

\*

( // : // :

.(Russel, 1961)

(Sparks

.and Huang, 1985)

(Martin and Sparks,

( )

.1985; Sparks and Huang, 1985)

.(Sparks, 1987)

(Jalali,

.2006)

.(Medvedeva, 1983)

.(Sparks, 1986)

.(Malakouti et al., 2005)

(Malakouti

.and Riazi Hamedani, 1991)

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.(Tu et al., 2007)

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.(Sparks, 1999)

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.(Sparks, 1989)

.(Song and Huang, 1988)

-

(Dhillon

and Dhillon, 1990; Cox et al., 1999; Jalali, 2005)

OH COOH

-

(Strobel, 2001)

-

OH

.(Fox, 1995)

.(Jones, 1998)

.(Song and Huang, 1988)

.(Strobel, 2001)

.(Russel, 1961)

(Hue et al.,1986; Fox,

1995; Drever and Stilling, 1997)

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.(Srinivasarao et al., 1997)

(1999) Hosseinpour .(Sadusky et al., 1987)

b a

$$(y = a + b\sqrt{t})$$

.t

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CaCl<sub>2</sub>

(

/

/

pH

pH

(Zhang and Bloom,

.1999)

/

pH

pH

(Hosseinpour, 1999)

NaOH

( )

%

Corning

( )

( )

(Chien and Clayton, 1980)

$[(\text{mmol K kg}^{-1})]^{-1}$	$= k_2$	$Q_t = k_2 Q_e^2 t / (1 + k_2 Q_e t)$
$(\text{mmol K kg}^{-1} \text{ day}^{-1})$	$= 1/\beta$	$Q_t = 1/\beta (\ln a \beta) + 1/\beta \ln t$
$(\text{mmol K kg}^{-1} \text{ day}^{-1})$	$= ab$	$Q_t = at^b$
$(\text{mmol K kg}^{-1} \text{ day}^{0.5})$	$= R$	$Q_t = C + Rt^{0.5}$
(mmol/kg)	$Q_e$ (mmol/kg)	$t$

MSTAT-C

Excel (2003)

Curve Expert

(SE)

( $r^2$ )

XRF

( )

$$SE = \sqrt{\frac{\sum(Q_1 - Q_2)^2}{n - 2}} \quad ( )$$

$Q_2$   $Q_1$  ( )

n

SE

SPSS9 Curve Expert 1.3

$r^2$

SAS8

**XRF**

Total	LOI*	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO	Fe <sub>2</sub> O <sub>3</sub>	CaO	K <sub>2</sub> O	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	MgO	Na <sub>2</sub> O
/	/	/	/	/	/	/	/	/	/	/	/
/	/	/	/	/	/	/	/	/	/	/	/

(Loss on ignition) °C

\*

(SE)

( $r^2$ )

( )

( )

(El Dessougi, 2001)

(Applet et al., 1975)

Goulding, )

(1984

%

		(SE)		(r <sup>2</sup> )				(μM)
SE	r <sup>2</sup>	SE	r <sup>2</sup>	SE	r <sup>2</sup>	SE	r <sup>2</sup>	
/	**	/	**	/	*	/	ns	
/	**	/	**	/	**	/	ns	
/	**	/	**	/	**	/	ns	
/	**	/	**	/	*	/	ns	
/	**	/	**	/	*	/	ns	
/	**	/	*	/	*	/	ns	
/	*	/	ns	/	ns	/	ns	
/	*	/	ns	/	ns	/	ns	
/	**	/	**	/	*	/	ns	
/	**	/	*	/	*	/	ns	
/	*	/	ns	/	ns	/	ns	
/	*	/	ns	/	ns	/	*	ns
/	**	/	*	/	ns	/	ns	
/	*	/	ns	/	ns	/	ns	
/	**	/	**	/	*	/	ns	
/	**	/	*	/	*	/	ns	
/	**	/	**	/	**	/	*	
/	**	/	**	/	**	/	*	
/	**	/	*	/	ns	/	ns	
/	**	/	**	/	**	/	ns	
/	**	/	**	/	**	/	*	
/	**	/	**	/	**	/	*	

ns / /

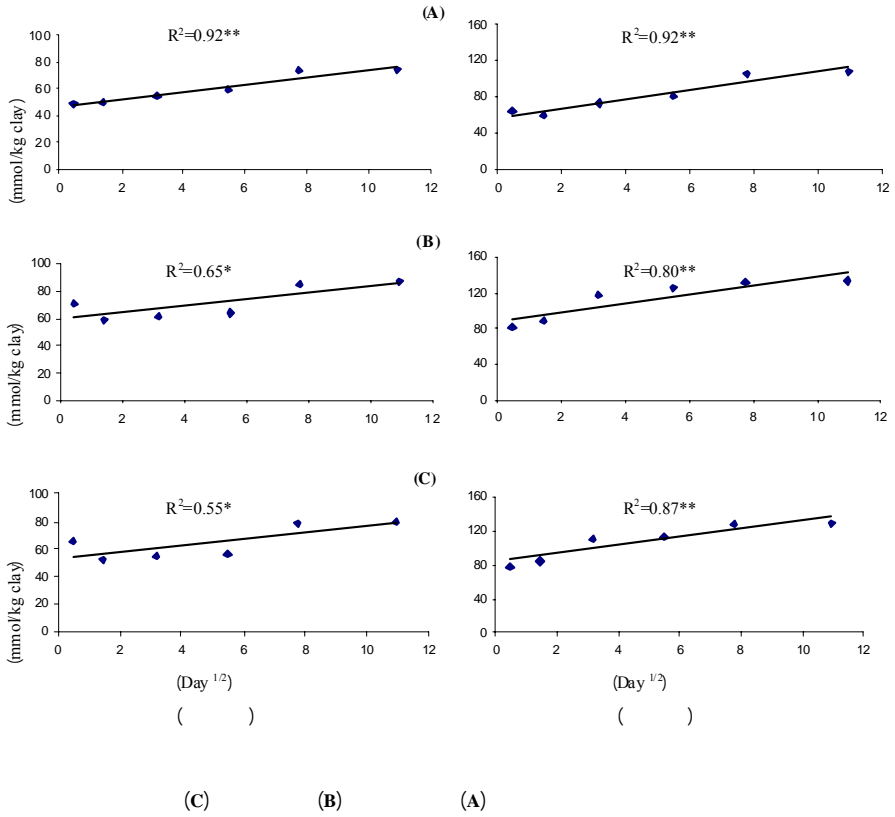
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/ /

/β

/β





(1988) Song and Huang

( ) /β  
 ( ) ab ( ) R  
 . ( )  
 ab R /β

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 × / × / ×  
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ab R /β

ab	R	/β	ab	R	/β
/ **	/ **		/ **	/ **	/β
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- ( $p < 0.01$ )

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ns / / \* \*\*

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(2007) Tu et al.

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(1988) Song and Huang

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(Zutic and

(Huang and Kiang, 1972)

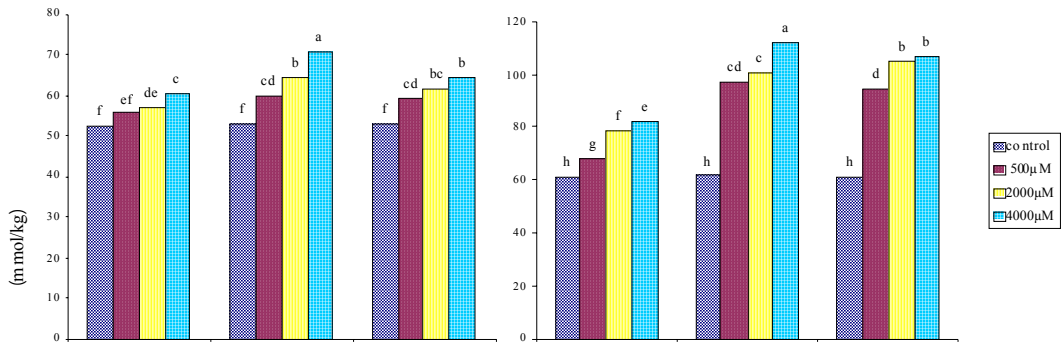
.Stumm, 1984; Furrer and Stumm, 1986)



Al pH

(Jones, 1998)

(Stumm et al., 1985)



( ) ( )  
( ) % ( )

( pH ) pH



(Blum and (1968) Manley and Evans .Lasaga, 1991)

Pohlman and (1986) McColl

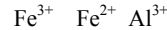
pH

pH

pH

(Chemical affinity)





## REFERENCES

- Applet, H., Coleman, N. T. and Pratt, P. F. (1975). Interactions between organic compounds, minerals and ions in volcanic-ash-derived soils. I: Adsorption of benzoate, salysilate and phthalate ions. *Soil Science Society of America Proceedings*, 39, 623-627.
- Blum, A. E. and Lasaga, A. C. (1991). The role of surface speciation in the dissolution of albite. *Geochimica et Cosmochimica Acta*, 51, 2193-2201.
- Chien, S. H. and Clayton, W. R. (1980). Application of Elovich equation to the kinetics of phosphate release and sorption in soils. *Soil Science Society of America Journal*, 44, 265-268.
- Cox, A. E., Joren, B. C., Brouder, S. M. and Gao, D. (1999). Plant available potassium assessment with modified sodium tetraphenylboron method. *Soil Science Society of America Journal*, 63, 902-911.
- Dhillon, S. K. and K. S. Dhillon. (1990) Kinetics of release of non-exchangeable potassium by cation-saturated resins from Red (Alfisol), Black (Vertisols) and Alluvial (Inceptisols) soils of India. *Geoderma*, 47 (3-4), 283-300.
- Dhillon, S. K. and K.S. Dhillon. (1992). Kinetics of release of potassium by sodium tetraphenylboron from some top soil samples of Red (Alfisol), Black (Vertisol) and Alluvial (Inceptisols and Entisols) soils of India. *Journal of Fertility Research*, 32, 135-138.
- Drever, J. I. and Stillings, L. L. (1997). The role of organic acids in mineral weathering. *Colloids and Surfaces. A: Physicochemical and Engineering Aspects*, 120, 167-181.
- El Dessougi, H. I. (2001). *Potassium efficiency of crop species as related to K dynamics in the rhizosphere simulated by mathematical modelling*. Ph. D. dissertation, Cuvillier Verlag, Gottingen, Germany.
- Fox, T. R. (1995). The influence of low molecular weight organic acids on properties and processes in forest soils. In W. W. McFee and J. M. Kelly (Eds.), *Carbon forms and functions in forest soils*. (pp. 43-62). Soil Science Society of America. Madison. WI.
- Furrer, G. and Stumm, W. (1986). The coordination chemistry of weathering: I. Dissolution kinetics of d-Al<sub>2</sub>O<sub>3</sub> and BeO. *Geochimica et Cosmochimica Acta*, 50, 1847-1860.
- Goulding, K. W. T. (1984). The availability of potassium in soils to crops as measured by its release to a calcium-saturated cation exchange resin. *Journal of Agriculture Science*, 103, 265-275.
- Havlin, J. L., Westfall, D. G. and Olsen, S. R. (1985). Mathematical models for potassium release kinetics in calcareous soils. *Soil Science Society of America Journal*, 49, 371-376.
- Hosseinpour, A. (1999). *A study of potassium fixation capacity, K quantity-intensity ratio and non-exchangeable K release rate in some soils of Iran*. Ph. D. dissertation, College of Agriculture, Isfahan University of Technology. (In Farsi)
- Huang, W. H. and Kiang, W. C. (1972). Laboratory

- dissolution of plagioclase feldspars in water and organic acid at room temperature. *American Mineralogist*, 57, 1849-1859.
- Hue, N. V., Craddock, G. R. and Adams, F. (1986). Effect of organic acids on aluminium toxicity in subsoils. *Soil Science Society of America Journal*, 50, 28-34.
- Jalali, M. (2005). Release kinetics of nonexchangeable potassium in calcareous soils. *Communications in Soil Science and Plant Analysis*, 36, 1903-1917.
- Jalali, M. (2006). Kinetics of nonexchangeable potassium release and availability in some calcareous soils of western Iran. *Geoderma*, 135, 63-71.
- Jalali, M. and Kolahchi, Z. (2004). Kinetics of nonexchangeable potassium release in selected soils from Hamadan. In: Proceedings of 8<sup>th</sup> Iranian Soil Science Congress, Gilan University, Gilan, Rasht, pp. 587-589. (In Farsi)
- Jones, D. L. (1998). Organic acids in the rhizosphere - a critical review. *Plant and Soil*, 205, 25-44.
- Mahdavi Hajilouyi, Sh. (2001) A study of nonexchangeable potassium release kinetics and its correlation with plant uptake in common soil series in Hamadan Province. M.Sc. Thesis, Tehran University. (In Farsi)
- Malakouti, M. and Riazi Hamedani, S. (1991). *Fertilizers and soil fertility*. Nashre Daneshgahi Press. (In Farsi)
- Malakouti, M., Shahabi, A. and Bazargan, K. (2005). *Potassium in Iranian agriculture*. Sana Press. (In Farsi)
- Manley, E. P. and Evans, L. J. (1986). Dissolution of feldspars by low molecular weight aliphatic and aromatic acids. *Journal of Soil Science*, 141, 106-112.
- Martin, W. H. and Sparks, D. L. (1985). On the behavior of nonexchangeable potassium in soils. *Communications in Soil Science and Plant Analysis*, 16, 133-162.
- Medvedeva, O. P. (1983). Nonexchangeable, fixed, fertilizer potassium as an indicator of potassium availability to plants. *Agrokimiya*, 11, 25-31.
- Mengel, K. and Uhlenbecker, K. (1993). Determination of available interlayer potassium and its uptake by ryegrass. *Soil Science Society of America Journal*, 57, 761-766.
- Pohlman, A. and McColl, J. (1986). Kinetics of metal dissolution from forest soils soluble organic acids. *Journal of Environmental Quality*, 15, 86-92.
- Russel, E. W. (1961). *Soil conditions and plant growth*. Longman. London.
- Sadusky, M. C., Sparks, D. L., Noll, M. R. and Hendricks, G. J. (1987). Kinetics and mechanism of potassium release from sandy middle Atlantic coastal plain soils. *Soil Science Society of America Journal*, 51, 1460-1465.
- Song, S. K. and Huang, P. M. (1988). Dynamics of potassium release from potassium bearing minerals as influenced by oxalic and citric acids. *Soil Science Society of America Journal*, 52, 383-390.
- Sparks, D. L. (1986). Potassium release from sandy soils. In: Proceedings of the 13<sup>th</sup> International Potash Institute Congress on Nutrient Balances and the Need for Potassium, Reims, France, pp. 93-105.
- Sparks, D. L. (1987). Potassium dynamics in soils. *Advances in Soil Science*, 6, 1-63.
- Sparks, D. L. (1989). *Kinetics of soil chemical processes*. Academic Press. San Diego, CA, USA.
- Sparks, D. L. (1999). Kinetics of soil phenomena: Future directions. In P. M. Huang, D. L. Sparks and S. A. Boyed (Eds.), *Future Prospects of Soil Chemistry*. (pp. 81-102). Soil Science Society of America, Madison, WI.
- Sparks, D. L. and Carski, T. H. (1985). Kinetics of potassium exchange in heterogeneous systems. *Applied Clay Science*, 1, 89-101.
- Sparks, D. L. and Huang, P. M. (1985). Physical chemistry of soil potassium. In R.D. Munson. (Ed.), *Potassium in Agriculture*. (pp. 201-276). Soil Science Society of America, Madison, WI.
- Srinivasarao, C. H., Datta, S. P., Subbarao, A., Singh, S. P. and Takkar, P. N. (1997). Kinetics of nonexchangeable potassium release by organic acids from mineralogically different soils. *Journal of the Indian Society of Soil Science*, 45, 728-734.
- Strobel, W. (2001). Influence of vegetation on low molecular-weight carboxylic acids in soil solution, A review. *Geoderma*, 99, 169-198.
- Stumm, W., Furrer, G., Wieland, E. and Zinder, B. (1985). The effects of complex-forming ligands on the dissolution of oxides and aluminosilicates. In J. I. Drever (Ed.), *The Chemistry of Weathering*. (pp. 55-74). Reidel Publishing Co., Boston.
- Tu, S. X., Guo, Z. F. and Sun, J. H. (2007). Effect of oxalic acid on potassium release from typical Chinese soils and minerals. *Pedosphere*, 17, 1-10.
- Zarrabi, M., Jalali, M. and Mahdavi Hajilouyi, Sh. (2006). Kinetics of nonexchangeable potassium release and its absorption capacity by malic acid in some soils of Hamadan province. *Journal of Iranian Agricultural Science*, 37 (6), 951-964. (In Farsi)
- Zhang, H. and Bloom, P. R. (1999). Dissolution kinetics of hornblende in organic acid solution. *Soil Science Society of America Journal*, 63, 815-822.
- Zutic, V. and Stumm, W. (1984). Effect of organic acids and fluoride on the dissolution kinetics of hydrous alumina, a model study using the rotating disc electrode. *Geochimica et Cosmochimica Acta*, 48, 1493-1503.