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IMPACT OF COMBINED APPLICATION OF FLY ASH AND FYM ON SOIL MICROBIAL PROPERTIES OF INCEPTISOL

BHARAT LAL*, V. K. SAMADHIYA, T. DEWANGAN, PRIYANKA SHARMA
Department of Soil Science and Agricultural Chemistry, IGKV, Raipur - 492012 (INDIA)
e-mail: bharatigkv1990@gmail.com

ABSTRACT

A field study was carried out on a sandy loam soil at the KVK farm of Janjgir Champa, Chhattisgarh to study the effect of enriched fly ash (FA) on rice and soil characteristics of inceptisol during kharif 2013-14. The test crop was rice var. MTU-1010. The Dehydrogenase activity (DHA) at tillering and harvesting stage of rice rhizosphere soil increased significantly, The highest DHA was recorded in 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) 19.80, 14.46 , while the lowest DHA was observed in control (T_1) 8.93,6.49 ìg TPF g^{-1} soil day^{-1} at tillering and harvesting stage respectively. The similar pattern were observed in both total bacterial count and soil microbial biomass carbon, that the treatment 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) had maximum and the minimum in control (T_1), the total bacterial count was 5.22, 5.01 and 5.05, 4.57 CFU 10^{-7} g^{-1} soil and soil microbial biomass carbon was 134.56, 111.65 and 90.25 , 65.12 µg C g $^{-1}$ dry soil at tillering and harvesting stage respectively. All microbial activity higher at tillering stage in 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) but decrease at harvesting stage.

KEY WORDS
Fly ash
FYM
Dehydrogenase
Soil microbial biomass carbon
Total bacteria

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***Corresponding author**

INTRODUCTION

Coal is a predominant source of global energy; at present in India it is major source of electrical energy in thermal power plants, which produce 175 million tonnes per year fly ash, which would require about 40,000 hectares of land for the construction of ash ponds (Lal *et al.*, 2012). Fly ash an amorphous ferroalumino silicate, Physically fly ash occurs as fine particles (60-70%) with a size below 0.075mm is a byproduct of pulverized coal fired thermal power station low to medium bulk density, high surface area and very light texture with pH ranged from 4.5 to 12 depending upon S content in the coal (Lal *et al.*, 2012). It can act as a secondary source of fertilizer nutrients like P ,K , Ca , Mg , S , Cu , Fe , Zn , Mn , Mo etc (Totawat *et al.*, 2002). The Ministry of Power and Planning Commission estimates that the coal requirement and generation of fly ash during the year 2031-32 would be around 1800 million tonnes and 600 million tons respectively (Kanungo, 2013). The fly ash utilization in the country is estimated to be about 59% only (Kanungo., 2013). Application of fly ash increased the yield in various crops with improvement in the soil physical, chemical and biological properties and found beneficial for soil and crop (Kohli *et al.*, 2010). It was found that the bacterial counts were enhanced due to presence of earthworm which bring about changes in the soil. In 5% amendment with earthworm, consecutive increase in the bacterial population was observed within 30 days of experiment. On the other hand a decrease in the count was observed in 10 and 15% amendment (Jabeen *et al.*, 2010). Fly ash ameliorate and increase in the usability percent a well known biological modifier, recycling of wastes using earthworm has become an important component of substantial agriculture, which has a multidirectional impact in terms of safe disposal of wastes preventing environmental pollution besides providing nutrient rich material (Jabeen *et al.*, 2012). The microbial flora in soil is an important constituent since soil fertility, plant growth performance and ultimately agriculture productivity depends on it and amendment of soil by FYM and other wastes showed significant increase in available phosphorus content, microbial biomass and dehydrogenase activity in soil (Kulkarni *et al.*, 2007). Hence, an experiment was conducted with the objective to find out the impact of combined application of fly ash on soil health, soil microbial properties of Inceptisol.

MATERIALS AND METHODS

A field experiment was conducted in a sandy loam soil at the KVK Research Farm, Janjgir Champa and Chhattisgarh during the *kharif* season, 2013-14. The experiment design was randomized block design comprised of eight treatment combinations with three levels of fly ash (20, 40 and 60 t ha^{-1}) and two levels of FYM (0 and 5 t ha^{-1}). Fly ash and FYM applied as per the treatments before transplanting the rice. 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 percent GRD. The rice var. MTU-1010 was used as the test crop. The fly ash was collected from, Madhya Bharat Paper Ltd. Village – Birgahni Champa Dist.- Janjgir Champa, Chhattisgarh.

Soil microbial Biomass carbon was determined by the fumigation extraction method as per the procedure of Jenkison and Powlson (1976). The dehydrogenase activity in soil was determined by method given by Klein *et al.* (1971).Total bacterial count followed was given by Wollum (1982).

RESULTS AND DISCUSSION

Dehydrogenase activity

Data revealed that dehydrogenase activity (DHA) at tillering and harvesting stage was found significant (Table 1). However it was higher at tillering stage then by harvest stage. At Tillering stage DHA of soil increased significantly by different doses of fly ash with and without FYM further the activity was slightly higher by application of different doses of fly ash without FYM than GRD. It was significantly increase with the fly ash applied with FYM over control. Fly ash treatments combined with FYM showed significantly higher DHA than the 100% GRD.That showed increase with increase in FA content and it ranged from 8.93, 13.61, 15.17, 14.72, 12.83, 18.53, 19.80 and 18.19 µg TPF g^{-1} soil day^{-1}. The highest DHA was recorded in 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) , which is comparable with 75% GRD + 20 t FA ha^{-1} + 5 t FYM ha^{-1} (T_6) and 75% GRD + 60 t FA ha^{-1} + 5 t FYM ha^{-1} (T_8) treatments , while the lowest DHA was observed in control (T_1).

At harvesting stage, DHA increased in all treatment significantly over control and it variation from 6.49, 10.27, 11.25, 10.52, 9.24, 13.63, 14.46 and 13.37 µg TPF g^{-1} soil day^{-1}. However it was significantly higher than GRD with influenced on 20 t FA ha^{-1} applied without FYM and for all the doses of fly ash applied with FYM. The maximum DHA was recorded in 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) and lowest in control.

Kalembasa *et al.* (2012) was found that when higher doses of FA applied, soil contamination with nickel had a negative impact on the activity of soil enzymes. The sensitivity of the analyzed enzymes to this heavy metal may be presented in the form of the following series: urease >dehydrogenases > alkaline phosphatase > catalase >arylsulphatase> â-glucosidase .The decrease in the activity of dehydrogenase and catalase with higher rate of fly ash application might be due to increase in soil pH and dilution effect on the organic substances

(Yeledhalli *et al.*, 2007) Soil dehydrogenase activity was greatest at 10% level of fly ash amendment since fly ash amendment at moderate levels provides nutrients to the micro organism for carrying out various metabolic activities without any adverse effect has been documented (Kohli *et al.,* 2010). Jabben *et al.* (2011) also reported that the significant stimulation of soil respiration and microbial activities (dehydrogenase activity) were observed up to 5% fly ash amendment when the soils contained earthworms. This may be due to increased microbial activity induced by substrates that are produced by the earthworms and soil organic matter becoming more susceptible to microbial attack and the contribution of cellular lysing from water-induced osmotic shock to an easily mineralizable C pool that is consumed by the surviving soil microbes.

Total bacterial count (TBC)

Data presented in (Table 2) revealed that total bacterial population at tillering and harvesting stages increased significantly by the application of different treatments.

At tillering stage varying from 5.05, 5.06, 5.07, 5.09, 5.02, 5.21, 5.22 and 5.16 CFU 10^{-7} g^{-1} soil, application of 75% GRD + 20 t FA ha^{-1} + 5 t FYM ha^{-1} (T_6) and 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) treatments were higher TBC over control and 100% GRD. The application of different fly ash doses with FYM showed higher TBC than without FYM. The treatment 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) had maximum bacterial population, which were at par with GRD but had higher number of counts, the counts were higher when fly

ash combined with FYM than without FYM and the minimum in control (T_1) .

At harvesting stage all treatments showed significantly higher TBC further different fly ash doses with and without FYM over control it varied from 4.57, 4.85, 4.89, 4.86, 4.84, 4.98, 5.01 and 4.95CFU 10^{-7} g^{-1} soil, Keeping in view of estimated total bacteria population per gram of soil by dilution planting method 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) showed the highest , which at par with 100% GRD were 75% GRD + 40 t FA ha^{-1} (T_4), 75% GRD + 60 t FA ha^{-1} (T_5) , 75% GRD + 20 t FA ha^{-1} + 5 t FYM ha^{-1} (T_6) and 75% GRD + 60 t FA ha^{-1} + 5 t FYM ha^{-1} (T_8), while control (T_1) was low .

Application of fly ash along with recommended dose of NPK fertilizers increased the population of bacteria but when applied higher doses was mainly attributed to pozzolonic effect of fly ash which reduced the air capacity of the soil and reduced

Table 1: Effect of enriched fly ash on Dehydrogenase activity

Treatments	Dehydrogenase activity (μg TPF g^{-1} soil day^{-1}) Tillering	Harvesting
T_1Control	8.93	6.49
T_2 100% GRD(100:60:40)	13.61	10.27
$T_3$75% GRD + 20t FA ha^{-1}	15.17	11.25
$T_4$75% GRD + 40t FA ha^{-1}	14.72	10.52
$T_5$75% GRD + 60t FA ha^{-1}	12.83	9.24
T_6 75% GRD + 20t FA ha^{-1}+5t FYM ha^{-1}	18.53	13.63
$T_7$75% GRD + 40t FA ha^{-1}+5t FYM ha^{-1}	19.80	14.46
$T_8$75% GRD + 60t FA ha^{-1}+5t FYM ha^{-1}	18.19	13.37
SEm±	0.88	0.2
CD (p = 0.05)	2.66	0.6

Table 2: Effect of enriched fly ash on total bacterial count

Treatments	Total bacterial count (CFU 10^{-7} g^{-1} soil) Tillering	Harvesting
T_1 Control	5.05	4.57
T_2 100% GRD(100:60:40)	5.06	4.85
T_3 75% GRD + 20t FA ha^{-1}	5.07	4.89
T_4 75% GRD + 40t FA ha^{-1}	5.09	4.86
T_5 75% GRD + 60t FA ha^{-1}	5.02	4.84
T_6 75% GRD + 20t FA ha^{-1}+5t FYM ha^{-1}	5.21	4.98
T_7 75% GRD + 40t FA ha^{-1}+5t FYM ha^{-1}	5.22	5.01
T_8 75% GRD + 60t FA ha^{-1}+5t FYM ha^{-1}	5.16	4.95
SEm±	0.043	0.057
CD (p = 0.05)	0.13	0.17

Table 3: Effect of enriched fly ash on soil microbial biomass carbon

Treatments	Soil Microbial Biomass Carbon (μg C g^{-1}dry soil)	
	Tillering	Harvesting
T_1Control	90.25	65.12
T_2 100% GRD(100:60:40)	105.22	97.20
$T_3$75% GRD + 20t FA ha^{-1}	111.65	84.99
$T_4$75% GRD + 40t FA ha^{-1}	116.14	90.25
$T_5$75% GRD + 60t FA ha^{-1}	121.46	75.38
T_6 75% GRD + 20t FA ha^{-1}+5t FYM ha^{-1}	130.26	105.23
$T_7$75% GRD + 40t FA ha^{-1}+5t FYM ha^{-1}	134.56	111.65
$T_8$75% GRD + 60t FA ha^{-1}+5t FYM ha^{-1}	128.23	98.55
SEm ±	3.07	3.63
CD (P = 0.05)	9.30	11.03

bacterial population this have been documented by Yeledhalli *et al.* (2007). Similar results are also found by Jabeen *et al.* (2011) the bacterial population showed a gradual rise reaching to maximum on 90th day at a time interval of 15 days, in 5% FA amendment in the presence of earthworms and decrease with doses increased.

Soil microbial biomass carbon (SMBC)

It is evident that increase in application of fly ash with and without FYM increased the Soil microbial biomass carbon (SMBC) at tillering and harvesting stages (Table 3). It showed difference from 90.25, 105.22, 111.65, 116.14, 121.46, 130.26, 134.56 and 128.23 µg C g^{-1}dry soil. At tillering, SMBC significantly increased in all the treatments over control, 75% GRD + 60 t FA ha^{-1} (T_5), 75% GRD + 20 t FA ha^{-1} + 5 t FYM ha^{-1} (T_6) , 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) and 75% GRD + 60 t FA ha^{-1} + 5 t FYM ha^{-1} (T_8) treatments showed significantly higher SMBC over 100% GRD . The 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) was recorded maximum SMBC which is comparable with 75% GRD + 20 t FA ha^{-1} + 5 t FYM ha^{-1} (T_6) and 75% GRD + 60 t FA ha^{-1} + 5 t FYM ha^{-1} (T_8) treatments, while lowest observed in control (T_1) .

At harvest, it was significantly increased in all the treatments over control and it ranged from 65.12, 97.20, 84.99, 90.25, 75.38, 105.23, 111.65 and 98.55μg C g^{-1}dry soil, among the treatment 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) showed significantly higher SMBC as compare to 100% GRD. The control showed the lowest SMBC.

Nayak *et al.* (2014) confirmed increased microbial population with FA addition to the release of nutrients from FA with time. However, FA also has a high content of toxic heavy metals which can hinder normal microbial metabolic processes when added in the soil at higher concentrations. Kohli *et al.* (2010) reported that microbial biomass in soil was highest at 10 % FA amendment, since FA amendment at moderate levels provides nutrients to the micro-organisms for carrying out various metabolic activities without any adverse effect when FA was added at higher levels (than 10%), a decline in microbial activity was observed, this could have been due to a decrease insubstrate availability associated with accumulation of persistent lignite-derived organic carbon compounds.

However, no conflict arises in the reduction in microbial activity in soils when fly ash is applied at rates above acritical level due to the adverse impact of high salinity, pH, and concentration of certain heavy metals (Lim *et al.,* 2014).

The applied organic sources were able to get mineralized rapidly in early days of incubation; hence there was more mineralization than immobilization which consequently provided sufficient nutrition for the proliferation of microbes and their activities in terms of soil enzymes, the mineralized nutrients were highly available up to 60 days, therefore rapid increase in microbial activity was observed during this period of incubation. After the harvest can be attributed to oxidation status of the soil as water was drained at maturity and lack of moisture reduced microbial activity. Addition of organic sources acts as good source of carbon and energy to heterotrophs by which their population increased with an increase in enzymic activities. Similar results reported by Jala (2005) and Kohli *et al.* (2010).

REFERENCES

Jabeen , S., Kumari, S., Saha , P., Yadav, N. , Kumari, S., Raipat, B. S. and Sinha , M. P. 2010. Identification and characterizationof dominant bacteria coal fly ash amended soil. *The Bioscan: Special Issue.* **1:** 105-114.

Jabeen, S. and Sinha, M. P. 2011. Ameliorating effect of earthworm on soil metabolism in fly ash amended soil. *The Ecoscan: Special issue.* **1:** 239-245.

Jabeen, S. and Sinha, M. P. 2012. Impact of earthworm inoculation on physicochemical profile of fly ash amended soil. *The Ecoscan. Special issue.* **1:** 77-82.

Jala, S. 2005. Fly ash as an amendment agent for soil fertility. PhD.Thesis, Thapar Institute of Engineering and Technology, Patiala (Punjab).

Jankinson, D. S. and Powlson, D. S. 1976. The effect of biocidal treatment on soil.VA method for measuring soil biomass. *Soil Boil. Biochem.* **8:** 209-213.

Kalembasa, S. and Symanowicz, B. 2012. Enzymatic activity of soil after applying various waste organic materials, ash and mineral fertilizers. *Poll. J. Environmental Stud.* **21(6):** 1635-1641.

Kanungo, S. P. 2013. Laboratory studies and field application of fly ash in forest nurseries and plantation at CSIR- IMMT, National workshop on use of fly ash in forestry and development of degraded/ wasteland , held during sept. 12-13, 2013, pp. 23-33.

Klein, D. A., Loh, T. C. and Coudling, R. L. 1971. Arapid procedure to evaluate dehydrogenase activity of soils low in organic matter. *Soil Biol. Biochem.* pp. 385-387.

Kohli, S. J. and Goyal, D. 2010. Effect of fly ash application on some soil physical properties and microbial activities. *Acta Agrophysica.* **16(22):** 327-335.

Kulkarni, N. S., Jaiswal, J. V. and Bodhankar, M. G. 2007. Influence of agro waste amendment on soil microbial population in relation to plant growth response. *J. Environmental Biology.* **28(3):** 623-626.

Lal, K., Chhabra, R., Mongia, A. D. Meena, R. L. and Yadav, R. K. 2012. Release and uptake of potasium and sodium with fly ash application in rice on reclaimed alkali soil. *J. The Indian Society of Soil Science.* **60:** 181-186.

Lim, S. S. and Choi, W. J. 2014. Changes in microbial biomass, CH4 and CO2 emissions and soil carbon content by fly ash co application with organic inputs with contrasting substrate quality under changing water regimes. *Soil Biology and Biochemistry.* **68:** 494-502.

Nayak, A. K., Kumar, A. and Raja, R., Rao, K. S., Mohanty, S., Shahid, M., Tripathy, R., Panda, B. B. and Bhattacharyya, P. 2014. Fly ash addition affects microbial biomass and carbon mineralization in agricultural soils. *Bull Environ. Cotam. Toxical.* **92:** 160-164.

Totawat, K. L., Nagar, G. L., Jat, S. L. and Jangir R. K. 2002. In: Symposium on Effect of fly ash on the performance of wheat on ustochrepts of sub humid plains of India., held during 14-21 August 2002, Thailand, Symposium no. 24, Paper no 215, pp. 1-11.

Wollum, A. G. 1982. Cultural methods for soil microorganisms. In: Page, A.L., Miller, R.H. and Keeney, D.R. (ed.). Methods of soil analysis. Prat 2. Chemical and microbiological properties, Agronomy monograph No. 9, ASA-SSSA Publisher, Mandison, Wisconsin, USA. pp. 781-814.

Yeledhalli, N. A., Prakash, S. S., Gurumurthi, S. B. and Ravi, M. V. 2007. Coal Fly Ash as Modifier of Physico-Chemical and Biological Properties of Soil. *Karnataka J. Agric. Sci.* **20(3):** 531-534.