Article

Diatomite and re-use coal waste as promising alternative for fertilizer to environmental improvement

Mohammad Hassan Sayyari-Zahan[1], **AbdolHamid Gholami**[2], **Somayeh Rezaeepour**[2]
[1]Assistant Prof, Department of Soil Science, Faculty of Agriculture, University of Birjand, Birjand, Iran
[2]Department of Soil Science, Faculty of Agriculture, University of Birjand, Birjand, Iran
E-mail: msayari@birjand.ac.ir, mh.sayyar@gmail.com

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Abstract
Application of conventional fertilizers has been contributing much pollutant to the environment. This study aimed to assess the potential of diatomite and re-use coal waste as a non chemical fertilizer to environmental improvement. The experiments were evaluated in 2kg pots under greenhouse conditions at 4 levels of diatomite powder including 0, 10, 20, 40 g/kg soil as well as 5 levels of coal waste powder including 0, 20, 40, 80, 160 g/kg soil based on completely randomized design with three replications. Treatments of diatomite and coal waste were mixed well and kept under field capacity moisture for 4 months. The results showed that the effects of diatomite and coal were significant on EC, K and P concentrations in soil while the coal waste showed more influenced on decreasing of soil pH. Adding diatomite up to 40 g/kg in soil increased EC, K and P viz. 2.92, 1.19 and 1.54 times respectively compared to control sample. Using of 160g/kg of coal in soil increased EC (2.89 times) and decrease pH (1.06 times) which had led to increased availability of trace elements that enhance plant growth. The highest bio-available concentrations of K and P in soil obtained at 80 and 40 g/kg of diatomite and coal waste respectively. This study demonstrates that a good fertilizer can be produced by using diatomite and coal waste; however, further research is required.

Keywords diatomite; coal waste; phosphorus; potassium; EC; pH.

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1 Introduction

Agricultural activities related to fertilizers have been contributing many toxic contaminants to the environment, which mostly consist of organic and in organic compounds, posing serious risks to water, air and soil sources as well as health of society (Sayadi and Rezaei, 2014, Sayyed and Sayadi, 2011). Using of chemical fertilizer and the discharge of their waste into the environment (soil, water, and air) has become a critical problem in many countries including Iran. The environmental pollution due to using chemical fertilizer is a condition of global concern with regards to its implications on plants, animals, and human health (Bindu et al., 2009).

Application of non chemical fertilizer has provided high quality products free of harmful agrochemicals for human safety (Sayadi and Torabi, 2009).

Several studies have been done on the effect of different non chemical fertilizer on soil physico-chemical properties to improve environmental quality. Disposal of coal mine waste is a costly problem for solid waste management. Coal is a sedimentary rock and combustible and it is generally including the elements of carbon, hydrogen, nitrogen, sulfur. Major applications of coal used as a fuel. This matter is important due to major mines and availability of sedimentary rock in Iran. Up to now a few studies were done on the various uses of coal in soil science. The researchers found that the use of coal has great effect on reducing the problems of smectite clays in the soil. Major impacts of coal waste are commonly related with changes in soil chemistry, including pH and concentrations of elements (soil fertility) and also can improve soil structure and water-holding capacity (Carlson and Adriano, 1993). However, Van der Burg et al. (2012) has been reported the negative effect of coal on the stability and soil fertility.

Diatomite has high porosity, high permeability, small particle-size, large surface area, low thermal conductivity, for this that makes it suitable for a wide range of industrial applications (Inglethorpe 1993). Typical chemical analyses of pure diatomites generally contain 70-80% silica (SiO_2), porosity 85%, bulk density 0.2-0.4 g/cm^3, and contain other elements like TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5. Diatomite is a modifier material which used in the making of nitrogen fertilizers for agriculture. Physical characteristics of pure diatomite are similar chalk and usually white to gray. Particle size of diatomite varies from 5 to 1000 µm, but the dominant size is between 50 to 100 µm. Abdalla (2011) reported that using of different diatomite application 0, 1.5, 3 and 4.5 g/kg soil, reduced the negative effects of salinity on two varieties of clover. Karatepe et al. (2004) by examining of factorial design studied the effect of diatomite and modified diatomite on lead available in soil and reported that manganese diatomite compared to crude diatomite had more effective on decreasing of lead concentration and increasing of soil pH as well. Therefore, in the present study, an attempt is made to assess the potential of diatomite and re-use coal waste as a non chemical fertilizer to environmental improvement.

2 Material and Methods

In order to study the effect of diatomite and coal waste on some chemical properties of soil, an experiment was conducted in a completely randomized design with 3 replications in the greenhouse of the Faculty of Agriculture, University of Birjand in 2013. Treatments of diatomite including control (D_0), 10 (D_{10}), 20 (D_{20}) and 40 (D_{40}) g/kg soil and amounts of coal waste were used control (C_0), 20 (C_{20}), 40 (C_{40}), 80 (C_{80}) and 160 (C_{160}) g/kg soil. Powder of coal and diatomite well mixed with the soil and transferred to the pots. The soils have been incubated for 4 months under field capacity moisture condition then transferred to the laboratory for testing. In this study, some chemical properties of soil were measured such as changes in pH, EC (dS/m), P and K available of soil. To measure the pH, EC, the soil paste was prepared and then was measured by using a pH meter devices and EC meter. Olson method was used to measure the amount of available P of soil samples by spectrophotometer and for soil available K was used method of ammonium acetate and was analyzed flame photometer. Results were analyzed using SAS 9.1.3 for comparison protected LSD test at a significance level of 1%.

3 Results and Discussion

Analysis of variance showed a significant effect of the use of coal and diatomite ($P<0.01$) on changes in soil EC (Table 1).

Table 1 Variance analysis of different treatments of Coal and Diatomite on EC, pH, K and P in soil.

Effect	Df	Coal (g/kg soil)				Df	Diatomite (g/kg soil)			
		EC dS/m	pH	K ppm	P ppm		EC dS/m	pH	K ppm	P ppm
Treatment	4	1.42 **	0.11 **	824.19 **	5.28 **	3	1.70 **	0.04 ns	999.39 **	11.6 **
Residual	10	1.012	0.003	49.24	0.58	8	0.005	0.011	15.89	0.255
CV (%)		6.45	0.68	3.94	7.52		3.96	1.32	2.18	4.65

ns,*,**: non-significant and significant at 5% and 1% probability level respectively.

Increasing of coal to the soil caused rising of soil EC significantly compare to control so that the least amount of EC observed in control (0.9 dS/m) and the maximum of it in adding 8%wt coal (2.60 dS/m). At the levels of 2, 4, 8 and 16 %wt coal, EC of soil had increase 1.42, 1.89, 2.89 and 2.48 times compared to the control respectively (Fig. 1). Based on the results to achieve and optimize the use of coal as a cheap and convenient way to adjust the salinity of soils in arid and semi arid areas, because the salinity problem faced mainly in these areas. Adding of coal up to 8% wt increased salinity of soil from 0.9 to 2.89 dS/m and if the amount of coal (8%wt) was calculated for the weight of one hectare of soil, (by assuming soil depth: 15 cm, bulk density:1.4 g/cm^3 and area of 1 ha: 10000m^2, so 1 ha= 2,100,000 kg soil) so it is equal to around 160 ton/ha, therefore by adding of high amount of coal rising rate of salinity is low and it has positive effect on physico-chemical characteristics of soil.

The results of the mean comparison showed that the lowest EC observed in the control (0.9 dS/m) and the highest of it was obtained in 4% wt of diatomite (2.63 dS/m). Adding of diatomite 1, 2, 4 g/kg soil caused increase in electrical conductivity of soil (ECe) as mentioned 1.46, 2.18 and 2.92 times compared with the control respectively (Fig. 2).

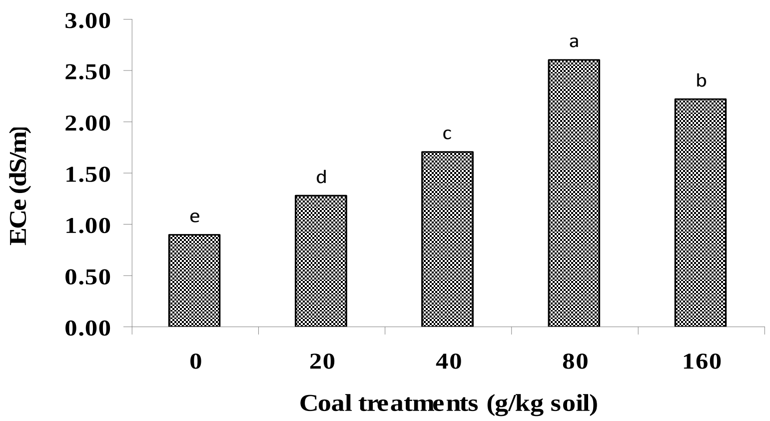

Fig. 1 The effect of coal treatment on ECe of soil (small letters indicated significant difference).

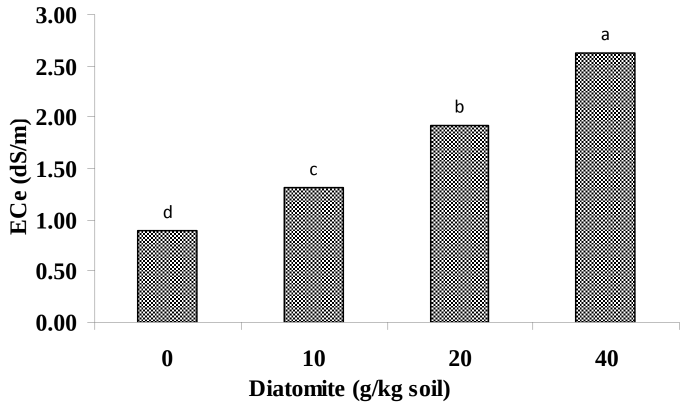

Fig. 2 The effect of diatomite treatment on ECe of soil (small letters indicated significant difference).

Based on the analysis of variance, using different levels of coal had significant effect ($P<0.01$) on soil acidity but diatomite effect was not significant on soil pH (Table 1).

The results showed that low levels of coal (0, 2 and 4 wt%) had no significant effect on soil pH, but the higher amounts (8 and 16% wt) was significantly reduced soil pH (Fig. 3). Soil pH in treatments of D_8 and D_{16} had decrease of 4.56 and 5.20% respectively compared to control. This decline in soil pH may be due to a combination of elemental sulfur in the coal. Since soil pHs is a major factor in the solubility and availability of plant nutrients (Koocheki and Sarmadnya, 1998) and often of nutrients is available at a pH of between 6-7 (Truog, 1961). Heidari zadeh et al. (2013) reported that low acidity of coal dissolved is a useful of its chemical properties and this factor is important to amendment of saline-sodic soil and probably low pH in solution environment of the given coal in soil caused by soluble sulfate anion. These results to accord with the studies of Rahimi et al. (2008), they studied the effects of coal mining on water pH and showed that coal mining caused a sharp decrease in the pH of water around environment. But Codling et al. (1997) revealed that use of coal combustion products is useful for amendment of acid soils and found that this type of matters have positive effect on increasing soil acidity. Results showed that diatomite application had no effect on soil acidity.

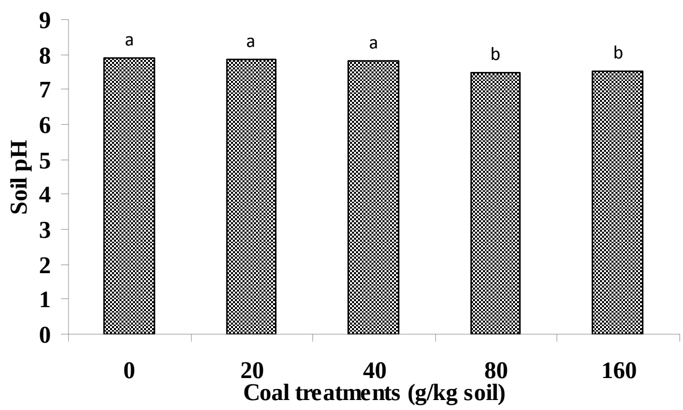

Fig. 3 The effect of coal treatment on soil pH (small letters indicated significant difference).

Adding coal and diatomite caused in the changing of soil available phosphorus and potassium and these changes were significant (P<0.01, Table 1). The results of the compare means showed that maximum available K was observed in the treatment D_8 (203.44 mg/ kg soil) and minimum of it in D_{16} (160.62 mg/kg soil) (Fig. 4). Heidarizadeh et al. (2013) by using of 0, 5, 10, 20 and 50 tons waste coal dust per hectare stated that the maximum amount of potassium obtained in application of 50 ton/ha in sandy soil and application of 5 ton/ha in clay soil. According to the results (Fig. 5), it could be expressed that the highest available K (208.34 mg/kg soil) obtained when was added 4% wt diatomite and lowest of it in 1 %wt (165.69 mg/kg soil).

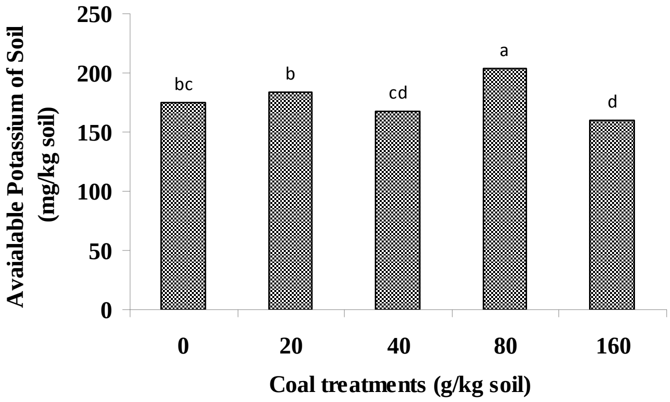

Fig. 4 The effect of coal treatment on available K in soil (small letters indicated significant difference).

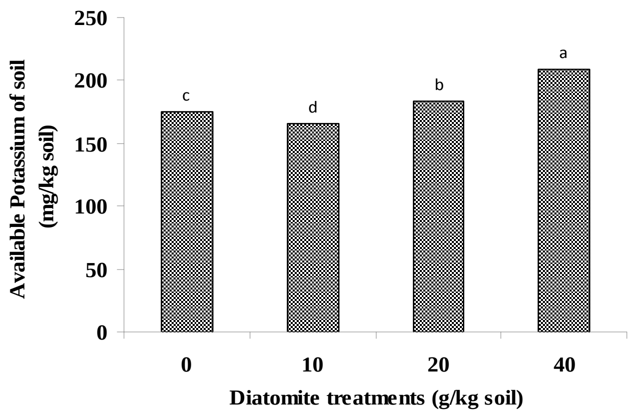

Fig. 5 The effect of diatomite treatments on available K in soil (small letters indicated significant difference).

Comparing of the effect of different treatments of coal on available P of soil showed that maximum of P (11.89 mg/kg soil) observed in 4 %wt coal and minimum of P in the control (8.2 mg/kg soil) (Fig. 6). Heidari zadeh et al. (2013) was reported the maximum of available P observed in 20 tons waste coal per hectare in light and heavy soils. Results revealed that by increasing of diatomite increase soil P concentration of soil and with application of 10, 20 and 40 g/kg soil, soil P concentrations increased 1.30, 1.47 and 1.54 times more compared to the control. The highest P concentration (12.61 mg/kg) was obtained in 4%wt of diatomite. There was no significant relationship between 2%wt and P concentration in soil and lowest of P concentration observed in the control (8.2 mg/kg soil) (Fig. 7).

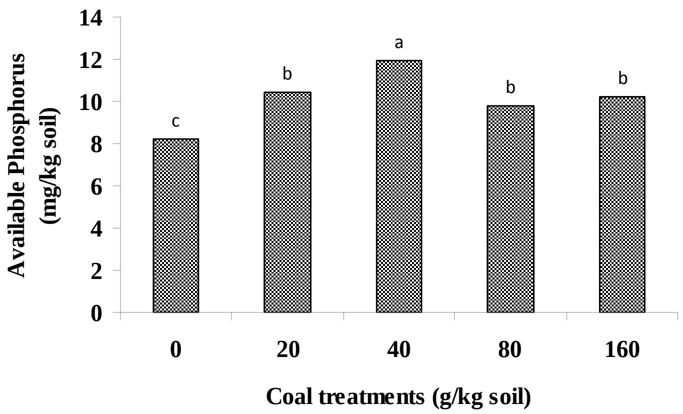

Fig. 6 The effect of coal treatment on available P in soil (small letters indicated significant difference).

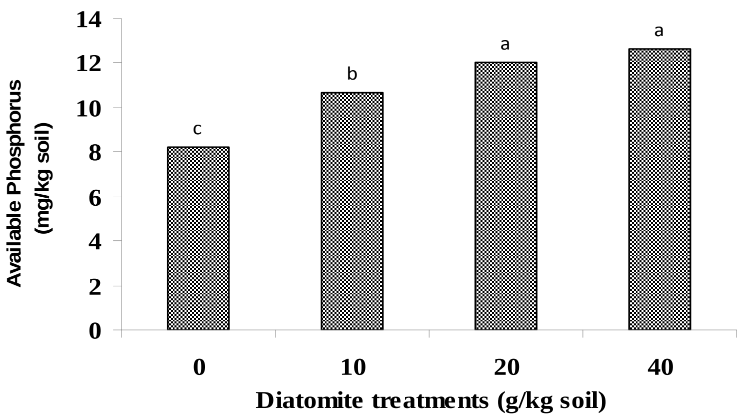

Fig. 7 The effect of coal treatment on available K in soil (small letters indicated significant difference).

4 Conclusion

Anthropogenic activities such as agricultural practises related to fertilizers are treating the environment by releasing many pollutants to air, water and soil. The environmental pollution due to using chemical fertilizer is a condition of global concern regarding environmental health. Application of non chemical fertilizer has provided high quality products free of harmful agrochemicals for human safety. Re-use of coal waste and diatomite showed increasing availability of P and K in soil and decreasing of soil pH by adding of coal as well which had led to increased availability of trace elements that enhance plant growth. This study demonstrates that a good fertilizer can be produced by using diatomite and coal waste; however, further research is required.

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