Growth with Some Biochemical Responses in Two Cultivars of *Cicer arietinum* L. to Fly Ash Amended Soil

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**ABSTRACT**

**Background:** According to the United Nations “the world population prospects 2019” report, the population of the world is expected to increase currently from 7.7 billion to 9.7 billion in 2050. This rapid growth in the population will adversely put incredible stress on our climate, food and health. As we are already running out of natural resources, it is high time to rethink our policies. Sustainable development is the need of an hour. Some policy decisions are required to overcome such expected challenges. To maintain the balance between the demand and supply there should be a prearranged, preplanned mechanism to be adopted for the sustainable growth and development of the production-cum-consumption system at a global level. In this paper, we will try to experimentally demonstrate how the growth of some legume crops is helpful to us we will also scientifically prove the utility of environmental pollutant fly-ash as an alternative fertilizer.

**Methods:** An experiment was conducted during the month of October to February (2018-2019) at the C.C.S. University Campus, Meerut. Different amounts of fly ash of 20, 40, 60 gm/m² and two diverse chickpea genotype JG-11 and JG-14 were taken as experimental material.

**Result:** Fly ash in a sufficient amount increases the availability of macro- and micro-nutrient of the soil which is beneficial to plant growth and development. Fly ash significantly improved the physio-chemical properties of soil such as pH, CEC, BD, PD and also improves chickpea growth and yield. Fly ash found safe for agriculture applications in 20-40 gm/m² range in the context of fertilizer.

**Key words:** Chickpea, Fly ash, Productivity, Soil fertilizer.

**INTRODUCTION**

Increased population, urbanization and industrialization enhance environmental pollution level around the globe. Coal-based brick kiln fly ash (FA) is one of the examples of environmental hazards across the globe. In India every year thermal power plants produce approximately hundred million tonnes of FA but its utilization is less than approx.15%. In 2016 fly ash production was about to 235 million tonnes and its utilization only 59% in India (Prakash et al. 2019). Leguminosae are the most tolerant to FA (Cheung, 2000). Chickpea (*Cicer arietinum* L.) member of Leguminosae family and a prominent pulse crop of India in terms of production. Chickpea is a good source of protein (19.5%), fats (11.4%) and carbohydrates (57-60%) (Roy et al. 2019).

Being a pulse crop it improves the soil through symbiotic N₂ fixation. The supply of S and P to the legumes is more important than of N because S and P cannot be fixed by the legume crops through symbiosis process. In point of fact, practically in FA have all the essential elements such as SiO₂ (55.60), Al₂O₃ (34.80), Fe₂O₃ (4.92), CaO (2.69), MgO (1.75), K₂O (1.09), TiO₂ (1.14), Na₂O (0.70) and the trace elements: Cu (78.7), Zn (86.9), Mn (650), Mo (2.6), As (3.0), Se (2.1), Pb (53.7), Ni (45.31), Cr (1.90), Co (12.19), Cd (0.46) and B (1.5) in mg/kg (Nivetha et al. 2017). Thus, its utilization reduces inorganic and organic fertilizers and has beneficial for non-nitrogenous crops and legumes. Considering the disposal problems of FA and the vital importance of chickpea, that’s why a year experiment was conducted to assess the potential use of FA as a soil fertilizer in an optimum range.

**MATERIALS AND METHODS**

**Materials and experimental design**

The experimental material consist 2 diverse chickpea genotypes (JG-11 and JG-14) procured from ICRISAT, Hyderabad and FA was collected from the brick kiln at the town Hastinapur, Meerut, India. The experiment conducted in a randomized block design with three replications at the research Farm, Department of Botany, C.C.S. University Campus, Meerut, India during the year of 2018-2019. Each genotype was raised in 24 plots of equal size (1×1 m²), 18 plots for the treatment and 6 plots for the control. Three samples of different concentrations of FA were prepared such as 20, 40 and 60 gm/m².
RESULTS AND DISCUSSION

Effect of fly-ash on soil physical properties

Soil pH

Measured pH of FA was highly acidic (2.96) and soil pH was alkaline (7.08). Highly (acidic) soil pH was examined in 60 gm/m² FA treated soil as compared to other FA treated soil (Fig 1). Basic oxides FA like CaO and MgO react with H₂O in the presence of CO₂ and produce hydroxyl ions (OH⁻) and carbonate precipitate (CO₃²⁻), which increase the soil acidic pH. FA helps in improving soil texture and pH which directly or indirectly help in plant growth and development (Siddharth et al. 2011).

Cation exchange capacity (CEC)

Maximum soil CEC was observed in untreated soil while minimum in 60 gm/m² FA treated soil (Fig 2). As the quantity of FA increases, soil CEC decreases. The application of FA causes soil acidification which in turn loss to the base cations and reduces the CEC of soils (The relationship of FA and CEC of soil is inversely proportion (Goulding, 2016).

Bulk Density (BD) and Particle Density (PD)

Lowest PD and BD of soil were found in 60 gm/m² of FA treated soil (Fig 3). Alike to the present findings Mishra et al. (2017) also reported a stable negative correlation of PD and BD of soil with enhancing levels of FA. BD of soil decreases with an increasing amount of FA due to increased proportion of clay particle. Another reason may be that the Ca elements of FA (which is a third predominant element of FA) readily replace the Na elements at the soil exchange site and thereby enhancing the flocculation of soil particles (Sahu et al. 2017).

Porosity of soil

The maximum porosity of soil was analyzed in the 60 gm/m² FA treated soils as compared to control and other FA treated plots (Fig 4). As the concentration of FA from 20 to 60 gm/m² increases the soil porosity also increases. Soil porosity increases may be due to the increasing amount of FA. Thereafter increases the solid particles percentage (%) in the soil which converts the soil porosity into micro-porosity. Later on micro-porosity increases the water holding capacity of soil (increases availability of water in the soil) which is
beneficial for plant buildup. Mishra et al. (2017) also found the percentage of porosity increases and the percentage of solids decreases with an increasing amount of FA incorporation.

**Effect of fly-ash on physiological properties of plant**

**Germination Percentage (%)**

Seed germination was counted at 05, 10, 15 days interval after sowing the seeds. In JG-11 the seed germination % showed better response in comparison to JG-14 genotype. Overall the maximum germination % was observed in 20 gm/m² FA treated plots of JG-11 (Fig 5). Plants use FA as a source of important plant supplements, which enhances the germination % of the seed. In the present study, it was observed that the FA treatment was beneficial for germination JG-11 genotype but the JG-14 genotype of chickpea genotype had no such potential to utilize FA as a fertilizer in initial as well as in later stages of seed germination. From the present result, one can conclude that the JG-11 chickpea genotype has the potential to convert FA pollutant to a fertilizer (Rajpoot et al. 2018).

**Plant length**

The maximum plant length including root and shoot length was observed greater in 40 gm/m² FA treated plot in genotype JG-14 as compared to control and other treatments. At the same time the second genotype JG-11 shows maximum root, shoot and total length in 20 gm/m² FA treated plot. Both the genotype of chickpea showed superior growth rates compared to control as seen in Fig 6. The superior growth of chickpea plants in FA treated plots is due to three main effects: firstly, increase in soil moisture-holding capacity; secondly, improve the soil texture quality. Thirdly, the availability of micro- and macro-nutrients in FA. Changes in soil properties may directly or indirectly affect the microbial activity in the soil which can be beneficial for the growth of the plants. Increased growth counter of the crop is attributed to the availability of nutrient elements which are present in FA (Kumar and Kumar, 2016).

**Pods/plant**

The maximum numbers of pods/plant was counted in 40 gm/m² FA treated plot of both the genotypes of chickpea. Plants from FA treated plots of 40 and 60 gm/m² showed superior growth rates in both the cultivars compared to their respective control and 20 gm/m² FA treated plots as seen in Fig 7. The presence of micro- and macro-elements in the FA used by plants as a nutrient/supplement maybe is the reason. It may be explained on account of to the fact that micro- and macro-nutrients of FA promote the chlorophyll, amino acid and protein synthesis activity which ultimately enhance the productivity level of a plant. Faizan and Kausar, (2010) also reported that the FA dynamize the plant growth and productivity by improving photosynthetic activity. Overall the number of pods/plant got increased because the essential elements released from the FA to the soil, which help to enhance the crop growth and their productivity (Raj et al. 2016).

**Nodules attributes**

Maximum nodulation was observed in 40 gm/m² FA treated plots as compared to 0 and other 20 gm and 60 gm/m² FA treated plots respectively (Fig 8 and 9) in both the genotypes. Nodules number/plant were improved with micronutrient application in chickpea. Mo is a key factor of nitrogenase enzyme which involves in symbiotic N₂ fixation and nodulation of legumes crop. Fe and Mo application can improve the nitrogenase enzyme activity which is closely associated with plant growth and yield performance (Nasar et al. 2019). Fly ash has these two metals in a sufficient amount. Faizan and Kauser (2010) were also reported that the 20-40 gm/m² use of FA application cause a significant response on the number and weight of the nodules.
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**Biomass**

Higher fresh and dry weight of shoot and root was found in 20 gm/m² FA treated plots in both the genotype (Fig 10). Higher concentration (60 gm/m²) of FA shows a depressive effect on biomass, length and yield of the plant. Heavy metals in FA are directly related to reducing the biomass, length and yield of the plant (Faizan and Kausar, 2010; Rajpoot et al. 2018).

**Effect of fly-ash on biochemical properties of plant**

**Protein content**

Higher protein content was analyzed in 40 gm/m² FA treated plots in both the genotypes of chickpea as compared to 0, 20 and 40 gm/m² FA treated plots (Fig 11). Present result shows that the lower amount of FA exhibits a positive effect on protein content. Pani et al. (2015) also observed that protein contents significantly increased with a lower amount (20-40%) of FA application. A lower amount of FA exhibits a positive effect on protein content; metal catalysts such as Fe, Cu, Ni and Cr which increases the activity of proteases or other catabolic enzymes. These enzymes activate the metabolic reactions or pathways which involve protein synthesis in plants (Pandey et al. 2010). However, reduction in the protein content was also reported under a higher amount of FA. Dash et al. (2017) was also reported that higher amounts of FA causes decrement in total protein content due to the presence of free radicals of metal ions which degrade the chlorophyll and ultimate disrupt the photosynthesis process.

**Chlorophyll**

Maximum chlorophyll content was analyzed in 40 gm/m² FA treated plots in both the genotype as compared to control and other treatments (Fig 12). A minimum amount of chlorophyll was found in 60 gm/m² FA treated plots but more...
Proline content

Maximum proline content was found in 60 gm/m² FA treated plot as compared to 0 and other 40 and 60 gm/m² FA treated plots in both the genotypes (Fig 13). It indicates that the FA induces drought stress to plants with an enhancement of proline contents (Kumar and Kumar, 2016). Heavy metal of FA such as Fe, Ni, Cr, Cu, Pb and Cd accumulate and disrupt the other metabolic pathways of plants and enhances the drought stress conditions. Pb and Ni (heavy metals) present in FA are known to be the responsible elements for the accumulation of proline contents in treated plants (Singh et al., 2012). However, 20-40 gm/m² FA treated plots show moderate to a low level of proline content. It may be due to 20-40 gm/m² FA which reduces the stress conditions (to provide a better internal environment for metabolic activity of the plants) (Rai, 2016).

Nitrogen content

Nitrogen is essential for synthesis for amino acids, nucleic material and proteins. (Kaur and Kaur 2018) Highest nitrogen content values were found in 40 gm/m² FA treated plot of the genotype JG-14 of chickpea (Fig 14). In the JG-14 the maximum nitrogen content was found in 20 gm/m² FA treated plot as compared to the control and other remaining treated plots. 20-40 gm/m² FA dose shows positive effect on the nitrogen content of leguminous crops. Presence of Mo in FA and a sufficient quantity of N₂ occurs in the soil might have increased the rate of nitrate reductase activity and enhance the nitrogen content in leaves (Rajpoot et al., 2018). Mishra (2017) also reported that higher concentration of FA causes a negative effect on the nitrogen content because the availability of As (arsenic) in the FA causes the phytotoxicity symptoms in plants.

CONCLUSION

FA has been found to be a good soil ameliorant as well as a source of micro- and macro-nutrients. Application of FA improves texture, aeration, BD, PD, porosity, CEC and pH. FA is also a good amendment for sodic and saline soils as well as for reclamation of other degraded/problematic soils. It also raises plant growth and yields at a 20-40 gm/m² optimum range in chickpea genotype. But results show that JG-14 genotype shows better response rather than JG-11. Based on a one-time field experiment it can be concluded that there is ample scope for the safe utilization of brick kiln coal FA in agriculture without serious harmful effects at low doses (20-40 gm/m²). After analyzing all the results of the experiment it was adduced that the impact of FA in a sufficient amount increases the availability of macro- and micro-nutrient of the soil which is useful to plant growth and development.

Future line

Firstly, Laboratory and field research, as well as large scale field demonstration projects, need to encourage for utilization of FA in agricultural practices. Secondly, check the adverse effect of FA on soil or crop quality up to 7-8 years. Thirdly, India is also working hard to improve its agriculture output from the available cultivable area to meet the growing needs. FA can play an important role in this context.

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