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Utilization of Fly ash for Crop Production: Effect on the Growth of Wheat and Sorghum Crops and Soil Properties

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ABSTRACT

Present paper reports the results of the study on the effects of varying levels of fly ash (0,5,10,20 t./ha) and nitrogen (0,10,20 ,40 kg/ha) on germination, growth parameters, yield of wheat and sorghum crops and soil properties. Field experiments were carried out at the Muthiani village near National Capital Power Project (NCPP), Dadri, U.P.and Research Farm CCR (PG) College, Muzaffarnagar,U.P. during the years, 2004-06. Germination and early growth was affected adversely in wheat but increasing levels of fly ash did not cause any harmful effect in sorghum. Grain yield of both the crops was slightly increased at higher levels of nitrogen and ash i.e. 20t/ha coal burnt ash + 120kg/ha N (wheat) or 40 kg/ha N (sorghum). Water transmission characteristics of experimental soil (saturated hydraulic conductivity) decreased but water retention improved with addition of increasing levels of fly ash.

Key words: Sorghum, Wheat, Crop Growth, Soil Properties, Fly ash

Introduction

Every year thermal power plants in India produce more than 100 million tonnes of fly ash, which is expected to reach 175 millions in the near future (Jamwal Nidhi, 2003). Disposal of this huge quantity of fly ash is posing a great problem due to its limited utilization in the manufacturing of bricks, cements, ceiling and other civil construction activities. This would further bring changes in land-use patterns and contribute to land, water and atmospheric degradation, if proper management options for handling ash are not undertaken (Deshpande *et al*., 1993, Pathak *et al*., 1996 and Kalra *et al*., 1996b). The countries like Germany, Denmark, France, U.K., USA, and the Netherlands utilize fly ash (up to 70 %) as a building material and for other construction purpose, but in India its utilization is less than 15 % (Sinha and Basu, 1998). Use of fly ash in agriculture provides a feasible alternative for its safe disposal to improve the soil environment and enhance the crop productivity. However, a judicious management strategy has to be developed to abate the land pollution from the heavy metals present in the fly ash. Present study deals with the effect of the application of varying levels of fly ash and nitrogen on early plant growth and yield of wheat and sorghum crops along with the properties of the cultivated soil on farmer's field.

Materials and Methods

Field experiments were conducted during 2004-05 and 2005-06 with wheat (*Triticum aestivum* L) and sorghum(*Sorghum bicolor*) grown with different levels of fly ash in farmer's field at Muthiani village near Dadri Distt Bulandshahr and C.C.R. (P.G.) College,

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Agricultural Research Farm, Muzaffarnagar(UP). Soils from both experimental sites and fly ash used in the present study were analyzed for their physical and chemical characteristics as suggested by Jackson (1973). Surface soil samples (0-30 cm) of each location were collected, analyzed and averaged for sites' characterization. Wheat cultivar, HD- 2285 was tested for four levels of fly ash, i.e., 0, 5, 10 and 20 t/ha and four levels of N, i.e., 0, 25, 50 and 100 kg/ha at Muthiani village. Cultivar, Lok-1 was also grown under same levels of fly ash and nitrogen at C.C.R. (P.G.) College, Agricultural Research Farm, Muzaffarnagar. N levels for Sorghum (cultivar CSH-1) were 0, 10, 20 and 40kg/ha at both the sites. Fly ash was applied uniformly in the entire experimental field and ploughed to mix it properly in the soil (In the last week of November for wheat and last week of June for sorghum during both the years). Irrigation scheduling, fertilizer application (except N) and intercultural operations were followed as per normal agronomic recommendations. The experiment was laid out in a completely randomized block design with three replications. Above ground biomass and grain yield were recorded at harvest for all treatments. At harvest of crops, surface soil samples (0-30cm)were collected and analyzed for bulk density, saturated hydraulic conductivity, field capacity, permanent wilting point, pH, electrical conductivity, organic carbon, sodium, calcium and available N, P, K as per standard laboratory methods (Jackson 1973).

Results and Discussion

Fly ash and Soil Properties

Fly ash is a heterogeneous mixture of amorphous and crystalline phases and generally considered as ferroaluminosilicate. It comprised of about 69 percent silt and clay size fractions. Low value of its particle density established its potential for dust formation (Sharma *et al*., 2001). High water holding capacity of ash was due to its dominant silt and clay size fractions. Fly ash contained about 93 percent of silica and sesquioxides (Al_2O_3 and Fe_2O_3). And in the remaining portion, Ca^{2+} was the dominant cation followed by Mg^{2+}, Na^+ and K^+. The bulk density of fly ash was 1.01 Mg/m^3. Organic carbon content in the ash was 0.36 percent. Water holding capacity of fly ash was 56.9 percent. pH and electrical conductivity values were 6.98 and 0.65 dS/m, respectively. Physical and chemical characteristics of surface-soil layer (0-30 cm) at both sites are given in Table1.

(i) Response of Wheat to fly ash

Average grain & biomass yields of wheat as affected by the application of different levels of fly ash and nitrogen fertilizer during 2004-05 & 2005-06 are being discussed here. At Muthiani village, grain and biomass yield increased slightly with fly ash and nitrogen application rates. However, yield values at 5, 10 and 20 t/ha fly ash and nitrogen at 25, 50 and 100 kg/ha only showed non-significant values over control (no ash and N). Similarly at C.C.R. (P.G.) College, Agricultural Research Farm, Muzaffarnagar, grain and biomass yields also increased continuously with combined application of fly ash and nitrogen levels and were 11.8 percent and 14.3 percent higher with 20 t/ha fly ash and 100 kg/ ha N level over control with its values of 2.85 t/ha and 9.70 t/ha, respectively. It implies that application of fly ash in combination with nitrogen had some advantageous effect on grain and biomass yield of wheat crop irrespective of the variety though the positive effect was non-significant.

(ii) Response of Sorghum to fly ash

Average values of growth parameters and yield of sorghum during 2004-05 & 2005-06 are being discussed here. Growth characteristics of sorghum were influenced significantly by increasing levels of fly ash and nitrogen. Highest average plant heights of 162 cm were recorded with 40 kg N + 20 t/ ha fly ash. Test weight of grain was also increased significantly with increasing levels of fly ash. N and fly ash levels also increased the harvest index of sorghum ranging from 21.6 to 29.0 percent with mean value of 24.95 percent. However, interactive effect of N and fly ash levels on Sorghum growth and yield parameters was also non-significant. Grain yield of sorghum as influenced by increasing

Table 1. Soil properties (0-30 cm) of experimental sites

Parameters	C.C.R. (P.G.) College, Agricultural Research Farm, Muzaffarnagar (UP)	Muthiani village Dadri, Bulandshahr (UP)
Soil Texture	Sandy loam	Sandy loam
Bulk Density (Mg/m^3)	1.53	1.51
Field Capacity(percent, w/w)	13.5	16.5
WP (percent, w/w)	5.8	5.4
Available Water(cm/m)	1.30	1.63
pH	7.2	8.71
EC (dS/m)	0.401	0.205
OC (percent)	0.382	0.441
Nitrogen (kg/ha)	145	89
Potassium (kg/ha)	201	110
Phosphorus (kg/ha)	18	2.70

Table 2. Average Grain yield (t/ha) of 2004-05 & 2005-06 of Sorghum under different levels of Fly Ash and N application at Muthiani village and CCR (PG) College Farm

location	N-levels (kg/ha)	Fly ash levels (t/ha)				
		0	5	10	20	Mean
MuthianiVillage Dadri,UP	0	1.20	1.23	1.28	1.29	1.25
	10	1.40	1.41	1.43	1.45	1.42
	20	1.58	1.61	1.63	1.65	1.62
	40	1.80	1.82	1.85	1.87	1.82
	Mean	1.49	1.52	1.55	1.56	1.53
CD(5%)		0.037 (N and Fly ash)				
CCR(PG)CollegeMuzaffarnagar(UP)	0	1.35	1.39	1.45	1.51	1.42
	10	1.47	1.50	1.57	1.60	1.53
	20	1.68	1.71	1.75	1.77	1.73
	40	1.89	1.93	2.01	1.99	1.95
	Mean	1.60	1.63	1.70	1.72	1.66
CD (5%)		0.026 (N and Fly ash)				

levels of N and fly ash at Muthaini village and CCR College Research Farm is given in Table2**.**

It is evident that the average grain yield of sorghum increased significantly from 1.49 t/ha (control) to 1.56 t/ha with 20 t/ha of fly ash. Similarly N levels of 0, 10, 20 and 40 kg/ha produced grain yield of 1.25,1.42,1.62 and 1.83 t/ha, respectively. The best interactive treatment of 40 kg/ha N + 20 t/ha fly ash produced the maximum grain yield of 1.87 t/ha. Based on experimental results, it may be implied that fly ash level up to 20 t/ha can be applied to sorghum crop without any deleterious effect for obtaining maximum grain yield. However, interaction effect of fly ash and N on grain yield of sorghum was found to be non-significant.

Changes in Soil Physical and Chemical Properties

Changes in physical and chemical properties of soil after two years of experimentation (2004-05 & 2005-06) are being discussed here. Fly ash treated plots tended to have lower bulk density (BD) of surface soil (0-30 cm), though the differences over control were non-significant at both the test sites for both the crops. At harvest of wheat in C.C.R. (P.G.) College, Agricultural Research Farm, Muzaffarnagar, BD values reduced over control by 5.9 percent under 20 t/ha fly ash treatment. This might be due to changes in total porosity as well as modifications in pore size distribution as reported by Adriano *et al.*, 1980 and Chang *et al.*, 1977. Saturated hydraulic conductivity (HC) was significantly reduced in fly ash treated plots from both the locations, primarily due to decreased micropores, even when lowest amount of fly ash was added in the soil. At harvest of wheat crop in the C.C.R. (P.G.) College, Agriculture Research, Farm, Muzaffarnagar the HC value reduced by 8.2 percent under 20 t/ha fly ash application. Modifications in the pore size distribution by adding fly ash had pronounced influence on the field capacity (FC) and wilting point (WP). At both the locations, FC and WP values increased in accordance with the amount of ash added in the soil. Since both FC and WP values got elevated by fly ash addition, the available water values (the difference between the two) were more or less similar under different treatments. pH value decreased, whereas electrical conductivity (EC) increased, in accordance with the amounts of ash added in the soil. Organic carbon and sodium increased with fly ash addition, whereas phosphorus, potassium and calcium decreased. The response varied, depending upon soil as well as ash amount and characteristics. Keeping in view the high buffering capacity of soil, it also becomes important to work out for the time up to which any change persists.

Conclusions

Utilization of fly ash in agriculture may provide a feasible alternative for its safe disposal without serious deleterious effects. However, fly ash varied widely in its physical and chemical composition, therefore, the mode of use in agriculture is different and depends on the characteristics of soil or soil type. Fly ash application in soil, modified the physical and chemical properties of soil along with the growth and yield of wheat and sorghum crops. At prevailing rates of fly ash application in farmers fields in villages around NCPP, growth and yield of both the crops increased, but the results were non-significant and hence need to be verified in a well-designed long-term experiment. Relative contributions of soil and canopy environment factors responsible for changes in growth and yield of crops by fly ash in soil have to be evaluated. Further there is need to investigate the fate of trace/heavy metals in soil-water-plant system with fly ash applications.

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