EFFECT OF DRYING UPON AVAILABILITY OF POTASSIUM IN PARSONS SILT LOAM

by

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INTRODUCTION AND REVIEW OF LITERATURE

Potassium has been recognized as being important in crop production since the beginning of the nineteenth century. Often referred to as the third fertilizer element, its importance as a constituent of commercial fertilizer has not been realized until rather recent times. The mysterious behavior of potassium in the soil has been extensively investigated in only the past 25 or 30 years.

Various effects of soil drying upon potassium availability have been noted. In this study an attempt was made to determine the influence of drying upon availability of potassium to plants.

A number of workers have reported the effects of drying on the release or fixation of potassium.

Volk (9) was one of the first workers in this country to establish that a portion of potassium applied to soils as fertilizers was converted to a nonexchangeable form. This fixation was found to be dependent on the nature and quantity of colloids present. Alternate wetting and drying of a soil treated with soluble potassium salts was found to facilitate this conversion.

Hoagland and Martin (6) observed that soils high in replaceable potassium tend to induce "luxury" consumption of this element by crops grown on it. Under intensive cropping conditions, the proportion of potassium derived from the non-replaceable form increases until that point is reached at which no further loss of replaceable potassium can occur. At this point the solubility of the non-replaceable form determines the supplying power of the soil. In some soils this rate of release from the non-replaceable form may be adequate for normal plant growth, while in others it may not be adequate and the plants will be deficient in potassium.

The observation that some soils apparently contain more available potassium in the spring than they contained the previous fall prompted a study by Fine, et al. (5). This study was to determine the effects of alternate freezing and thawing of moist soils. These workers found that in some cases, net releases of as much as 150 pounds of potassium per acre resulted and in other cases some potassium was fixed. Through a fixation treatment, the amount of non-exchangeable potassium in the Chico soil was increased. This fixation was accomplished by drying the samples three times at 90° C after wetting while saturated with exchangeable potassium. Upon freezing there was a greater release of potassium from this treated soil than from the untreated soil.

Attoe (1) found that the drying of unfertilized soils at room temperature resulted in an increase in content of exchangeable potassium. Drying of fertilized soils fixed potassium. The drying of unfertilized Miami silt loam soil increased its content of exchangeable potassium and also increased the amount of potassium removed by crops. This supported information that potassium released from the non-exchangeable form through drying was available for plant use. Attoe also observed that the fixation of potassium in a fertilized soil increased as the relative humidity of the air in which the soil was exposed, decreased.

According to Reitemeier (8) the various forms of soil potassium are interrelated. A change in one form occurs at the expense of one or more other forms of soil potassium. The availability to plants depends on the rate of release to the available forms from reserve supplies.

The objectives of this study were: (1) to measure the increase in exchangeable potassium which occurs as a result of drying; (2) to measure the influence of soil drying upon the increase in uptake of potassium by plants; (3) to compare the increase in exchangeable potassium with the increase in uptake of potassium by plants, both for surface soil and subsoil.

METHODS OF STUDY

Soil Material Used

Parsons silt loam soil material, both surface soil and subsoil, was obtained from near Thayer, Kansas in November 1954. This southeastern Kansas soil material was used because of its comparatively low content of exchangeable potassium.

Laboratory Analyses

Laboratory analyses of both Parsons surface soil and subsoil were made with respect to pH, lime requirement, available phosphorus, exchangeable potassium in the soil at the beginning and at the end of the experiment and percent organic matter content. Plant material was analyzed for uptake of potassium. The results of the initial laboratory analyses are shown in Table 1.

Table 1. Chemical properties of soil materials used in greenhouse experiment.

Soil material	pH	Lime requirement lbs/acre	Available phosphorus lbs/acre	Organic matter content %
Surface	5.42	5,000	15.2	3.1
Subsoil	5.80	3,000	17.5	1.5

The pH determination was made with the standard glass electrode using a soil to water ratio of 1:1. Lime requirement was established by combining use of the glass electrode and use of a buffered solution at pH 7 as suggested by Woodruff (10). The composition of this buffered solution is a mixture of calcium acetate, P-nitrophenol, and magnesium oxide. The advantages of this buffered solution is that there is not an unfavorable reaction with the soil being tested and the rate of reaction is rapid. Furthermore, the depression in pH is a convenient way to determine the hydrogen ion content of the soil.

The colorimetric method of Bray and Kurtz (3) was used to determine available phosphorus. Available phosphorus was extracted from the soil with a solution that was 0.025 N with respect to HCl and 0.03 N with respect to NH_4F. A soil to solution ratio of 1:50 was used in the extraction of available phosphorus.

The procedure by Peech et al. (7) was used for the determination of percent organic matter in both soils.

Potassium in the plant material was determined by the method suggested by Attoe (2).

For the determination of exchangeable potassium in the soil, 10 grams of soil which passed a 10-mesh sieve were used. To this soil were added 50 mls. of 1N ammonium acetate extracting solution. The solution was then shaken mechanically for 10 minutes. The suspension was filtered.

An internal standard, lithium nitrate, was added to a portion of the filtrate. The filtrate was then analyzed for content of potassium with the Perkin-Elmer flame photometer.

Greenhouse Technique

Surface soil and subsoil of the Parsons silt loam was divided into two lots for each material. One lot each of both the surface soil and subsoil was maintained in a continuously moist state from December 22, 1954, until the time of planting (February 7, 1955). The moisture content always was about 25 percent with the subsoil and about 14 percent with surface soil material. One lot each of both soil materials was allowed to dry until the moisture content was approximately 1.5 percent. After attainment of these specified moisture levels, 28 greenhouse containers were filled with soil from each lot (one moist and one dry) of each soil material (surface and subsoil). The amounts used in individual greenhouse containers are shown in Table 2.

Table 2. Amounts of soil material used in greenhouse experiment, 1955.

Soil material	Moisture content (%)	Amount of soil material added to containers	
		Moist soil (gm)	Dried soil (gm)
Surface soil	13.56	3,000	2,640
Subsoil	23.60	2,700	2,180
Surface soil	1.25	2,673	2,640
Subsoil	1.70	2,220	2,180

Calcium carbonate was added at the rate of 6.6 grams per culture of surface soils (2,640 grams of oven dry soil) which corresponded to 5,000 pounds $CaCO_3$ on an acre basis. Each culture of subsoils received 3.27 grams of calcium carbonate (2,180 grams of oven dry soil) which corresponds to a 3,000 pounds $CaCO_3$ per acre application. These rates were applied to satisfy the respective lime requirements.

Each container of soil irrespective of other treatments or amount of soil in the container received one gram of commercial grade mono-ammonium phosphate fertilizer (11-48-0).

Seven levels of potassium were used on each series of soil materials. Potash was applied at the rates indicated in Table 3.

Table 3. Amount of potassium added for various soil treatments, 1955

Potash treatment rate of K_2O(lbs/acre)	Amount of KCl added (gm/pot) Surface soil	Subsoil
0	-	-
40	0.0844	0.0696
80	0.1688	0.1392
160	0.3376	0.2784
320	0.6752	0.5568
640	1.3504	1.1136
1280	2.7008	2.2272

Four successive crops of soybeans were planted and harvested at about the time of seed pod formation. Plant material was dried and weighed to permit determination of yields of plant material. It also was analyzed for content of potassium.

EXPERIMENTAL RESULTS

Since the determination of exchangeable potassium content of the moist soils indicated relatively small amounts, it was thought that drying of the soils would affect release of potassium. Determination of the total uptake of potassium by plants therefore would afford a sound basis for interesting comparisons and conclusions from the experimental data.

Effect of Drying upon Soil Content of Exchangeable Potassium

Both soils were dried in a forced air furnace at 110° F. As indicated in Fig. 1, the original content of exchangeable potassium in the surface soil and subsoil was 116 and 136 pounds per acre respectively. Upon drying the soils until both contained a moisture content of 6 percent, the subsoil released 45 pounds per acre of exchangeable potassium whereas no release at this moisture level had taken place in the surface soil. The soils then were dried further at the same temperature, 110° F, until both soils contained 1.5 percent moisture. At this moisture level the surface soil was found to have 239 pounds of exchangeable potassium per acre. This value was a little more than double the value of exchangeable potassium at the 24 percent moisture level. The subsoil which was dried to a moisture content of 1.5 percent contained 269 pounds of exchangeable potassium per acre. This value was almost twice the amount of exchangeable potassium originally present.

Yield Results

Yield results of the plant material are shown in Table 4.

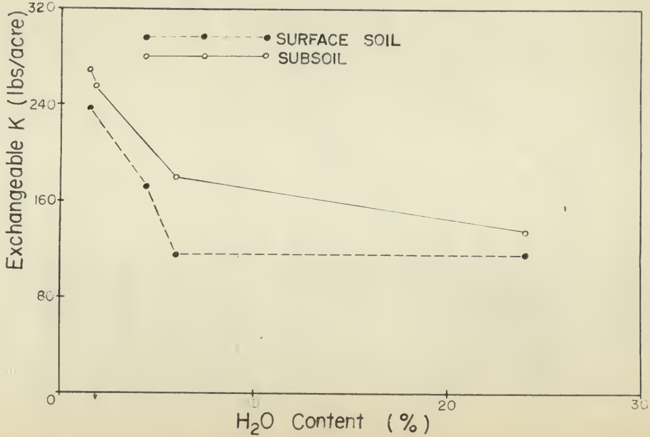

Fig. 1. Influence of soil drying upon exchangeable potassium content of Parsons silt loam.

Table 4. Relationship between potassium applied and yield of plant material of surface soils and subsoils.

Amount of K added lbs/acre	Total yield[1] of soybean plant material (gm/pot)			
	Surface soil		Subsoil	
	Moist	Dried	Moist	Dried
0	31.77	35.09	24.57	29.02
40	29.92	31.15	27.77	30.04
80	29.41	31.53	27.51	28.26
160	31.53	32.15	30.08	30.82
320	31.12	33.73	30.95	32.24
640	32.06	34.59	33.32	29.71
1280	31.25	36.32	34.72	30.49

Least significant difference between treatments (.05)
Surface soil = 3.13 gm.
Subsoil = 2.87 gm.

[1]Total yield of plant material for four crops.

Only one lot of soil reflected marked increase in yield of plant material from potassium fertilization. This increase occurred on the subsoil which had been maintained in a continuously moist state. The other lots of soil generally did not respond. Visual symptoms indicated that potassium deficiency was sufficient to limit yields, especially at lower rates of added potassium. It was suspected that response of grain yields to potash fertilization might have been significant, however the objective of this study was such that grain yields were not of prime interest and such data were not obtained.

Effect of Drying Upon Uptake of Potassium by Plants

Indicated in Fig. 2 are the results of the first soybean crop harvested on surface soil. There appeared to be little difference in total uptake of potassium between the moist and dried soil for all treatments except with no treatment. The untreated soil which had been dried, furnished considerably more potassium for plant uptake than did untreated soil which was

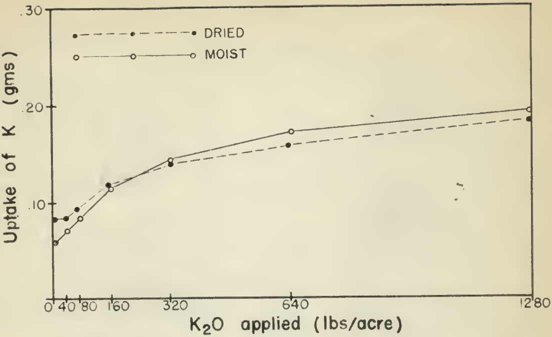

Fig. 2. Uptake of potassium by the first crop of soybeans grown on Parsons surface soil.

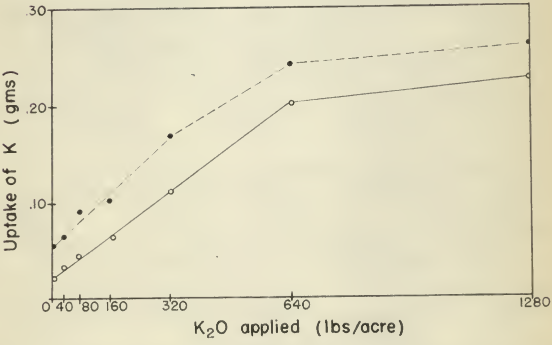

Fig. 3. Uptake of potassium by the second crop of soybeans grown on Parsons surface soil.

maintained in a moist state.

Figure 3 indicates data for the second crop of soybeans which were harvested from the original surface soil. Here the uptake of potassium at the no treatment level was twice as great on the dried soil as it was on the untreated moist soil. Approximately the same relative difference in uptake of potassium was maintained for all treatments. Moist soil furnished lower levels of available potassium while the dried soil maintained a higher level for each treatment. Evidence of potassium fixation and/or inability of plants to absorb more potassium occurred on the dried soil at the 320 pounds application level of K_2O. This effect on the moist soils occurred at the level of the 640 pounds application of K_2O.

Results for the third crop of soybeans are reported in Fig. 4. Again, total uptake of potassium from untreated soil was twice as great for the dried soil as it was for the moist soil. The same relative difference in potassium taken up appears to be maintained for each treatment and the dried soil seemed to render more potassium available for plant use than did moist soils. However, the total potassium uptake for the third crop was lower than the second crop for each level of applied K_2O.

In Fig. 5 are reflected the results of the fourth and last crop grown on the surface soil. On the dried soil, more potassium again was taken up at the no treatment level than was taken up through cropping on the moist soil. The advantage of potassium being made available through drying was somewhat diminished. Evidence was indicated here that both the moist and dried surface soils were tending to approach the same low min-

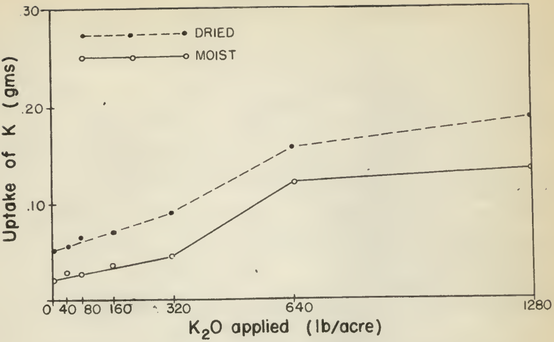

Fig. 4. Uptake of potassium by the third crop of soybeans grown on Parsons surface soil.

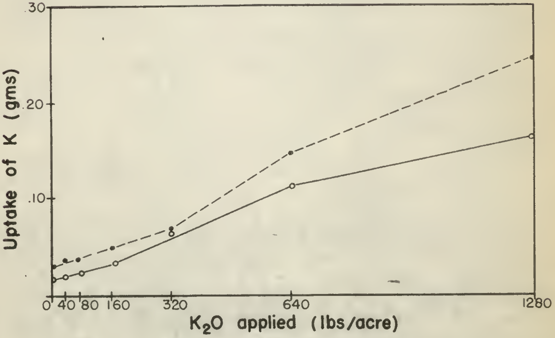

Fig. 5. Uptake of potassium by the fourth crop of soybeans grown on Parsons surface soil.

imum value of potassium that was available for plant uptake. This was true especially at the lower application levels. At the two highest rates of application however, there was considerably more potassium taken up by plants from the dried soil than from the moist soil. It is believed that when the one lot of soil was dried, appreciable exchangeable potassium may have been absorbed by organic colloids instead of being fixed by the inorganic soil fraction. Thus, the potassium originally absorbed by organic matter was made available for plant use when the soil was undergoing intensive cropping.

It may be seen in Fig. 6 that from untreated dried subsoil, soybeans absorbed twice as much potassium as did the soybeans on the untreated moist soil. Uptake of potassium from both the moist and dried lots of subsoil approached the same value where 320 pounds per acre of potash were applied and was approximately the same for the two higher levels of added potassium. There is a linear trend on the dried subsoils which increases from the no treatment level to the point where 160 pounds per acre of potash were applied. There is no further increase in potassium taken up after this level. This is attributed to potassium fixation and/or inability of the plants to absorb more potassium. There was a similar trend on the moist lot of subsoil material. However, the trend in this instance increased from the level where no potassium was applied up to the point where 320 pounds per acre of potash were applied. There was no further increase above this level due to potassium fixation and/or the inability of the plants to absorb more potassium.

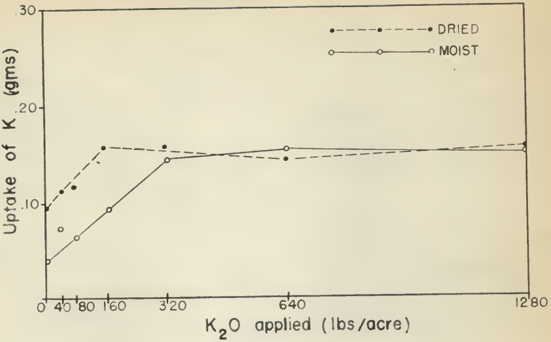

Fig. 6. Uptake of potassium by the first crop of soybeans grown on Parsons subsoil.

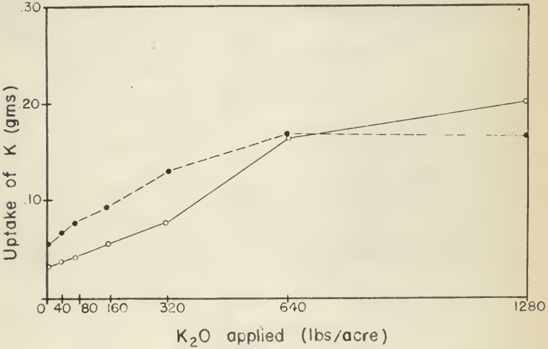

Fig. 7. Uptake of potassium by the second crop of soybeans grown on Parsons subsoil.

Figure 7 reflects results from the second crop of soybeans grown on the subsoil. Greater uptake of potassium was produced on the dried subsoil up to the level where 320 pounds per acre of K_2O had been applied. At the 640 pounds level of application the values were approximately the same for total uptake. The moist subsoil provided for greater uptake of potassium at the highest rate of application. Apparently, this was due to more of the added potassium being fixed through drying and therefore not being relatively as available at the higher rate of application as was potassium furnished by the moist subsoil which had received the corresponding high rate. On the untreated dried subsoil there was almost twice as much potassium taken up by plants as that absorbed by plants from the untreated moist subsoil.

The trend with the third crop, as indicated in Fig. 8, seemed like that of the second crop. However, the differences were not as great for the lower rates of application as they were in the previous crop. The uptake trend for the moist subsoil when presented graphically was linear from no treatment to the 1280 pounds per acre application level. This trend does not suggest any evidence of potassium fixation. It is interesting to note here that the advantage of drying had practically diminished as the total uptake of potassium on the dried and moist subsoils are approaching similar values. As in the previous crop, the 1280 pounds per acre application on the moist subsoils furnished more potassium for plant consumption than was furnished by dried subsoil at the same rate of potash application.

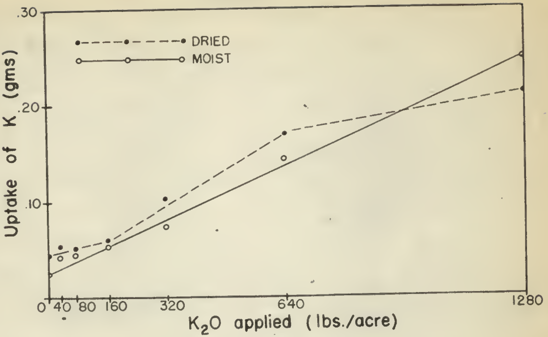

Fig. 8. Uptake of potassium by the third crop of soybeans grown on Parsons subsoil.

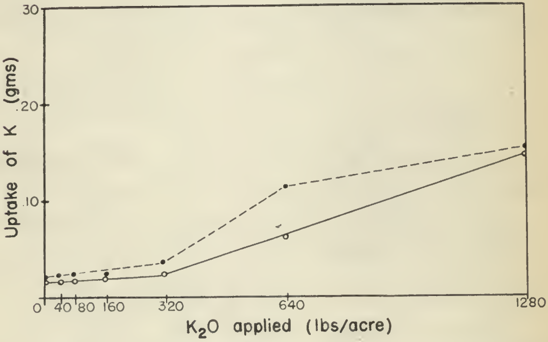

Fig. 9. Uptake of potassium by the fourth crop of soybeans grown on Parsons subsoil.

Comparable results for uptake of potassium with the fourth crop produced on subsoil material are indicated in Fig. 9. The tendency of a soil to approach a minimum limiting value of potassium which is available to plants was indicated with this crop. The graphic presentation of results suggest that although there was still a slight advantage on the dried soils as to potassium available for plant uptake, the values are practically the same for all treatments except where 640 pounds of K_2O had been applied.

Potassium Availability as Indicated by Plant Uptake

Assuming that plants have access to two sources of a nutrient, namely, the soil and the fertilizer, and that plants will absorb this nutrient in proportion to the amounts available; Dean (4) suggested a method for evaluating the phosphorus fertility status of soils. This was accomplished by constructing yield-of-nutrient curves. These curves were constructed by plotting the amounts of phosphorus applied on the abscissa and the quantity of phosphorus absorbed on the ordinate. An estimate of amount of available soil phosphorus was obtained by extrapolating the yield-of-nutrient curves to the intersection with the abscissa. The number of units from the origin to the point of intersection was the amount of soil phosphorus as available as the phosphorus in the fertilizer added to obtain the yield-of-nutrient curve.

This part of the discussion is a consideration of the yield-of-potassium curves as a basis for evaluating the potassium fertility status of Parsons surface soil and subsoil.

Indicated in Fig. 10 are comparable results for total potassium taken up on the moist and dried subsoil. It can be seen for the moist subsoil there was an increasing linear trend from the no treatment level up to the point where 640 pounds per acre of potash had been applied. By extrapolating the linear trend to the point where it intersected the horizontal axis, the number of units from the origin to the point of intersection was 166.4 pounds per acre of potash. This value is the equivalent of applied potassium which the moist subsoil has furnished to the four crops of soybeans.

Extrapolation of the linear trend on the dried subsoils to the point where it intersects the horizontal axis reflects the value of 268.8 pounds per acre of potash. This value is the amount of soil potassium which was available as fertilizer potassium which the four crops of soybeans have taken up from the dried subsoil.

In Fig. 11 the total uptake of potassium by four crops of soybeans on surface soils is shown. On both the dried and moist surface soil, there was a linear trend increasing upwards from the point where no potassium had been applied to the application level of 640 pounds of potash per acre. Extrapolation of the linear trend on the moist surface soils reflected a value equivalent to application of 160 pounds per acre of potash. The equivalent amount of potassium in terms of applied potash, which four crops of soybeans had taken up from the dried soils, was found to be 275 pounds of potash per acre. This value was determined through extrapolation of the linear potassium uptake curve for the dried surface soils.

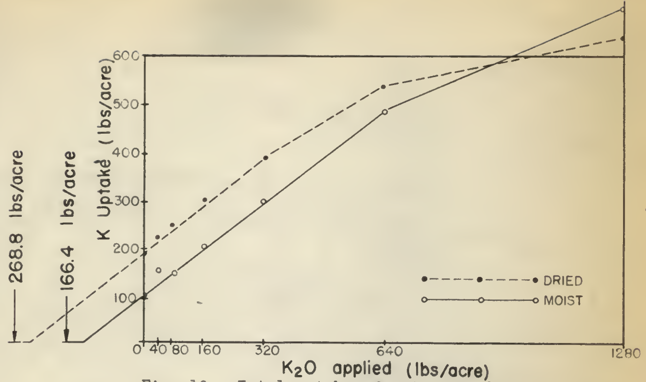

Fig. 10. Total uptake of potassium by four crops of soybeans from various applications of K_2O to the Parsons subsoil.

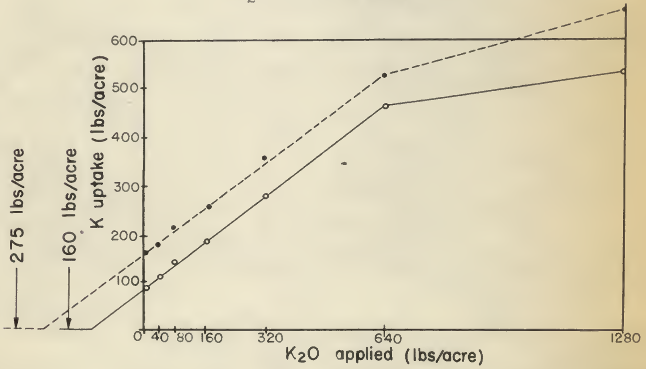

Fig. 11. Total uptake of potassium by four crops of soybeans from various applications of K_2O to the Parsons silt loam surface soil.

Comparison of Availability as Indicated by Exchangeable Potassium Measurement and by Plant Uptake

It was interesting to note that extrapolated available potash values compared reasonably well in a relative way with the original values of exchangeable potassium determined for moist and dried subsoils. The value for the moist subsoil was 136 pounds of exchangeable potassium whereas the extrapolated value was found to be 166.4 pounds per acre of potash. For the dried subsoil the amount of exchangeable potassium determined was 269 pounds per acre and the extrapolated value for the same soil was 268.8 pounds per acre of potash.

Comparison of extrapolated values with exchangeable values of potassium for surface soil moist and dried was made. The original exchangeable potassium value for moist surface soil was 116 pounds per acre which compares rather well with the extrapolated value of applied potash which was 160 pounds per acre. Values for the dried surface soil appeared to compare reasonably well. The original value for the dried surface soil was 239 pounds per acre of exchangeable potassium which compares favorably with the extrapolated value of 275 pounds per acre of K_2O.

Comparison of availability of exchangeable potassium contained in subsoil with that contained in surface soil may be made and similarly comparison of availability of exchangeable potassium contained in moist soil with that contained in dried soil may be accomplished. These comparisons are made possible by a consideration of the ratios presented in Table 5.

Table 5. Ratio between available potash values obtained by extrapolation and exchangeable potassium values obtained by ammonium acetate extraction.

Soil material	Extrapolated K_2O value ÷ Exchangeable K value	
	Moist soil	Dried soil
Surface	1.38	1.15
Subsoil	1.22	1.00

It may be observed that the ratio between the extrapolated available K_2O value and the exchangeable potassium value for dried subsoil was unity (1.00). This apparently means that one unit of exchangeable potassium had the same availability as did one unit of added fertilizer potash. In the case of each other situation the ratio was greater than unity, suggesting a greater relative availability of the exchangeable potassium contained in these other soil situations. Briefly the greater availability may be summarized. Exchangeable potassium was 22 percent relatively more available in moist subsoil than in the dried subsoil material. It was 23 percent relatively more available in moist surface soil than in dried surface soil material. Similarly exchangeable potassium in moist surface soil was 16 percent relatively more available than in moist subsoil. Finally, exchangeable potassium in dried surface soil was 15 percent relatively more available than in dried subsoil.

Exchangeable Potassium Remaining in Soil

In Table 6 are found the values for exchangeable potassium remaining in the soils at the termination of cropping.

Table 6. Content of exchangeable potassium at end of experiment.

Amount of K added lbs./acre	Exchangeable K content (lb/acre)			
	Surface soil		Subsoil	
	Moist	Dried	Moist	Dried
0	50.99	52.85	52.24	37.48
40	52.01	66.07	62.24	57.15
80	58.44	72.09	89.92	91.85
160	64.54	82.58	98.35	107.09
320	84.94	93.75	103.90	115.71
640	106.47	138.68	142.30	142.93
1280	452.14	439.19	504.39	589.12

It is noted that in each instance the removal of potassium on unfertilized soils did not deplete all of the original exchangeable potassium present in the soil. However, in both the surface soil and subsoil, the removal of potassium was greater from the dried soils than was the net loss in exchangeable potassium in the moist soils. With both the dried surface soil and dried subsoil, the net loss in exchangeable potassium was slightly greater than the amount removed by four successive crops of soybeans. These losses in exchangeable potassium are attributed to potassium fixation or conversion to a form which was not available for plant use.

SUMMARY AND CONCLUSIONS

In summarizing these results, it can be said in answer to the initial objectives:

(1) That drying of either the surface soil or the subsoil approximately doubled the content of exchangeable potassium.

(2) For the total of four crops of soybeans, drying of the soil nearly doubled the uptake of potassium from soil which had received no potassium application.

(3) In comparing extrapolated values pertaining to potash availability with exchangeable potassium values, it appeared that a unit of exchangeable potassium present in moist soils was about 22-23 percent relatively more available than a unit of exchangeable potassium present in dried soils. Furthermore it appeared that a unit of exchangeable potassium present in surface soils was about 15-16 percent more available than a unit of exchangeable potassium present in subsoils.

ACKNOWLEDGEMENT

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APPENDIX

Table 7. Analysis of variance for potassium uptake, first crop, moist and dried Parsons surface soil.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	55	0.12095	0.00220
Between blocks	3	0.00118	0.00039
Between treatments	13	0.10536	0.00810**
Error	39	0.01440	0.00036

L.S.D. (.05) = 0.0275 gms.

Table 8. Analysis of variance for potassium uptake, first crop, moist and dried Parsons subsoil.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	55	0.08790	0.00159
Between blocks	3	0.00048	0.00016
Between treatments	13	0.07606	0.00585**
Error	39	0.01136	0.00029

L.S.D. (.05) = 0.0244 gms.

Table 9. Analysis of variance for potassium uptake, second crop, moist and dried Parsons surface soil.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	55	0.35738	0.00650
Between blocks	3	0.00050	0.00017
Between treatments	13	0.35063	0.02697**
Error	39	0.00623	0.00016

L.S.D. (.05) = 0.0181 gms.

Table 10. Analysis of variance for potassium uptake, second crop, moist and dried Parsons subsoil.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	55	0.18148	0.03299
Between blocks	3	0.00093	0.00031
Between treatments	13	0.17292	0.01330**
Error	39	0.00762	0.00019

L.S.D. (.05) = 0.0200 gms.

Table 11. Analysis of variance for potassium uptake, third crop moist and dried Parsons surface soil.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	55	0.17411	0.00316
Between blocks	3	0.00043	0.00014
Between treatments	13	0.16593	0.01276**
Error	39	0.00774	0.00019

L.S.D. (.05) = 0.0201 gms.

Table 12. Analysis of variance for potassium uptake, third crop, moist and dried Parsons subsoil.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	55	0.29279	0.00532
Between blocks	3	0.00161	0.00053
Between treatments	13	0.28480	0.21908**
Error	39	0.00636	0.00016

L.S.D. (.05) = 0.0182 gms.

Table 13. Analysis of variance for potassium uptake, fourth crop, moist and dried Parsons surface soil.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	55	0.25188	0.00458
Between blocks	3	0.00357	0.00119
Between treatments	13	0.24467	0.01882**
Error	39	0.00685	0.00018

L.S.D. (.05) - 0.0189 gms.

Table 14. Analysis of variance for potassium uptake, fourth crop, moist and dried Parsons subsoil.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	55	0.13938	0.00253
Between blocks	3	0.00001	0.00000
Between treatments	13	0.13731	0.01056
Error	39	0.00205	0.00005

L.S.D. (.05) = 0.0104 gms.

EXPLANATION OF PLATE I

Fig. 1. Second crop of soybeans on moist Parsons surface soil.

Treatments were as follows:

NT-no treatment

40-40 lb/A K_2O

80-80 lb/A K_2O

160-160 lb/A K_2O

Fig. 2. Second crop of soybeans on moist Parsons surface soil.

Treatments were as follows:

320-320 lb/A K_2O

640-640 lb/A K_2O

1280-1280 lb/A K_2O

PLATE I

Fig. 1

Fig. 2

EXPLANATION OF PLATE II

Fig. 1. Second crop of soybeans on dried Parsons surface soil.

Treatments were as follows:

320-320 lb/A K_2O

640-640 lb/A K_2O

1280-1280 lb/A K_2O

Fig. 2 Second crop of soybeans on dried Parsons surface soil.

Treatments were as follows:

NT-no treatment

40-40 lb/A K_2O

80-80 lb/A K_2O

160-160 lb/A K_2O

PLATE II

Fig. 1

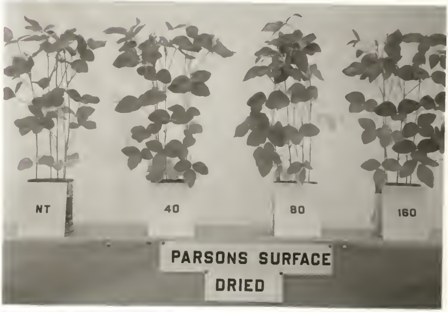

Fig. 2

EXPLANATION OF PLATE III

Fig. 1. Second crop of soybeans on moist Parsons subsoil.

Treatments were as follows:

NT-no treatment

40-40 lb/A K_2O

80-80 lb/A K_2O

160-160 lb/A K_2O

Fig. 2. Second crop of soybeans on moist Parsons subsoil.

Treatments were as follows:

320-320 lb/A K_2O

640-640 lb/A K_2O

1280-1280 lb/A K_2O

PLATE III

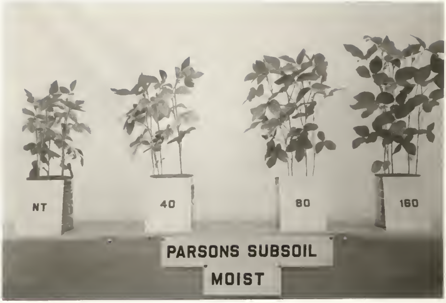

Fig. 1

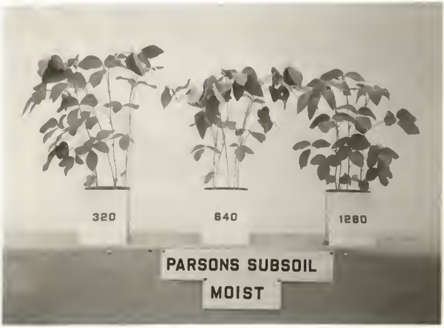

Fig. 2

EXPLANATION OF PLATE IV

Fig. 1. Second crop of soybeans on dried Parsons subsoil.

Treatments were as follows:

NT-no treatment

40-40 lb/A K_2O

80-80 lb/A K_2O

160-160 lb/A K_2O

Fig. 2. Second crop of soybeans dried Parsons subsoil.

Treatments were as follows:

320-320 lb/A K_2O

640-640 lb/A K_2O

1280-1280 lb/A K_2O

PLATE IV

Fig. 1

Fig. 2

EXPLANATION OF PLATE V

Fig. 1. Second crop of soybeans on Parsons soil.
Treatments were as follows, left to right:
M-moist surface soil, no fertilizer treatment
D-dried surface soil, no fertilizer treatment
M-moist subsoil, no fertilizer treatment
d-dried subsoil no fertilizer treatment

Fig. 2. Second crop of soybeans on Parsons soil.
Treatments were as follows, left to right:
M-moist surface soil, 40 lb/A K_2O
D-dried surface soil, 40 lb/A K_2O
M-moist subsoil, 40 lb/A K_2O
D-dried subsoil, 40 lb/A K_2O

PLATE V

Fig. 1

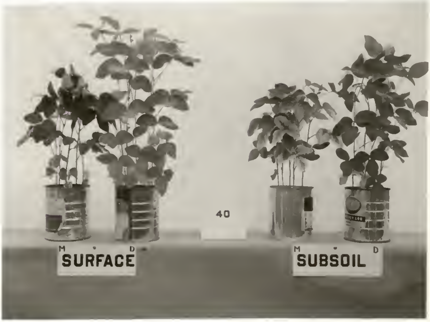

Fig. 2

EXPLANATION OF PLATE VI

Fig. 1. Second crop of soybeans on Parsons soil.
Treatments were as follows, left to right:
M-moist surface soil, 160 lb/A K_2O
D-dried surface soil, 160 lb/A K_2O
M-moist subsoil, 160 lb/A K_2O
D-dried subsoil, 160 lb/A K_2O

Fig. 2. Second crop of soybeans on Parsons soil.
Treatments were as follows, left to right:
M-moist surface soil, 80 lb/A K_2O
D-dried surface soil, 80 lb/A K_2O
M-moist subsoil, 80 lb/A K_2O
D-dried subsoil, 80 lb/A K_2O

PLATE VI

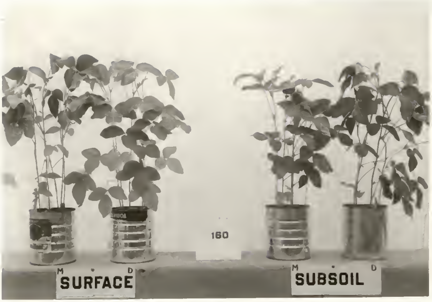

Fig. 1

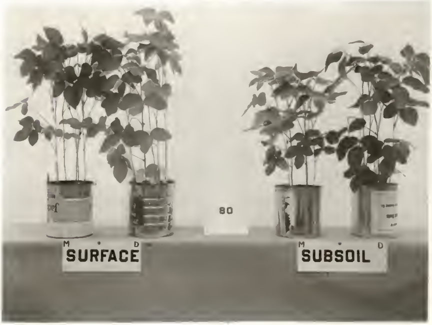

Fig. 2

EXPLANATION OF PLATE VII

Fig. 1. Second crop of soybeans on Parsons soil. Treatments were as follows, left to right:

M-moist surface soil, 320 lb/A K_2O
D-dried surface soil, 320 lb/A K_2O
M-moist subsoil, 320 lb/A K_2O
D-dried subsoil, 320 lb/A K_2O

Fig. 2. Second crop of soybeans on Parsons soil. Treatments were as follows, left to right:

M-moist surface soil, 1280 lb/A K_2O
D-dried surface soil, 1280 lb/A K_2O
M-moist subsoil, 1280 lb/A K_2O
D-dried subsoil, 1280 lb/A K_2O

PLATE VII

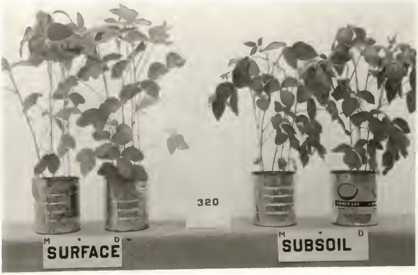

Fig. 1

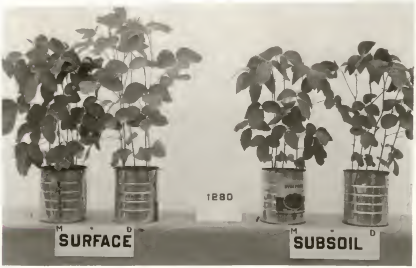

Fig. 2

EXPLANATION OF PLATE VIII

Fig. 1. Second crop of soybeans on Parsons surface soil.

Treatments were as follows, left to right:

M-moist surface soil, no treatment.
D-dried surface soil, no treatment
M-moist surface soil, 160 lb/A K_2O
D-dried surface soil, 160 lb/A K_2O

Fig. 2. Second crop of soybeans on Parsons subsoil.

Treatments were as follows, left to right:

M-moist subsoil, no treatment
D-dried subsoil, no treatment
M-moist subsoil, 160 lb/A K_2O
D-dried subsoil, 160 lb/A K_2O

PLATE VIII

Fig. 1

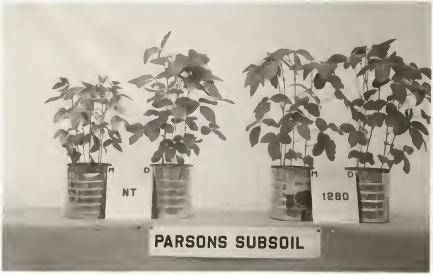

Fig. 2

EXPLANATION OF PLATE IX

Fig. 1. Second crop of soybeans on Parsons surface soil.
Treatments were as follows, left to right:
M-moist surface soil, no treatment
D-dried surface soil, no treatment
M-moist surface soil, 1280 lb/A K_2O
D-dried surface soil, 1280 lb/A K_2O

Fig. 2. Second crop of soybeans on Parsons subsoil.
Treatments were as follows, left to right:
M-moist subsoil, no treatment.
D-dried subsoil, no treatment
M-moist subsoil, 1280 lb/A K_2O
D-dried subsoil, 1280 lb/A K_2O

PLATE IX

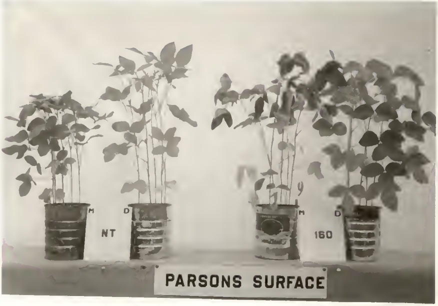

Fig. 1

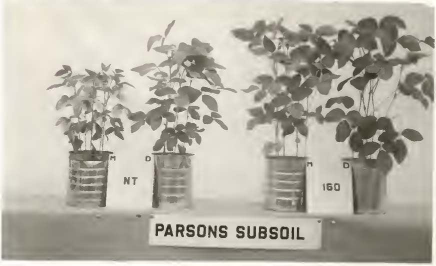

Fig. 2

EXPLANATION OF PLATE X

Fig. 1. Third crop of soybeans on moist Parsons surface soil.
Treatments were as follows:
NT-no treatment
40-40 lb/A K_2O
80-80 lb/A K_2O
160-160 lb/A K_2O

Fig. 2. Third crop of soybeans on moist Parsons surface soil.
Treatments were as follows:
320-320 lb/A K_2O
640-640 lb/A K_2O
1280-1280 lb/A K_2O

PLATE X

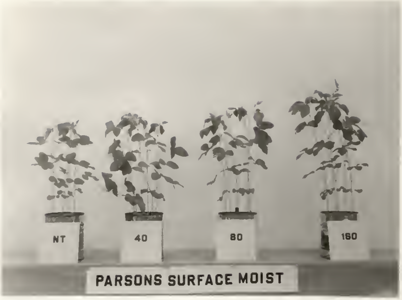

Fig. 1

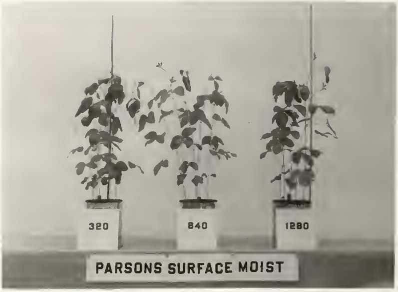

Fig. 2

EXPLANATION OF PLATE XI

Fig. 1. Third crop of soybeans on dried Parsons surface soil.

Treatments were as follows:

NT-no treatment
40-40 lb/A K_2O
80-80 lb/A K_2O
160-160 lb/A K_2O

Fig. 2. Third crop of soybeans on dried Parsons surface soil.

Treatments were as follows:

320-320 lb/A K_2O
640-640 lb/A K_2O
1280-1280 lb/A K_2O

PLATE XI

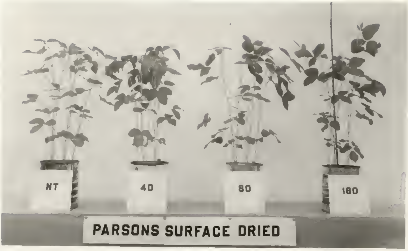

Fig. 1

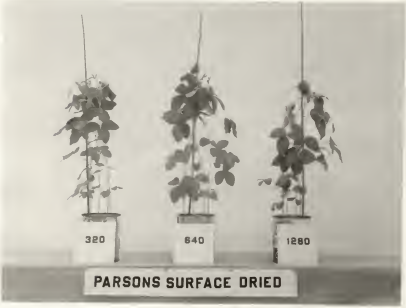

Fig. 2

EXPLANATION OF PLATE XII

Fig. 1. Third crop of soybeans on moist Parsons subsoil.
Treatments were as follows:
NT-no treatment
40-40 lb/A K_2O
80-80 lb/A K_2O
160-160 lb/A K_2O

Fig. 2. Third crop of soybeans on moist Parsons subsoil.
Treatments were as follows:
320-320 lb/A K_2O
640-640 lb/A K_2O
1280-1280 lb/A K_2O

PLATE XII

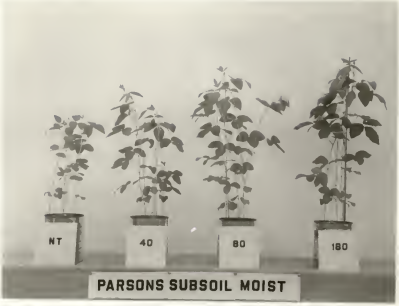

Fig. 1

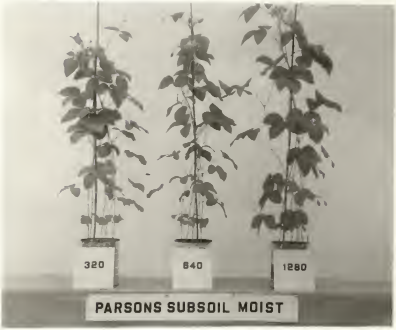

Fig. 2

EXPLANATION OF PLATE XIII

Fig. 1. Third crop of soybeans on dried Parsons subsoil.

Treatments were as follows:

NT-no treatment
40-40 lb/A K_2O
80-80 lb/A K_2O
160-160 lb/A K_2O

Fig. 2. Third crop of soybeans on dried Parsons subsoil.

Treatments were as follows:

320-320 lb/A K_2O
640-640 lb/A K_2O
1280-1280 lb/A K_2O

PLATE XIII

Fig. 1

Fig. 2

EXPLANATION OF PLATE XIV

Fig. 1. Third crop of soybeans on Parsons soil.
Treatments were as follows, left to right:
M-moist surface soil, no treatment
D-dried surface soil, no treatment
M-moist subsoil, no treatment
D-dried subsoil, no treatment

Fig. 2. Third crop of soybeans on Parsons soil.
Treatments were as follows, left to right:
M-moist surface soil-40 lb/A K_2O
D-dried surface soil-40 lb/A K_2O
M-moist subsoil-40 lb/A K_2O
D-dried subsoil-40 lb/A K_2O

PLATE XIV

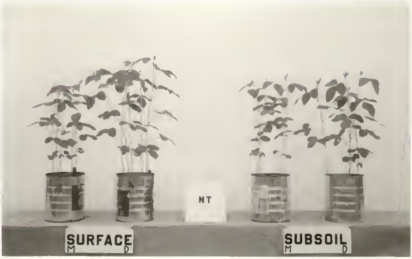

Fig. 1

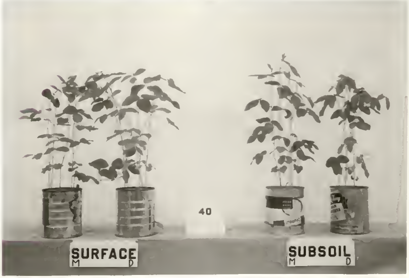

Fig. 2

EXPLANATION OF PLATE XV

Fig. 1. Third crop of soybeans on Parsons soil.
Treatments were as follows, left to right:
M-moist surface soil, 80 lb/A K_2O
D-dried surface soil, 80 lb/A K_2O
M-moist subsoil, 80 lb/A K_2O
D-dried subsoil, 80 lb/A K_2O

Fig. 2. Third crop of soybeans on Parsons soil.
Treatments were as follows, left to right:
M-moist surface soil, 160 lb/A K_2O
D-dried surface soil, 160 lb/A K_2O
M-moist subsoil, 160 lb/A K_2O
D-dried subsoil, 160 lb/A K_2O

PLATE XV

Fig. 1

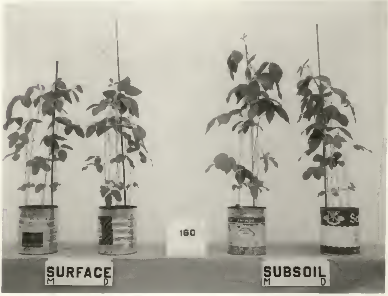

Fig. 2

EXPLANATION OF PLATE XVI

Fig. 1. Third crop of soybeans on Parsons soil.
Treatments were as follows, left to right:
M-moist surface soil, 320 lb/A K_2O
D-dried surface soil, 320 lb/A K_2O
M-moist subsoil, 320 lb/A K_2O
D-dried subsoil, 320 lb/A K_2O

Fig. 2. Third crop of soybeans on Parsons soil.
Treatments were as follows, left to right:
M-moist surface soil, 1280 lb/A K_2O
D-dried surface soil, 1280 lb/A K_2O
M-moist subsoil, 1280 lb/A K_2O
D-dried subsoil, 1280 lb/A K_2O

PLATE XVI

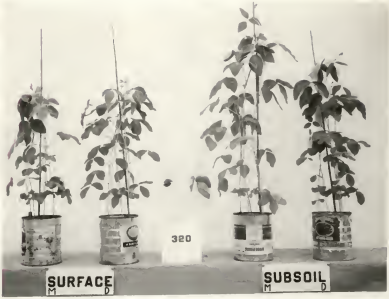

Fig. 1

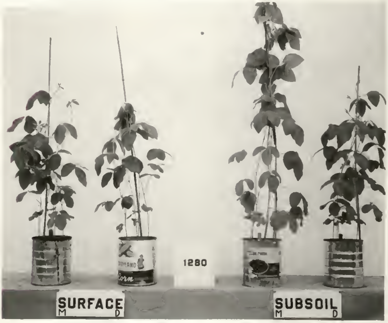

Fig. 2

EXPLANATION OF PLATE XVII

Fig. 1. Third crop of soybeans on Parsons surface soil.
Treatments were as follows, left to right:
M-moist surface soil, no treatment
D-dried surface soil, no treatment
M-moist surface soil, 160 lb/A K_2O
D-dried surface soil, 160 lb/A K_2O

Fig. 2. Third crop of soybeans on Parsons subsoil.
Treatments were as follows, left to right:
M-moist subsoil, no treatment
D-dried subsoil, no treatment
M-moist subsoil, 160 lb/A K_2O
D-dried subsoil, 160 lb/A K_2O

PLATE XVII

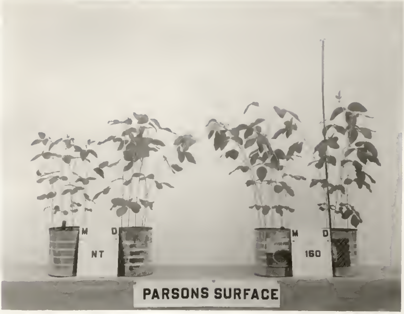

Fig. 1

Fig. 2

EXPLANATION OF PLATE XVIII

Fig. 1. Third crop of soybeans on Parsons surface soil.
Treatments were as follows, left to right:
M-moist surface soil, no treatment
D-dried surface soil, no treatment
M-moist surface soil, 1280 lb/A K_2O
D-dried surface soil, 1280 lb/A K_2O

Fig. 2. Third crop of soybeans on Parsons subsoil.
Treatments were as follows, left to right:
M-moist subsoil, no treatment
D-dried subsoil, no treatment
M-moist subsoil, 1280 lb/A K_2O
D-dried subsoil, 1280 lb/A K_2O

PLATE XVIII

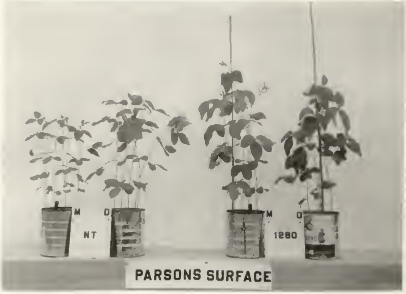

Fig. 1

Fig. 2

EFFECT OF DRYING UPON AVAILABILITY
OF POTASSIUM IN PARSONS SILT LOAM

by

THOMAS WALTER SCOTT

B. S., Pennsylvania State University, 1952

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1956

EFFECT OF DRYING UPON AVAILABILITY OF POTASSIUM IN PARSONS SILT LOAM

For the purposes of this study, Parsons silt loam soil material, both surface soil and subsoil, was obtained from near Thayer, Kansas. Surface soil and subsoil of the Parsons silt loam was divided into two lots for each material. One lot each of both the surface soil and subsoil was maintained in a continuously moist state until time of planting. One lot each of both soil materials was allowed to dry until the moisture content was approximately 1.5 percent. Then 28 greenhouse containers were filled with soil from each lot of each soil material.

Calcium carbonate was added to each culture of surface soils to correspond to a field application of 5,000 pounds per acre. Each culture of subsoils received a calcium carbonate treatment which corresponded to a field application of 3,000 pounds per acre.

Each greenhouse container of soil irrespective of other treatments or amount of soil in the container received one gram of commercial grade mono-ammonium phosphate fertilizer (11-48-0).

Seven levels of potassium were used on each series of soil materials.

Four successive crops of soybeans were planted and harvested at about the time of seed pod formation. Yields of plant material and uptake of potassium were determined.

The original content of exchangeable potassium in the surface soil and subsoil was 116 and 136 pounds per acre respectively.

Both soils were dried until they contained a moisture percentage of 1.5. The exchangeable potassium content at that moisture level was found to be 239 pounds per acre on the surface soil and 269 pounds per acre on the subsoil.

The first soybean crop on surface soils, both moist and dried, showed little difference in total uptake of potassium except with no potassium treatment where uptake was considerably greater as a result of drying. The second crop on surface soils reflected greater differences in total uptake of potassium because moist soils furnished lower levels of available potassium while the dried soils maintained a higher level for each treatment. The total potassium uptake in the third crop was lower than the second crop for each treatment. However, uptake of potassium from the dried soils always was higher than from the moist soils. With the fourth crop, evidence of the soil attaining its minimum content of exchangeable potassium was indicated inasmuch as the total uptake on both soils appeared to be approaching the same low value.

From untreated dried subsoils, soybeans absorbed twice as much potassium as did the soybeans on the untreated moist soil. Uptake of potassium from both the moist and dried series of subsoil approached the same value where 320 pounds per acre of potassium was applied and was about the same for the two higher levels of added potassium. The second crop on subsoils again produced higher uptake of total potassium on the dried soils up to an application of 320 pounds per acre of potash, however, the values were the same at the 640 pounds per acre application.

The moist subsoil provided for greater uptake of potassium where 1280 pounds per acre had been added. The third crops seemed to follow the trend of the second crop although differences in uptake of potassium on the dried soils at the lower applications were not so great. Comparable values for uptake with the fourth crop produced on subsoils were about the same except at the level where 640 pounds per acre were added.

There was little variation in total yields of plant material. Only one lot of soil material reflected marked increase in yield of plant material from potassium fertilization. This increase occurred on the subsoil which had been maintained in a continuously moist state. Visual symptoms indicated that potassium dificiency was sufficient to limit yields, especially at lower rates of added potassium.

Removal of potassium on unfertilized soils did not deplete all of the original exchangeable potassium present in the soil. However, in both the surface soil and subsoil, the removal of potassium was greater than the net loss in exchangeable potassium in the moist soil. On the dried soils, the net loss in exchangeable potassium was slightly greater than the amount removed by four crops of soybeans.

Extrapolation of available potassium value was made for each soil. These extrapolated values compared reasonably well with the initial exchangeable potassium values.

Comparison of availability of exchangeable potassium contained in subsoil with that contained in surface soil may be made and similarly, comparison of availability of exchangeable potassium contained in moist soil with that contained in dried soil may be accomplished. In the dried subsoil, apparently one unit of exchangeable potassium had the same availability as one unit of added fertilizer potash. In the case of each other situation the ratio was greater than unity, suggesting a greater relative availability of the exchangeable potassium contained in these other soil situations. Briefly the greater availability may be summarized. Exchangeable potassium was 22 percent relatively more available in moist subsoil than in the dried subsoil material. It was 23 percent relatively more available in moist surface soil than in dried surface soil material. Similarly exchangeable potassium in moist surface soil was 16 percent relatively more available than in moist subsoil. Finally, exchangeable potassium in dried surface soil was 15 percent relatively more available than in dried subsoil.