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IS THERE A DEFICIENCY OF AVAILABLE POTASSIUM IN SO-CALLED ALKALI SOILS OF IOWA?

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A review of the literature reveals conflicting opinions regarding the effects of lime upon the liberation of potassium in soils. The early investigators and most textbooks on soils adhere to the viewpoint that the addition of lime to soils results in the liberation of potassium through chemical reaction. It is believed by some that addition of calcium to soil materially affects the solubility of the potassium from the soil, so much so as to be of considerable practical value under field conditions. According to Jenny (3), as early as 1847 Liebig pointed out that the addition of lime furnished an invaluable means of liberating from the soil those alkalies that are indispensible to the existence of plants. Hall (2) in 1921 reported that the action of lime upon the potassium compounds in the soil is very marked. The explanation is given that as the water carries down the dissolved calcium bicarbonate, the zeolitic double silicates in the clay are attacked and some of their soluble bases, potassium among them, change place with the lime and go into solution.

On the other hand, many investigators have reported that lime does not liberate potassium and in some cases it even decreased the quantity of potassium available to plants. Gaither (1) found that although lime tended to liberate such elements as magnesium, silica, iron and aluminum, it had no appreciable effect upon potassium. The analyses of wheat grown on limed plots showed that lime actually decreased the amount of potassium assimilated by wheat. MacIntire and his co-worker (4) conducted a number of lysimeter studies and found that lime additions did not liberate potassium from the soil complex but instead fixed the potassium in the soil. The experiments showed that liming materially reduced the outgo of both native and added potassium. Observations of barley grown on land that had been limed gave every indication that the addition of lime may depress the solubility of both native and added supplies of potassium to the point of bringing about a potash deficiency for certain crops.

The so-called alkali soils or high-lime soils of Iowa have been found to contain an abundance of calcium carbonate and calcium bicarbonate. Warner (7) reported that neither of these salts are injurious except in strong concentrations but that large amounts of calcium bicarbonate in combination with smaller amounts of other alkali salts result in crop injury. He found that the characteristic stunted and unsatisfactory growth of corn on alkali land was quite similar to that caused by poor drainage, or lack of some plant food element. In some cases it was found that the injury may be due to the lack of potassium. Stevenson and others (6) reported beneficial effects from potassium fertilizer and have recommended that farmers test the value of muriate of potash on their alkali soils.

Since it seems possible that the lack of potassium in alkali soils may be one of the reasons why they are unproductive, a study was made to determine the quantity of total and available potassium in several alkali soils of the state. Twelve alkali soils from various sections of the Wisconsin drift area were brought to the laboratory and analyzed for reaction, total potassium and available potassium. The reaction of the soils was determined by the quinhydone electrode. Total potassium was determined by fusing the soil with ammonium chloride and calcium carbonate and precipitating the potassium according to the potassium perchlorate method. The available potassium of the soils was determined by the *Aspergillus niger* method of Mehlich, Truog and Fred (5).

The results of the experiment are given in table I and show that all the soils studied had a high pH value, ranging from a

Table I — Total and Available Potassium in Some Alkali Soils In Iowa

Soil Series	pH Value	Percentage total potassium	Mgms. K_2O per 100 grams soil
1101	7.82	1.33	12.76
2101	8.14	1.27	11.25
3101	8.12	1.30	12.50
4101	8.09	1.41	13.25
5101	8.11	1.48	16.25
6101	7.89	1.62	18.40
7101	8.17	1.45	16.62
9101	8.14	1.53	17.48
10101	7.80	1.27	23.10
11101	7.95	1.30	15.50
12101	8.24	1.58	16.70
13101	8.21	1.55	15.70

pH 7.80 to 8.24. With such high pH values it appears evident that the soils are high in alkali salts. From the results of the total potassium content it was found that all of the soils contained a sufficient quantity of potassium so that the amount of available potassium should be sufficient for plant growth. However, according to the *Aspergillus niger* test it was found that the majority of

the soils were deficient in available potassium. According to Mehlich, Truog and Fred (5) soils with less than fifteen milligrams of potash per one hundred grams of soil need potassium fertilization, those containing fifteen to twenty milligrams of potassium may respond and soils with twenty or more milligrams of potassium will probably not need potassium fertilization. In comparing these figures with the quantity present in the alkali soils it is evident that four of the soils need potassium, seven would probably respond to light applications and one has a sufficient amount so that potassium fertilization is not likely to be necessary.

A study was also made to determine the effect of potassium chloride on the availability of potassium in several soils of Iowa. Four soils ranging from pH 5.59 to pH 7.83 in reaction were brought to the greenhouse and treated with five hundred pounds and one thousand pounds of potassium chloride per acre, respectively. They were then allowed to stand fallow for several months. Available potassium was determined by the *Aspergillus niger* method on samples taken six weeks after treatment.

From the results secured as shown in table II, it was found that the amount of available potassium was increased in every

Table II — The Effects of Potassium Chloride on the Availability of Potassium as Determined by the Aspergillus niger *method*

Soil	Treatment	Mgms. K_2O per 100 gms. dry soil Oct. 27	Mgms. K_2O per 100 gms. dry soil Dec. 9
Tama silt loam	Check	24.40	20.15
Tama silt loam	500# KCl	30.10	29.75
Tama silt loam	1000# KCl	35.60	34.50
Webster clay loam	Check	21.50	24.60
Webster clay loam	500# KCl	30.90	31.00
Webster clay loam	1000# KCl	33.50	34.50
Webster silty clay loam	Check	23.10	24.60
Webster silty clay loam	500# KCl	30.12	32.25
Webster silty clay loam	1000# KCl	34.85	34.90
Cass silt loam	Check	18.15	19.25
Cass silt loam	500# KCl	28.90	27.30
Cass silt loam	1000# KCl	30.20	31.00

soil, but not above the quantity added. The five hundred pound application of potassium chloride gave a greater increase in available potassium in proportion to the quantity added than did the one thousand pound application. All of the soils — acid, neutral and basic — showed practically the same increase in available potassium due to the addition of the potassium fertilizer. The amount of available potassium in all of the soils except in the very acid soil, Tama silt loam, tended to increase six weeks after treatment.

A study was also made to determine the effects of various treatments on the growth of wheat on two alkali soils, Webster clay loam and Cass silt loam. The treatments made were as follows:

POT NO.	TREATMENT
1	Check
2	100# KCl per acre
3	200# KCl per acre
4	500# KCl per acre
5	Straw (2 tons per acre, dry wt.)
6	Straw + 200# KCl per acre
7	Sweet clover (2 tons per acre, dry wt.)
8	Sweet clover + 200# KCl per acre

The results of the crop test are given in table III. They show that all treatments of the soils increased the yield of wheat. The

Table III — Effect of Treatment on Yield of Wheat Grown on Alkali Soil

TREATMENT	WEBSTER CLAY LOAM :			CASS SILT LOAM		
	WHOLE PLANT	STRAW	GRAIN	WHOLE PLANT	STRAW	GRAIN
	gms.	gms.	gms.	gms.	gms.	gms.
Check	45.45	29.10	16.35	28.75	17.00	11.75
100 lbs. KCl	51.49	31.40	20.09	46.55	28.20	18.35
200 lbs. KCl	57.94	35.82	22.12	49.69	30.06	19.63
500 lbs. KCl	62.15	39.02	23.13	51.55	30.30	21.25
Straw	54.75	32.48	21.47	45.64	28.33	17.31
Straw + 200 lbs. KCl	65.29	39.67	25.62	54.09	33.57	21.70
Sweet clover	48.61	30.40	18.21	37.30	21.70	15.60
Sweet clover + 200 lbs. of KCl	57.20	35.62	21.58	48.15	28.27	19.88

soils receiving the combination of straw and potassium chloride gave the highest yields while the soils treated with five hundred pounds of potassium chloride per acre gave slightly lower yields. The soils receiving 200 pounds of potassium chloride per acre gave about the same yield as those treated with sweet clover and potassium chloride. From the results it is apparent that the application of straw, sweet clover and potassium chloride proved beneficial on both alkali soils.

SUMMARY

A study was made to determine the availability of potassium in twelve so-called alkali soils occurring in the Wisconsin drift area. In light of the experiments reported in this paper, it appears evident that there is a sufficient quantity of total potassium in alkali soils, but they are apparently lacking in available potassium. According to the analyses for available potassium, four of the soils need potassium fertilizers, seven would probably respond to light applications, and one has a sufficient amount so that potassium fertilizers are not likely to be necessary.

The results of the effects of various applications of potassium

chloride on the availability of potassium in four Iowa soils show that various additions of potassium chloride increased the quantity of potassium absorbed by *Aspergillus niger*.

A greenhouse study of the effects of treatment on the growth of wheat on two alkali soils showed that all treatments — straw, sweet clover, and potassium chloride — increased the yield of wheat, with the combination of potassium chloride and straw giving the greatest yield. It is shown conclusively that alkali soils may be made more productive by applying potassium chloride and straw.

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