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RESEARCH ARTICAL

Effect Of Fly Ash On Morpho-Physiological Properties Of Soil And *Vigna Mungo* L.

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Abstract

Study was conducted on the effect of fly ash on the morpho-physiological characteristics of soil and *Vigna mungo* L. Results obtained reveals that the increasing proportion of fly ash in soil considerably increases the value and characteristics. Effect of these changes show positive changes on germination, plant length (like root length, shoot length), nodulation (like number of nodules, weight of nodules), and grain yield per plant of *Vigna mungo* L. All these were found to be favourably affected by fly ash induced changes in soil characters. Hence through the present study we can conclude that fly ash in moderate percentage can be a boon for sustainable agriculture.

Keywords : Seeds, Nodulations, pH, Soil, Vigna Mungo

Introduction

Leguminous plants are well known for their utility to humanity. They have a special interest because of their economic and ecological importance. Legumes have been domesticated for the production of food, fuel, feed, forage, fibres, flowers industrial and medicinal compounds, etc. They play a unique role in agriculture worldwide due to their ability to fix atmospheric nitrogen (N_2), and their high protein contents (Messina, 1999). Grain legumes are common food throughout the world. The genus *Vigna* comprises of ~150 species, of which *Vigna mungo* L. or black gram is one of the most important food legume species. It has been reported to be originated in India with a secondary centre of origin in central Asia (Pratap and Kumar, 2011).

Soil is a thin layer of earth's crust and is a living media, which is one of the significant factor of crop production and serves as a natural nutrient source for the plant growth. The mechanism of the soils are mineral material, organic inorganic matter, water and air, the magnitude of which vary and which together form an arrangement for plant growth. Protection of the soil health is essential to make certain physical, chemical and biological activities for supporting higher crop productivity (Singh *et al.* 2015).

Intensive agriculture and decreasing inputs of organic materials have led to severe degradation of soil fertility and productivity which can be replenished to some extent by application of coal ash (Swain *et al.* 2014).

Coal ash is one of the major solid waste products and also a environmental pollutant comes out from brick kiln and thermal power plant etc. Basically, coal ash is a heterogeneous mixture of amorphous and crystalline phases and is generally considered to be a ferro-aluminosilicate element characteristically high in potassium, sodium, calcium, magnesium and sulphur content (Dwivedi and Jain 2014).

Sheoranl *et al.* (2015) found that the beneficial effect of fly ash on improvement of soil texture in respect of physico-chemical parameters, nutritional status and microbial population may be due to the cumulative effect of improvement in individual Physico-chemical characteristics. They suggest that due to the presence of Ca and Si minerals, having pozzolanic properties its addition to soil likely to improve physical properties. The fly ash brings improvement in various Physico-chemical properties such as Bulk Density, porosity, Water Holding Capacity, and hydraulic conductivity etc. of the soil.

The present investigation on the effect of coal fly ash in agriculture field of *Vigna mungo* L. were under taken with a view to develop data from field experiments on the beneficial/adverse effects of fly ash with special emphasis on changes in physico-chemical properties of soil and *Vigna mungo* L.

Material And Methods

The present investigation was conducted to find out the "Effect of fly ash on Physio-chemical properties of soil and *Vigna mungo* L.". The details of material used for experimental purposes and techniques adopted in the present investigation are described as follow.

Geographical Situation

The Meerut district is situated between 29^0 01N latitude and 77^0 45E longitude at an altitude of 237 meters above sea level. The university is situated at the distance of about 10km from Meerut city railway station and near about 12km on Delhi-Dehradun highway. The total geographical area of Meerut district is 2564 km^2. The district falls under western plain zone of Utter Pradesh, sub region of upper Gangetic plain.

Experimental site

The field experiments was conducted during

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Figure: A *Vigna mungo* L. (Control)

Figure: B *Vigna mungo* L. (Treatment-I)

Figure C: *Vigna mungo* L. (Treatment-II)

Figure D: *Vigna mungo* L. (Treatment-III).

the kharif season in the month of March to June in 2016 -2017 to evaluate the response of Fly ash on the Physio -Chemical property of soil and growth and yield of *Vigna mungo* L. The seeds of *Vigna mungo* L. were grown in the field of Botany department, C.C.S. University Meerut. The experiment designed in four plots of equal size (1×1meter), three plots for the treatment and one plot for the control. Three samples of different amount of fly ash were prepared such as 25g, 50g, and 100g. First plot is designed for control, second plot was treated with 25g, third plot was treated 50g and fourth plot was treated 100g of Fly ash.

In the experimental work, 1kg soil taken from each plot and such as 25g, 50g and 100g is mixed evenly, and then it distributed in each of the plot uniformly except in the control before sowing of *Vigna mungo* L. seeds. Fly ashes of different amount were mixed with soil as following:

25g X 1kg
50g X 1kg
100g X 1kg

Treat the soil with Fly ash according to the above method. Then treated soil with Fly ash is spread in each of three plots, and then mixed soil is uniformly distributed in the three plots.

Material used

Pure seeds of *Vigna mungo* L. were collected from IARI, New Delhi.

Fly ash was collected from the fields near brick kiln at Hastinapur Meerut, U.P. INDIA.

Other Details (Experimental Details)

Total no. of block – 4
Control - 1
Total no. Of treated plots – 3
Plot size (area of plot) – 1X1 meter.

Forty healthy seeds of *Vigna mungo* L. were sown in every plot. All plots were irrigated with tap water. The seed germination percentage was calculated after counting the difference between germinated (coming out of soil) and non-germinated seeds (remaining inside, non emergent).

Measurement of particle density (Dp) of soil

Particle density of soil was measured by Blake *et al* (1986) method. The Particle density of a soil is referred to the mass of a unit volume of soil particles (Soil solids). It is determined by measuring the mass and volume of soil solids. When a known mass of dry soil is immersed in water and air is expelled out, the amount of displaced water is equals to the volume of soil particles (Piper, 1966).

For the measuring of particle density of soil, weigh empty pycnometer with stopper and fill the dry pycnometer with water. Then wipe outer side of the pycnometer with a piece 0f filter paper and weigh it and then pour out water and dry it from outside with a piece of filter paper. Now put 10 g of oven-dry soil into the

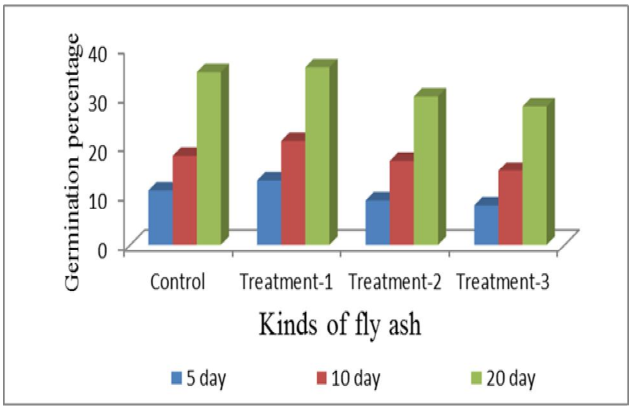

Figure 1: Effect of fly ash on germination percentage of *Vigna mungo* L.

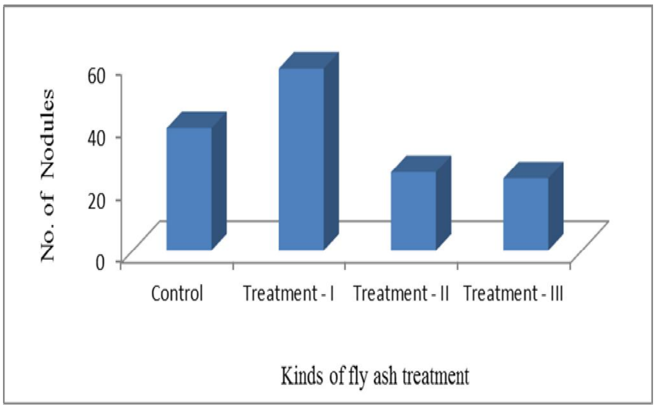

Figure 2.1: Effect of fly ash on number of nodule of *Vigna mungo* (L).

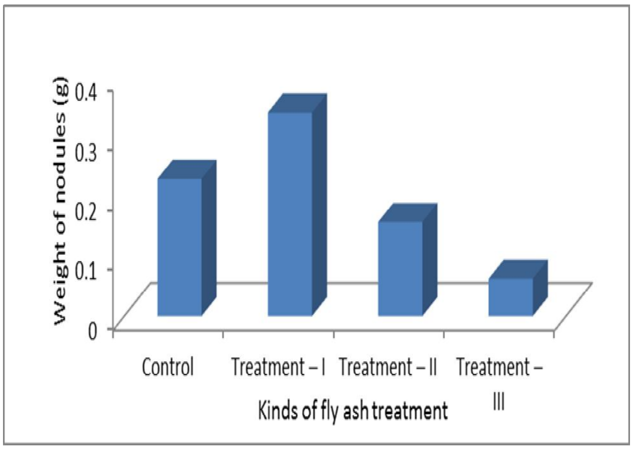

Figure 2.2: Effect of fly ash on weight of nodule of *Vigna mungo* L.

pycnometer and fill the pycnometer to about half with water using the wash bottle and wash with a jet of water and any particle sticking to the inner side of the neck. Expel the entrapped air by gently shaking the contents. Fill the pycnometer to the mark with water from the wash bottle. Fix the stopper well and clean the outer side of the pycnometer with a filter paper and weigh it.

Calculation

Weight of water displaced by soil

i.e. volume of Soil solids= $(W_2 + 10) - W_3$

$$\text{Particle density } (Mg\ M^{-3}) = \frac{10}{(W_2 + 10) - W_3}$$

Measurement of bulk density (Db) of soil

The bulk density of soil was measured by Liebig *et al* (2010) method; dry soil bulk density is defined as the ratio of mass of oven dry soil to its bulk volume and is expressed as g cm-3 or Mgm-3. The bulk volume is the volume of soil particles plus pore space. The mass of the oven-dry soil which fills the container of a known volume is determined by weighting. The volume of the packed soil will be equal to the capacity of the container. Bulk density is then calculated as the ratio of mass of soil to its volume. For the measuring of the particle density of soil, weigh an empty bottle of 100 ml capacity without stopper now fill this bottle with soil up to the mark and tap it 15-20 times by letting it fall gently on the table from a height of approximately 2.5 cm each time. Weigh the bottle with soil. Empty the bottle and write down its volume in 100 ml. (Tapping is assumed to produce the same state of packing as occurring naturally in the field. However, this assumption is not strictly correct) (Piper, 1966).

Calculation:

Weight of soil = W_2-W_1

$$\text{Volume of soil V} = \frac{\text{Needed water to fill the bottle (ml)}}{(W_2 \quad W_1)}$$

$$\text{Bulk density } (MgM^{-3}) = \frac{(W_2 - W_1)}{V}$$

Measurement of porosity of soil

The porosity of soil was measured by Nimmo (2004) method; porosity of a soil sample is it's that volume which is occupied by air and water or it is also defined as the fraction of soil volume not occupied by soil particles.

To determine the soil bulk density (Db) particle density (Dp) and calculate the total porosity by using formula of % pore space (Piper, 1966).

Formula used for calculation-

Bulk density of a soil = (Db) = ________Mgm-³

Particle density of a soil = (Dp) = ________Mgm-³

$$\text{Percent pore space} = 100 \times \frac{(Db \times 100)}{Dp}$$

Results And Discussion

Germination Percentage

`It was noticed that applications of fly ash increase the germination percentage of seeds in treatment-I as compared to control and treatment-II and treatment-III. Similar results were also reported by Aggarawal, *et al.* (2004), that seed germination percentage in fly ash amended soil was recorded better than unammended soil. This could be due to improvement in soil properties. Fly ash amended soil enhance water holding capacity and aeration resulting with higher germination percentage (Fig.1).

Nodulation

Maximum no. of nodules were found in the case of treatment–I and minimum in treatment-III as compared to control. Beside number, the weight of nodules was also got affected by the treatment. Maximum weight of nodule was found in the treatment-I and minimum in treatment-III. Application of coal ash at 25%

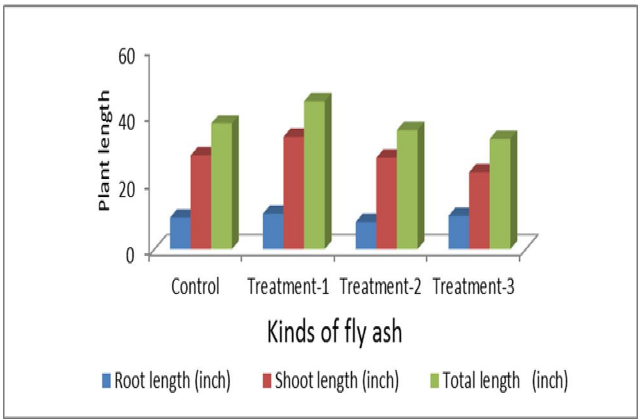

Figure 3: Effect of fly ash on total length of plant *Vigna mungo* L.

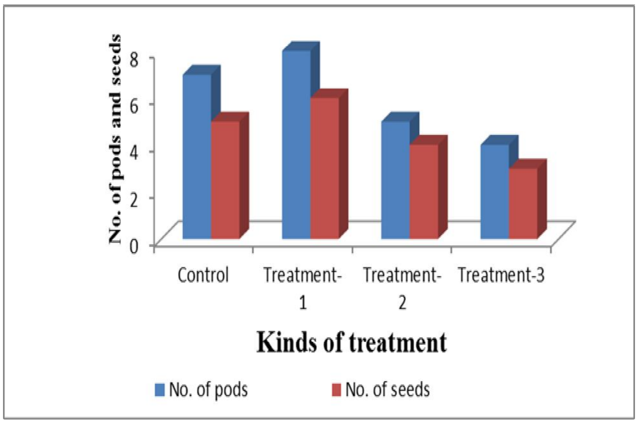

Figure 4: Effect of fly ash on Number of seeds and pods of plant *Vigna mungo* L.

caused a significant increase in nodule number functional nodules and dry weight of the nodules. Increased nodulation at 25% coal ash content may be attributed to the uptake of optimum amount of metals by the plants. Increased nodulation probably enhances the site of root infection for *Rhizobium* hence leads to higher rate of biological nitrogen fixation (Singh, 1996). The symbiotic activity was reduced with increasing dose of coal ash as evidenced by less number of nodules in comparison to that of control. The ability of *Rhizobium* species to fix nitrogen is reduced with increasing stress as also reported by Lal and Khanna (1994). Better nodulation at 25% coal ash content is observed because of availability of micronutrients for various physiological processes. So, coal ash is preferred in low concentration for the productivity of the plant (Fig.2.1 and 2.2).

Plant length

The plant is a measure of length of its roots and shoots. Maximum root and shoot length was measured in case of treatment – I and minimum root and shoot length was measured in treatment – II & treatment – III of fly ash respectively . Singh *et al.* (1997) also reported the stimulation in plant growth at lower applications of FA to the soil. This clearly indicates the easy availability of certain essential elements, like Ca, Mg, K, Mn, Mo, Zn, S, etc., present in the fly ash to plants, which not only enhanced seed germination but also stimulated the seedling growth at subsequent stage. Khan (2001) also reported that 25% application of fly ash increase plant length, number of branches and flowers of cosmos plant, whereas higher percentage of fly ash reduce them significantly (Fig.3)

Number of Pods and Seeds

Maximum number of pods and seeds were observed in treatment-I while minimum number of pods and seeds were observed in case of treatment-III plants with fly ash. Same results were also reported by Carlson and Adirano, (1991). Enhancement may be because fly ash contains sufficient concentration of micro and macronutrients like calcium, iron, manganese, boron, nitrogen, phosphorous and potassium which can be better utilised by plants, and can boost up to production. These micro and macro nutrients may be responsible for increased number of pods per plants and number of seeds in per pod (Fig.4).

pH

Maximum pH of soil was analysed in the case of treatment-III as compared to control and other treatments. Minimum pH of soil was observed in the control. Nature of fly ash as acidic or alkaline is based on the source of coal, used to buffer the soil pH (Phung *et al.* (1979). A number of earlier studies have shown that addition of alkaline ash can increase the pH of acidic soil (Plank et al. 1975). The electrical conductivity of soil increases with fly ash application and so does that the metal content. Lime in fly ash readily reacts with acidic component in soil and release nutrients like S, B and Mo in forms and amount beneficial to crop plants (Fig.5).

Bulk Density

Maximum bulk density of soil was analysed in the control as compared to all treatments, and it was minimum observed in treatment-III of fly ash. These results have supports from observations of others also as those of Page *et al.* (1979). Decrease in bulk density help in improving the porosity and better workability and enhancing water retention capacity (Fig.6).

Particle Density

After particle density analysis it, was found lowest particle density of soil was found in the soil with treatment–III of fly ash. Amendment with fly ash at various ratios increased the pH, the particle density, porosity and water holding capacity in comparison to controls. This amendment also decreased bulk density in the amended soil as compared to non-amended soil. Same such results are also reported by Pandey *et al.* (2009) (Fig.7).

Porosity of soil

Adverse effects of fly ash on soil porosity as also reported earlier by Sinha *et al.* (2013) were seen i.e. fly ash decreases porosity this in term is known to increases the water holding capacity. This would ultimately be facilitating the absorption of nutrients as well as photosynthetic activity of plants.

Conclusion

After analysing all the results of experiment it was concluded that application of fly ash to a certain limit results in an increase of available macronutrients and micronutrient of the soil. Fly ash acts as an excel-

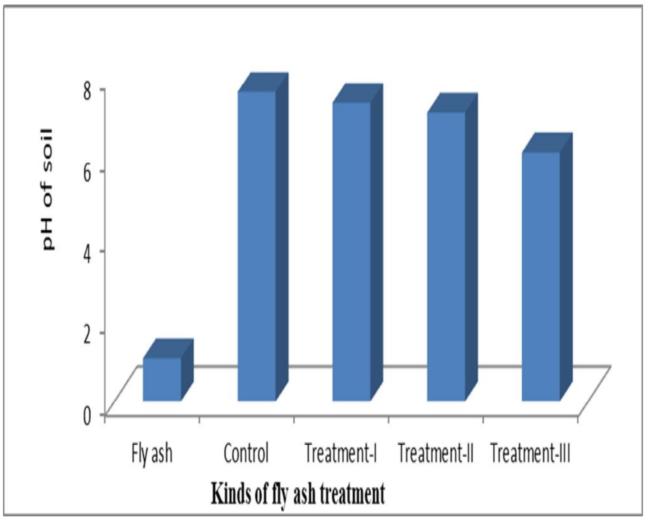

Figure 5: Effect of fly ash on pH content of *Vigna mungo* (L.).

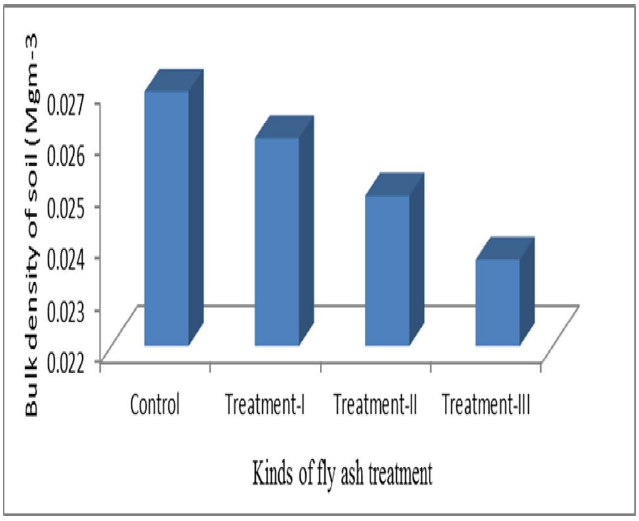

Figure 6: Effect of fly ash on Bulk density of soil.

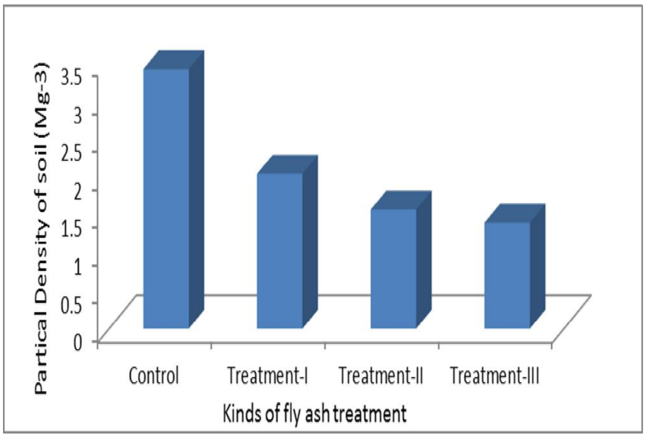

Figure 7: Effect of fly ash on particle density of soil.

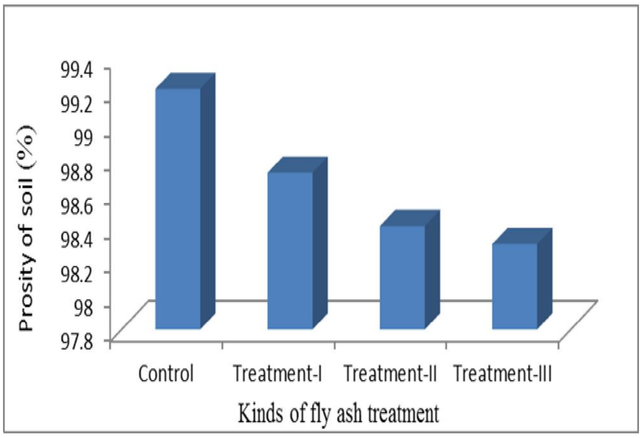

Figure 8: Effect of fly ash on porosity of soil.

lent soil modifier and conditioner a very good liming agent, and a source of essential plant nutrients for appreciably improving the texture and fertility of the soil with significant increases in crop yield over the control. Fly ash in low concentration may serve as an opportunity to be used as an eco-friendly non-conventional fertilizer. At the same time it will be safe and eco-friendly disposal option for huge amount of fly ash. However, there is a need of detail study to declare fly ash totally safe and eco-friendly to be used as for fertilizer.

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