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The Effect of Drying Soil Samples on Soil Test Potassium Values

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BACKGROUND

Extreme temporal and spatial variability of soil test potassium values (STK) was measured on small plots (12-ft x 40-ft) being used for a STK correlation and calibration study on a Crider soil in Larue County, Kentucky. Twelve periodic samplings of the 20 small plots in this study over a period of 18 months showed as much as two-fold temporal differences in STK within individual plots, many of which had received no potassium (K) fertilizer during the study. Spatial variability of STK also varied as much as two-fold among the individual small plots at any given sampling time for similar treatments. Such differences of STK values from the same site could cause wide variations in recommendations for rates of K fertilizers needed. Several possible sources of this variability were considered for further investigation.

All soil analyses were performed by the University of Kentucky's soil testing laboratory at Lexington, and the quality control system used in that lab (every 20th sample analyzed is a control sample of known values), together with results of blind samples submitted to them, indicated that laboratory error was not a likely cause of the variability observed in STK values from those 20 plots.

Research conducted earlier at the University of Kentucky (Cook, 1959; Dowdy, 1961) showed that drying field-moist soils could affect the fixation and release of K from soils containing the clay mineral vermiculite. Both these studies indicated that in such soils, exchangeable K would be fixed by drying soil if the exchangeable K was greater than 0.4-0.5 meq/100g (300-400 lbs K/A), and would be released by drying if exchangeable K was less than this. Implications of these findings would suggest the possibility that the routine soil test procedure of drying soil before analyzing them could affect STK values from vermiculite-containing soil samples. In such instances, exchangeable K could be released upon drying of soils containing less than 300-400 lbs exchangeable K/A, thereby giving a false high STK value. Conversely, exchangeable K could be fixed upon drying soils containing more than 300-400 lbs exchangeable K/A, resulting in a false low STK value.

This effect was tested on field-moist samples taken from the twenty small plots from the Larue County field experiment. Results (figure 1) showed that drying these samples did, indeed, affect exchangeable K. It was increased when exchangeable K of moist soil was less than 200 lbs/A (100 ppm) and decreased when exchangeable K was greater than 200 lbs/A. Clay mineral analysis indicated that vermiculite and interstratified vermiculite made up 30-40% of the clay in the samples. The exchangeable K level at equilibrium between fixation and release on these samples was 200 lbs/A, in contrast to the Cook (1959) and Dowdy (1961) indication of 300-400 lbs/A. This was likely due to the samples in this study being from the 0 to 4 inch surface layer, which contained less clay than samples from deeper in the soil, thereby lessening the degree of fixation and/or release. Dowdy (1961) indicated that the lower clay content of the surface samples fixed and released less exchangeable K than the subsurface samples of higher clay content.

Because of the temporal variability observed in STK values from the Crider soil at the Larue County site, samples taken in November, 1997, were tested to determine if routine drying changed STK values. As shown in figure 1, it did. Since the fundamental work previously conducted by Cook (1959) and Dowdy (1961) had shown that drying samples of vermiculite-containing soil could cause fixation or release of exchangeable K, a study was designed to sample other Crider soils to determine if the routine soil test procedure of drying soil samples in the lab prior to their analysis could cause variable STK values. Knowledge of this could be very important in making fertilizer K recommendations on Crider soils, since they are one of the most widely occurring soils in Kentucky and are intensively used for agricultural production. Several other areas of the state also have soils containing significant amounts of vermiculite in the clay mineral fraction (Karathanasis, 1985; 1986; 1987).

DESCRIPTION OF THE STUDY

County agricultural agents from counties in the Western Pennyroyal Area (where the most extensive acreage of Crider soils occur) were asked to locate a site on soils maps of the USDA-NRCS soil survey report for their county, and sample Crider soils on 2-6% slopes from fields at that site which (a) had a history of high fertilization with K (in an attempt to obtain soils containing more than 300-400 lbs/A of STK), and (b) were from a nearby Crider soil which would not have had a history of high rates of K fertilization (in an attempt to obtain soils containing less than 300-400 lbs/A of STK). On this basis, samples were obtained from Caldwell, Christian, Logan, Simpson, Todd, and Trigg counties. Crider soil samples from field experiments being conducted in Hardin, Larue, and Meade counties were also included. Additionally, surface soil samples from on-going field experiments on Nicholson (Grant Co.), Maury (Fayette Co.), and Pope (Breathitt Co.) soils were also included, for a total of 33 samples used in the study.

According to Karathanasis (1985), all these soils are known to contain vermiculite. Therefore, we assumed all soil samples collected and analyzed in the study contained vermiculite without analyzing the clay mineralogy of each sample. At each sample site, bulk, field-moist samples from the 0-6 inch surface layer were taken, mixed thoroughly by hand, sealed in air-tight plastic bags, and stored for further use. Subsamples of each bulk sample of moist soil were taken to determine moisture content and for submission to the soil testing lab where they were routinely dried in a large cabinet at 95° F, ground, and sieved through a 2 mm sieve before soil test analysis. At the same time, subsamples of each field moist soil were weighed out, based on moisture content, to deliver the same amount of soil as those that were dried and volumetrically sampled for routine soil testing. Potassium from both oven dry and field moist samples was extracted by Mehlich-3 extractant used in UK's soil testing lab. Additionally, cation exchange capacity (CEC) and exchangeable K for each sample were measured in the UK soil testing lab by use of neutral, normal ammonium acetate (NH_4OAc) on both field moist and routinely dried samples. For the field moist samples, soil was weighed to deliver 10 g of routinely dried soil (95° F) based on moisture content. For the routinely dried soil, 10 g of soil was weighed for CEC determination. Analysis of the resulting data is based on our assumption that NH_4OAc-extractable K from field moist soil is a more accurate measure of "exchangeable K" and better expresses what is found under field conditions. Thus, the effect of routine drying was expressed as the positive or negative change in exchangeable K ()K) of field moist soil due to drying.

RESULTS AND DISCUSSION

Data for CEC, NH_4OAc exchangeable K, and Mehlich-3 (routine soil test) extractable K are shown in Table 1 for samples from the 21 Crider soil samples, and in Table 2 for the 12 samples from the other sites. Values for CEC decreased on 17 samples, increased on 3 samples, and remained the same on 1 sample of the 21 Crider samples, due to routine drying. Of the other 12 samples, drying decreased CEC of 11 of them and increased it on 1 of them. Plots of)K (change in exchangeable K due to drying) as a function of exchangeable K (NH_4OAc on moist soil) are shown separately for the two groups of samples in figures 2 and 3, and combined in figure 4. Despite some scatter, linear regression equations explained 76% of the variability in the Crider soil data, 69% for the other soils, and 60% when combined, and the regression coefficients were highly significant ($p = .01$) for all three regression plots. The equilibrium coefficient for the linear equations describing the data for K fixation/release (where)K = 0) was 70-84 ppm (140-168 lbs/A) of available K (NH_4OAc-exchangeable K on moist soil). This contrasts to the 150-200 ppm (300-400 lbs/A) reported by Cook (1959) and Dowdy (1961). The lower)K equilibrium values resulting from this study probably relate to the samples studied being surface samples of silt loam texture containing an estimated 15-20% clay size fraction in contrast to 30-40% clay size fraction in subsoil samples, as noted by Dowdy (1961).

Regarding the practical consideration of whether routine STK values (Mehlich-3 extractable K from routine drying) mean anything relative to exchangeable K (NH_4OAc extractable K from moist soil), a regression of these data is shown in figure 5. The derived linear regression equation explains 99% of the variability of the observations relative to the calculated regression line. However, the regression deviates from the 1:1 line at somewhere around 200 ppm (400 lbs/A) exchangeable K, and progressively decreases below the 1:1 line as exchangeable K levels progressively increase. Based on interpretation of these data, routine values of STK (Mehlich-3 extractable K on routinely dried soil) would be an accurate representation of exchangeable K (NH_4OAc extractable K from moist soil) up to around 200 ppm (400 lbs/A) of exchangeable K.

On this basis, it could be predicted that routine STK (Mehlich-3 extractable K from routinely dried soil) levels below 200 lbs/A (100 ppm) would likely overestimate available K on soils in which vermiculite was a significant component of their clay mineralogy and underestimate available K on soils with more than 200 lbs/A STK. However, the overestimation would be small and in the range of 20-40 lbs STK/A. Such an interpretation of routine STK values would result in small decreased fertilizer K recommendations on soils testing less than 200 lbs/A STK, and small increased fertilizer recommendations for corn on soils testing greater than 200 lbs/A STK. This would apply only to vermiculite-containing soils, which are found in large areas of Kentucky (Karathanasis, 1985).

CONCLUSIONS

Results from this study of Crider soils sampled from sites in Kentucky's Western Pennyroyal soils area, and from other areas where vermiculite is known to be present in soil, indicate that:

1- The routine soil test lab procedure of drying field moist soil samples does, in fact, cause a change in STK levels as compared to exchangeable levels (soil test levels of K measured on field moist soils).

2- Routine STK levels from extraction of routinely dried samples with the Mehlich-3 extractant can be interpreted relative to whether drying causes fixation or release of K, within the routine STK range of 0-400 lbs/A.

3- The change in exchangeable or soil test levels of K due to drying field moist samples is likely to:

    a- increase if routine STK values measured on dry soil are below 200 lbs/A (100 ppm), due to K-release.

    b- decrease if routine STK values measured are above 200 lbs/A (100 ppm),due to K-fixation.

4- Plant available K is likely to be overestimated at routine STK values less than 200 lbs/A, with resultant K fertilizer recommendations being less than the actual amount required.

5- Plant available K is likely to be underestimated at routine STK values greater than 200 lbs/A, with resultant K fertilizer recommendations being greater than the actual amount required.

6- The changes in K-fixation and release due to routine soil test drying appear to be small in the range of STK levels commonly found in Kentucky. Therefore, differences in K fertilizer recommendations would be small for corn.

7- Generally, the current routine practice of drying soil samples at 95° F used by UK's soil testing lab and then extracting K with the Mehlich-3 extractant will give acceptable STK values on vermiculite-containing soils in the range of 0-400 lbs STK/A

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Table 1. Effect of Oven Drying on CEC and Soil Test K Values of Crider Soils

County	Sample No	me/100g C.E.C. (NH_4OAc) Moist Soil	me/100g C.E.C. (NH_4OAc) Dry Soil	ppm K (NH_4OAc) Moist Soil	ppm K (NH_4OAc) Dry Soil	ppm K (Mehlich-3) Moist Soil	ppm K (Mehlich-3) Dry Soil
Caldwell	24	13.82	7.65	122	118	110	115
Caldwell	22	11.47	8.82	150	146	126	142
Caldwell	6	8.53	7.65	79	71	71	71
Trigg	2	10.88	10.88	79	79	79	83
Trigg	3	10.29	7.65	324	280	265	285
Christian	4	10.29	11.47	474	434	391	426
Christian	8	12.06	11.18	166	162	150	154
Todd	30	23.53	10.00	106	127	118	122
Todd	27	17.65	12.65	150	142	135	135
Logan	5	7.35	7.65	229	210	190	210
Logan	25	13.24	9.12	166	166	154	162
Logan	11	12.94	10.88	517	494	486	530
Simpson	7	7.94	6.91	288	272	241	253
Simpson	1	10.88	9.41	537	494	470	478
Larue	20	9.41	8.24	91	91	83	83
Larue	23	9.12	5.29	91	83	75	75
Hardin	16	10.00	7.94	154	154	146	146
Hardin	15	8.24	10.29	135	130	122	130
Hardin	13	13.82	9.71	158	142	146	154
Meade	26	14.71	12.65	249	233	201	227
Meade	17	9.41	8.82	250	205	190	198

Table 2. Effect of Drying on CEC and Soil Test K Levels From Nicholson, Maury, and Pope Soils in Grant, Fayette, and Breathitt Counties

		me/100g C.E.C. (NH_4OAc)		ppm K (NH_4OAc)		ppm K (Mehlich-3)	
County	Sample No	Moist Soil	Dry Soil	Moist Soil	Dry Soil	Moist Soil	Dry Soil
Grant	9	10.00	10.15	213	192	178	194
Grant	21	12.94	9.71	35	55	51	51
Grant	12	16.91	12.50	229	205	181	201
Grant	18	17.94	11.47	438	399	336	379
Grant	14	15.88	9.71	241	95	193	205
Grant	10	12.06	9.41	106	102	87	95
Fayette	29	25.00	20.59	209	154	134	185
Fayette	28	32.35	20.59	576	391	304	533
Fayette	31	19.12	12.65	332	312	288	300
Fayette	19	23.53	10.29	192	189	170	189
Breathitt	33	25.00	11.18	134	106	102	122
Breathitt	32	23.53	10.00	205	170	126	150

Figure 1. Effect of Routine Drying (95°F) on Exchangeable K

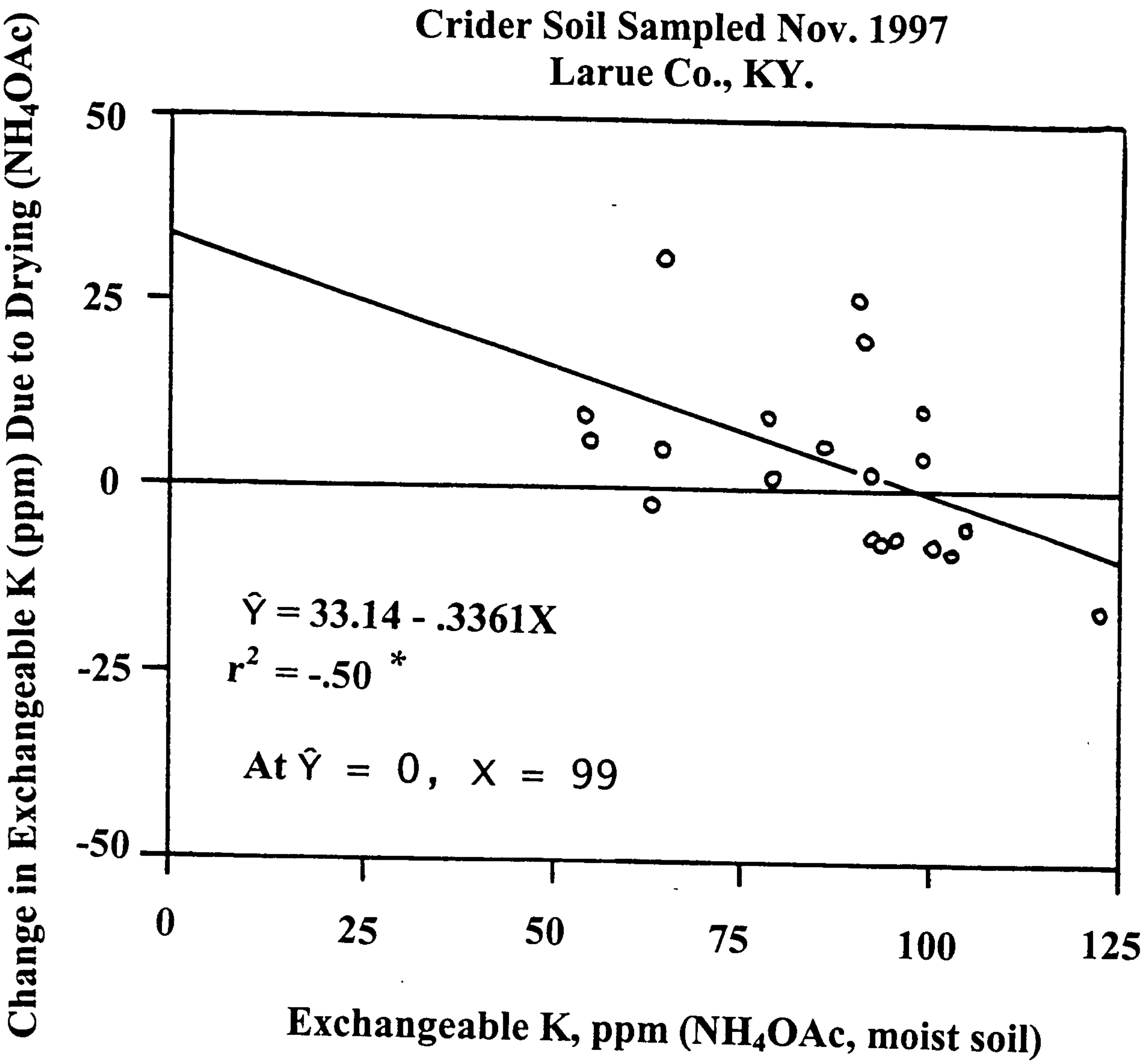

Figure 2. EFFECT OF ROUTINE DRYING ON EXCHANGEABLE K ON CRIDER SURFACE SOIL FROM 21 SITES

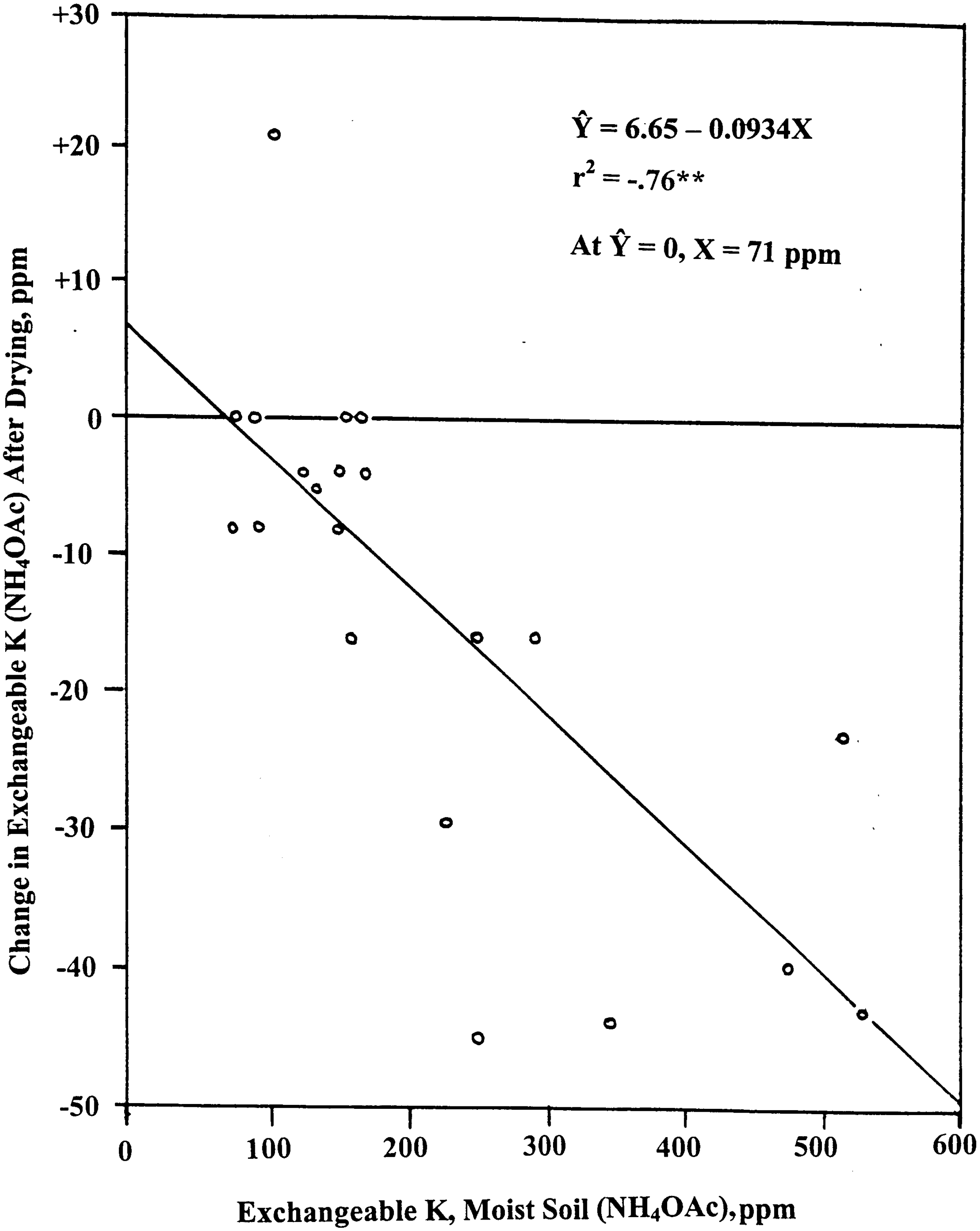

Figure 3. EFFECT OF ROUTINE DRYING ON EXCHANGEABLE K ON NICHOLSON, MAURY, AND POPE SOILS FROM 3 SITES

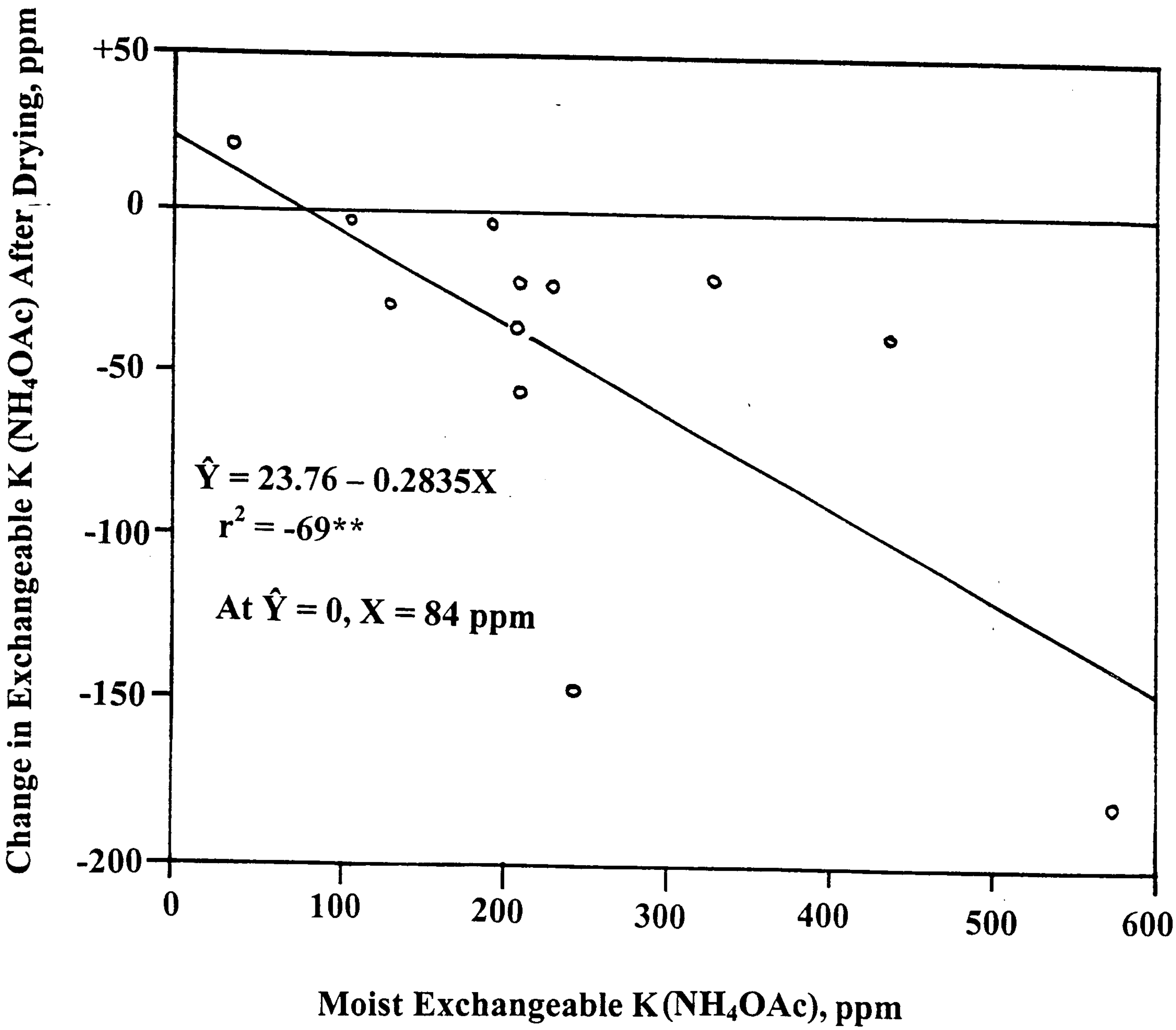

Figure 4. EFFECT OF ROUTINE DRYING ON EXCHANGEABLE K ON CRIDER, NICHOLSON, MAURY, AND POPE SOIL (33 SITES)

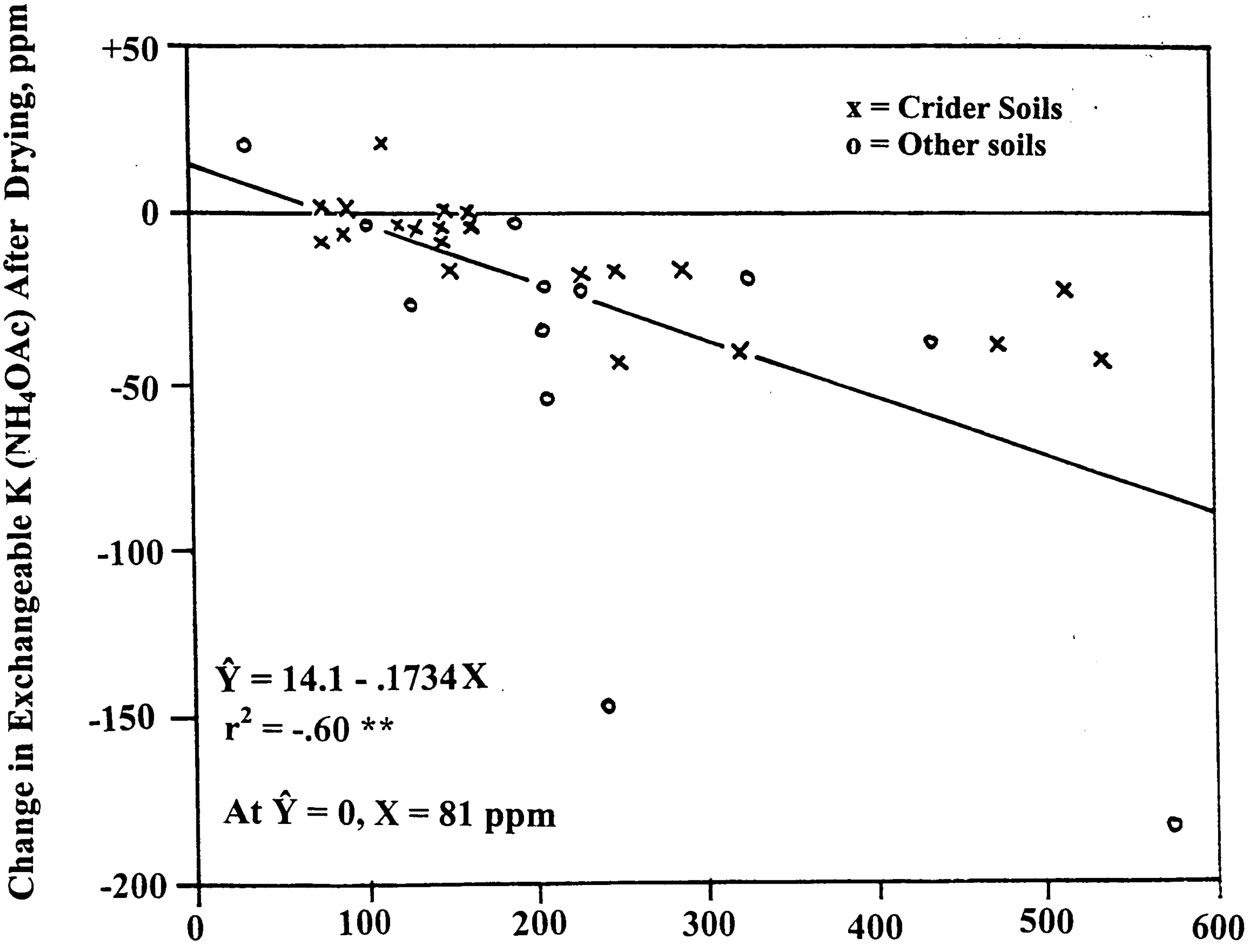

Figure 5. RELATIONSHIP BETWEEN ROUTINE STK LEVELS (Mehlich-3) AND "AVAILABLE" K LEVELS (NH₄OAc, moist soil)