INFLUENCE OF FLY ASH INCORPORATION ON SOIL PROPERTIES AND PRODUCTIVITY OF CROPS: REVIEW

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Abstract : Fly ash (FA) is the byproduct of the coal combustion. There are several industries which depend upon coal as raw material for the production of electricity. The waste which is produce consists of major portion of FA. In today's scenario FA is one of the growing solid waste of the industrial sector which need a safe disposal due to its environmental constrains. FA plays a significant role in agriculture, because it has unique physical and chemical properties. It contains almost all the essential nutrients which are beneficial for plant growth and development. In the sector of agriculture, for buffering of the soil pH particular amendment is used which is known as fly ash. Fly ash is the residual component of thermal power plants and it remains stored in ash ponds where it leads to undesirable environment. In recent scenario the main objective is to make use of the fly ash in the agriculture sector and to find out its effect on the health of the soil. This investigation should be beneficial for various health organizations in mitigating the contamination which results from solid waste contamination.

Keywords: Crop growth, crop yield, fly ash, waste management and environment.

1. INTRODUCTION

Fly ash is a fine grey powder, produced by combusting coal in thermal power station. Coal combustion by-products (CCPs) such as boiler slag, fly ash, bottom ash, Flue Gas Desulphurization (FGD), gypsum and other type of materials such as fluidized bed combustion ash, cansopheres and scrubber residues are produced in thermal power plants for generation of electricity when combustion of bituminous and sub-bituminous coal, lignite is carried out (Vom Berg., 1998). India annually produces 235 million tons (2013) of fly ash which is projected to exceed 1000 million tons by 2031-32(Kumar and Jha, 2014).Characteristics and properties offly ash vary depending onthe condition of combustion, type of collector setup, boiler type, andtype of coal burned (Adriano *et al*., 1980; Carlson *et al*., 1993). Fly ash produced by burning of anthracite, bituminous and lignite coal has different compositions (Kishore *et al*., 2010).Fly ash generally has a siltloam texture with 65-90% of the particles having diameters of less than 0.010 mm, low bulk density (1.01-1.43 g/cm^3) and specific gravity(1.6-3.1 g/cm^3) (Daniels *et al*., 2002).Mean particle density for non-magnetic and magnetic particles is 2.7 and 3.4 g cm^3, respectively (Natusch*et al*., 1974).Flyash exhibits high surface area and light texture due to the presence of large, porous and carbonaceous particles(Kishore *et al*., 2010). FA has physical and chemical properties. Including physical properties such as Specific gravity is one of the key physical properties needed to use coal ashes. The specific gravity of coal ashes is generally about 2.0, but it can vary widely (1.6 to 3.1). Distribution of grain size shows the weather of a material that is fine, coarse, well graded or poorly graded, etc. Based on the distribution of grain size, coal ashes can be classified as sandy silt to silty sand. The chemical properties of coal ashes mainly affect the impacts of their use/disposal on the environment. The adverse effects include surface and subsurface water contamination with toxic heavy metals present in the ashes of coal, loss of soil fertility around the sites of the plant, etc. pH, and total soluble solids.

1.1 Use of fly ash in Agriculture

In the sector of agriculture, for buffering of the soil pH particular amendment is used which is known as fly ash Phung *et al.,* (1978). The usage of such amendments improves soil texture as well as enhances the percentage of nutrient in the soil **(**Fail and Wochok 1977**;** Chang *et al.,* 1977**).** Fly ash is the residual component of thermal power plants and it remains stored in ash ponds where it leads to undesirable environment. In recent scenario the main objective is to make use of the fly ash in the agriculture sector and to find out its effect on the health of the soil. The main aim is to recognize the effect of this amendment on the physico- chemical, biochemical, and microbial properties of the soil and what are the changes produced by fly ash on the productivity of agricultural sector. This investigation should be beneficial for various health organizations in mitigating the contamination which results from solid waste contamination through Rautaray *etal.,* (2003).

1.2 Effect on soil health:-

(Jala and Goyal, 2006**)** stated that fly ash physical chemical and mineralogical properties varies with the type of coal used, the devices which are used to control the emission waste, the conditions in which the coal was burnt and how efficiently it was handled and stored. **(**Pandey and singh, 2010**)** pin pointed the alterations which can be done by the uses of fly ash in the soils as well as the nutrient benefits of the fly ash. (Lee *et al.,* 2006**;** Singh and Aggarwal, 2010**)** conducted an experiment in the Korean soils and found that fly ash is beneficial in many ways like its help to alter the pH of the soil provides elements like silicon, phosphorous, other inorganic amendments to the soil as well as help in maintaining the nutritional balance in the soil under rice cultivation. (Ahmaruzzaman, 2010**)** carried out an experiment in the Varanasi city of India which concluded that fly ash is rich in calcium, potassium, sodium , titanium and other trace elements along with silicon, aluminium and iron. This research determined that by the uses of fly ash in mung bean crop has increased the vitamins and mineral content and has also enhances the mineralogical properties of the soil under paddy cultivation. (Matti *et al.,* 1990Ahmaruzzaman, 2010, Pandey and singh 2010, Singh and Aggarwal, 2010)indicated that the uses of various doses of fly ash at 5, 10, 15, and 25 enhances the amount of iron by using 52, 91, 169.1 and 211% respectively, over control. On the other hand experiment revealed that when fly ash was incorporated in the soil at 5, 10, 15, and 20% the most prevailing cation was calcium which was succeeded by magnesium, potassium and sodium.

Yield Response:-

(Jala and Goyal, 2006; Gupta *et al.,* 2002) focused that according to the society of humans the most important parameter for all the crops cultivated are yield attributes. The previous experiments revealed that fly ash is one of the amendments which can use to enhance the yield of the plants. In the recent studies various factors which affect the yield were taken in consideration which are number of ears per plant, grains number per plant, test weight and harvest index. This study concluded that there was increase in the above mentioned parameters when fly ash was incorporated <5-10%. (Lee *et al.,* 2006) studied that there was an increase in the yield of Korean rice cultivar when fly ash was added @90mg/ha. (Dwivedi *et al.,* 2007) investigated the three indigenous cultivars of rice which are Samba, Sugandha-3 and Saryu -52 and found that when fly ash was used at 25% there was an increment in the weight of grains. (Singh and Aggarwal, 2010)concluded that 5-10% fly ash leads to an increment in the yield of mung bean by 29.5-40.6%. The recent experiment stated that grain yield can be enhanced by the application of fly ash @10% whilst there was decrement in the yield when fly ash was incorporated @ 20% in the rice cultivar Samba, Sugandha-3 and Saryu -52 over the control one.

2.1. Effect of fly ash on physico chemical properties in relation to growth and yield attributing characters:

Growth and yield of any crop are regarded as most important parameter and major concern to accept any recommendation for any agricultural inputs. Many researches were made to examine the impact of fly ash on various growth and yield attributing parameters in various crops under various soil conditions (Kesh*et al*., 2003; Jala and Goyal, 2006; Kishore *et al*., 2010; Pandey *et al.*, 2009; Aggrawal,2009; Pandey and Singh, 2010; Sarkar *et al*., 2013). Rice grain yield has been found to be improved under different climatic and soil conditions with addition of fly ash at various doses ((Lee *et al*., 2006; Dwivedi*et al*., 2007; Sarkar *et al*., 2013) FA amendments in soil caused significant improvement in soil quality and germination percentage of rice seeds (Mishra *et al.,* 2007). Growth (shoot length, leaf area and pigment composition) and yield (panicle length, seeds per panicle, seed weight and yield per plant) of rice increased with an increase in FA amendments.Flooded-rice soil amended with FA not only improved the physical properties of the soil but also contributed to better growth and yield of rice (Mishra *et al.,* 2007).About 29.5 – 40.6 % increase in economical yield of mung bean plants with 5 – 10 % fly ash was also reported (Aggarwal, 2009). An increase in plant height and metabolic rate in presence of fly ash at low dose application in maize and soybean was observed (Mishra *et al.,* 1986). Thisresponse was explained considering the correction of boron deficiency by fly ash deposition. The high dose, however, reduced the pigment content and dry matter production, which might be attributed to the excessive uptake and accumulation of boron, and alkalinity caused by excessive soluble salts on the leaf surface. In a separate experiment, effects of various concentrations of FA (20, 40, 60, 80 and 100%) on thegrowth and photosynthetic activity in rice and maize were studied (Panda *et al.,* 2015).Plant growth was mostly enhanced in thetreatments with 20–40% fly ash, being optimal at 60%. From 80% onwards, themeasured parameters tended to reduce. Most economic level of fly ash incorporation was found to be 60% which improved growth stages of *Zea mays* and *Oryza sativa*. Molliner*et al*., (1982) also obtained an increase in dry matter yield of corn (*Zea Mays* L.) on the Myakka is soil when limed with either $CaCO_3$ or fly ash.

It has been revealed that inclusion of FYM with lime, fly ash or gypsum resulted in about 5 q/ha higher yield over their sole application. One-time application of fly ash to first crop stabilized maize yield up to third season with heavy metal (Pb, Cd, Cr) accumulation below toxic level in fly ash treatments (Chandraka*et al.,*2015)

Saxena*et al.,*(2010) found that with fly-ash application, the edible yields of tomato, cabbage, potato, wheat, pea, onion, rice, sunflower, maize, etc. increased from 12 to 46%, compared to the control soil where no fly ash was used. This positive effect on yield might be due the changes inthe biotic and abiotic properties of soil with application of fly ash. Taking wheat as a test crop in field and pot studies with boiler ash application at various doses (@ 3, 12, 25, 50, 125 and 250 t $ha^{-1)}$, 50 t $ha^{-1}$was found to improve yield of wheat in calcareous soil (Khan *et al*., 2008)

2.2. Effect of fly ash on biological properties in relation to growth and yield attributing characters:-

A field experiment was conducted in the rice research station, Ambasamudram. In this recent research, to estimate the effect of fly ash (FA) amendment alone or along with the combination of various liming materials such as lime and dolomite, different recommended dose of fertilizer (RDF) doses are applied to check the status of soil. With regard to the highest grain yield (5.93 t ha^{-1}) and straw yield (6.32 t ha^{-1}) were determined with the application of 50% FA+RDF which was succeeded by 50% lime + 50%FA + RDF (grain yield 5.72 t ha^{-1} andstraw yield 6.10 t ha^{-1}). In this plot the highest yield were recorded with the application of 50% dolomite +50% FA+ RDF that was best for bacterial and Actinomycete population and the lower yield were estimated with the higher application of fly ash due to the development of obstacle in the root elongation as the higher doses leads to their aggregation of fly ash particles (Dwivedi *et al.,* 2007). Although, the yields for @30 and 40 t ha^{-1} FA+RDF were not reduced over the control plot also plot receiving 100% RDF alone. It is stated that the application of fly ash in the soil which leads to the buffering soil pH and that is beneficial for growth of soil microbes in acid soil. While the application of 50% dolomite +50% FA+RDF were used which enhance the microbial population of bacterial and Actinomycete whereas lime or dolomite + RDF and FA @ 20 t ha^{-1} was good for fungal populations **(**Sharma and Kalra, 2001**)** revealed that grain yield (2.58 to 2.78 t ha^{-1}) and biomass (5.6 to 6.2 t ha^{-1}) of maize enhanced at harvest significantly in Muthiani. On the other hand with the application of @10 t ha^{-1} fly ash were recorded that the maize yield and biomass showed no difference between No fly ash and fly ash at Gulawathi village. In Muthani village, with the incorporation of fly ash treated plots yield of rice enhanced up to 1.3% as compared to the no fly ash was used value 6.83 t ha^{-1} respectively. Also the biomass showed 4.4% more values than the control where no fly ash was used value 17.6 t $ha^{-1.}$ At Gulawathi village grain yield and biomass were examined more or less similar with respect to control where no fly ash was used and the application of fly ash @ 10 t ha^{-1} values of 6.9 to 16.8 t ha^{-1}. Due to fly ash incorporation maize yield were increased tillers, spike length and grains per spike and test weight. These results stated that to check the effect of different concentration of the fly ash (2%, 4%, 6%, and 8%) on growth of different crop plants such as fenugreek, spinach, and coriander. Germination and early growth was affected in selected crop plants but higher levels of fly ash did not cause any harmful effect. This coal fly ash was taken from thermal power plant, Bhusawal. This statement showed that the application of fly ash in agriculture holds a potential to enhance the average yield 10-15% yield of crop plants through vishal and Praveen, (2013).The recent study stated that soil having lower population of microbes is not a good indicator. Some result showed that at lower percentage of fly ash a few species of the fungi can adopt the conditions and further develop themselves but with higher doses the growth and development of the microbes ceases. The result concluded that at lower concentration the fly ash was beneficial tool in increasing the fertility status while the uses of higher doses are lethal to the advantageous microbial population Shrivastava *et al*., (2018).

3. CONCLUSION

Fly ash is a byproduct obtained from combusting coal in thermal power station and traditionally considered as a waste product. It becomes a challenging task for a country like India to handle and manage such a huge amount of fly ash in respect of their disposal, storage, land use, and mitigating their impact on environment. The disposal of fly ash is becoming a major concern, keeping an eye on human health and environmental pollution. Most commonly fly ash is dumped in landfills and fly ash basins (dry method) or may be washed out with water in creation of pond ash (Wet method). However, both methods cause the disposal in open land in huge amount which opens the possibility of tiny particles of fly ash to be suspended in air leading to environmental pollution. However, in recent years concepts on fly ash is changing from considering it only as a waste material to economically resource material. It has become a socio-economic challenge to convert the threat to opportunity. For environmentally safe use of fly ash, efforts are being made to utilize it as a resource material for brick preparation, cement manufacturing, road surfacing and other many purposes. But, only a meagre amount of ash is being utilized in the country like India. It has already been established that fly ash possesses a unique potentiality to supply various plant nutrients which include particularly secondary nutrients and micronutrients (like Ca, Mg, S, Fe, Mn, Zn, Cu), to improve the physicochemical properties of the soil, to reclaim problematic soils and also to protect crops from pests

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