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Response of Fly ash and farmyard manure on soil Properties and yield of rice (*Oryza sativa)*

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ABSTRACT

The present investigation was carried out during kharif season of 2015 at Gaitara village, Tilda block, Raipur district (C.G.) to evaluate the effect of different doses of fly ash applied with or without farmyard manure on physico-chemical properties of soil, yield attributes and yield of rice (Oryza sativa L.). The experiment was laid out in randomized block design with eight treatments and three replications. Results revealed that there was no any significant impact on soil pH, EC, bulk density and Partical density while organic carbon content was significantly increased with graded doses of fly ash with and without FYM. The application of graded dose of fly ash with and without FYM could not influence the status of available soil N significantly but available soil P and K increased significantly over control. The yield attributes viz. effective tillers per hill^{-1}, number of grain per panicle and test weight, grain and straw yield of rice increased significantly with graded doses of fly ash with and without FYM. The treatment of 75% GRD + 40 t fly ash + 5 t FYM ha^{-1} (T_7) gave highest effective tillers per hill^{-1}(6.15), number of grain per panicle (96.35), test weight (25.72g), grain yield (48.00 q ha^{-1}) and straw yield (68.73 q ha^{-1}) of rice.

Key words: Fly ash, FYM, organic carbon, yield, rice.

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important crop and the primary source of food for more than half of the world's population, especially in Asia. Rice contains a large amount of starch, some proteins, minerals, fibers and vitamins like B and E. The slogan 'Rice is life' is most appropriate for India as this crop plays a vital role in our national food security and is a means of livelihood for millions of rural household. In India, it accounts for > 40% of food grain production, providing direct employment to 70 % people in rural areas. India has the largest acreage under rice of 44 mha and with a production of about 141 mt and the national productivity of 3.21t ha^{-1}. The burgeoning population of our country may stabilize around 1.4 and 1.6 billion by 2025 and 2050, requiring annually 380 and 450 mt of food grains respectively. In Chhattisgarh state more than 70 % area comes under the rain fed condition, where rice cultivation is depends on south-west monsoon in spite of that state is known as "Rice Bowl of India". About 130 coal-based thermal power stations in India are producing over 165 million tons fly ash per year. Fly ash is a by-product of the thermal power station, where coal energy is converted into electrical energy. The demand for electrical energy is increasing day by day and in the absence of its utilization of the byproduct of thermal plant, it is getting accumulated and for storing large area of arable land will be required which is therefore finding immediate use of fly ash for different purposes is very important. Fly ash being an inert heterogeneous SiO_2, Al_2O_3 and Fe_2O_3 as a main components and material containing mineral nutrients as minor components which attracts the agriculture scientists for its utilization in improving crop and soil productivity. The fly ash generation is expected to increase to 300 million tons per annum by 2017 and 900 million tons per annum by 2031-32. It is a fine, grey, amorphous powder and rich in Si, Al, spherical in shape having excellent physical properties. The physico-chemical properties of fly ash may vary widely, depending upon the nature of the coal, the efficiency of the coal combustion process and the selection process. It is similar to soil in some of physical and chemical properties, as it contains major, secondary and trace elements, which are found in earth crust.

Presence of organic matter (FYM) in soil has an additive effect as it reduces the concentration of toxic metals through sorption,

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lowers the C/N ratio and provides organic compounds, which promote microbial proliferation and diversity. The emerging scenario necessitates the need for the adoption of package of practices which maintain soil health, makes the production system more sustainable and provides better food for meeting the nutritional requirements. The use of organic soil amendments has been associated with desirable soil properties including higher plant available water holding capacity and cation exchange capacity and lower bulk density, and can foster beneficial microorganisms. In combination with various organic manures, fly ash can enhance soil physico-chemical properties, nutrient availability and plant productivity. The combined effect of fly ash and FYM on available nutrient status and recorded the highest available N, P, K, Fe and Zn contents at the harvest of rice crop (Reddy *et al.,* 2010). Singha (2013) reported that fly ash in combination with farmyard manure or other organic amendments improves soil physico-chemical characteristics, yield and microbial processes in paddy fields and concluded that fly ash at lower doses improving paddy crop yields. Hence, the study was carried out to assess the response of graded doses of fly ash applied with and without FYM on physico-chemical properties of soil and yield attributing characters of rice.

MATERIALS AND METHODS

The present experiment was conducted at the research village - Gaitara, Tilda block, Raipur district (C.G.) during *kharif* season - 2015. Raipur lies at $21^0$4' North latitude and $81^0$35' East longitude with an altitude of 290.20 meter above the mean sea level. The soil of experimental site was sandy in texture with pH 6.8, EC 0.12 dSm $^{-1}$ and CEC 19.15 cmol (p $^{+}$) kg $^{-1}$, organic carbon 4.2 gkg^{-1}, available N 138 kg ha^{-1}, available P 2.3 kg ha^{-1}, available K 228 kg ha^{-1}, Rice plants variety MTU-1010 was transplanted in open field on 2nd August 2015 with 15 cm x 10 cm spacing. The experiment was carried out using 8 treatments namely T1-Control,T2- GRD (100:60:40), T3- 75% GRD + 20 t fly ash ha^{-1}, T4- 75% GRD + 40 t fly ash ha^{-1}, T5- 75% GRD + 60 t fly ash ha^{-1}, T6- 75% GRD + 20 t fly ash + 5 t FYM ha^{-1}, T7- 75% GRD + 40 t fly ash + 5 t FYM ha^{-1}, T8-75% GRD + 60 t fly ash + 5 t FYM ha^{-1}. The treatments were replicated three times in randomized block design. All nutrients management practices (chemical fertilizers, organic manures and fly ash) were applied as per the treatments. Nutrients were applied through urea, DAP, muriate of potash, FYM and fly ash respectively. The soil samples collected after harvest were analyzed for pH and EC (Jackson, 1973), organic carbon (Walkley and Black, 1934), bulk density, particle density by using picnometer. Available N was determined by alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus by Olsen method (Olsen *et al.,* 1954) and available K by flame-photometer in 1 N NH_4OA_C extract. The total number of tillers, effective tillers plant^{-1} was recorded at harvest. The seed and straw yield of rice was recorded from each net plot and reported in q ha^{-1}.

RESULTS AND DISCUSSION

Physico-chemical properties of fly ash

The physico-chemical properties of fly ash ((Table 1) depends on the quality of coal which is used as source, process of combustion, extent of weathering, particle size, collection setup. Attempts are being made to find out its useful application dose for growing of rice. The fly ash used in the experiment was having particle size (2-0.02mm) 44%, (0.02-0.002mm) 50% and (<0.002mm) 6%. The bulk density of the fly ash was 0.71 Mg m^{-3} (Karmakar *et al.,* 2010). Fly ash is a complex heterogeneous material consisting of both amorphous and crystalline phases. The pH of the fly ash sample

Table 1: Physico-chemical properties of fly ash

Particulars	Analysis value
Particle size	
(a) 2-0.02 mm	44%
(b) 0.02-0.002 mm	50%
(c) <0.002 mm	6%
Clay (%)	
pH	7.72
EC (dSm^{-1})	0.17
Organic carbon (g kg^{-1})	3.6
Particle density (Mg m^{-3})	2.22
Bulk density (Mg m^{-3})	0.71
Water holding capacity (%)	70.22
Total N (%)	0.144
Total P (%)	0.075
Total K (%)	0.028

was 7.7. The total nitrogen, phosphorus and potassium content S of fly ash were 0.14, 0.08 and 0.02 %, respectively (Ravi kumar *et al.*, 2008).

Physico-chemical properties of soil

The application of fly ash doses either with or without FYM had no significant influence on soil reaction (pH) after harvest of crop (Sikka and Kansal, 1995). Similarly there was no significant difference in treatments for EC of soil (Robinson *et al.,* 2001). The soil organic carbon content was significantly affected by the different treatments as compared to 100 % GRD and control (Table 2). The treatment 75% GRD + 40 t fly ash + 5 t FYM ha^{-1} (T_7) showed highest organic carbon content (5.5 gkg^{-1}) as compared to 100 % GRD, but it was at par with 75% GRD + 20 t fly ash ha^{-1} (T_3), 75% GRD + 40 t fly ash ha^{-1} (T_4), 75% GRD + 60 t fly ash ha^{-1} (T_5), 75% GRD + 20 t fly ash ha^{-1} + 5 t FYM ha^{-1} (T6) and 75% GRD + 60 t fly ash +5 t FYM ha^{-1} (T_8). The minimum amount (4.4 g kg^{-1}) was found in control (T_1). The different graded dose of fly ash with FYM was found to increase the organic carbon content than without FYM. Increase in organic carbon due to graded doses of fly ash and FYM was more pronounced than that of no FYM (Sarangi *et al.,* 2001). The data show that application of fly ash did not change the bulk density and particle density of soil significantly over control (Sharma and Kalra, 2006). Deshmukh *et al.,* (2000) also reported a decrease in the soil bulk density as the fly ash levels increased.

Table 2: Effect of different combinations of treatments on physico–chemical and available macronutrient status (kg ha^{-1}) of soil

Treatments	pH	EC (dS m^{-1})	Organic carbon (g kg^{-1})	BD (Mg m^{-3})	PD (Mg m^{-3})	Avail. nutrients (kg ha^{-1})		
						N	P	K
T_1	6.81	0.08	4.4	1.56	2.54	127.9	2.7	220.5
T_2	6.83	0.1	4.6	1.51	2.57	134.6	3.3	229.8
T_3	6.8	0.09	4.7	1.57	2.54	132.8	3.2	234.7
T_4	6.82	0.1	4.9	1.57	2.51	131	3.4	235
T_5	6.75	0.1	5	1.54	2.57	129.6	3.2	226.6
T_6	6.8	0.12	5.3	1.58	2.55	133.6	3.3	236.8
T_7	6.8	0.11	5.5	1.55	2.53	139.1	3.5	239.2
T_8 -	6.72	0.14	5.2	1.54	2.54	135.6	3.2	235
SEm±	0.03	0.01	0.02	0.02	0.02	3.39	0.12	2.42
CD (P = 0.05)	NS	NS	0.08	NS	NS	NS	0.37	7.34

Note- EC: Electrical Conductivity; BD: Bulk Density; PD: Particle Density;

Available macronutrients status

The different treatments had no significant effect on available soil N status (Table 2) but when fly ash was applied with FYM, soil available N increased compared to without FYM and 100 % GRD. It ranged between 127.9 and 139.1 kg ha^{-1}. The maximum available N in soil (139.1 kg ha^{-1}) was recorded with 75% GRD + 40 t fly ash + 5 t FYM ha^{-1} (T_7) while, the minimum under control (127.9 kg ha^{-1}). The higher status of soil available N by integration of fly ash and FYM may be ascribed to increase release and availability of soil N due to additive effect of mineralization of FYM. All the treatments showed significantly higher soil available P as compared to control. The differences among the treatments were non-significant with respect to soil P status at harvest (Table 2). The maximum P content (3.50 kg ha^{-1}) was found under 75% GRD + 40 t fly ash + 5 t FYM ha^{-1} (T_7) while, the minimum (2.70 kg ha^{-1}) in control. The increase in soil P content may be ascribed to P content of fly ash and FYM. (Lee *et al.*2007). The amount of available soil K was increased significantly with application of treatments over control except 75% GRD + 60 t fly ash ha^{-1} (Table 2). The treatment 75% GRD + 40 t fly ash + 5 t FYM ha^{-1} (T_7) showed highest soil K status (239.2 kg ha^{-1}) as compared to 100 % GRD. but it was at par with 75% GRD + 20 t fly ash ha^{-1} (T_3), 75% GRD + 40 t fly ash ha^{-1} (T_4), 75% GRD + 20 t fly ash + 5 t FYM ha^{-1} (T6) and 75% GRD + 60 t fly ash +5 t FYM ha^{-1} (T_8). The minimum value (220.5 kg ha^{-1}) was observed in control. The increased availability of K with application of fly ash and FYM may be attributed to addition of K by fly ash and FYM (Das *et al.,* 2013)

Table 3: Effects of different combinations of treatments on yield attributes and yield of rice

Treatments	Effective tillers/Hill	Grain per panicle	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1 – Control	3.74	68.65	18.58	17.17	48.83
T_2 - GRD (100:60:40)	4.82	80.6	20.45	39.57	52.37
T_3 - 75% GRD + 20 t fly ash ha^{-1}	4.99	79.14	21.88	38.97	55.77
T_4 - 75% GRD + 40 t fly ash ha^{-1}	4.69	83.38	20.73	41.17	52
T_5 - 75% GRD + 60 t fly ash ha^{-1}	4.97	81.5	21.61	42.73	51
T_6 - 75% GRD + 20 t fly ash + 5 t FYM ha^{-1}	5.4	85.2	24.38	43.67	57.97
T_7 - 75% GRD + 40 t fly ash + 5 t FYM ha^{-1}	6.15	96.35	25.72	48	68.73
T_8 - 75% GRD + 60 t fly ash + 5 t FYM ha^{-1}	5.65	94.97	23.23	44.33	56.13
SEm±	0.24	4.54	1.18	1.1	2.1
CD (P = 0.05)	0.75	13.79	3.59	3.6	6.4

Yield attributes and Yield

The effective tillers per $hill^{-1}$ were significantly affected by various treatments (Table 3) and the maximum value (6.15) was recorded in 75% GRD + 40 t fly ash + 5 t FYM ha^{-1} (T_7) while, the minimum (3.74) in control. The treatments 75% GRD + 40 t fly ash + 5 t FYM ha^{-1} (T_7) and 75% GRD + 60 t fly ash + 5 t FYM ha^{-1} (T_8) showed significantly higher effective tillers as compared to 100 % GRD and control. Increase in the number of tillers and productive tillers could be attributed to the enhanced germination of crop, improvement in soil physical and chemical properties and abundance of nutrients in soil by the addition of fertilizer, FYM and fly ash (Karmakar *et al.,* 2010). Number of grains per panicle significantly enhanced with75% GRD + 40t fly ash + 5 t FYM ha^{-1} (T_7) over control. Higher root activity and nutrient absorption and consequent complementary effect of fly ash and FYM on soil properties might have resulted in higher number of grains per panicle of rice. (Karmakar *et al.,* 2010) reported similar results. Application of different treatment combinations significantly affected the test weight of rice over control (Table 3). The maximum test weight (25.72 g) was recorded in 75% GRD + 40 t fly ash + 5 t FYM ha^{-1} (T_7), and lowest (18.58 g) in control. Increase in test weight of rice could be due to abundance of different nutrients by the addition of fertilizer, FYM and fly ash (Sahu *et al.* 2007). In general, highest values of all the yield attributes viz. effective tillers $hill^{-1}$, number of grain per panicle and test weight were noticed with 75% GRD + 40 t fly ash + 5 t FYM ha^{-1}(T_7) might be due to improved soil health by combined application of fly ash with chemical fertilizer and FYM (Sahu *et al.,* 2007; Karmarkar *et al.,* 2009).

The grain yield of rice (Table 3) was influenced significantly with different treatments over control. The treatment 75% GRD + 40 t fly ash + 5 t FYM ha^{-1} (T_7) produced the highest yield (48.00 q ha^{-1}) while the lowest (17.17 q ha^{-1}) was in control. The fly ash when applied alone increased the yield, but was at par with 100 % GRD. Further, the different doses of fly ash with FYM showed significantly higher yields over 100 % GRD (T_2). Similar result was recorded for straw yield. The higher straw yield (68.73 q ha^{-1}) was recorded in 75% GRD + 40 t fly ash + 5 t FYM ha^{-1} (T_7), while the minimum (48.83 q ha^{-1}) in control. The results also clearly indicate that the effect of fly ash was more pronounced in the presence of organic source. The conducive physical environment leading to better aeration, root activity and thereby increase in soil moisture holding capacity and nutrient absorption by the consequent complementary effect of fly ash and FYM application would have produced higher crop growth and yield attributing characters and which resulted in increased grain and straw yield of rice (Das *et al.,* 2013).

The results indicated that the application of 75% GRD + 40 t fly ash + 5 t FYM ha^{-1} significantly increased the available soil P, K status, grain and straw yield of rice. This treatment may be recommended for rice cultivation as an alternative source of nutrients to further improve the physico – chemical properties of soil as well as nutrient availability and yield of rice.

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