutralize acidity for both were found to be .0037 gm.$CaCO_3$ per gram of soil or about four tons of ground limestone per surface eight

inches. These determinations were made by the Veitch method using Truog's method to obtain the end point.

Known amounts of soil, about 10000 gms. were placed in 2-gal. jars. The fertilizers were mixed with the soils about February 10. C.P. $CaCO_3$ was used and C.P. monocalcium phosphate. The phosphate was applied at the rate of .0002 gm. per gram of soil or at the rate of about 400 pounds per acre. The fertilizer and lime carbonate treatment of the soils was as follows:-

Good soil

Jar 1	-	lime requirements
2		" "
3		" "
4		" "
5		1/2 " "
6		" " "
7		Phos - 1/2 " "
8		" - 1/2 " "
9		" -full " "
10		" - " " "
11		" alone
12		" "
13		" "
14		" "
15		double lime requirements
16		" " "
17		Phos - " " "
18		" - " " "
19		no treatment
20		" "
21		" "
22		" "
23		lime requirements
24		" "
25		1/2 " "
26		1/2 " "
27		Phos - 1/2 " "
28		" - 1/2 " "
29		" "
30		" "
31		Phos. alone
32		" - lime requirements
33		" - " "
34		" alone
35		" "
36		" "

Jar 37 double lime requirements
38 " " "
39 Phos - " " "
40 " - " " "
41 no treatment
42 " "
43 " "
44 " "

Poor soil

45 lime requirements
46 " "
47 " "
48 " "
49 1/2 " "
50 1/2 " "
51 Phos - 1/2 " "
52 " - 1/2 " "
53 " - full " "
54 " - " " "
55 " alone
56 " "
57 " "
58 " "
59 double lime requirements
60 " " "
61 Phos - " " "
62 " - " " "
63 no treatment
64 " "
65 " "
66 " "
67 lime requirements
68 " "
69 " "
70 " "
71 1/2 " "
72 1/2 " "
73 Phos - 1/2 " "
74 " - 1/2 " "
75 " - full " "
76 " - " " "
77 " alone
78 " "
79 " - double lime requirements
80 " - " " "
81 double " "
82 " " "
83 no treatment
84 " "
85 " "

After the fertilizers had been thoroughly mixed with the soil, the soils were kept moderately moist with distilled water until planting time. An attempt was made to bring the water content of the jars up to 25% of the weight of the soil, but this was found impossible since it took too long for the water to soak in. The water content finally decided on was 1/7 of its weight for the fertile soil and 18% of its weight for the poorer soil.

March 1 the jars were planted to alsike clover and timothy. Jars 1 to 22 inclusive were planted to timothy, and jars 23-44 inclusive were planted to alsike. Jars 45 - 66 inclusive were planted to timothy and jars 67 - 84 inclusive were planted to alsike. After being planted the jars were watered moderately every day or so as they needed it until April 21, when they were for the first time brought up to the water content stated above. April 26 they were again brought up to water content and again once each week until harvested. In between weekly waterings, however, they were watered moderately as they needed it. Rain water was used after planting.

About March 12 "damping off" fungus got into the alsike and the timothy destroyed a number of the plants. The jars were left dry several days to check the disease, and March 20 they were sprinkled with a .4% solution of potassium sulphide. The disease was checked.

About April 8 all the jars were thinned to approximately one hundred plants each and April 19 they were thinned to fifty plants each except jars 59, 60, 53, 48, and 49 which did not

have fifty plants in them. Jar 59 had no growth in it other than two or three little spears of grass altho it was planted twice. What plants were in jar 53 were as large as those in its duplicate jar 54. In jars 60, 48, and 49 all the plants were small and most of them dried up and died.

May 22, after 83 days growth the plants were harvested. They were placed in paper bags and the bags allowed to stand open for four days in the green house. The weather was damp most of the time, however, and so, they became only wilted. May 26 they were placed in an oven and dried, and May 28 and 29 they were weighed.

Results Obtained from Growing Alsike Clover and Timothy on a Poor Acid Soil

treatment	Lime req.		½ lime req.		Phos.& ½ lime req.		Phos.& full lime req.		Phos. alone		Double lime.		Phos.& double lime		no treatment	
	Jar No.	wt. of plants	Jar No.	wt. of plants	Jar No.	wt. of plants	Jar No.	wt. of plants	Jar No.	wt. of plants	Jar No.	wt. of plants	Jar No.	wt. of plants	Jar No.	wt. of plants
		gms.														
	45	1.7	49	0.8	51	11.5	53	[Δ] 2.7	55	12.6	59	no growth	61	13.5	63	2.8
av. timothy wt.	46	1.3	50	0.6	52	13.6	54	10.1	56	15.6	60	0.2	62	13.9	64	2.3
	47	1.4							57	9.8					65	2.5
	48	0.7							58	13.4					66	2.2
		1.3		0.7		12.6		6.4		12.9		0.1		13.7		2.5
av. alsike wt.	67	3.8	71	1.7	73	12.2	75	11.6	77	10.0	81	4.6	79	12.3	83	5.8
	68	3.2	72	2.0	74	10.9	76	11.5	78	10.7	82	4.8	80	12.4	84	4.5
	69	3.5													85	5.4
	70	4.2														
		3.7		1.9		11.6		11.6		10.4		4.7		12.4		5.2

[Δ] All but 10 of the plants in this jar died.
Those remaining were as healthy as those in 54 its duplicate.

Results Obtained from Growing Alsike Clover and Timothy on a Good Acid Soil

treatment	Lime req.		½ lime req.		Phos & ½ lime req.		Phos. & full lime req.		Phos. alone		Double lime		Phos. & double lime		no treatment	
	Jar No.	wt. of plants	Jar No.	wt. of plants	Jar No.	wt. of plants	Jar No.	wt. of plants	Jar No.	wt. of plants	Jar No.	wt. of plants	Jar No.	wt. of plants	Jar No.	wt. of plants
		gms.														
timothy	1	12.0	5	9.5	7	12.4	9	14.1	11	11.8	15	12.8	17	15.0	19	8.1
	2	11.5	6	9.7	8	11.5	10	14.2	12	12.9	16	10.4	18	12.9	20	9.3
	3	10.8							13	9.9					21	12.7
	4	11.8							14	10.8					22	10.3
av. wt.		11.5		9.6		12.0		14.2		11.4		11.1		14.0		10.1
Alsike	23	13.2	25	11.8	27	14.1	32	14.9	31	14.1	37	11.9	39	14.7	41	10.4
	24	12.9	26	11.5	28	14.8	33	15.7	34	12.8	38	14.8	40	14.4	42	12.6
	29	12.8							35	14.7					43	10.0
	30	14.6							36	12.5					44	11.6
av. wt.		13.4		11.7		14.5		15.3		13.6		13.4		14.6		11.2

		% gain of phos. over Blank	% gain of average lime over Blank	% gain of average lime and phos. over phos. alone
Timothy	Good soil	10%	10%	18%
	Poor soil	416%	- 72%	- 16%
Alsike clover	Good soil	22%	14%	9%
	Poor soil	108%	- 35%	15%

Interpretation of results,-

In all cases phosphorus gave increased returns over blanks. This increase was especially marked in the case of the poor soil which was undoubtedly deficient in phosphorus. On the poor soil timothy responded more to phosphorus than did alsike. On the good soil, on the other hand, alsike responded more to phosphorus than did timothy. On the good soil both crops responded to lime a 10% increase for the timothy and a 14% increase for the alsike, but on the poor soil where lime was used alone it was greatly toxic, being more toxic to the timothy than to the alsike. On the poor soil lime in the lime and phosphorus treatment produced an increased return, but with timothy on this same soil lime in the lime and phosphorus treatment decreased the returns.

If, however, we do not count jar 53 four-fifths of the plants of which died perhaps due to "dampening off" fungus we will get an increase of timothy on the poor soil from lime and phosphorus over phosphorus alone. The toxicity of the lime was further noted in that besides dwarfing all the plants where lime alone was used on the poor soil, it killed many plants. This was particularly noticeable in jars 60, 48, and 49 and in 59 in which all the plants were killed.

It is concluded from the results obtained that for fertile acid soils lime treatment is beneficial to alsike and timothy, but for poor acid soils the fertility and particularly the phosphorus content needs first attention.

Effect of phosphorus alone on the poor soil.

Effect of lime alone on the poor soil.

Approved H. L. Walster

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