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SOME PHYSICO-CHEMICAL EFFECTS OF ORGANIC SOIL COLLOIDS

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An investigation was undertaken to determine the reason for injurious effects of lime to grains grown on certain acid organic soils which occur in the Great Lakes region. Analyses were made of the soils (table I) and crops (table II) in order to determine if a harmful physical change occurred in the soils after liming or if lime was chemically injurious. The organic soils studied were black, powdery, acid and deficient in potash as shown by the soil analyses. Crop injury following use of lime to correct acidity in these soils is an unexpected response which occurs frequently enough to justify investigation.

The immediate effect of lime was an apparent improvement of texture, as the pulverulent surface layers developed a well aerated crumb structure. To determine if this change in texture was produced at the expense of the colloidal or dispersed portion of the soils, decolorization effects of the soils on weak dye solutions were studied. In no case did the limed soils show a decrease in amount of dye taken up and hence presumably no decrease in the amount of dispersed material. The treated and untreated soils absorbed 20 to 34 per cent of their own weight of dye as shown in table III. To be certain of the relative amounts of dispersed material, limed and unlimed soils were separated into "colloid" and "non-colloid" fractions according to the methods of the United States Bureau of Soils (1). Even though there was no decrease in the amount of dye adsorbed the limed soils showed a diminution in the amount of "colloidal" material (table IV). The fact that there was no change in the amount of dye adsorbed following liming, then, may not be taken as an indication that no physical change has occurred in the soil.

Adsorptive capacities of "colloid" and "non-colloid" fractions for Malachite Green were measured. The "non-colloid" fraction showed an adsorption of 25 to 40 per cent of its own weight of dye while the "colloid" fraction adsorbed only 9 to 15 per cent of dye. This behavior is the opposite of that occurring on mineral soils. Many soil scientists have chosen to consider organic soils essentially col-

TABLE I

SOIL ANALYSES

	SOIL I	SOIL II
Total Potassium..................	0.29%	1.52%
Total Calcium....................	3.44%	0.08%
Total Iron........................	1.21%	2.02%
Total Volatile Matter............	48.10%	42.61%
Insoluble (silicates, etc.)..........	15.50%	26.80%
Lime Requirements...............	2700.00 ppm.	3500.00 ppm.

loidal on account of their high adsorptive capacity, yet it is illuminating to observe that the dispersed fraction of these soils adsorbed much less efficiently than the coarser, undispersed fraction. The dispersed fraction of the limed soils adsorbed less dye than the dispersed fraction of the unlimed soils, but the adsorption values for the undispersed portion were not uniform either in direction or amount. In making aqueous extracts of the limed soils to determine amounts of water soluble materials it was found that they were acid to indicators at first but on standing eventually turned alkaline to them. The color change from acid to alkaline toward methyl orange and phenolphthalein usually occurred within 48 hours. This lag in attainment of chemical equilibrium over so wide a range of hydrogen ion concentration is striking. It shows how slowly the acidity of organic acids is overcome. The great potential acidity of organic soils makes determination of their lime requirement very difficult.

TABLE II

CHEMICAL ANALYSES OF ENTIRE PLANTS

	CORN							
	SOIL I				SOIL II			
	CHECK	400 KCl PPM.	4000 $CaCO_3$ PPM.	400 KCl & 4000 $CaCO_3$ PPM.	CHECK	400 KCl PPM.	4000 $CaCO_3$ PPM.	400 KCl & 4000 $CaCO_3$ PPM.
Plant Dry Wt. in Gms.	7.45	8.50	6.20	7.10	6.88	4.75	5.95	5.20
Percentage Potassium	0.42	0.78	0.30	0.74	0.45	0.62	0.42	0.43
Percentage Calcium	0.18	0.14	0.21	0.22	0.15	0.14	0.23	0.23
	WHEAT							
Plant Dry Wt. in Gms.	4.74	5.80	2.70	3.55	4.64	2.30	3.81	3.28
Percentage Potassium	0.55	0.78	0.40	0.62	0.61	0.77	0.57	0.65
Percentage Calcium	0.21	0.17	0.28	0.10	0.22	0.18	0.41	0.20

OATS								
Plant Dry Wt. in Gms.	4.38	4.87	2.76	4.05	4.24	2.10	3.70	2.98
Percentage Potassium	1.01	1.24	0.99	1.23	0.77	0.97	0.49	0.75
Percentage Calcium	0.17	0.22	0.25	0.23	0.15	0.09	0.20	0.16
CLOVER								
Plant Dry Wt. in Gms.	2.00	1.72	2.41	2.16	1.95	1.46	2.18	1.74
Percentage Potassium	0.71	0.98	0.70	0.84	0.80	0.99	0.75	0.64
Percentage Calcium	0.22	0.18	0.28	2.26	0.19	0.17	0.23	0.23

TABLE III

ABSORPTION OF MALACHITE GREEN BY LIMED AND UNLIMED SOILS, AS PERCENTAGE OF SOIL WEIGHT

	SOIL I	SOIL II
UNLIMED		
Entire Soil	32.74	20.76
Dispersed Fraction	14.80	9.24
Undispersed Fraction	41.60	25.38
LIMED		
Entire Soil	34.41	26.72
Dispersed Fraction	9.78	8.86

Although the aqueous extracts of limed soil showed no decrease in the amount of potash, this element did not seem as available to grain crops on alkaline as on acid soils. Tissue analyses revealed uniform depression in potassium assimilation following liming, which often went to the extreme of potash starvation manifested by arrestation of growth, etiolation, and leaf scorch on hot, sunny days. Additions of potash to the limed injured soils did not improve crops nor materially increase the quantity of potash assimilated. This response differs from that shown by mineral soils, because on them lime injury to crops can be corrected by potash applications.

There was no visible difference in plant roots on limed soils to

TABLE IV

PERCENTAGE OF DISPERSED AND UNDISPERSED FRACTIONS IN SOILS BEFORE AND AFTER LIMING

	SOIL I	SOIL II
UNTREATED SOILS		
Dispersed Fraction	25.60	28.60
Undispersed Fraction	74.40	71.40
LIMED SOILS		
Dispersed Fraction	22.10	21.46
Undispersed Fraction	77.90	78.54

account for the low crop yields. Further, the adsorptive power of limed and unlimed grain roots, as shown by dye taken up, was the same.

From the foregoing, it would appear that decreased potash assimilation is coupled with change from acidity to alkalinity in the soil, or with release by replacement of some toxic substance. The latter is a possibility in this case as the soils contained moderate amounts of iron of which toxic quantities were liberated by liming.

Clover was observed to maintain a constant supply of potash whether soils were limed or not. The best yields of clover were on limed soils. This shows a difference in nutrient requirement or absorptive capacity of roots. Clover roots, weight for weight, absorbed twice as much dye from a solution of Malachite Green as grain roots, indicating apparently that the ability to maintain a constant supply of potash in the plant may be due to higher absorptive efficiency of roots. This greater absorptive efficiency of clover may be merely a matter of greater surface area of the rootlets, or other factors may also be involved.

Due to the difficulty of securing dispersal of colloidal material, especially in organic soils, much work of the type here reported is open to question. Yet it appears that lime used to correct acidity and improve tilth on organic soils deficient in potash, induces profound physical and chemical changes in the soil which may be more objectional than the original acidity. In the case of grains the injurious effect of lime is due to diminished potassium intake. Use of potash following lime injury to grains does not restore yield on organic soils as it has been known to do on mineral soils. The response of crops to lime differs according to their nutrient requirements and absorptive ability.

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