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On the chemistry of potassium in sandy soils*

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Extended abstract of the following papers:

Sparks D.L., Martens D.C., Zelazny L.W.: Plant Uptake and Leaching of applied and indigenous Potassium in Dothan Soils.
Sparks D.L., Zelazny L.W., Martens D.C.: Kinetics of Potassium Exchange in a Paleudult from the Coastal Plain of Virginia.
Sparks D.L., Zelazny L.W., Martens D.C.: Kinetics of Potassium Desorption in Soils using Miscible Displacement.
Sparks D.L.: Chemistry of Soil Potassium in Atlantic Coastal Plain Soils: A Review.

Introduction

Potassium fertilization has failed to increase corn *(Zea mays* L.) yields on certain soils of the Atlantic Coastal Plain region. These soils characteristically have sandy surface horizons and high K concentrations in clayey subsoil. Normally, K fertilization recommendations are based on samples collected from the surface 18 to 20 cm. Often these samples contain low levels of extractable K and, yet, there is no yield response to K fertilization. This lack of response could reflect availability of subsoil K. The objectives of this phase of the study were to evaluate the plant availability of subsoil K in two Dothan fine sandy loam soils from the Virginia Coastal Plain and to determine if the subsoil K was derived from leaching of applied K or from genetic origin. The plant availability and movement of K was evaluated during two growing seasons. Selection of the two soils was based on differences in total K in their Ap, A2, and B21t horizons.

Forms of soil K

The K status of the two soils was evaluated by the dilute HCl-H_2SO_4 extractable K and exchangeable K availability indexes (table 1). Dilute HCl-H_2SO_4 extractable K is used in Virginia and many other southeastern states to assess K fertilization requirements. The Ap horizon contained a medium level of dilute HCl-H_2SO_4 extractable K in the Greensville County soil and a low level in the Nottoway County soil according

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to calibration data for the procedure *(Rich,* 1955). The sum of either dilute $HCl-H_2SO_4$ extractable K or exchangeable K was higher in the three horizons for the Greensville County soil than for the Nottoway County soil. This may reflect K fertilization during the many years of crop production in the former soil. An increase in both dilute $HCl-H_2SO_4$ extractable K and exchangeable K was evident from the A2 to B21t horizons for both soils.

The three horizons of the two soils contained relatively high amounts of total K ranging from 6,5 to 12,0 meq/100 g (table 1). Greater than 90% of the total K in each horizon of the two soils was in feldspar and mica forms. The high portion of total K in these primary mineral forms suggests that parent material was the origin of most of the K in each horizon of the two soils. Relatively large portions of the total K were present in the silt fraction of both soils and even in the sand fraction of the Nottoway County soil. The presence of K in primary minerals in the sand and silt-sized fractions supports the conclusion that much of the total K in the two soils was

Table 1 Forms of K in Dothan soils from Greensville and Nottoway Counties

Horizon	Depth	Dilute $HCl-H_2SO_4$ ext. K	Exchangeable K	Non-exchangeable K	Primary mineral K		Total K	Total K		
					Feldspar	Mica		Sand	Silt	Clay
	cm	meq/100 g								
		Greensville County								
Ap	0–20	0,11	0,11	0,17	5,4	0,8	6,5	0,3	3,7	2,5
A2	20–31	0,06	0,11	0,19	5,7	0,9	6,9	0,4	3,4	3,1
B21t	31–41	0,10	0,22	0,38	5,1	3,6	9,3	0,2	1,4	7,7
		Nottoway County								
Ap	0–15	0,07	0,10	0,22	11,3	0,4	12,0	2,5	4,1	5,4
A2	15–33	0,03	0,09	0,19	8,2	2,3	10,8	2,0	5,5	3,3
B21t	33–68	0,08	0,13	0,24	5,4	5,6	11,4	1,8	4,7	4,9

Table 2 Effect of K application on yield, K concentration, and K removal of corn on Dothan soils from Greensville County for 1977 and from Nottoway County for 1977 and 1978

Treatment*	Yield			K in ear leaf	K removal		
kg K/ha	Grain kg/ha	Stalk	Total	%	Grain kg K/ha	Stalk	Total
	Greensville County, 1977						
0	330 a**	5300 a	5 630 a	2,0 b	1 a	70 b	71 b
83	340 a	5240 a	5 580 a	2,1 b	1 a	85 ab	86 ab
249	230 a	4590 a	4 820 a	2,5 a	1 a	113 a	114 a
	Nottoway County, 1977						
0	4940 a	4890 b	9 830 b	1,0 b	12 a	46 a	58 a
83	5110 a	6060 a	11 170 a	1,5 a	13 a	54 a	67 a
	Nottoway County, 1978						
0	6430 b	7330 a	13 760 b	0,7 b	11 b	19 b	30 b
83	8380 a	9220 a	17 600 a	1,2 a	14 a	66 a	80 a

* The K was applied annually.

** Column means for each treatment are significantly different at the 0,10 probability level if followed by different letters for a given year.

genetic in origin *(Barshad,* 1964). Amounts of the nonexchangeable K forms were relatively low in the three horizons of the two soils *(Yuan et al.,* 1976), which would be expected where much of the total soil K was in feldspar and mica forms.

Effect of K application on tissue K levels and corn yield

Applications of K generally increased the K concentrations of the corn plant ear leaves during the early silk growth stage on both soils (table 2). *Jones* (1967) reported that a K concentration in ear leaves at this growth stage of <1,25% indicates inadequate K for normal corn plant growth and of 1,71 to 2,25% indicates adequate K for maximum corn yields. Relationships between K application and corn yield were consistent with these critical levels. That is, K application increased the total grain and stalk yields where the ear leaves from plants on control plots contained 1,0 and 0,7% K on the Nottoway County soil in 1977 and 1978, respectively; whereas K application did not increase total yields on the Greensville County soil where the ear leaves of plants on control plots contained 2,0% K. The yields were much higher on the Nottoway County soil in 1978 than in 1977. The lower yield in 1977 reflects the severe drought that was only partially overcome by irrigation. Corn grain yield was exceedingly low on the Greensville County soil in 1977 due to a severe lack of rainfall during the grain filling stage. The amount of rainfall at this site was 3,5 cm in June and 6,9 cm in July.

The sum of either dilute $HCl-H_2SO_4$ extractable K or exchangeable K in the Ap, A2, and B21t horizons was higher in the Greensville County soil, than in the Nottoway County soil (table 1). These data suggest a higher level of plant available K in

Table 3 Effect of K application and sampling time on exchangeable K in three horizons of the Greensville and Nottoway County soils

Treatment*	Horizon	Sampling date						
		6/77	8/77	11/77	3/78	6/78	9/78	12/78
kg K/ha		meq exchangeable K/100 g						
		Greensville County						
0	Ap	0,09 cA**	0,07 cBC	0,08 cAB	0,07 bBC	–***	–	0,06 cC
83	Ap	0,12 bA	0,09 bBC	0,09 bBC	0,11 abAB	–	–	0,08 bC
249	Ap	0,19 aA	0,13 aB	0,12 aB	0,12 aB	–	–	0,11 aB
0	A2	0,12 aA	0,09 bB	0,10 bAB	0,10 bAB	–	–	0,08 bB
83	A2	0,13 aA	0,10 bB	0,10 bB	0,12 abAB	–	–	0,12 bAB
249	A2	0,13 aB	0,13 aB	0,13 aB	0,15 aB	–	–	0,19 aA
0	B21t	0,20 aA	0,16 aB	0,16 aB	0,18 aAB	–	–	0,13 bC
83	B21t	0,20 aAB	0,16 aBC	0,19 aABC	0,15 aC	–	–	0,23 aA
249	B21t	0,19 aB	0,16 aB	0,18 aB	0,18 aB	–	–	0,24 aA
		Nottoway County						
0	Ap	0,11 bA	0,07 bB	0,08 bB	0,07 bB	0,07 bB	0,05 bC	0,05 bC
83	Ap	0,13 aA	0,09 aCD	0,10 aBC	0,10 aBC	0,11 aB	0,08 aD	0,09 a D
0	A2	0,08 aA	0,06 aBC	0,07 aAB	0,07 aAB	0,06 bBC	0,06 bBC	0,05 bC
83	A2	0,07 aBC	0,06 aC	0,07 aBC	0,06 aC	0,09 aA	0,08 aAB	0,08 aAB
0	B21t	0,12 aA	0,10 aBC	0,12 aA	0,10 aBC	0,11 AB	0,11 aAB	0,09 aC
83	B21t	0,10 aBC	0,09 bC	0,10 aBC	0,10 aBC	0,11 aB	0,13 aA	0,10 aBC

* The K treatment was applied after soil sampling in 3/77 and in 3/78.

** Column means for each horizon are significantly different at the 0,10 level of probability if followed by different lower case letters. Row means are significantly different at the 0,10 level of probability if followed by different higher case letters.

*** Soil samples were not obtained.

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the surface three horizons of the former soil. Accordingly, K concentration in ear leaves and total K uptake was higher in corn plants grown in 1977 on the Greensville County soil (table 2). More K was present in corn stalks, than in grain. This was most evident on the Greensville County soil in 1977 where grain yield was exceedingly low due to lack of rainfall, but also was evident on the Nottoway County soil in 1978 where rainfall was nearly adequate. Overall, these data indicate much greater K removal from soil where corn was harvested for silage than for only grain. Total uptake data show that application of 83 kg K/ha would not always be adequate to replenish the soil K removed when plants were used for silage.

Uptake of subsoil K

As expected, K application increased the exchangeable K in the Ap horizons of both soils (table 3). Decreases in exchangeable K occurred in the Ap horizons of both soils during the June to August 1977 and the June 1977 to December 1978 samplings in control and K-treated plots. These decreases in exchangeable K are attributable mainly to crop uptake and leaching of K, and possibly to some K fixation. Decreases in exchangeable K occurred in the A2 and B21t horizons of control plots on both soils during the June 1977 to August 1977 samplings. These decreases indicate that corn roots, which were visibly detected in these horizons, were able to extract K from the subsoil even though the pH levels in the B21t horizons of both soils were below 5,0. Plants would not absorb K from B horizons where root growth was inhibited by Al and Mn toxicities. Likewise, plant sorption of K would not occur from B horizons where roots did not grow into this horizon due either to lack of O_2 or to pan development.

Leaching of K

Although corn plants could not be grown on the Greensville County soil in 1978, the study was continued to determine the effect of a high level of K application combined with relatively low K removal (table 2) on leaching of K. Application of the 249 kg K/ha level increased exchangeable K in the A2 horizon of the soil on the August 1977 through December 1978 samplings (table 3). Exchangeable K was increased in the B21t horizon of the soil in the December 1978 sampling from application of both 83 and 249 kg K/ha. These increases in exchangeable K indicate downward movement of K into the soil, assuming a similar amount of K release in the A2 and B21t horizons of control and K-treated plots. This conclusion for leaching of K would not be altered either if K release would be higher in the A2 and B21t horizons of K-treated plots due to greater crop uptake of K or if crop uptake of leached K was greater from the A2 and B21t horizons of the K-treated plots.

Downward movement of K into the A2 horizon of the Nottoway County soil was indicated by increases in exchangeable K from application of the 83 kg K/ha level in this horizon during the June 1978 to December 1978 samplings (table 3). An effort was made to select very uniform experimental areas for this study, nevertheless, slight variation in exchangeable K occurred in the B21t horizon between the control and K-treated plots. For example, exchangeable K was higher in the B21t horizon in the control plots than in the K treated plots for the August 1977 sampling. The higher exchangeable K concentrations in this soil on June 1978 and September 1978 sampling dates, than on the August 1977 sampling suggest downward movement of K into the B21t horizon of the soil.

Kinetics of K adsorption and desorption in sandy soil

A voluminous amount of research has been performed on various aspects of ionic exchange with K, but a meager amount has appeared in the literature on the rate of K exchange or the kinetics of K adsorption and desorption in soil systems. While research has been conducted on the kinetics in pure clay systems, little has been conducted on soil systems where complex mixtures of clay minerals and organic matter are present. Furthermore, the kinetics of ion-exchange reactions are not understood in either system *(Thomas,* 1977). The purpose of the following studies was to investigate the kinetics of K exchange on the Ap, A2, B21t, and B22t horizons of the Dothan soils alluded to earlier.

K sorption vs. time

Potassium sorption was noninstantaneous for the Al- and Ca-saturated samples from the Ap and B22t horizons of the Greensville County location (fig. 1–4). Although not shown, a similar trend occurred in the other horizons from this location and in all horizons from the Nottoway County location. The noninstantaneous sorption differs from findings of others *(Way,* 1850; *Malcom* and *Kennedy,* 1969) with pure systems.

The sorption process was virtually complete in the 5 and 25 ppm K-treated Al- and Ca-saturated Ap horizons of the Greensville County site in 2 hours (fig. 1 and 2). The 100 ppm K-treated soils sorbed more K than either the 5 or 25 ppm K-treated soils, which is expected from a concentration standpoint *(Kelley,* 1948), and resulted in a relatively linear relationship when plotted logarithmically. However, equilibrium was not reached until approximately 24 hours of equilibration time. The Ca-saturated Ap horizon of the Greensville County soil sorbed considerably more K than the Al-saturated soil (fig. 2), which can be expected on the basis of easier displacement of divalent Ca than trivalent Al by K *(Helfferich,* 1962). Although not reported, both the A2 and B21t horizons were similar to the Ap horizon for sorption vs. time plots (fig. 1 and 2), which would be expected since similar mineralogy and clay contents were present.

Aluminum- and Ca-saturated soils from the B22t horizon sorbed considerably more K than did those from other horizons (fig. 3 and 4). The higher clay content of this horizon afforded more exchange sites for sorption of K in the Al- or Ca-saturated samples. The 5- and 25-ppm K-treated soils reached equilibrium in approximately 1 hour while equilibrium was not reached in the 100-ppm K-treated soils until about 24 hours. Similar to the other horizons, the Ca-saturated soil sorbed much more K than did the Al-saturated soil.

These data showing noninstantaneous ion-exchange for K by Al- and Ca-saturated soils suggest diffusion controlled exchange. These soils contained vermiculitic clay minerals and mica which others have shown to exhibit slow diffusion-related exchange *(Barshad,* 1955; *Malcom* and *Kennedy,* 1970). A practical aspect of this slow rate of sorption is that K could remain in the soil-solution phase for longer times where it might be either leached or taken up by plants.

Adsorption rate coefficients

Reaction rates are directly proportional to k_a values *(Selim et al.,* 1976). Measured k_a values decreased with increasing ionic strength (table 4), which confirms a faster exchange rate for the lower concentrations of added K as indicated by Bronsted's activity rate theory *(Moore,* 1972). A trend for a faster rate of exchange in the Ca-saturated system than in the Al-saturated system was also indicated by these k_a values. The k_a values of the same horizons were similar at both locations, which suggests that similar exchange reactions were taking place as would be expected because of similar mineralogy. Apparently, the past cropping history had no major influence on kinetics.

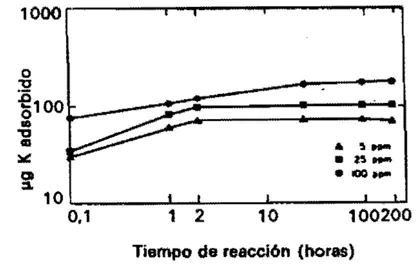

Fig. 1. Potassium adsorption by Greensville County Ap soil horizon (Al-saturated) as a function of time plotted on a logarithmic scale at 25°C.

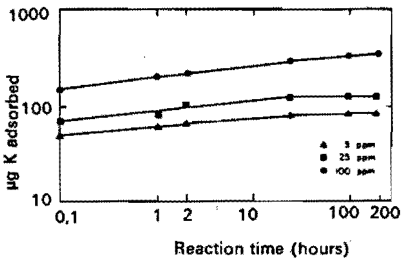

Fig. 2. Potassium adsorption by Greensville County Ap soil horizon (Ca-saturated) as a function of time plotted on a logarithmic scale at 25°C.

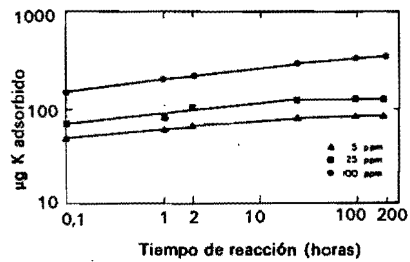

Fig. 3. Potassium adsorption by Greensville County B22t soil horizon (Al-saturated) as a function of time plotted on a logarithmic scale at 25°C.

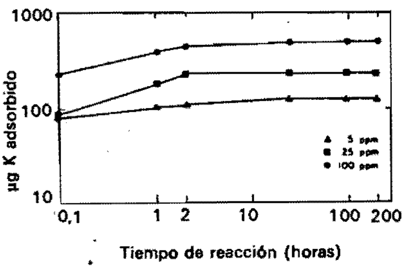

Fig. 4. Potassium adsorption by Greensville County B22t soil horizon (Ca-saturated) as a function of time plotted on a logarithmic scale at 25°C.

The k_a values of these soils ranged from about 1 to 20 hours^{-1}, which suggest slow rates of reaction (fig. 1–4) as compared with values of 81 to 216 hours^{-1} calculated for Florida soils *(Selim et al.,* 1976). This can be explained on the basis of the predominance of kaolinite in the Florida soils as compared with vermiculitic minerals in the Virginia soils.

Table 4 Adsorption rate coefficients for Dothan soil from Greensville and Nottoway Counties

Horizon	Saturation treatment	K_{Co}	k_a Greensville	k_a Nottoway
		ppm	hour^{-1}	
Ap	Al	5	10,23	12,07
		25	3,13	3,26
		100	1,08	0,95
Ap	Ca	5	14,23	12,93
		25	3,75	4,36
		100	1,84	2,07
A2	Al	5	12,79	10,00
		25	2,85	2,30
		100	1,60	0,75
A2	Ca	5	11,74	11,12
		25	4,54	3,92
		100	2,20	2,19
B21t	Al	5	13,22	10,85
		25	3,47	3,93
		100	1,92	1,55
B21t	Ca	5	15,75	14,26
		25	4,65	4,31
		100	2,46	2,30
B22t	Al	5	12,26	14,38
		25	3,64	4,64
		100	2,02	2,17
B22t	Ca	5	20,01	21,91
		25	4,53	8,45
		100	3,84	5,67

Kinetics of K desorption in sandy soil

Potassium desorption in the Dothan soils conformed to first-order kinetics (fig. 5). The first-order rate equation described K desorption for an average of 165 and 172 min for the Al- and Ca-saturated samples, respectively, in the Ap, A2, and B21t horizons, and for an average of 439 and 505 min for the Al- and Ca-saturated samples, respectively, in the B22t horizon (table 5). These represent times when K desorption was virtually complete in the respective soil horizons. The first-order rate equation described K desorption well with r values ranging from –0,993 to –0,998 (fig. 5). The finding that the kinetics of K desorption is first-order supports the proposal by *Selim et al.* (1976).

The $k/_d$ values at a flow velocity of 1,0 ml min^{-1} decreased from the Ap to the B22t horizons in the Greensville and Nottoway soils as clay content increased (table 5). Desorption would be expected to be slower where higher contents of clay are present due to increased intraparticle transport and to diffusion. There tended to be a higher $k/_d$ in the Al- than in the Ca-saturated systems (table 5). The range in the $k/_d$ values in the four horizons was small which was also observed for the adsorption rate coefficients *(Sparks et al.,* 1980). The small range in the $k/_d$ values suggests that similar desorption reactions were occurring throughout the soil profile at this flow velocity *(Evans* and *Jurinak,* 1976).

Kinetics of K desorption in the two Dothan soils was 2 to 8 hours slower than the kinetics of K adsorption *(Sparks et al.,* 1980). This would be expected due to the difficulty in desorbing K from partially collapsed interlayer positions *(Sawhney,*

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1966). Once K is adsorbed into the interlayer positions the coulombic attraction between K ions and the clay layers would be greater than the hydration forces of the ion, resulting in partial layer collapse (*Sawhney*, 1966). The observation of slower desorption than adsorption conforms with findings of others (*Kuo* and *Lotse*, 1973) and suggests that the K kinetic reactions in the Dothan soils were nonsingular or that hysteresis could be occurring (*Ardakani* and *McLaren*, 1977; *Rao* and *Davidson*, 1978).

Potassium desorption, as plotted by the *Elovich* equation (*Chien* and *Clayton*, 1980), in the original Al- and Ca-saturated systems was rapid at first and leveled off with time in the Ap horizon (fig. 6) and in the B22t horizon (fig. 7) of the Nottoway soil suggesting ease in desorption initially followed by more difficult desorption reactions. This trend was also observed for the kinetics of K adsorption in these soils (*Sparks et al.*, 1980). The percent K desorbed at 10 minutes in the Al- and Ca-saturated Ap horizon was approximately 84,4 and 62,4%, respectively. In the Al- and Ca-saturated systems of the B22t horizon, 56,0 and 64,0% of the K was desorbed in 10 minutes. The rate of K desorption for a given cation saturation was exponentially related to the percent K saturation until almost all K was desorbed, at which point

Table 5 Apparent desorption rate coefficients ($k/_d$) calculated at 1,0 ml min.$^{-1}$ flow velocity, values of K_o, and the amount of time the first-order rate equation described K desorption for Dothan soil from Greensville and Nottoway Counties

Horizon	Saturation treatment	K_o*		Time of first-order conformity**		$k/_d$	
		Greensville	Nottoway	Greensville	Nottoway	Greensville	Nottoway
		µg/g soil		minutes		hour^{-1}	
Ap	Al	220	225	152	160	0,90	0,87
	Ca	251	259	163	170	1,30	1,23
A2	Al	238	242	161	175	0,96	0,92
	Ca	259	264	166	183	0,81	0,79
B21t	Al	249	251	162	177	0,84	0,80
	Ca	265	273	169	186	0,70	0,64
B22t	Al	310	312	438	440	0,44	0,40
	Ca	351	362	500	510	0,36	0,30

* Represents quantity of K on exchange sites at zero time of K desorption.
** Represents time for which the first-order rate equation described K desorption.

Table 6 Effect of flow velocity on the magnitude of the $k/_d$ of the Ap and B22t soil horizons from Nottoway County

Horizon	Flow velocity	$k/_d$ (hour^{-1})	
	ml min^{-1}	Al-saturated	Ca-saturated
Ap	0,0	0,83*	1,11*
	0,5	0,85	1,18
	1,0	0,87	1,23
	1,5	0,91	1,32
B22t	0,0	0,33*	0,26*
	0,5	0,37	0,28
	1,0	0,41	0,30
	1,5	0,48	0,34

* These $k/_d$ values were obtained by plotting a regression line of the triplicate $k/_d$ values vs. flow velocity. The r values were 0,970 and 0,973 for the Ap and B22t horizons respectively, which were significant at the 1% level of probability.

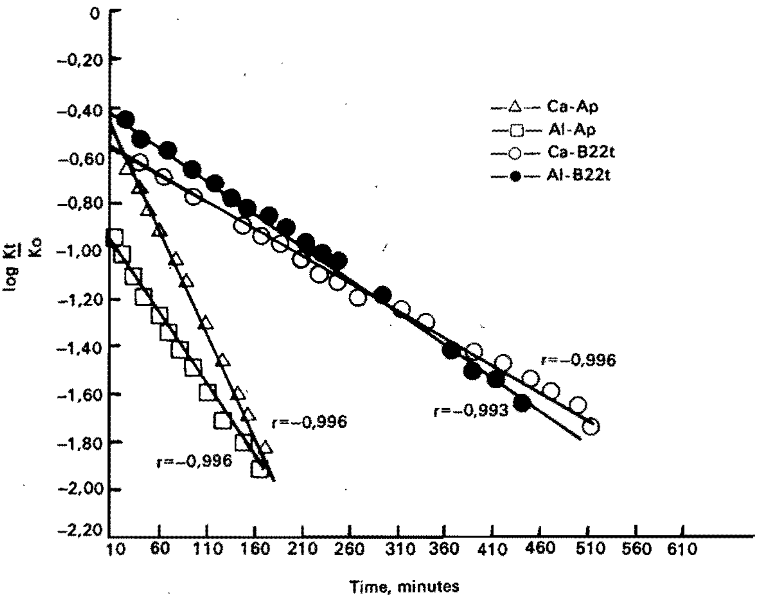

Fig. 5. Log (K_t/K_o) vs. time of leaching with 0,01 M $CaCl_2$.

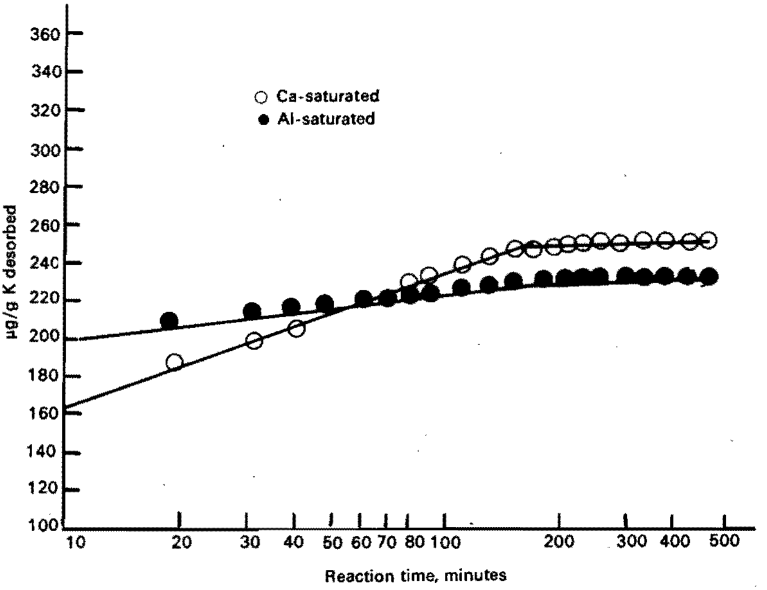

Fig. 6. Potassium desorption at 25°C using 0,01 M $CaCl_2$ at a flow velocity of 1,0 ml min^{-1} in Ap horizon.

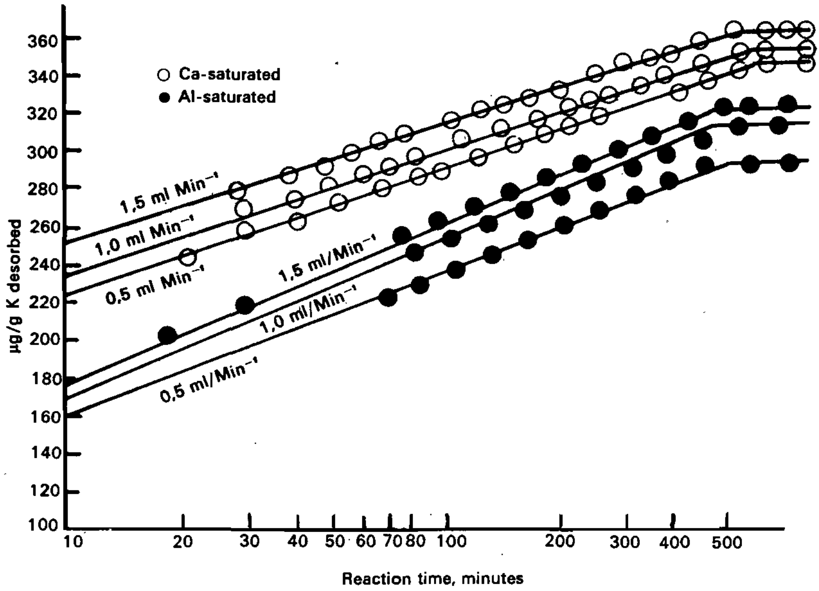

Fig. 7. Potassium desorption at 25°C using 0,01 M $CaCl_2$ at flow velocities of 0,5, 1,0, and 1,5 ml min^{-1} in B22t horizon.

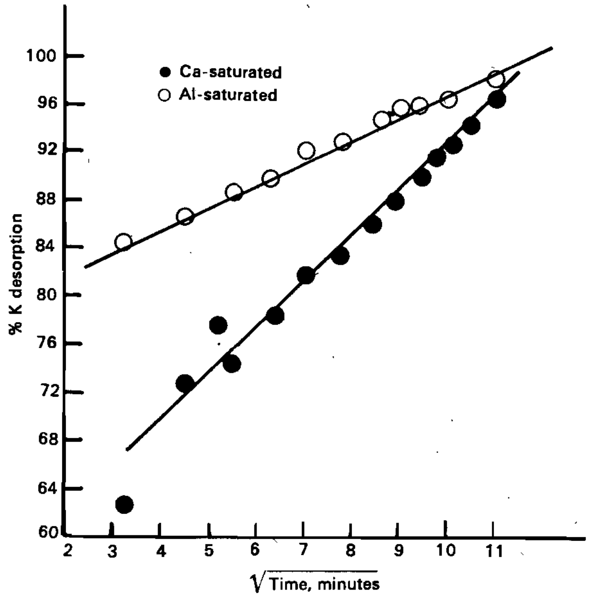

Fig. 8. Percent K desorption vs. time$^{1/2}$ for Dothan soil.

it decreased. The reaction was nearly completed in about 3 and 4 hours in the Al- and Ca-saturated systems, respectively, of the Ap horizon. Desorption was essentially completed by this time as little K was detected in the leachate solutions. Approximately 95–98% of the adsorbed K in these soils was subsequently desorbed. This would suggest that K adsorption-desorption using miscible displacement is a reversible process. However, approximately 2–5% of the adsorbed K could not be desorbed by Ca which could result from adsorption of K on specific sites. The Al-saturated Ap horizon initially desorbed more K than the Ca-saturated soil, but by the end of the desorption reaction the total amount of K desorbed was greater for the Ca-saturated soil. The latter observation parallels the adsorption data obtained earlier (*Sparks et al.*, 1980). This would be expected since the Ca-saturated system initially adsorbed more K.

The effect of different flow velocities in the B22t horizon of the Nottoway soil is shown in figure 7. At any given time, the amount of K desorbed increased as flow velocity increased. These data agree with findings of *Sivasubramaniam* and *Talibudeen* (1972) and are a result of more displacing Ca passing through the column at the faster flow velocity. The apparent equilibrium between K–Ca exchange favored Ca adsorption and K desorption at higher flow velocities. The slower flow velocity would provide a greater contact time between solution desorbed K and the soil. In the Dothan soils, the rate of K desorption increased slightly with flow velocity since the rate is concentration dependent (fig. 7). However, the $k/_d$ values increased little with flow velocity (table 6).

A low rate of K desorption has been noted by others (*Talibudeen* and *Dey*, 1968; *Feigenbaum* and *Levy*, 1977). The slow K desorption probably indicates diffusion-controlled exchange due to the vermiculitic clays present in the Dothan soils (*Barshad*, 1954; *Reed* and *Scott*, 1962; *Chute* and *Quirk*, 1967; *Sawhney*, 1966; *Sparks et al.*, 1980). Different types of exchange sites in vermiculite have different desorption rates. While the external planar surface sites and the edge sites desorb K readily, the desorption of K from interlayer sites involves a low rate of diffusion (*Sawhney*, 1966). That diffusion was the predominant mechanism of K desorption in the Dothan soils is illustrated in figure 8 by the linear relationship between time$^{1/2}$ versus percent K desorption in the Ap of the Nottoway soil. *Barshad* (1954) ascribed a linear relationship between time$^{1/2}$ versus percent K desorption to diffusion-controlled exchange. There was some deviation in linearity of the diffusion plot during the initial period of K desorption (fig. 8). *Chute* and *Quirk* (1967) note that diffusion-controlled exchange may not be strictly obeyed during the initial period of K desorption. This could be due to mass action exchange at sites on external surfaces (*Chute* and *Quirk*, 1967).

Although not shown, similar K desorption kinetics were observed in the A2 and B21t horizons of the Nottoway soil and in the Ap, A2, and B21t horizons of the Greensville soil. This would be expected due to the similar clay mineral suites and clay contents in these horizons (*Sparks et al.*, 1980).

Both soils desorbed considerably more K in the B22t horizon (331 µg K/g soil which represents the mean of the Al- and Ca-saturated B22t horizons at three flow velocities) than in the other three horizons (mean of 245 µg K/g soil). The larger quantity of desorbed K in this horizon (fig. 7) is attributed to the higher clay content present. The higher quantity of clay would offer more exchange sites to adsorb K, and, subsequently, to desorb K. Loss of K was complete in about 8 and 9 hours for the Al- and Ca-saturated systems, respectively.

The rate of K release from the exchangeable, nonexchangeable, and mineral forms in these soils needs to be further investigated. With kinetic data, predictive models could be developed for these soils which would aid in making sound fertilizer recommendations.