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Effect of flyash on soil micronutrients under sunflower spinach sunflower crop rotation

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Abstract
Fly ash is waste product that is produced in huge amount by combustion of coal in thermal power plants. The management of this huge amount of waste is a prime concern for the present and future at both regional as well as global level. Different types of nutrients and heavy metals are found in fly ash. The present study aimed to determine the effect of fly ash on soil health under sunflower spinach sunflower crop rotation. Three replications were carried out in a Randomized Block Design with seven treatments. The fly ash was applied T1, T2, T3, T4, T5, T6 and T7 at the rate of 0, 5, 10, 20, 30, 40 and 50 ton/hectare respectively. Most of the heavy metals such as Zinc, Copper and Iron were found higher at 0-15 cm depth of soil than the depth of 15-30 cm but Iron was found lower at 0-15 cm depth of soil than the depth of 15-30 cm. The heavy metals have significant effect on soil health on the accumulation of these elements.

Keywords: Fly ash, soil, heavy metal, micronutrient

1. Introduction
Every year a lot of thermal power plant is running in Indian and produced more than 110 million tons of fly ash. The main problem of this huge quantity of fly ash due to limited source to utilizations in manufacturing purposes like bricks, cements ceiling and civil construction. If proper management will not be adopted then it will lead serious problems in land use pattern, water and atmospheric degradation. (Pathak *et al.*, 1996; Kalra *et al.*, 1996) [9, 6]. Use of fly ash in agriculture practices as manures provides a feasible substitute for its safe disposal to improve the soil environment and improve the crop productivity. Near about 80 and more coal-fired thermal power plants are running at different parts of India and generated 58651 MW of energy out of 96948 MW total power generation up to 2000 A.D.(TERI, New Delhi, 2001) [15]. Fly ash consist different types of plant macronutrients such as Na, K, P and Fe and micro-nutrients Co, B, Zn, Cu and Mn, except these Pb, Ni, Cr, Cd and a few more elements also occur abundantly that may cause contamination/toxicity (John *et al.*, 2009; Fytianos *et al.*, 2001) [4, 3]. Further, plant micro-nutrients at high concentrations can cause toxicity (Miller *et al.*, 2000) [7]. Fly ash can use based on its limited potential and nutrient supply which endorse the growth of plants and improve the circumstances of nutrient deficiency in soils (Singh *et al.*, 2008; Jothinayagi *et al.*, 2009; Singh and Agrawal, 2010) [13, 5, 12]. It can also be used as a liming agent not for both mono and dicotyledons plants for better yields of crops (Ahmed *et al.*, 1986; Sarangi and Mishra, 1998; Singh and Siddhiqui, 2003) [1, 10, 14]. Fly ash with enriching soil increased the growth and yield of cereal crops like tomato, potato, cabbage, pea, wheat, mustard (Mittra *et al.*, 2005; Saxena *et al.*, 2005) [8, 11].
The present study aimed to determine the effect of fly ash on soil micronutrients under sunflower spinach sunflower crop rotation.

Materials and Methods
The experiment was conducted in Nursery, College of Forestry, SHUATS in 2016-17 which is away approximate 6.8 km from Prayagraj city.

Physico- Chemical Properties of Flyash
The fly ash was brought from the IFFCO Phulpur. After homogenization and drying three portions was took, digested with a nitric perchloric solution and toxic element concentrations was determined by Atomic Absorption Spectrophotometer. The physical property of fly ash such as bulk density, water holding capacity and porosity was 0.86 g/c.c., 11.21 m/day and 35.58% respectively, and chemical property of fly ash like pH, EC, Copper, Zinc, Iron, Lead were 7.83, 0.43 dSm^{-1}, 44.17 mg kg^{-1}, 33.42 mg kg^{-1}, 34.21 mg kg^{-1} and 31.14 mg kg^{-1} respectively.

Experimental Field Design:

The field experiment was conducted at the Research farm of department of Environmental Sciences and NRM, College of Forestry and Environment, Sam Higginbottom University of Agriculture, Technology and Sciences (Formerly Allahabad Agricultural Institute), Prayagraj in order to find out the effect of different levels of fly ash and accumulation of heavy metals viz. Cu, Zn, Fe and Pb on soil.

Experimental fields were prepared on randomized block design with 3 replications. Fields were prepared by ploughing and the cultivation was done according to agronomic practices. Fly ash were mixed uniformly in soils as 0, 5, 10, 20, 30, 40 and 50 ton/hectare and designated as T1, T2, T3, T4, T5, T6 and T7 respectively.

Results

The present study focussed on effect of fly ash on soil under sunflower spinach sunflower crop rotation.

Table 1: Effect of Fly ash on Zinc (mg kg^{-1}) of Post-Harvest Soil under Sunflower Spinach Sunflower Crop rotation

Treatment	0-15 cm				15-30 cm			
	Sunflower	Spinach	Sunflower	Mean	Sunflower	Spinach	Sunflower	Mean
T_1	0.29	0.23	0.22	0.25	0.30	0.28	0.18	0.26
T_2	0.27	0.26	0.25	0.26	0.31	0.25	0.21	0.25
T_3	0.33	0.31	0.30	0.31	0.35	0.31	0.28	0.32
T_4	0.33	0.31	0.30	0.31	0.37	0.32	0.29	0.33
T_5	0.46	0.40	0.40	0.42	0.48	0.42	0.37	0.42
T_6	0.46	0.41	0.40	0.42	0.49	0.43	0.40	0.44
T_7	0.47	0.46	0.42	0.45	0.53	0.50	0.40	0.48
F-test	S	S	S	S	S	S	S	S
S. Ed. (±)	0.01	0.03	0.02	0.02	0.03	0.02	0.01	0.02
C.D. at 5%	0.03	0.06	0.03	0.04	0.07	0.04	0.02	0.04

The maximum zinc was found 0.45 (mg kg^{-1}) and minimum 0.25 (mg kg^{-1}) in T7 (Flyash @ 50 metric tons ha^{-1}+ RDF) and T1 at 0-15 cm soil depth and similarly the maximum zinc was found 0.48 (mg kg^{-1}) and minimum 0. 25 (mg kg^{-1}) in T7 and T2 respectively at 15-30 cm. T7 is statistically at par with the T5 & T6 in both 0-15 cm and 15-30 cm of depth. Table 1 showed that the soil zinc was increases with the increased dose of fly ash in each treatment and also observed that the zinc decreases after harvesting of each crop under crop rotation.

Table 2: Effect of Fly ash on Copper (mg kg^{-1}) of Post-Harvest Soil under Sunflower Spinach Sunflower Crop rotation

Treatment	0-15 cm				15-30 cm			
	Sunflower	Spinach	Sunflower	Mean	Sunflower	Spinach	Sunflower	Mean
T_1	0.11	0.10	0.09	0.10	0.13	0.10	0.09	0.11
T_2	0.20	0.19	0.17	0.19	0.24	0.20	0.19	0.21
T_3	0.26	0.22	0.21	0.23	0.30	0.23	0.21	0.24
T_4	0.67	0.62	0.59	0.63	0.71	0.58	0.51	0.60
T_5	0.92	0.90	0.88	0.90	0.96	0.88	0.80	0.88
T_6	0.92	0.91	0.89	0.91	0.96	0.90	0.87	0.91
T_7	0.99	0.92	0.90	0.94	1.08	0.96	0.90	0.98
F-test	S	S	S	S	S	S	S	S
S. Ed. (±)	0.04	0.02	0.02	0.02	0.08	0.04	0.02	0.04
C.D. at 5%	0.07	0.04	0.04	0.05	0.16	0.08	0.03	0.09

Table 2 showed the variations of Copper at different treatments. The maximum copper were found 0.94 and 0.98 in T7 and minimum was 0.10(mg kg^{-1}) and 0.11(mg kg^{-1}) in T1 (Control) at 0-15 cm and 15-30 cm respectively. Increasing trends (T1 to T7) shows due increase dose of fly ash at both 0-15cm and 15-30 cm.

Table 3: Effect of Fly ash on Lead (mg kg^{-1}) of Post-Harvest Soil under Sunflower Spinach Sunflower Crop rotation

Treatment	0-15 cm				15-30 cm			
	Sunflower	Spinach	Sunflower	Mean	Sunflower	Spinach	Sunflower	Mean
T1	0.04	0.04	0.03	0.04	0.05	0.04	0.03	0.04
T2	0.83	0.80	0.75	0.79	0.88	0.78	0.72	0.79
T3	3.34	3.10	2.93	3.13	3.44	2.40	1.39	2.41
T4	3.55	3.29	2.99	3.28	3.66	2.87	1.67	2.73
T5	4.80	4.44	4.09	4.45	5.70	3.17	1.78	3.55
T6	4.81	4.49	4.15	4.48	5.78	3.49	2.06	3.78
T7	5.64	5.07	4.61	5.11	6.16	3.75	2.21	4.04
F-test	S	S	S	S	S	S	S	S
S. Ed. (±)	0.42	0.34	0.27	0.34	0.35	0.17	0.12	0.21
C.D. at 5%	0.86	0.71	0.56	0.71	0.73	0.34	0.24	0.44

The maximum lead were found 5.11(mg kg^{-1}) and 4.04(mg kg^{-1}) in T7 at 0-15 cm and 15-30 cm respectively and minimum was found 0.4(mg kg^{-1}) in T1 at both 0-15 cm and 15-30 cm depth of soil. Table 3 shows the increasing trend with increasing dose of fly ash but decreasing trends shows during the depth of soil.

Table 4: Effect of Fly ash on Iron (mg kg^{-1}) of Post-Harvest Soil under Sunflower Spinach Sunflower Crop rotation

Treatment	0-15 cm				15-30 cm			
	Sunflower	Spinach	Sunflower	Mean	Sunflower	Spinach	Sunflower	Mean
T1	0.91	0.87	0.81	0.86	1.16	0.97	0.81	1.16
T2	1.96	1.59	1.14	1.56	2.20	1.83	1.31	2.20
T3	2.15	1.94	1.82	1.97	2.40	2.03	1.88	2.40
T4	2.88	2.32	1.92	2.37	2.96	2.68	2.07	2.96
T5	3.34	2.82	2.31	2.82	3.62	2.94	2.52	3.62
T6	3.35	2.94	2.45	2.91	3.63	3.03	2.90	3.63
T7	4.00	3.14	2.58	3.24	4.07	3.14	2.94	4.07
F-test	S	S	S	S	S	S	S	S
S. Ed. (±)	0.34	0.13	0.16	0.21	0.24	0.17	0.10	0.17
C.D. at 5%	0.69	0.27	0.34	0.43	0.49	0.35	0.20	0.35

Table 4 also showed the variations of Iron in soil at different treatments. The maximum Iron 3.24(mg kg^{-1}) and 4.07 (mg kg^{-1}) were found in T7 and minimum 0.86 (mg kg^{-1}) and 1.16(mg kg^{-1}) was found in T1 at 0-15 cm and 15-30 cm respectively. Increasing trends shows due to increases dose of fly ash at different treatment but increasing trends also flowed by soil depth. The increasing trends of Iron increasing in depth may due to leaching.

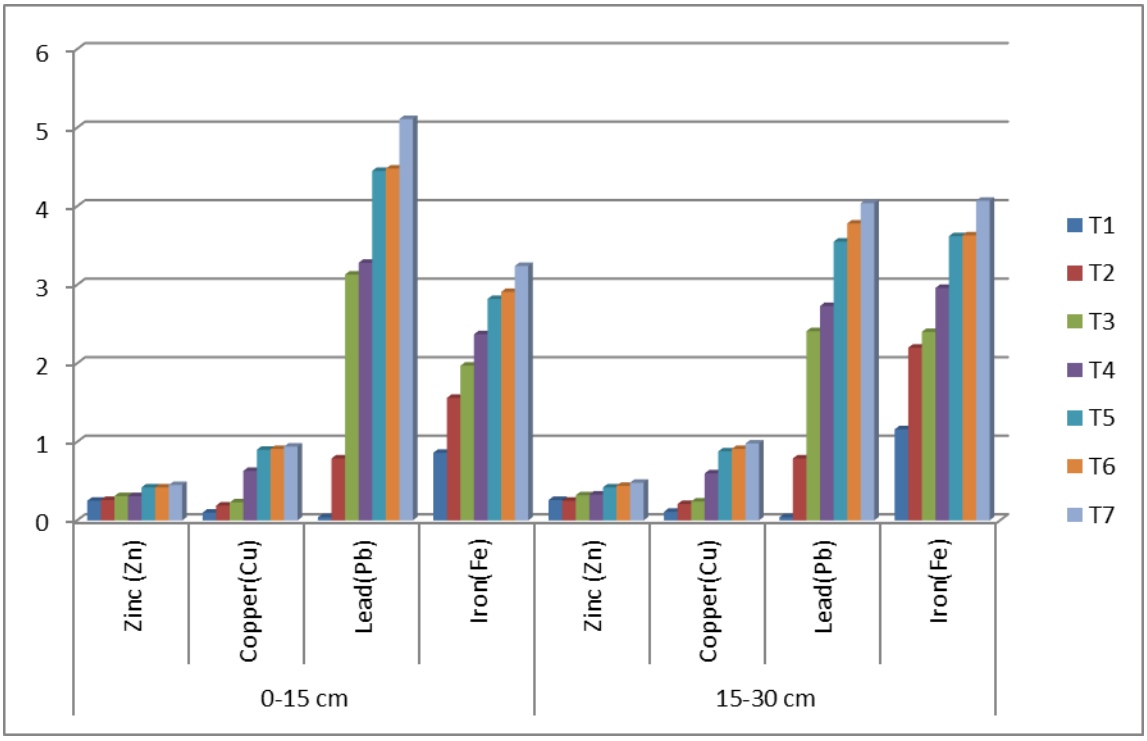

Fig 1: Variation of Heavy metals at different treatments and depths

Figure 1 represents the variation of heavy metals in soil at different treatment. All of these heavy metals show the increasing trends up to T7 at 0-15cm and 15-30 cm. The main reason of increasing trends is increasing dose of fly ash at different treatments. The figure also shows that Zn, Cu, Pb is higher at soil depth of 0-15 cm than the depth of 15-30 cm but iron shows the minimum at the depth of 0-15 cm.

Discussion

Present study showed that the heavy metals Zinc, Copper, Lead and Iron were found significant. The minimum values of heavy metal were found in T1 (control) and maximum values of heavy metals was found T7. All heavy metals show increasing trends up to T7 in post-harvest soil. In post-harvest soil under Sunflower Spinach Sunflower Crop rotation the heavy metals were accumulated in the following order: Zn<Cu< Fe<Pb, respectively. Among these, the Pb was the greater accumulation of these elements in the soil followed by Zn<Cu< Fe. Calmano *et al.* (1993) [2] determined that higher yield of sunflower in FA soil was due to the supply of some nutrients without any interference of the higher pH range, but the results reveals that if fly ash will be used in soil for agricultural practices, it will show good response for crops but the concentration of heavy metals go higher in soil that is not good for soil health.

Conclusion

Present study revealed the heavy metals variations under Sunflower Spinach Sunflower Crop rotation. The increasing doses of fly ash had significant levels of the accumulation of Zn<Cu< Fe<Pb in soil. That mean accumulation of these heavy metals increased the concentration of these metals in the soil. Thus the results showed that Zn<Cu< Fe<Pb at higher concentrations exerted toxic effects on soil health.

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