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Effect of graded dose of fly ash integrated with and without FYM on rice productivity and nutrient status of soil

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Abstract
The present study was undertaken to examine the effect of the application of different doses of fly ash (20, 40, 60 t ha^{-1}) with and without FYM on nutrient status and rice productivity. The test crop was rice variety (Rajeshwari). Field experiment was conducted at Krishi Vigyan Kendra, Research Farm, Janjgir – Champa (C.G.) during *kharif* season 2016. The results showed that grain and straw yields were significantly increased in different fly ash treatments over control and GRD. The treatment which received 75% GRD + 40 t fly ash ha^{-1} + 5 t FYM ha^{-1} recorded the highest grain (50.67 q ha-1) and straw yield (78.67 q ha-1). Under integrated plant nutrition supply system the significant increase in available major nutrient status and organic carbon in soil due to application of different doses of fly ash in surface soil (0-15 cm). In subsurface (15-30 cm) soil non significant influence on major nutrient status by fly ash applied with and without FYM. Thus the integrated effect of fly ash, manures and fertilizer was well pronounced in improving the nutrient status, yield attributes and yield of rice.

Keywords: Fly ash, FYM, yield, yield attributes and major nutrients

Introduction
In India, the generation of huge quantity of fly ash nearly 120 million tonnes/year. The disposal of this huge quantity fly ash by conventional methods leads to degradation of arable land and contamination of ground water therefore, development of proper technologies for disposal of this solid waste in an eco-friendly manner becomes essential to derive maximum benefit from its heterogeneous nature (Gupta *et al*., 2002) [5]. Fly ash, a finely divided residue resulting from the combustion of bituminous coal of Thermal power Plant is regarded as an amorphous ferro- alumino – silicate mineral containing the naturally occurring essential elements similar to that of soil except humus and nitrogen (Tripathi *et al*., 1997) [22]. It has a certain physical and chemical properties that might be useful as soil amendment acting as a degraded soil, liming agent to neutralize soil acidity and improve crop production
It is a low density ferro alumino silicate and presence of various elements such as P, K, Ca, Mg, S and micronutrients in the fly ash make it a good source of supplemental plant nutrients (Deshmukh *et al.,* 1995) [4]. Therefore application of chemical fertilizer, industrial wastes and agricultural animal wastes in an integrated manner may bring changes in the decomposition process of organic materials and hence are likely to alter the nutrient release pattern of the soil. Complementary use of plant nutrients from waste materials along with mineral fertilizers is of great importance in the maintenance of farm productivity and profitability. Use of manures, organic and inorganic wastes is gaining wider acceptance to reduce input cost and to sustain soil fertility. Lot of research is still needed to improve the agricultural use of fly ash soil conditioner, with respect to improvement of quality of fly ash and its optimum use with respect to type of soil and crop. Hence, an experiment was laid out to study the effect of integrated use of fly ash with and without FYM on rice productivity and nutrient status of soil.

Materials and Methods
A field experiment was conducted at Krishi Vigyan Kendra, Research Farm, Janjgir – Champa (C.G.) during *kharif* season 2016. Study was laid out in Randomized Block Design with eight treatments i.e. Control, GRD (100:60:40), 75% GRD + 20 t ha^{-1} fly ash, 75% GRD + 40 t ha^{-1} fly ash, 75% GRD + 60 t ha^{-1} fly ash, 75% GRD + 20 t ha^{-1} fly ash + 5 t ha^{-1}FYM, 75% GRD + 40 t ha^{-1} fly ash + 5 t ha^{-1} FYM and 75% GRD + 60 t ha^{-1} fly ash + 5 t ha^{-1} FYM with three

replication. The fly ash used in the experiment was taken from Madhya Bharat Paper Ltd. Village – Birgahni Champa, Dist. - Janjgir Champa, Chhattisgarh. The rice cultivar Rajeshwari was selected as test crop and twenty five days old rice seedlings were transplanted in 20 x 15 cm spacing. The fly ash, fertilizer and the FYM were applied as per treatments one day ahead of transplanting. The composite soil samples before sowing and after harvest of crop from 0-15 cm and 15-30 cm soil depth were collected separately from each plot and analyzed for different soil properties by following different standard procedure.

The pH was measured with pH meter using 1:2.5 soil water suspensions (Black, 1965) [2]. The clear suspension extract obtained from pH was also utilized for EC measurement using conductivity bridge (Black, 1965) [2]. Soil texture was determined by International Pipette method as described by Piper (1966) [15]. Available N was determined by alkaline permanganate method as described by Subbiah and Asija (1956) [21]. Available P was determined by Olsen method using 0.5 M sodium bicarbonate (pH 8.5) as an extractant using charcoal free from soluble phosphorus was used to absorb the dispersed organic matter and make the filtrate colorless for further colorimetric analysis (Jackson, 1978) [6]. Available K was determined by flame photometer using 1N neutral ammonium acetate method described by Jackson (1978) [6].

Results and Discussion

Characterization of soil, fly ash and FYM: The nutrient content of soil, fly ash and FYM is given in table 1 & 2. The soil in was clay loam in texture, neutral in reaction, normal in soluble salts. The soil was low in available nitrogen, phosphorus and high in potassium.

Table 1: The initial soil physico-chemical properties of experimental soil

Particulars	Analysis value	Soil type
Soil texture		Clay loam
Sand (%)	30	
Silt (%)	30	
Clay (%)	40	
Soil reaction (pH)	7.5	
Electrical conductivity (dS m^{-1})	0.13	
Organic carbon (%)	0.44	
Available N(kg ha^{-1})	176.89	
Available P (kg ha^{-1})	5.56	
Available K (kg ha^{-1})	348.25	

Yield attributes of rice crop

The yield attributing characters of rice i.e. effective tillers and numbers of grain per panicle was significantly influenced by imposition of different treatments (Table 3). Application of difference doses of fly ash combined with and without organic fertilizer did not significant influence on total tillers, panicle length and test weight, however slightly increase as compare to control and 100% general recommended dose of NPK.

The application of 75% GRD + 40 t ha^{-1} fly ash + 5 t ha^{-1} FYM (T_7) produced higher number while, control showed lower number of total tillers and number of grains per panicle. Fly ash applied @ 20 and 40 t ha^{-1} with FYM and 75% GRD + 40 t ha^{-1} fly ash significantly increased effective tillers and all other treatments of fly ash was no significant influence as compare to GRD (100:60:40).

Table 2: Physico-chemical properties of fly ash and FYM

Particulars	Fly ash	FYM
(0.02- 2 mm)	50	
Particle size distribution (0.002-0.02mm)	33	
(< 0.002 mm)	17	
Soil reaction (pH)	7.90	-
Electrical conductivity (dS m^{-1})	0.21	-
Organic carbon (%)	0.23	3.12
Total N (%)	0.071	0.86
Total P (%)	0.049	0.21
Total K (%)	0.31	0.59

Table 3: Effect of fly ash doses and in combinations with and without FYM on total tillers, effective tillers, panicle length, number of grains per panicle and test weight of paddy at harvest

Treatment	Total tiller/hill	Effective tiller/hill	Panicle length (c.m.) per panicle	Number of grains per panicle	Test weight (g.)
T_1-Control	6.00	4.00	19.33	50.33	26.00
T_2- GRD (100:60:40)	5.67	5.00	20.00	73.67	26.00
T_3- 75% GRD + 20 t ha^{-1} fly ash	5.33	4.67	21.33	77.67	26.33
T_4- 75% GRD + 40 t ha^{-1} fly ash	6.00	5.67	22.00	84.33	26.67
T_5- 75% GRD + 60 t ha^{-1} fly ash	5.67	5.00	21.00	80.00	26.67
T_6- 75% GRD + 20 t ha^{-1} fly ash + 5 t ha^{-1} FYM	6.33	5.67	22.33	83.33	27.33
T_7- 75% GRD + 40 t ha^{-1} fly ash + 5 t ha^{-1} FYM	6.67	6.00	23.00	87.00	27.00
T_8-75% GRD + 60 t ha^{-1} fly ash + 5 t ha^{-1}FYM	6.00	5.33	21.33	85.00	26.33
SEm±	0.46	0.22	0.92	1.89	0.56
CD (P=0.05)	NS	0.67	NS	5.74	NS

Fly ash applied @ 20, 40 and 60 t ha^{-1} with and without FYM significantly increased grains per panicle except 75% GRD + 20 t ha^{-1} fly ash as compare to 100% recommended dose of NPK.

The increase in yield attributes characters by application of fly ash may be due to combined application of fly ash and chemical fertilizer with FYM helped in promoting tiller numbers and dry matters. When fly ash conjunction with FYM and chemical fertilizer helped in nutrient supplying capacity of soil and significant positive correlation between growth parameters and nutrient uptake.

Karmarkar *et al.* (2010) [9] reported that increase in yield attributes by the application of fly ash with FYM may be due to improve physical and chemical properties that enhanced availability by various nutrients required for plant growth, complementary effect of higher root growth and nutrient availability to plant might have resulted higher number of grain per panicle. Thus synergistic effect of integration of fly ash with FYM and chemical fertilizer on nutrient supply system might be resulted in better nutrient uptake which produced more numbers of yield attributes. Application of fly ash increased the availability of nutrients throughout the crop period, which might be the reason for higher growth parameters of rice. Similar results were also reported by Prakash (2014) [16].

Significantly increased effect tillers and higher number of grains per panicle was also reported by Yavarzadeh *et al.* (2012) [23], Khan *et al.* (2008) [10] and Sahu *et al.* (2007) [19].

Grain and straw yield

Influence by various doses of fly ash combined with and without FYM on grain yield significantly increased (Table 4). The grain yield was ranged from 19.83 to 50.67 q ha^{-1}. The highest yield of (50.67q ha^{-1}) was recorded by the addition of 75% GRD + 40 t ha^{-1} fly ash + 5 t ha^{-1} FYM which might be due to the favorable soil condition created by the fly ash with manures and fertilizers (Das *et al.*, 2013) [3]. Application of fly ash @ 40 and 60 t ha^{-1}+ 75% GRD with FYM and 75% GRD + 40 t ha^{-1} fly ash increased significantly over 100% GRD (100:60:40). The increase in the grain yield by application of 75% GRD + 40 t ha^{-1} fly ash + 5 t ha^{-1} FYM was 28.27 % when compared over 100% recommended dose of NPK (100:60:40). The difference in grain yield among the various fly ash doses with and without FYM was non significant.

Interaction of varied levels of fly ash with different treatments showed a significant variation in straw yield (Table 3). Application of 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) produced the highest (78.67 q ha^{-1}) straw yield and control showed the lowest (32.17 q ha^{-1}). Application of different doses of fly ash with and without FYM straw yield similar to GRD. The increase in the straw yield by application of 75% GRD + 40 t ha^{-1} fly ash + 5 t ha^{-1} FYM was 21 % when compared over 100% GRD (100:60:40).

Table 4: Effect of fly ash doses and in combinations with and without FYM on grain and straw yield of paddy at harvest.

Treatment	Grain Yield q ha^{-1}	Straw yield q ha^{-1}
T_1-Control	19.83	32.17
T_2- GRD (100:60:40)	39.50	65.00
T_3- 75% GRD + 20 t ha^{-1} fly ash	44.00	67.37
T_4- 75% GRD + 40 t ha^{-1} fly ash	47.17	71.50
T_5- 75% GRD + 60 t ha^{-1} fly ash	41.33	63.67
T_6- 75% GRD + 20 t ha^{-1} fly ash + 5 t ha^{-1} FYM	48.17	74.00
T_7- 75% GRD + 40 t ha^{-1} fly ash + 5 t ha^{-1} FYM	50.67	78.67
T_8-75% GRD + 60 t ha^{-1} fly ash + 5 t ha^{-1}FYM	45.00	69.00
SEm±	2.44	4.96
CD (P=0.05)	7.42	15.05

The results indicated that FA dose along with 75% recommended dose of NPK and FYM had positive effects on yield and yield components which might be due to improvement in physical properties of soil accompanied with balanced availability of applied nutrients. Integration of FA with FYM reduced the fertilizer budget as well as improves soil properties.

The increase in grain and straw yield may be due to the presence of many chemical constituents of fly ash which may have a beneficial effect on soil properties. Rautaray *et al.* (2003) [17] concludes that the dry matter production of rice is an important character which indicates the extent of accumulation of photosynthates and an indirect indication of photosynthetic activity.

Mittra *et al.* (2003) [13] also reported that fly ash in combination with organic sources and fertilizers increased the grain yield of rice by 31% as compared to the chemical fertilizers alone. Integration of fly ash with inorganic fertilizer and FYM produced considerably higher grain and straw yield was also reported by Reddy *et al.* (2010) [18] and Yelendhalli *et al.* (2008) [24].

Soil reaction (pH), electrical conductivity and organic carbon of soil

The addition of different dose of fly ash with different combination of organic and inorganic fertilizer did not influence soil pH and electrical conductivity in both 0-15 cm and 15-30 cm soil depth (Table 5) while, marginal increase compare than initial value.

Fly ash can change soil pH in both directions i.e. increase or decrease depending on fly ash pH. Acidic nature fly ash decreased soil pH while alkaline fly ash can raised pH of acidic soils (Pathan *et al.*, 2003 and Skousen *et al.*, 2013) [14, 20]. One possible reason for this may be that salts might have move down at lower depth with water and resulting in no significant influence on electrical conductivity of the soil. These observation corroborate with the earlier work reported by James *et al.* (2014) [8].

Table 5: Effect of fly ash doses and in combinations with and without FYM on soil pH, electrical conductivity and organic carbon of different depth at harvest

Treatment	pH (1:2.5)		EC dS m^{-1}		Organic carbon (%)	
	0-15	15-30	0-15	15-30	0-15	15-30
T_1-Control	7.69	7.91	0.12	0.12	0.41	0.28
T_2- GRD (100:60:40)	7.77	7.97	0.13	0.13	0.49	0.30
T_3- 75% GRD + 20 t ha^{-1} fly ash	7.93	8.05	0.13	0.14	0.50	0.31
T_4- 75% GRD + 40 t ha^{-1} fly ash	7.79	7.92	0.14	0.13	0.54	0.33
T_5- 75% GRD + 60 t ha^{-1} fly ash	7.87	7.93	0.12	0.15	0.51	0.32
T_6- 75% GRD + 20 t ha^{-1} fly ash + 5 t ha^{-1} FYM	7.76	8.06	0.13	0.13	0.57	0.32

T_7- 75% GRD + 40 t ha^{-1} fly ash + 5 t ha^{-1} FYM	7.81	8.09	0.14	0.15	0.61	0.39
T_8-75% GRD + 60 t ha^{-1} fly ash + 5 t ha^{-1}FYM	7.95	7.94	0.13	0.13	0.58	0.33
SEm±	0.18	0.20	0.008	0.007	0.01	0.03
CD (P=0.05)	NS	NS	NS	NS	0.04	NS

The effect of different treatments on the status of available carbon content was found significantly at surface soil and non significant influence in subsurface soil depth (Table 3). All the treatments of fly ash had increased the organic carbon content and more in surface than subsurface soil depth. In surface soil fly ash applied @ 20, 40 and 60 t ha^{-1} + 75% GRD with FYM and 75% GRD + 40 t ha^{-1} fly ash significantly increased organic carbon content as compare to 100% recommended dose of NPK.

Fly ash applied @ 40 t ha^{-1} combined with 5 t ha^{-1} FYM and 75% (GRD) recommended dose of NPK recorded the highest organic carbon content in 0-15 cm (0.65 %) and 15-30 (0.42 %) cm soil depth and control showed lowest.

Organic-C increased with subsequent increase in fly ash doses over control. This might be due to faster oxidation (decomposition) of fly ash under the influence of chemical fertilizer and FYM which have resulted in accumulation of organic matter in contrast to the former. The results on increased soil organic carbon by fly ash applied was also reported by Das *et al.* (2013) [3] and Jala (2005) [7].

Available major nutrients of soil

The available nutrients in 0-15 and 15-30 cm soil depths of the post-harvest soil were found to increase by the addition of graded levels of fly ash with and without FYM (Table 6). Fly ash applied @ 20, 40 and 60 t ha^{-1} with and without FYM significantly increased nitrogen status over 100% recommended dose of NPK in 0-15 cm depth soil. Application of 75% GRD + 40 t fly ash ha + 5 t FYM ha recorded highest available nitrogen (225.41 kg ha^{-1}), while absolute control showed the lowest (178.01 kg ha^{-1}).Different treatments of fly ash non significant increased is soil available nitrogen content in subsurface (15-30 cm) soil.

Table 6: Effect of fly ash doses and in combinations with and without FYM on soil available major nutrients of different depth at harvest

Treatment	Available N (Kg ha^{-1})		Available P (Kg ha^{-1})		Available K (Kg ha^{-1})	
	0-15	15-30	0-15	15-30	0-15	15-30
T_1-Control	178.01	132.90	5.81	3.94	351.78	243.98
T_2- GRD (100:60:40)	198.13	141.26	5.90	4.12	366.40	283.19
T_3- 75% GRD + 20 t ha^{-1} fly ash	212.62	145.44	6.64	5.09	392.08	285.51
T_4- 75% GRD + 40 t ha^{-1} fly ash	215.24	153.80	7.28	5.26	413.33	287.84
T_5- 75% GRD + 60 t ha^{-1} fly ash	211.09	145.44	6.96	5.16	407.18	272.62
T_6- 75% GRD + 20 t ha^{-1} fly ash + 5 t ha^{-1} FYM	219.00	153.80	8.09	5.39	436.80	284.31
T_7- 75% GRD + 40 t ha^{-1} fly ash + 5 t ha^{-1} FYM	225.41	156.16	8.29	5.41	439.18	291.44
T_8-75% GRD + 60 t ha^{-1} fly ash + 5 t ha^{-1}FYM	220.77	157.98	9.27	5.25	445.41	292.12
SEm±	1.95	8.49	0.31	0.63	4.57	10.60
CD (P=0.05)	5.92	NS	0.94	NS	13.88	NS

Soil available phosphorus content in various doses of fly ash at harvest increased significantly with and without organic fertilizer except 75% GRD + 40 t fly ash ha as compare to 100% GRD in surface(0-15 cm) soil. However, non significant increased is soil available P in subsurface (15-30 cm) soil. Fly ash applied @ 60 t ha^{-1} fly ash + 75% GRD+ 5 t ha^{-1} FYM recorded the highest (9.27 kg ha^{-1}) while control was the lowest (5.81 kg ha^{-1}) soil available phosphorus in 0-15 cm depth soil.

Available K status of soil increased over control and 100% GRD in all the treatments consisting of with and without FYM blended with various doses of fly ash in 0-15 cm soil depth. Among the treatments 75% GRD + 60 t ha^{-1} fly ash + 5 t ha^{-1}FYM recorded the highest (445.41 kg ha^{-1}) while, control showed the lowest (351.71 kg ha^{-1}) soil available K. However, non significant increased is soil available K in subsurface (15-30 cm) soil by different doses of fly ash.

The results showed that available major soil nutrients in 0-15 and 15-30 cm dept soil of difference between the two levels of FA along with 75 % recommended dose of NPK was not significant. This increase in available nutrients in soil after harvest of rice might be due to chelating effect of FYM and FA which did not allow the nutrients to be lost or adsorbed to the soil. Mineralization of nutrient from fly ash and organic manure, which is a slow process and provides all the major and micro-nutrients during the crop requirement at later stage.

The increased soil nutrient status can be attributed to decomposition of crop residues resulting in enzyme-aided nutrient mineralization carried out by the native microbial population present in the soil. The favorable effect of fly ash on nutrient availability was ascribed to its effect on biotic activity and the nutrient release via biotic activity.

Khan *et al.* (1996) [11] reported increase in available P and K status in soil and they attributed it to the P and K content of fly ash. The combined addition of fertilizer and FYM recorded higher availability of post-harvest soil nutrients. The synergistic effect of fly ash, FYM and fertilizer would have resulted in higher soil fertility status after harvest of rice crop. Similar results were also reported by Bhoyar (1998) [1].

Lee, *et al.* (2005) [12] are also reported to increased available major nutrients due to fly ash addition.

Conclusion

The results recorded from the study reveals that fly ash a supplemental source of nutrient essential for crops growth and it could be used for crop production. The application of fly ash @ 40 t ha^{-1} +75% GRD along with 5.0 t ha $^{-1}$ FYM had significant effect on yield, yield attributes of rice, major nutrient and organic carbon status of soil. Fly ash application enriched the soil led to the relative impoverishment of grain yield, straw yield, macro nutrients and organic carbon content. When combined application of fly ash with FYM, more pronounced beneficial effects were recorded in the present study. So fly ash when applied along with organics can be a potential supplemental source of nutrients for crop.

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