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Potassium Fixation and Supply

By Soils With Mixed Clay Minerals

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Summary

Studies were made on three agriculturally important soils of South Texas and Northern Mexico to determine their potassium (K)-supplying power, the influence of cropping on fixation of K and the response of grain sorghum to fertilizer K. Under greenhouse conditions, Laredo si l supplied 3.29 me K/me of exchangeable K to the plants while Cameron clay supplied only 1 me/me of exchangeable K. The capacity of all the soils to fix K increased with increasing removal of K by cropping. The increase in fixation was assumed to be partially due to the removal of fixed K by the plants. Grain sorghum growth on any of the soils was not increased by the addition of K fertilizer after nine crops.

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*Billy W. Hipp**

THE POTASSIUM STATUS OF SOILS of the Midwest, Northeast and Southeast United States has been investigated. Little work has been done, however, on soils of the Southwest. Soils of the West and Southwest are generally quite high in K, and responses are not usually obtained from the addition of K fertilizers. Since the Southwest is rapidly becoming one of the most important agricultural areas of the U.S., more knowledge concerning the K supplying power of these soils is desirable.

Previous work by Hipp and Thomas (3) pointed out the importance of clay type in the assessment of K availability in certain soils of Texas. Fraps and Fudge (2), investigating the chemical properties of some Texas soils, found many of them to be quite high in total and "active" K. Laws (5) found that no crop response to applied K was obtained in several soils of Central Texas.

To obtain additional information regarding the K status of soils of the Southwest, greenhouse and laboratory experiments were conducted on three soils common to South Texas and Northern Mexico.

MATERIALS AND METHODS

Soil was collected from the surface 15 cm of three soils that are of agricultural importance in South Texas and Northern Mexico. Description of the chemical properties of the soils is given in Table 1. The soils were from cropped areas which had not received K fertilizers recently. The soils were allowed to air dry. Then they were crushed to pass through a 2mm screen. Four plastic pots were filled with 3000 g of each of the three soils. A sample of each soil was retained for K determinations. Potassium was extracted from the air-dry soils with normal ammonium acetate at pH 7.0 and K determinations made with a Techtron Atomic Absorption Spectrophotometer. Each of the pots was cropped with grain sorghum for nine successive crops. The number of plants per pot varied from five to 20, but each pot had the same number of plants for any one crop period. The plants were watered with distilled water throughout the experiment. The plants were grown from 30 to 32 days, but plants of each crop in all pots were allowed to grow the same length of time. Each crop was harvested at the end of the growth period by cutting the entire plant at soil level. The plants were rinsed in distilled water and dried at 70° C. Then the dry weights were recorded. The whole plants were dry ashed as outlined by Chapman and Pratt (1), and K determinations made by atomic absorption. Calculations were made to determine the me K/100 grams removed from each pot by each crop. After each crop was harvested, the soil from each pot was remixed, and a 100-g sample of soil was removed for exchangeable K determinations. The soils were fertilized with Nitrogen (N), Phosphorus (P), Iron (Fe) and Zinc (Zn) as required after each cropping period, but none of the pots received K fertilizers. At the end of the ninth crop, K was added (as KCl) to two replications of each soil at the rate of 0.1 me K/100g then one more crop of grain sorghum was grown to determine whether a response to applied K could be obtained after removal of K by nine crops of sorghum.

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TABLE 1. CHEMICAL PROPERTIES OF THE SOILS USED IN THE STUDY

Soil	Saturated paste pH	me/100 gram					Predominant clay mineral	Secondary clay mineral
		K	Mg	Na	Ca	CEC (approximate)		
Cameron clay	8.2	2.1	5.3	1.2	29.4	38	Montmorillonite	Mica
Laredo silt loam	8.2	0.7	4.2	1.3	15.8	22	Mica	Montmorillonite
Willacy fine sandy loam	7.9	1.2	3.1	0.7	11.0	16	Mica	Montmorillonite

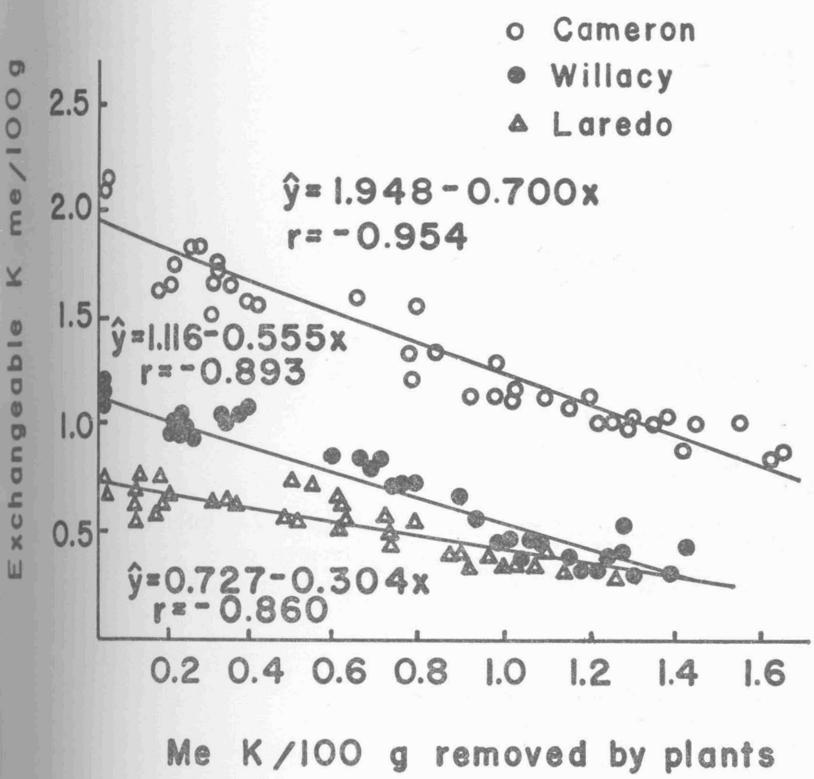

Figure 1. Relationship between K removed and exchangeable K on 3 soils.

Fixation of applied K was determined for each soil after each crop. The 100-g sample removed after each crop harvest was used for this purpose, and the fixation of K was determined as described by Jackson (4), except that the soils were subjected to six cycles of wetting and drying.

RESULTS AND DISCUSSION

The relationship between K removal by the plants and exchangeable K is shown in Figure 1. The slope of each regression equation can be regarded as an indication of the potassium supplying power for that soil. The slopes indicate that the soils are different in their capacity to supply K to growing plants. Laredo has a relatively flat slope of −0.304 indicating that for each milliequivalent of exchangeable K extractable with ammonium acetate, 3.29 me[1] will become available to plants. Similarly, Willacy will supply 1.81 me K/me of exchangeable K. The CEC as indicated in Table 1 is not necessarily an indication of the K supplying rate of these soils. The soil with predominantly montmorillonitic clay (Cameron) has a much higher b value (−0.700) indicating that non-exchangeable K is becoming exchangeable at a less rapid rate than in the two soils with primarily micaceous clay minerals. All the soils would be expected to have smaller b values under field conditions because of the numerous wetting and drying cycles during and between yearly cropping periods. Also, tillage practices would possibly decrease the b value.

$\frac{1}{\text{Slope}}$ = me available K/me exchangeable K.

The data in Figure 2 indicate that the capacity of all three soils to fix K increased with cropping. The constants for K fixation and release were similar on Laredo si l ie.; exchangeable K decreased at a rate of 0.304 me/me removed, and fixation increased at the rate of 0.336 me/me removed. Exchangeable K decreased in Cameron soil at 0.700 me/me K removed, but the fixation due to the nine cropping periods was only 0.240 me fixed/me removed. These data suggest that a considerable amount of fixed K was utilized by plants grown on Laredo si l, but a small amount of fixed K was utilized by plants grown on Cameron clay. If the sequence of weathering on these soils is Illite→Montmorillonite, these data suggest that the use of fixed K by plants proceeds at a faster rate than the decrease in K fixing capacity brought about by the weathering process.

TABLE 2. POTASSIUM CONTENT OF GRAIN SORGHUM PLANTS GROWN ON THREE TEXAS SOILS

Crop number	Percent potassium in whole plant		
	Cameron	Laredo	Willacy
1	3.46	2.91	3.28
2	2.52	2.28	2.55
3	2.45	2.10	2.17
4	2.31	1.98	1.88
5	2.07	2.00	1.71
6	2.15	1.98	1.85
7	2.26	2.06	2.13
8	2.35	2.13	2.08
9	2.25	1.88	1.95

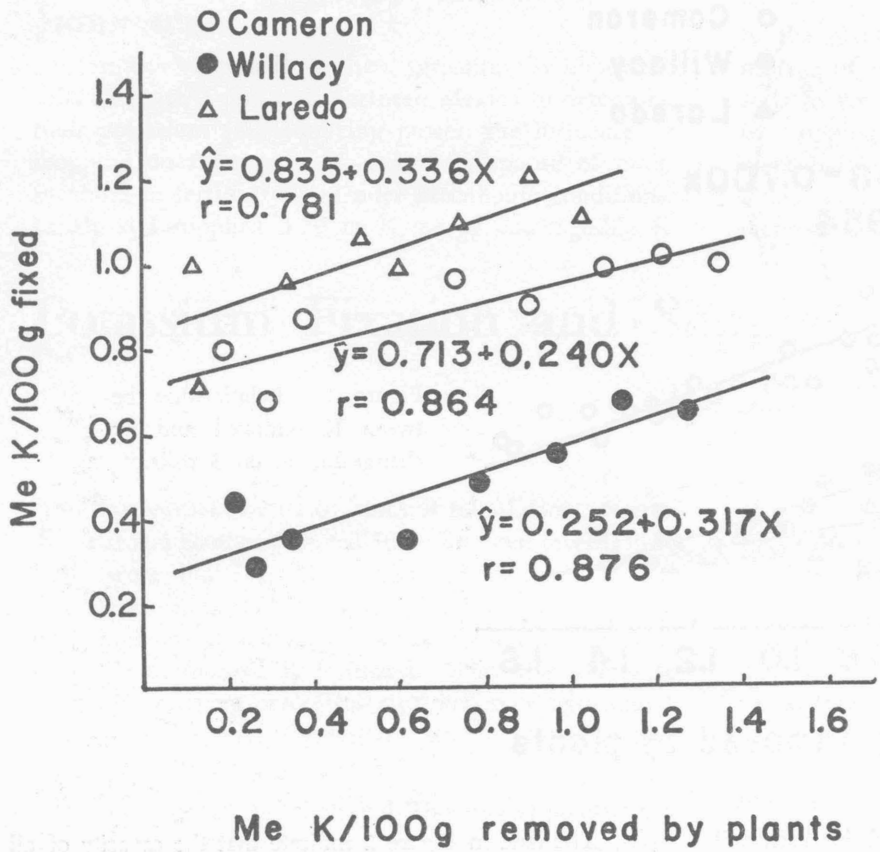

Figure 2. Influence of K removal on the K fixing capacity of 3 soils.

The K content of grain sorghum plants grown on each soil is indicated in Table 2. There was a sharp decrease in K content of the plants after the first crop of sorghum, but then the decline was gradual until the sixth crop when an increase occurred in K content of plants grown on all the soils. The fluctuations in K content of the plants were attributed to the unequal age and number of plants per pot at each cutting and seasonal temperature and light fluctuations in the greenhouse during the experimental period.

The influence of K fertilizer on growth of grain sorghum in each of the soils after nine crops is shown in Table 3. From these data it can be concluded that the level of exchangeable K is high enough after nine successive crops of sorghum to preclude an increase in plant growth from added K.

These studies indicate that the soils of South Texas and Northern Mexico with a mixed clay mineralogy have a high capacity for supplying K to plants, and a response to applied K on the soils described as well as on related soils of the area is not likely for several years. Fixation studies indicate that the fixing capacity of all the soils is increased by cropping, but the increase is not the same for all the soils. The increase in fixing capacity was attributed to removal of fixed K by plants.

TABLE 3. INFLUENCE OF POTASSIUM FERTILIZER ON GROWTH OF GRAIN SORGHUM AFTER NINE SUCCESSIVE CROPS

	Grams per plant 0 potassium	0.1 me K/100 grams
Cameron	2.50	2.44
Willacy	2.50	2.50
Laredo	2.19	2.25

LITERATURE CITED

1. Chapman, H. D. and P. F. Pratt. 1961. Methods of analysis for soils, plants and waters. Univ. of Calif., Div. of Agri. Sci.
2. Fraps, G. S. and J. F. Fudge. 1937. Chemical composition of soils of Texas. Tex. Agri. Exp. Sta. Bul. 549.
3. Hipp, B. W. and G. W. Thomas. 1967. Influence of soil clay type on potassium availability. Tex. Agri. Exp. Sta. M.P. 829.
4. Jackson, M. L. 1958. Soil chemical analysis. Prentice Hall. Englewood Cliffs, N. J.
5. Laws, W. D. 1962. Potassium status of eight Texas soils as related to crop yield and plant composition. Soil Sci. 94:230-234.