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EFFECT OF PARTICLE SIZES OF CHARCOAL ON THE DESORPTION CAPACITY OF POTASSIUM BY USING DIFFERENT CONCENTRATIONS OF KCL SOLUTION

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ABSTRACT
Laboratory experiment was carried out to study effect of particle sizes of charcoal on desorbed of adsorbed potassium using silt clay loam texture soil collected from Abo- Graib research station/ Department of researches and studies/ Horticulture office. ten ml of potassium chloride solutions (0, 5, 10, 20, 60, 100 and 200 mg K L^{-1}) was added to (soil, soil+ charcoal 0.5mm and soil+ charcoal 1mm) treatments. the weight of the used charcoal was (0.05gm) and it was added to (soil+ charcoal 0.5mm, soil+ charcoal 1mm) treatments All treated samples were incubated for 72 h at 20±2 C^o. the adsorbed potassium was extracted by using 1M- NH_4AOc- pH = 7 and potassium concentration in leachates were Determined. The results showed that charcoal treatments have higher potassium desorbed capacity compound with the soil treatment in the different concentrations The desorbed potassium was 395 mg K kg^{-1} soil for (soil + charcoal diameter- 1 mm) treatment at a concentration of 5 mg K L^{-1} and 386.5 mg K kg^{-1} soil for (soil + charcoal diameter- 0.5 mm) treatment and the lowest amount of desorbed potassium 383 mg K kg^{-1} was in soil for soil treatment and this trend was matched different concentrations of the added potassium**.** Curves of Potassium desorbed indicated increase amount of the desorbed potassium with charcoal adding especially increasing the particle sizes. The percentage of desorbed potassium was 4.30% in (soil + charcoal diameter- 1 mm) treatment of 5 mg K L^{-1} concentration and decreased to 2.19% in (soil + charcoal diameter- 0.5 mm) treatment and the lowest percentage of desorbed potassium was 1.30% in (soil) treatment. The results of the study indicated that amount of the desorbed potassium was negatively proportional with decrease sizes of charcoal particle and this may affect the efficiency of soil fertilization with potassium.

KEY WORDS: charcoal, potassium desorption, potassium desorption curves, equilibrium solution.

INTRODUCTION:
Charcoal is known as an organic matter. It is produced by the pyrolysis of the main material, and it is best described as (feedstock) soil conditioner (Demibas ,2004). There are different organic Matter kinds which can be used as biomass feedstock to make charcoal and it includes wood , different plant residues, while its suitability to prepare the charcoal and then adding it to the soil depends on chemical , physical, environment, economical and local factor (Demirbas,2004;Winsly,2007). Some researchers pointed out the adding charcoal to the soil aims to improving of the soil qualities which work on the continuity of conserving the fixation or separating the sequester carbon and sometime it is improving the soil qualities now or in the future (Lemann et al ,2006, Downie et al 2009 , Nair et al ,2013).
Potassium is considered to be one of the main important nutrient for most agriculture and economical crops. It comes thirdly after Nitrogen and phosphorus elements Stanley, (2005) said that the highest production comes from removing potassium from soil , so it is very important in the agriculture production in both quality and quantity. This make the necessity of studying the condition of this element in soil to raise its production and it is the responsibility of the researchers in soil chemistry section the task to reach to the quickest and most accurate ways to analyses and discover the level of this element in order to express accurately the need of fertilizing. Many studies showed that Iraq soil have big space of potassium as the soil of dry areas, but the speed of potassium emission is low and it is not enough for the need of several crop especially in intensive agriculture (Al-Zubaidi, 2003). Pal et al. (1999) showed that the potassium can be adsorbed by the soil and it changes according to the quality of the clay in soil . It appears clearly in soil that contains Ellite and Vermiculite materials (Goulding, 1987). According to study conducted by Brady (1992), most potassium added to the soil will be fixed in the spaces between clay lattice and plants can utilize only 1-2%, meanwhile, organic fertilizers can increase fertilization efficiency. One way to overcome problems of soil fertility and K availability is by adding biochar. which is produced from biomass pyrolysis. Biochar is a material containing hydrocarbon aromatic polycyclic carbon with functional groups (Schmidt & Noack, 2000; Preston & Schmidt, 2006; Krull et al., 2009; Chintala et al., 2013). Biochar has surface area and porosity which are significant in improving water holding capacity, adsorption, and nutrient retention (Downie et al., 2009; Sohi et al., 2010; Chintala et al., 2013). Biochar can affect soil structure, texture, porosity, particle size distribution, and density so it can improve *aerase*, water storage capacity, microbes, and nutrient

availability in the root zone of plants (Amonette & Joseph, 2009). Application of biochar leads to changes in pH, electrical conductivity (EC), cation exchange capacity (CEC), and nutrient availability (Liang et al., 2006; Gundale & DeLuca, 2007; Warnock et al., 2007).

MATERIALS & METHODS

Soil Samples were collected from soil surface (0-25 cm depth) from Abu Ghraib Research Station /Research and Studies Department /Horticulture office. Composte soil sample was air dried and passed through a 60-mesh sieve to use. Some of the soil chemical and physical properties are given in Table (1).

TABLE 1: Some chemical and physical properties of the soil

Property	Value	Unit
EC (1:1)	**4.34**	$ds.m^{-1}$
pH (1:1)	**7.72**	-
CEC	**10.70**	$cmol_c\ kg^{-1}$
Organic matter	1.00	$gm\ kg^{-1}$ soil
Carbonate minerals	26.00	
Gypsum	0.99	
Ca^{2+}	**2.64**	$cmol\ L^{-1}$
Mg^{2+}	**1.00**	
Na^{+}	**2.00**	
K^{+}	**0.50**	
HCO_3^{-}	**0.38**	$cmol\ L^{-1}$
SO_4^{2-}	2.**04**	
Cl^{-}	**2.10**	
CO_3^{2-}	Nil	
available N	**58.00**	$mg\ kg^{-1}$ soil
available P	8.00	
available K	378	
Sand	**157**	$gm\ kg^{-1}$ soil
Silt	**465**	
Clay	**378**	
Texture	silt clay loam	-

The used biochar was prepared at Zafaraniya Research Station / Research and Studies Department /Horticulture office. The palm tree charcoal was prepared by drying and chopping palms into 1 meter length parts and placing the palms that have more leaves (the end of the palms) at the bottom of the burning device and the palms which have less leaves (the bases of the palms) were put over the first one. Fifth of burning device was left empty to obtain more amount of charcoal, burning was done and the burning device was left working overnight. The obtained charcoal pieces were collected, crushed and milled using 4.2 mm diameter sieve (Salman, 2015) tow different sizes of charcoal minutes were obtained by using sieves having 0.5mm and 1.0mm diameter openings. Some of the used charcoal chemical properties are shown in Table (2).

TABLE 2: Some chemical properties of charcoal

Property	Value	Unit
EC 1:5	3.60	$ds.m^{-1}$
PH	7.64	-
C:N ratio	48.03	-
C	332	$mg.g^{-1}$
N	8.80	
P	2.08	
K	9.23	
Na	0.81	
Ca	7.49	
Mg	1.94	

Potassium adsorption

Three kinds of treatments were chosen, they were (soil, soil + charcoal 0.5 mm and soil +charcoal 1 mm), the weight of soil and charcoal were 5g. and 0.05g. respectively. The materials of the last three treatments were placed into 100 ml capacities plastic bottle, and 10 ml of solution containing (0, 5, 10, 20, 60, 100 and 200 mg K L^{-1}) was added to each plastic bottle. Then, the bottles were shaken and incubated in the laboratory for 72 hours at 20 ± 2 C^{o} (Bangroo et al., 2012).

Desorption of the adsorbed potassium

After end of incubation period, extraction was done on all the treatments by using 1 M- NH_4AOc- pH = 7 and then amount of the desorbed potassium in the leachate was determined by using a flame photometer device.

RESULTS & DISCUSSION

The results showed that charcoal has an effective role in increasing the amount of desorbed potassium as shown in Figure 1. Potassium desorbed curves indicate the superiority of the treatment (soil + charcoal-1 mm) in the amount of desorbed potassium and different concentrations. The amount of potassium desorbed at the concentration of 5 mg K L^{-1} was 395 mg K kg^{-1} soil while the amount of potassium desorbed for treatment (soil + charcoal-0.5 mm) was 386.5 mg K kg^{-1} soil. The decrease in amount of desorbed potassium may be attributed to the increase of the specific surface area by reducing the volume of charcoal minutes and thus increasing the adsorption capacity (Saman, 2009). The minimum amount of desorbed potassium was 383 mg K kg^{-1} soil for soil treatment and concentration of 5 mg K L^{-1}. This may be due to soil texture (silt clay loam). Clay and silt worked on stabilizing potassium, especially in calcareous soil with a base pH, this is consistent with what happened (Abdul Hannan et al., 2007). The reason for the superiority of charcoal treatments is due to the role of active aggregates on the charcoal surfaces (Nitro-NO2, Ester- (C = O) OR, Amino-NH2, ketone -OR, Hydroxyal OH, Aldehde- (C = O) H, Carboxyl- (C = O) OH), which are distributed on the surface of the carbon plates and the intercellular spaces where they worked on adsorption For potassium and desorbed into the soil solution by Chemo physics changes of the soil solution (Harris, 1997 and Van et al., 2009).

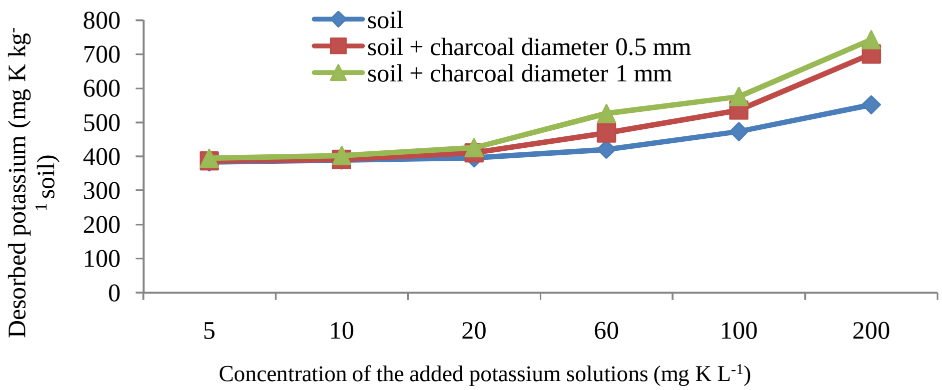

FIGURE 1. Potassium desorbed curves

Table 3 shows the Percentage of desorbed potassium for the different concentrations of the added potassium and the different treatments. They as calculated according to the following equation.

% Desorbed potassium = desorbed potassium - soil potassium / desorbed potassium * 100

The highest levels of desorbed potassium were 4.30 % when treated (soil + charcoal 1 mm) with the added potassium concentration 5 mg K L^{-1}, and 2.19 % for (soil + charcoal 0.5 mm) treatment at the same concentration. The increase in the potassium free ratio of charcoal treatments may be due to the specific surface area and the high cation exchange capacity as well as the negatively charged surfaces that have made the potassium adsorbation replaceable and non-stabilized (Yuan JH et al., 2011), While the Percentage of desorbed potassium for (soil) treatment was 1.30 %. This trend was consistent with potassium concentrations 10, 20, 60, 100, 200 mg K L^{-1}. The decrease in the amount of potassium desorbed for soil treatment may be due to the high content of this element, potassium stabilization in clay minerals, especially vermiculite and for its high reliability (Mengel and Uhlenbecker, 1993).

TABLE 3: Percentage of desorbed potassium

Concentration of added	% desorbed potassium		
potassium (mg K L^{-1})	soil	Soil +charcoal (0.5mm)	Soil +charcoal (1mm)
5	1.30	2.19	4.30
10	2.82	3.32	6.20
20	4.30	7.91	11.26
60	10.10	19.40	28.13
100	20.08	29.47	34.37
200	31.52	46.07	49.12

Figure 2 shows the percentage of desorbed potassium at the different concentrations of potassium added to (soil) treatment. The lowest potassium desorbed rate was 1.30 % at 5 mg K L^{-1} . The percentage of the desorbed potassium increased with increase of concentrations the added potassium to the highest desorbed potassium was 31.52% desorbed at the concentration of 200 mg K L^{-1} This may be due to the rapid saturation of specialized and non-specialized sites of potassium adsorption, which can occur during the first hours of the equilibrium period, leading to the occupancy of most adsorption sites in the soil, Potassium in the added potassium does not form a pressure on a part of the potassium found in the equilibrium solution and its spread into the crystalline structure of clay minerals. Therefore, the percentage of potassium desorbed increased with addition of the added concentrations of potassium (Bangroo et al., 2012).

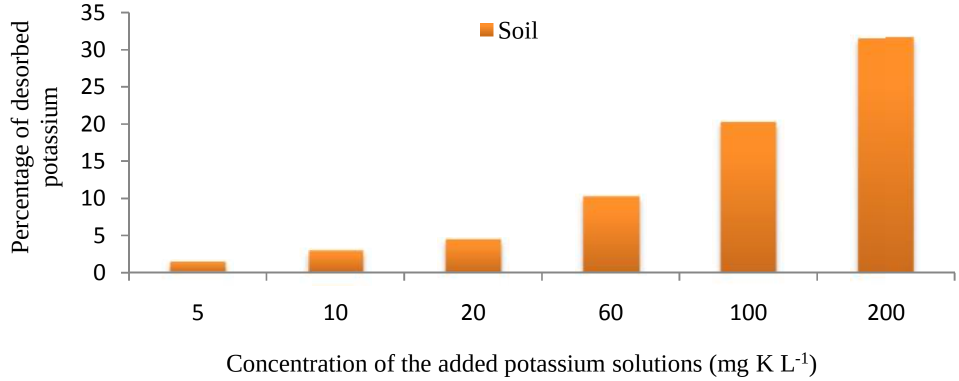

FIGURE 2. Percentage of desorbed potassium in (soil) treatment

Figure 3 shows the percentage of the desorbed potassium at the different concentrations of the added potassium to (soil +charcoal- 0.5 mm) treatment where the lowest desorbed rate of potassium was 2.19% at 5 mg K L^{-1} concentration and percentage of the desorbed potassium with increasing potassium concentrations. The highest percentage of the potassium desorbed was 46.07% at of 200 mg K L^{-1} concentration.
Figure 4 shows (soil +charcoal 1 mm) treatment results in which the lowest desorbed rate of potassium was 4.30% at 5 mg K L^{-1} concentration. Increased The concentrations added potassium increased potassium desorbed rate which was at 200 mg K L^{-1} concentration 49.12 %. This may be due to the saturation of the adsorption sites and free radicals on the surface of the charcoal. Therefore, increasing the concentration of the added potassium increases its concentration in the equilibrium solution to increase the desorption percentage in extraction (Downie et al., 2009 and Sohi et al., 2010).

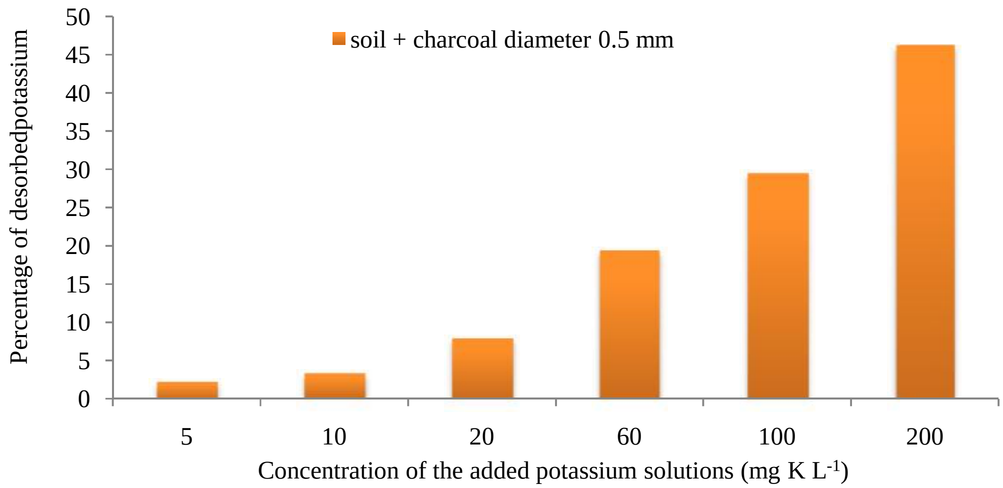

FIGURE 3. Percentage of desorbed potassium in (soil +charcoal diameter 0.5 mm) treatment

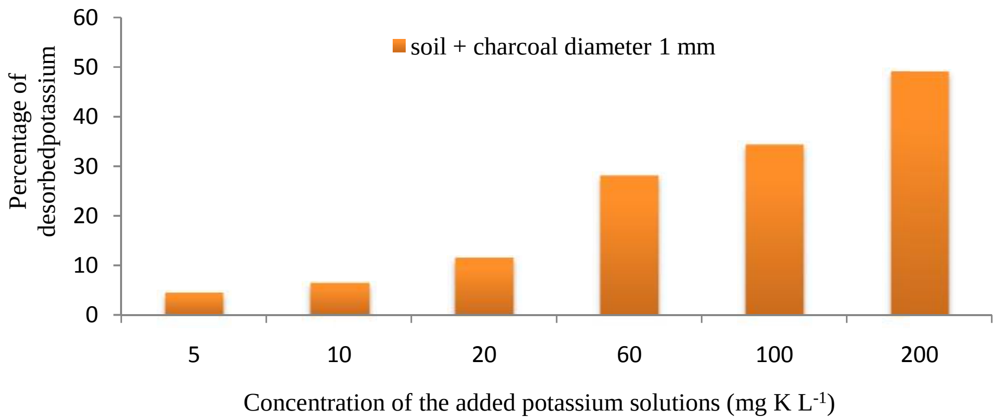

FIGURE 4. Percentage of desorbed potassium in (soil +charcoal diameter 1mm) treatment

REFERENCES

Abdul Hannan, A.M., Rahmatullah, R., Waqas, M. and Niaz, A. (2007) Potassium adsorption characteristics of four different textured alkaline calcareous.

Al – Zubaidi, A.H. (2003) Potassium status in Iraqi soils: Potassium and water management in West Asia and North Africa. The National Center for Agricultural research and Technology Transfer, Amman, Jordan. 129-142.

Amonette, J. E. and Joseph, S. (2009) Characteristics of biochar: microchemical properties. Chapter 3. In J.Lehmann, & S. Joseph (Eds.), Biochar for environmental management science and technology (pp. 33-52).

Bangroo, S.A., Wani. M.A. and Malik, M.A. (2012) Potassium adsorption characteristics of soils under long term maize – legume cropping sequence. African Journal of Agricultural Research. 7(48):6507 – 6507.

Brady, C.N. (1992) The Nature and Properties of Soil. New York: Macmillan Pub. Co.

Chintala, R., Mollinedo, J., Schumacher, T.E., Malo, D.D., Papiernik, S., Clay, D.E. and Gulbrandson, D.W. (2013) Nitrate sorption and desorption by biochars produced from microwave pyrolysis. Microporous and Mesoporous Materials, 179, 250-257.

Demirbas, A. (2004) Effects of temperature and particle size on bio-char yield from pyrolysis of agricultural residues. Journal of Analytical and Applied Pyrolysis 72(2): 243-248.

Downie, A., Crosky, A. and Munroe, P. (2009) Physical properties of biochar. In J. Lehmann & S. Joseph (Eds.), *Biochar for Environmental Management: Science and Technology* (pp. 13-32). United Kingdom: Earthscan.

Downie, A., Crosky, A. and Munroe, P. (2009) Physical properties of biochar. In J. Lehmann & S. Joseph (Eds.), Biochar for Environmental Management: Science and Technology (pp. 13-32).

Goulding, K.W.T. (1987) Potassium fixation and release. Proceedings of the colloquium of international Potash Institute 10:131-136.

Gundale, M.J. and DeLuca, T.H. (2007) Charcoal effects on soil solution chemistry and growth of *Koeleria macrantha* in the ponderosa pine/Douglas-fir cosystem. Biology Fertilizer of Soils, 43, 303-311.

Harris, P.J.F. (1997) Structure of non-graphitizing carbons. International Materials Reviews.42 (5): 206-218.

Krull, E. (2009) Stabilisation of organic carbon in soil through biochar production. In: An analysis of greenhouse gas mitigation and carbon sequestration opportunities from rural land use, CSIRO National Research Flagships: Sustainable Agriculture.

Lehmann, J., Gaunt, J. and Rondon, M. (2006) Bio-char sequestration in terrestrial ecosystems- A review. Mitigation and Adaptation Strategies for Global Change 11(2): 403-427.

Liang, B., Lehmann, J., Solomon, D., Kinyangi, J., Grossman, J., O'Neill, B. and Neves, E.G. (2006) Black carbon increases cation exchange capacity in soils. Soil Science Society of America Journal, 70: 1719-30.

Mengel, K. and Uhlenbecker, K. (1993) Determination of available nterlayer potassium and its uptake by ryegrass. Soil Sci. Soc. Am. J. 11:206-225.

Nair, A., Kruse, R.A., Tillman, J.L. and Lawson, V. (2013) Biochar Application in Potato Production. Iowa State Research Farm Progress Reports, pp: 20-27.

Pal, Y., Wong, M.T.F. and Gilkes, R.I. (1999) The forms of potassium and Potassium adsorption in some virgin soils from South-Western Australia. Aust. J. Soil Res. 37:695-709.

Preston, C.M. and Schmidt, M.W.I. (2006) Black (pyrogenic) carbon: a synthesis of current knowledge and uncertainties with special consideration of boreal regions. Biogeosciences, 3, 397-420.

Salman, A.H. (2015) The Interaction effect of the Mycuraiza, covering soil and coal in the growth and yield of tomato and its relationship with some physiological and biochemical changes. PhD thesis, College of Agriculture. Baghdad University.

Sama, M. (2009) Production and characterization of activated carbon from cotton stalks and their application on adsorption of some dyes and phenols from aqueous solutions. Faculty of sciences, Aleppo University.

Schmidt, M.W.I. and Noack, A.G. (2000) Black carbon in soils and sediments: analysis, distribution, implications and current challenges. Global Biogeochemical Cycles, 14, 777-793.

Sohi, S.P., Krull, E., Lopez-Capel, E. and Bol, R. (2010) Chapter 2-A review of biochar and its use and function in soil. Advances in Agronomy, 105, 47-82.

Sohi, S.P., Krull, E., Lopez-Capel, E. and Bol. R. (2010) Chapter 2- A review of biochar and its use and function in soil. Advances in Agronomy, 105, 47-82.

Stanley, E.M. (2005) Environmental chemistry. International Standard Book, CRC Press, New York, U.S.A.

Van Zwieten, L., Singh, B., Joseph, S., Kimber, S., Cowie, A. and Chan, K.Y. (2009) Biochar and Emissions of Non-CO2 Greenhouse Gases from Soil. In: Biochar for Environmental Management: Science and Technology.

Warnock, D.D., Lehmann, J., Kuyper, T.W. and Rillig, M. C. (2007) Mycorrhizal responses to biochar in soil-concepts and mechanisms.Plant and Soil, 300, 9-20.

Winsley, P. (2007) Biochar and Bionenergy Production for Climate Change New Zealand Science Review 64 (1): 1-10.

Yuan, J.H., Xu, R.K., Zhang, H. (2011) The forms of alkalis in the biochar produced from crop residues at different temperatures. Biores Technol. 102:3488–97.