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INFLUENCE OF INTEGRATED EFFECT OF INORGANIC AND ORGANIC FERTILIZERS WITH FLY ASH ON HEAVY METALS ACCUMULATION OF SOIL AND PLANT UNDER RICE CROP

KIRAN PATEL[1]*, R. N. SINGH[1] AND A. K. PATEL[2]
[1]Department of Soil Science and Agricultural Chemistry,
Indira Gandhi Krishi Vishwavidyalaya, Raipur - 492 012, Chhattisgarh, INDIA
[2]Department of Physics, Amar Veerangana Rani Durgavati Government College, Tendukheda, Damoh- 470 880, Madhya Pradesh, INDIA

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***Corresponding author**

ABSTRACT

A field study was carried out during kharif season of 2014-15 at farmer field, Ajirma village, Surajpur district, (Chhattisgarh), to study the integrated effect of inorganic and organic fertilizers with different doses of fly ash on heavy metals accumulation of soil and plant under rice crop. The test crop was rice var. MTU-1010. The maximum available Cr, Co, Ni and Pb content was noted in treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} (0.27, 0.50, 0.43, and 1.76 mg kg^{-1}) while the minimum in control (0.17, 0.43, 0.33 and 1.20 mg kg^{-1}). The maximum Cr, Co, Ni and Pb content in grain was found in 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} (15.67, 0.68, 0.37 and 4.33 mg kg^{-1}) where it was minimum (12, 0.30, 0.20 and 1.33 mg kg^{-1}) in control. The maximum Cr, Co, Ni and Pb content in straw (27.0,1.67, 0.28 and 11 mg kg^{-1}) was found in 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} where it was minimum (18.20, 0.83, 0.13 and 6.00 mg kg^{-1}) in control.

INTRODUCTION

Fly ash is a product of "Thermal Power Plant", which is produced during burning of coal for energy purpose, is a major concern. Recently, more than 175 mt of fly ash is generated in India from several thermal power plants and it is expected about 300 mt of fly ash will be generated in the year of 2016-17 (Das *et al.*, 2011). Fly ash quality depends on coal type, coal particle fineness, percentage of ash in coal, combustion technique, air/fuel ratio, and boiler type (Dhadse *et al.,* 2008). In India, studies have been carried out toward management of fly ash disposal and utilization (Kumar *et al.,* 2003), it also contains toxic heavy metals which can move to the plants and accumulate resulting in toxicity to plants and animals. Heavy metals in soil have been a subject of extreme importance in recent years due to their greater potentialities to cause crop damage and adverse effect on animal health. Essential heavy metals in the form of micronutrients are required for plant growth and development and slightly excess amount of these metals in soil or growth medium may produce effects detrimental to the plants. Cu, Zn, Mo and Co is essential heavy metals for plants. However, the presence of traces of certain heavy metals like Pb, Cr, Cu, Ni and Mn in agriculture soil have greatly influenced the availability of other nutrient elements in plants grown in such soil (Khan *et al.*,1996; Mishra, 2000). Accumulation of metals in plant parts having secondary metabolites, which is responsible for a particular pharmacological activity. The issue of heavy metal pollution is very much concerned because of their toxicity for plant, animal and human beings and their lack of biodegradability.

Fly ash contains both micro- and macro nutrients useful for plant growth. Excess concentrations of heavy metals have adverse effects on plant metabolic activities hence affect the food production, quantitatively and qualitatively. Heavy metal when reaches human tissues through various absorption pathways such as direct ingestion, dermal contact, diet through the soil–food chain, inhalation and oral intake may seriously affect their health. In general the accumulation of metals was in the order of root>shoot>grain (Mishra, 2009). Keeping in view the above facts, it is needed to carry out an investigation entitled influence of integrated effect of inorganic and organic fertilizers with fly ash on heavy metals accumulation of soil and plant under rice crop.

MATERIALS AND METHODS

A field study in acid soil was carried out during season of 2014-15 at Farmer field, Ajirma village, Surajpur district, Chhattisgarh. The trial comprised of 8 treatments was laid out in Randomized Block Design with three replications. Fly ash and FYM applied as per the treatments before transplanting the rice. The rice cultivar MTU-1010 was selected as test crop and twenty five days old rice seedlings were transplanted in 20 x 10 cm spacing. All the plots received the 75 percent of general recommended dose (GRD) of NPK fertilizers (100:60:40 kg ha^{-1}) except control and 100% GRD. The use of fly ash in the experiment collected from National Thermal

Power Corporation (NTPC), Sipat, Bilaspur (Chhattisgarh). Composite soil samples before sowing and after harvest of crop from 0-15 cm were collected separately from each plot and analyzed for different soil properties by following different standard procedure. Available heavy metals (Cr, Co, Ni, Pb) i.e. Ni and Co were extracted by using 0.005 M diethylene triamine penta acetic acid (DTPA), 0.01 M calcium chloride dihydrate and 0.1 M triethanol amine (TEA) buffered at pH 7.3 and Pb and Cr were extracted by using 0.05M EDTA, disodium salt adjust pH of solution to 7.0 with 7M NH_4OH and the concentrations of the nutrients in the filtrate were analyzed by atomic absorption spectrophotometer (Lindsay and Norvell, 1978). Total heavy metals (Cr, Co, Ni, Pb) estimated by one gram oven dried plant sample (grain and straw), FYM and fly ash was digested with 10 ml of acid mixture (HNO_3 and HCl in 9:4 ratio) and final volume was made using 100 ml with deionized water. Total concentrations of Cr, Co, Ni and Pb were analyzed by atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Available heavy metals of soil after harvest of rice crop

Available Cr

The data presented in Table 2 and Fig.1 showed that ranged from 0.17-0.27 mg kg^{-1}. The maximum available Cr content was noted in treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t ha^{-1} 0.27 mg kg^{-1} while the minimum in control. The treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t ha^{-1} statistically at par with 75% GRD + 60 t fly ash ha^{-1} and 75% GRD + 40 t fly ash ha^{-1} + 5 t FYM ha^{-1}.

Available Co

The data presented in Table 2 and Fig. 1 showed that the cobalt status of the soil after harvest of rice crop was influenced significantly by various treatments. The maximum Co status 0.50 mg kg^{-1} was recorded in 75% GRD + 60 t fly ash ha^{-1} + 5 t ha^{-1} and the minimum in control (0.43 mg kg^{-1}). Co content is increased with the application of fly ash and FYM.

Available Ni

The data presented in Table 2 and Fig. 1 indicated that the different treatments has significantly influenced the Ni content of soil after harvest of crop. The maximum Ni content was found in 0.43 mg $kg^{-1}$and minimum in control (0.33 mg kg^{-1}). The treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t $ha^{-1}$was found statistically at par with treatment 75% GRD + 60 t Fly ash ha^{-1} and 75% GRD + 40 t fly ash ha^{-1} + 5 t FYM ha^{-1}.

Available Pb

The data presented in Table 2 and Fig. 1 indicated that the ranged from 1.20-1.76 mg kg^{-1}. The available Pb significantly affected by different treatment. The maximum available Pb content in soil was recorded under treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t $ha^{-1}$and minimum in control. Treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t ha^{-1} was found similar to 75% GRD + 40 t fly ash^{-1} , 75% GRD + 60 t fly ash ha^{-1} and 75% GRD + 40 t fly ash ha^{-1} + 5 t FYM ha^{-1}.

The metal content in soil was in the order of Pb > Co > Ni > Cr.

The finding indicate that the significant increase in Co, Cr, Pb and Ni content in soil amendment with fly ash however, there is a tendency of higher accumulation at increasing dose of fly ash due to high concentration of toxic heavy metal contain in fly ash. These finding were also supported by Rautary *et al*. (2003). Rao et al. (1990) have observed significant increase in Ca, Mn, K, Na, Co, Mo, Cr, Cu, Ni and Pb content in soil amended with fly ash. Similar findings have also been reported by Plank and Martens (1974), Elseewi *et al*. (1980), Khan *et al*. (1996).

Total heavy metals contents of rice crop at harvest stage

Table 1: Heavy metal content of fly ash, FYM and initial soil

Particulars	Initial Soil	Fly ash	FYM
Cr (mg kg^{-1})	0.16*	12**	6.0**
Co(mg kg^{-1})	0.40*	1.8**	0.8**
Ni (mg kg^{-1})	0.33*	1.6**	1.1**
Pb(mg kg^{-1})	1.18*	3.0**	5.0**

Where, * available heavy metal, ** total heavy metal

Table 2: Influenced by integrated effect of inorganic and organic fertilizers with fly ash on available heavy metals status of soil after harvest of rice crop

Treatments	Available chromium (mg kg^{-1})	Available cobalt (mg kg^{-1})	Available nickel (mg kg^{-1})	Available lead (mg kg^{-1})
T_1 Control	0.17	0.43	0.33	1.20
T_2 100% GRD (100:60:40)	0.17	0.45	0.34	1.40
T_3 75% GRD + 20 t fly ash ha^{-1}	0.19	0.44	0.37	1.42
T_4 75% GRD + 40 t fly ash ha^{-1}	0.23	0.47	0.39	1.52
T_5 75% GRD + 60 t fly ash ha^{-1}	0.26	0.48	0.41	1.52
T_6 75% GRD + 20 t fly ash ha^{-1} + 5 t FYM ha^{-1}	0.21	0.45	0.38	1.48
T_7 75% GRD + 40 t fly ash ha^{-1} + 5 t FYM ha^{-1}	0.24	0.49	0.42	1.56
T_8 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1}	0.27	0.50	0.43	1.76
SEm ±	0.01	0.01	0.006	0.08
CD (P = 0.05)	0.03	0.03	0.018	0.25

Table 3: DTPA extractable heavy metal concentration (mg kg^{-1}) in plant after the harvest of rice crop

Treatments	Cr		Co		Ni		Pb	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1 Control	12.00	18.20	0.30	0.83	0.20	0.13	1.33	6.00
T_2 100% GRD (100:60:40)	12.00	18.49	0.40	0.87	0.23	0.17	1.67	6.00
T_3 75% GRD+ 20 t fly ash ha^{-1}	12.70	19.30	0.50	0.93	0.24	0.20	2.00	8.00
T_4 75% GRD+ 40 t fly ash ha^{-1}	13.33	24.50	0.50	1.20	0.26	0.22	2.33	9.00
T_5 75% GRD+ 60 t fly ash ha^{-1}	14.00	26.90	0.67	1.27	0.33	0.27	2.67	8.33
T_6 75% GRD+ 20 t fly ash ha^{-} + 5 t FYM ha^{-1}	13.20	20.10	0.60	1.30	0.34	0.23	3.33	9.00
T_7 75% GRD+ 40 t fly ash ha^{-1} + 5 t FYM ha^{-1}	15.00	24.50	0.60	1.37	0.36	0.27	3.67	10.67
T_8 75% GRD+ 60 t fly ash ha^{-1} + 5 t FYM ha^{-1}	15.67	27.00	0.68	1.67	0.37	0.28	4.33	11.00
SEm±	0.49	0.18	0.02	0.12	0.02	0.02	0.32	0.29
CD (P = 0.05)	1.49	0.54	0.07	0.38	0.07	0.07	0.97	0.89

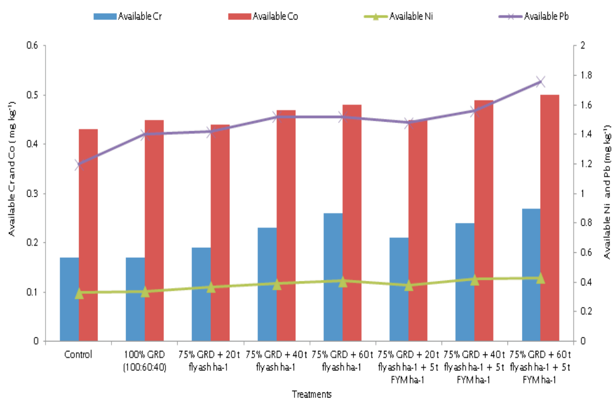

Figure 1: Influenced by integrated effect of inorganic and organic fertilizers with fly ash on available heavy metals status of soil after harvest of rice crop

Total chromium

The results on total chromium as influenced by treatments is presented in Table 3. The maximum chromium content in grain (15.67 mg kg^{-1}) was found in 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} where it was minimum (12 mg kg^{-1}) in control. The treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} at par with 75% GRD + 40 t fly ash ha^{-1} + 5 t FYM ha^{-1}. The maximum chromium content in straw (27 mg kg^{-1}) was found in 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} where it was minimum (18.20 mg kg^{-1}) in control. The treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} at par with 75% GRD + 60 t fly ash ha^{-1}.

Total cobalt

The results on total cobalt content as influenced by treatments is presented in Table 3. The maximum cobalt content in grain (0.68 mg kg^{-1}) was found in 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} where it was minimum (0.30 mg kg^{-1}) in control. The treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} at par with 75% GRD + 60 t fly ash ha^{-1}. The maximum cobalt content in straw (1.67 mg kg^{-1}) was found in 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} where it was minimum (0.83 mg kg^{-1}) in control. The treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} at par with 75% GRD + 20 t fly ash ha^{-1} + 5 t ha^{-1} and 75% GRD + 40 t fly ash ha^{-1} + 5 t FYM ha^{-1}.

Total nickel

The results on total nickel content as influenced by treatments is presented in Table 3. The maximum nickel content in grain (0.37 mg kg^{-1}) was found in 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} where it was minimum (0.20 mg kg^{-1}) in control. The treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} at par with 75% GRD + 60 t fly ash ha^{-1}, 75% GRD + 20 t fly ash ha^{-1} + 5 t ha^{-1} and 75% GRD + 40 t fly ash ha^{-1} + 5 t FYM ha^{-1}. The maximum nickel content in straw (0.28 mg kg^{-1}) was found in 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} where it was minimum (0.13 mg kg^{-1}) in control. The treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} at par with 75% GRD + 40 t fly ash ha^{-1}, 75% GRD + 60 t fly ash ha^{-1}, 75% GRD + 20 t fly ash ha^{-1} + 5 t ha^{-1}FYM and 75% GRD + 40 t fly ash ha^{-1} + 5 t FYM ha^{-1}.

Total lead

The results on total lead content as influenced by treatments is presented in Table 3. The maximum lead content in grain (4.33 mg kg^{-1}) was found in 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} where it was minimum (1.33 mg kg^{-1}) in control. The treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} at par with 75% GRD + 40 t fly ash ha^{-1} + 5 t FYM ha^{-1}. The maximum lead content in straw (11 mg kg^{-1}) was found in 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} where it was minimum (6.00 mg kg^{-1}) in control. The treatment 75% GRD + 60 t fly ash ha^{-1} + 5 t FYM ha^{-1} at par with 75% GRD + 40 t fly ash ha^{-1} + 5 t FYM ha^{-1}.

The metal content in rice crop was in the order of Cr >Pb>Co>Ni.

Metal content in soil as well as plant materials increased with increase application of ash. Al, Cu, Cr and Pb contents (mg/kg) were 9.9, 81.0, 89.0 and16.0 in soil with 20 tons/ha fly ash against 0.6, 5.0, 3.6 and 5.0 mg/kg respectively in control soil (with no ash application) (Mishra, 2009). Singh *et al.* (1994) have reported favoured growth of beet root and improved yield with lower dose of fly ash and metal contents in plant were within the limit suitable for human consumption.

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