

Flyash Incorporation Effect on Soil Health and Yield of Maize and Rice

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Received: 29 March 2001; accepted :24 April 2001

Field experiments were conducted in villages around National Capital Power Project (NCP), Dadri, Uttar Pradesh, India during 1995 to evaluate flyash incorporation effects on soil health and growth and yield of maize (*Zea mays L.*) and rice (*Oryza sativa L.*). Flyash application levels (up to 10t/ha) were decided on the basis of an ash/dust fall range of 5 to 12 t/ha/y in the villages adjoining thermal power station. The grain yield of maize increased in flyash added plots, whereas rice yield was similar to flyash treated plots. Flyash added plots had marginally higher uptake of Zn, Cu, Fe, Mn, and Cd, but values were insignificant. Flyash application in soil resulted in lower bulk density. Flyash addition also reduced hydraulic conductivity and improved moisture retention at field capacity and permanent wilting point. These changes in the soil characteristics might have been due to modifications in the macro- and micro-pore size distribution which also contributed to increased yield of maize in light and medium textured soils.

Introduction

The impact of flyash on environment depends on its properties in terms of physical, chemical, and physico-chemical properties and elemental composition. But the characteristics vary considerably, according to the geographical origin of the coal, condition during combustion of the coal and sampling position within the power plant. Disposal of the huge amount of flyash produced by thermal power plant is of major concern. This material finds use in civil construction activities, but is economically unavoidable. It may also be used as landfill activities or depending on its pH for reclaiming acid/sodic soils. But these producers do not utilize major portion of ash, and thus thermal power stations have to manage for its storage but with minimal air, water, and soil pollution associated with it. Trace elements in flyash exhibit concentrations higher than in coal and concentrations of biologically toxic elements like B, Mo, and Se greatly exceed to their concentration in soil¹. Various studies in the past evaluated impact of flyash on soil characteristics and growth and yield of agricultural crops, but most of them were confined in the laboratories or experimental farms²⁻⁸. The paper deals with flyash addi-

tion effects on growth and yield of maize and rice crops and soil health in farmers' fields at Muthiani and Gulawathi villages around National Capital Power Project (NCP), Dadri, Ghaziabad, Uttar Pradesh, India.

Materials and Methods

Field experiments were conducted during 1995 with maize (*Zea mays L.*) and rice (*Oryza sativa L.*) grown under various levels of flyash added in the soil at Muthiani and Gulawathi villages around NCP, Dadri, Ghaziabad. Soils of the experimental sites and flyash used in the study were analyzed for their physical and chemical characteristics as suggested by Hanway and Heidal⁹ and Jackson¹⁰. Surface soil samples (0-30 cm) of each location were collected, analyzed, and averaged for sites' characterization. The flyash application levels (on oven dry basis) were selected on the basis of ash/dust fall range of 5-12t/ha/y in the villages adjoining NCP. Maize cultivar (Ganga Safed-2 (GS-2)) was tested for two levels of flyash, i.e., no ash added (NFA), and FA at 10 t/ha applied in the soil at sowing at location 1 of both Muthiani and Gulawathi villages. Flyash was mixed with the soil at the time of sowing, i.e., first two

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Table 1 - Soil characteristics (top layer soil, 0-30 cm) of experimental sites before sowing maize and rice crop

Parameters	Muthiani		Gulawathi	
	1*	2*	1*	2*
Soil texture	Sandy loam	Sandy clay loam	Sandy loam	Sandy clay loam
Bulk density (Mg/m ³)	1.48	1.46	1.49	1.47
Field capacity (per cent w/w)	16.1	17.8	16.7	18.1
Wilting point (per cent w/w)	5.2	6.6	5.1	6.4
Available water (mm/cm)	1.61	1.62	1.73	1.72
pH	8.74	9.05	9.09	9.09
EC (mmhos/cm)	0.203	0.437	0.298	0.233
Organic carbon (per cent)	0.446	0.338	0.450	0.340
Nitrogen (ppm)	84	89	108	88
Potassium (ppm)	106	133	268	123
Phosphorous (kg/ha)	2.67	1.84	3.78	2.12

*1 and 2 indicate two different locations in a village

weeks of June. Rice (cv. Pusa 677) was transplanted (one month old seedlings) on 15 July at location 2 in both villages with two levels flyash, i.e., NFA and FA at 10t/ha applied to the soil one week before transplanting.

Fertilizers (N, P O and K O), irrigation scheduling, spacing, inter-culture⁵ operations were followed as per normal agronomic practices. Above ground biomass and grain yield were recorded at harvest for all treatments. Trace elements (Zn, Cu, Fe, Mn, and Cd) uptake by grains was analyzed by following standard techniques of digestion and using Atomic Absorption Spectrophotometer¹⁰. At harvest, bulk density, saturated hydraulic conductivity, moisture retained at field capacity and permanent wilting point, pH, electrical conductivity, organic carbon, sodium, calcium, and available N, P, K were determined for the surface soil under all treatments, following the standard methods¹¹⁻¹⁴. Statistical analyses were carried out to establish the effects of flyash addition on soil characteristics and maize and rice yields.

Results and Discussion

Flyash and Soil Characteristics

Flyash used in the study comprised about 69 per cent silt and clay size fractions. Low value of its particle den-

sity established its potential for dust formation. High water holding capacity of ash was due to silt and clay size fraction dominance. Flyash contained about 93 per cent of silica, Al O₃, and Fe O₃. In the remaining portion, Ca was the² dominant cation³ followed by Mg, Na, and K. The bulk density of flyash was 1.01 mg/m³. Water movement was slower in ash shown by saturated hydraulic conductivity value of 3.57 cm/d. Organic carbon content in the ash was 0.36 per cent. Water holding capacity of flyash was 56.9 per cent (on weight basis). pH, and electrical conductivity values were 6.98 and 0.65 mmhos/cm, respectively. Concentration of Zn, Cu, Fe, Mn, and Cd in flyash, expressed in ppm, averaged to 88.2, 77.6, 63237, 219.2, and 23.8, respectively.

Physical and chemical characteristics of topsoil layer (0-30 cm) at different locations of Muthiani and Gulawathi villages are given in Table 1.

Crop Growth Response

At Muthiani, grain yield and biomass of maize at harvest increased significantly 2.58 t/ha to 2.78t/ha and 5.86t/ha to 6.24 t/ha, respectively, (NFA). The maize yield and biomass showed insignificant differences between NFA and FA at 10t/ha in Gulawathi village (Table 2). At Muthiani, the grain yield of rice increased by 1.3 per cent in flyash treated plots compared with NFA value

Table 2 — Maize yields, above ground biomass (TDM) and attributes under different flyash application treatments at Muthiani and Gulawathi villages

Treatment	Grain yield (t/ha)	TDM (t/ha)	HI weight (g)	1000 grain (cm)	Plant height
Muthiani					
No flyash	2.50	5.86	0.43	221	249 (21.5)
Flyash (@ 10t/ha)	2.78	6.24	0.45	217	258 (23.2)
CD, 5 per cent level	0.25	0.47	0.021	6.5	5.6
Gulawathi					
No flyash	2.70	6.61	0.41	180	281 (15.7)
Flyash (@ 10t/ha)	2.67	6.67	0.40	188	250 (42.9)
CD, 5 per cent level	0.15	0.37	0.019	6.2	5.4

* Figure in the parenthesis is standard deviation

Table 3— Rice yield, above ground biomass (TDM) and attributes under different flyash application treatments at Muthiani and Gulawathi villages

Treatment	Grain yield (t/ha)	TDM (t/ha)	HI weight (g)	1000 grain (cm)	Plant height
Muthiani					
No flyash	6.83	17.63	0.387	23.5	120 (5.4)
Flyash (@ 10t/ha)	6.92	18.40	0.376	24.3	117 (5.9)
CD, 5 per cent level	0.23	0.75	0.023	0.75	5.4
Gulawathi					
No flyash	6.91	16.83	0.410	25.3	121 (7.9)
Flyash (@ 10t/ha)	6.92	16.53	0.418	25.6	120 (8.7)
CD, 5 per cent level	0.13	0.29	0.013	0.37	3.2

* Figure in the parenthesis is standard deviation

6.83 of t/ha. The above ground biomass showed 4.4 per cent higher than the control (NFA) value of 17.6 t/ha (Table 3). At Gulawathi village, grain yield of rice and biomass were observed more or less similar between control (NFA) and FA at 10t/ha, i.e., around 6.9 t/ha and 16.8 t/ha, respectively. The increased maize yield obtained under ash incorporation was primarily due to increased tillers, spike length, and grains per spike and test weight.

Trace Elements Uptake

Trace elements, like Zn, Cu, Fe, Mn, and Cd were used as heavy metal indicators by crop grown under

flyash added soil. The trace elements uptake by grains during harvesting of maize and rice under different treatment is reported in Table 4. Flyash added plots had marginally higher uptake of trace elements, but values were insignificant. Insignificant higher uptake of these metals in flyash treated plots was due to their presence in oxide form and so insoluble in water for becoming readily available for their uptake¹³.

Modifications in Soil Physical and Chemical Environment

Flyash treated plots tended to have lower bulk density (BD) of surface soil (0-30 cm), though the differ-

Table 4 — Metal uptake by maize and rice grains under different flyash application treatments

Location	Flyash level (t/ha)	Zn	Concentration (ppm)			
			Cu	Fe	Mn	Cd
Maize						
Gulawathi	0	68.4	2.7	362.3	15.8	N.D.
	10	67.1	3.3	396.6	15.9	0.5
Muthiani	0	76.4	3.0	212.1	7.9	0.3
	10	75.6	3.7	232.3	7.5	0.6
Rice						
Gulawathi	0	22.4	2.1	262.3	25.8	0.4
	10	26.5	2.3	248.1	31.6	0.6
Muthiani	0	36.4	2.0	312.1	13.4	0.5
	10	37.2	2.7	388.3	20.0	0.9

Note: CD at 5 per cent levels is non-significant

Table 5— Soil physical properties as influenced by flyash addition at Muthiani and Gulawathi villages

Ash level (t/ha)	BD (Mg/m ³)	HC (cm/d)	FC (per cent, w/w)	WP (per cent, w/w)	Avail. Water (mm/cm)
Muthiani village					
Location 1					
<i>At maize harvest</i>					
0	1.47	7.54	15.9	5.1	1.587
10	1.46	7.43	16.4	5.4	1.617
CD, 5 per cent level	0.09	0.10	0.53	0.43	0.012
Location 2					
<i>At rice harvest</i>					
0	1.45	7.63	17.8	6.5	1.638
10	1.44	7.45	18.3	6.7	1.670
CD, 5 per cent level	0.13	0.25	0.43	0.25	0.014
Gulawathi village					
Location 1					
<i>At maize harvest</i>					
0	1.48	6.72	16.8	5.0	1.746
10	1.47	6.53	17.0	5.3	1.729
CD, 5 per cent level	0.14	0.35	0.34	0.45	0.016
Location 2					
<i>At rice harvest</i>					
0	1.47	5.46	18.0	6.7	1.661
10	1.42	5.41	18.4	6.8	1.647
CD, 5 per cent level	0.12	0.32	0.37	0.23	0.011

Table 6— Soil chemical properties as influenced by flyash addition at Muthiani and Gulawathi villages

Ash level (t/ha)	pH	EC (mmhos/cm)	OC (per cent)	Na (ppm)	Ca (ppm)	K (ppm)	N (ppm)	P (kg/ha)
Muthiani village								
Location 1								
<i>At maize harvest</i>								
0	8.73	0.202	0.311	518	2041	97	84	3.35
10	8.72	0.221	0.339	575	1875	94	85	3.18
CD, 5 per cent level	0.18	0.017	0.021	36	119	11	9	0.14
Location 2								
<i>At rice harvest</i>								
0	9.05	0.437	0.335	580	1985	135	79	2.95
10	8.93	0.475	0.352	582	1980	136	85	2.83
CD, 5 per cent level	0.23	0.021	0.018	12	95	13	11	0.15
Gulawathi village								
Location 1								
<i>At maize harvest</i>								
0	9.51	0.314	0.316	931	2023	224	112	3.19
10	9.21	0.375	0.337	975	2025	198	115	2.93
CD, 5 per cent level	0.31	0.043	0.021	30	105	26	13	0.14
Location 2								
<i>At rice harvest</i>								
0	9.12	0.232	0.343	860	2040	240	112	3.74
10	8.97	0.254	0.346	860	1975	235	115	3.58
CD, 5 per cent level	0.18	0.021	0.011	12	107	18	13	0.18

ences over NFA were insignificant at all the locations (Table 5). At harvest of rice in Gulawathi village, BD values reduced over NFA by 3.4 per cent under FA at 10 t/ha treatment. This might be due to the changes in total porosity as well as modifications in pore size distribution.^{16, 17} Saturated hydraulic conductivity (HC) was significantly reduced in flyash treated plots at all the locations, primarily due to increased macro-pores even when small amount of flyash was added in the soil. Modifications in the pore size distribution by adding flyash had pronounced influence on field capacity (FC) and wilting point (WP). At all 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 flyash addition, the available water values were more or less similar under different treatments. pH value decreased, whereas electrical conductivity (EC), organic carbon (OC) and sodium increased in accordance with

the ash added in the soil (Table 6). Phosphorous, potassium, and calcium decreased in flyash treated plots. The response varies depending upon soil as well ash amount and characteristics. Keeping in view the high buffering capacity of soil, it also becomes important to work out time up to which any characteristics change persists.

Conclusions

Flyash application in sandy loam soil influenced soil characteristics and productivity of maize. At prevailing ash/dust fall rates in villages around NCPP, growth and yield of maize crop increased, but the results need to be established in a well designed long-term experiment. Relative contributions of soil and canopy environment factors responsible for changes in growth and yield of wheat crop by flyash addition in soil have to be evaluated. Fate of heavy metals in soil-water-plant system by flyash addition needs to be investigated.

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