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Effect of Fly Ash application on Microbial Population in Acid Soil

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A B S T R A C T

Fly Ash, a waste material from thermal power station is now considered as a resource, based on its use in different sector. In agricultural sector it has been used to enhance soil fertility and improve crop productivity as a nutrient source and as soil ameliorant. With the view to use Fly Ash as an ameliorant for acid soil, the present investigation has been carried out during 2015 –2016 at Rice Research Station, Ambasamudram, where the soil was acidic (pH-4.75). This is a comparative study of fly ash application alone in different levels and in combination with different liming materials *viz.,* Lime and Dolomite along with recommended dose of fertilizers on soil acid neutralizing capacity and nutrient availability of the soil. The treatments for the field experiment were laid out in RBD with 3 replications. The treatments include control, 100% RDF alone, Lime + RDF, Dolomite + RDF, FA @ 10,20,30 and 40 t ha^{-1} along with RDF, 50% Lime + 50% FA + RDF and 50% Dolomite + 50% FA + RDF. The pH of post-harvest soil ranged from 4.76 to 7.08. The highest value of 0.51% was observed for the addition of 50% dolomite + 50% FA + RDF which was 1.1 times increase over the control (0.24%). The bacterial (67 x 10^6 cfu gm^{-1} soil) and actinomycetes (59 x 10^3 cfu gm^{-1} soil) population of the post-harvest soil, recorded to be higher with the application of 50% Dolomite + 50% FA + RDF. The study on fungal population in post-harvest soil implied that, all the treatments imposed, recorded lower fungal count compared to that of the control (15 x 10^4 cfu gm^{-1} soil). The highest grain yield (5.93 t ha^{-1}) and straw yield (6.32 t ha^{-1}) were registered with 50% Dolomite + 50% FA + RDF.

Introduction

Fly Ash, an inorganic coal combustion residue from thermal power station is discussed to have all essential plant nutrients in available form for plants. Fly ash, due to their alkaline nature, buffer soil pH in an acid soil and favour the growth of soil microbes.

These beneficial soil microbes in turn enhance soil nutrient transformation and fertility which lead to increased crop production. Thus, with this background, present study has been carried out with fly ash on post-harvest soil's microbial population.

Materials and Methods

A comparative field study was taken up to study the effect of FA and other liming materials like lime and dolomite on alleviating soil acidity and improving soil fertility. The treatments of this study include, absolute control, 100% RDF alone, lime +

RDF, dolomite + RDF, FA @ 10, 20, 30 and 40 t/ha + RDF, 50% lime + 50%FA + RDF and 50% dolomite + 50% FA + RDF. These 10 treatments (T1 to T 10) were tried in Randomized block design with 3 replications and Rice (variety – ASD 16) was used as test crop. The dosages for lime, dolomite and FA were fixed with Ca equivalence using lime buffer method by shoemaker *et al.*, (1961). The FA used in this study was collected from Tuticorin thermal power station, Tamil Nadu, India and it was found to be alkaline with a pH of 8.6. It was also analysed for other chemical properties. The pH and EC values of the fly ash were 8.6 and 1.7 respectively. The initial soil was also analysed for its chemical properties. The pH and EC values of the initial soil were observed to be 4.65 and 0.50 respectively. The post-harvest soil was analysed for bacterial, fungal and actinomycetes population following the procedure of Waksman and Fred (1922) and pH (potentiometry) and Organic carbon (Walkley and Black, 1934). The results were statistically analysed using Aggress software at 5% level of significance (Table 1 and 2).

Results and Discussion

Soil pH

The highest soil pH of 7.08 was recorded with application of 50% Dolomite + 50% FA + RDF followed by 50% Lime + 50% FA + RDF (6.90) (Table 3). The treatment FA @ 40 t ha^{-1} recorded the pH of 6.23 and was on par with the application of Lime + RDF (6.05) and Dolomite + RDF (6.13). This might be due to the alkaline nature of FA used. The liming potential of Fly Ash is derived from the hydrolysis of CaO and MgO, the major constituents of Fly Ash. These basic oxides in Fly Ash reacting with water in presence of CO_2 form hydroxyl ions and Carbonates precipitate (Siddharth *et al.*, 2011). These basic hydroxides in turn increase soil pH. The treatment receiving 100% RDF alone recorded lower pH and was on par with control (4.76) with the value of 4.95.

Organic carbon

The organic carbon% of post-harvest soils ranged from 0.24% to 0.51% (Fig. 1). The highest value of 0.51% was observed for the addition of 50% dolomite + 50% FA + RDF which was 1.1 times increase over the control (0.24%). This was then followed by treatments receiving 50% lime + 50% FA + RDF and FA @ 40 t/ha + RDF which were on par with the values of 0.44 and 0.41 % respectively. The lowest value was noticed for the treatment 100% RDF alone (0.25 %), lime + RDF (0.26%) and dolomite + RDF (0.27%) which were on par with the control (0.24 %). This increase in OC% with increments of fly ash might be due to the un-burnt coal present in fly ash (Kumar, 2002).

Bacterial population

Regarding the bacterial population of the post-harvest soil, the treatment 50% dolomite + 50 % FA + RDF was highly significant with the value of 67 x 10^6 cfu gm^{-1} soil (Fig. 2). The Second highest bacterial count (54 x 10^6 cfu gm^{-1} soil) was implied with the application of FA @ 40 t/ha + RDF. The least count was registered with the control (9 x 10^6 cfu gm^{-1} soil). This indicated that neutral pH is more important than the nutritional aspect for bacterial growth as reported by Fettel *et al.*, (1998).

Fungal population

The study on Fungal population in post-harvest soil implied that, all the treatments imposed, recorded lower Fungal count compared to that of the control (15 x 10^4 cfu gm^{-1} soil) (Fig. 2). The control plot was highly significant over the imposed treatments.

Table.1 Physical, physico-chemical and chemical properties of fly ash

S.No.	Properties	Value
A.	PHYSICAL PROPERTIES	
1.	Particle Size Distribution	
	i. Sand (% w/w)	65.25
	ii. Silt (% w/w)	26.50
	iii. Clay (% w/w)	6.25
2.	Bulk Density (Mg m^{-3})	1.05
3.	Particle Density (Mg m^{-3})	2.22
4.	Total Porosity (%)	52.0
B.	PHYSICO-CHEMICAL PROPERTIES	
1.	pH	8.6
2.	EC (ds/m)	1.7
3.	Cation exchange capacity (cmol (p^+) kg^{-1})	20.0
C.	CHEMICAL PROPERTIES	
1.	Organic carbon (%)	0.30
2.	Total N (%)	0.003
3.	Total P (%)	0.36
4.	Total K (%)	0.86
5.	Available N (mg kg^{-1})	35.0
6.	Available P (mg kg^{-1})	116.0
7.	Available K (mg kg^{-1})	179.0
8.	Available Ca (mg kg^{-1})	30.0
9.	Available Mg (mg kg^{-1})	10.0
10.	DTPA Zn (mg kg^{-1})	1.5
11.	DTPA Fe (mg kg^{-1})	21.0
12.	DTPA Cu (mg kg^{-1})	1.6
13.	DTPA Mn (mg kg^{-1})	1.8
14.	Total Cr (mg kg^{-1})	0.03
15.	Total Cd (mg kg^{-1})	0.02
16.	Total Ni (mg kg^{-1})	0.40
17.	Acid insolubles (%)	53.5

Table.2 Initial characterization of experimental soil

S.No	Properties	
A.	**PHYSICAL PROPERTIES**	
1.	Particle size distribution(Sandy Loam)	
	i. Sand (%w/w)	61.60
	ii. Silt (%w/w)	25.00
	iii. Clay (%w/w)	10.58
2.	Bulk density (Mg m^{-3})	1.28
3.	Particle density (Mg m^{-3})	2.25
4.	Total porosity (%)	45.3
B.	**PHYSICO - CHEMICAL PROPERTIES**	
1.	pH	4.75
2.	EC (dS m^{-1})	0.50
3.	Cation exchange capacity (cmol (p^{+}) kg^{-1})	31.0
C.	**CHEMICAL PROPERTIES**	
1.	Organic carbon (%)	0.23
2.	Available N (kg ha^{-1})	185
3.	Available P (kg ha^{-1})	70.0
4.	Available K (kg ha^{-1})	230.0
5.	Available Ca (mg kg^{-1})	12.5
6.	Available Mg (mg kg^{-1})	4.50
7.	DTPA Fe (mg kg^{-1})	20.70
8.	DTPA Mn (mg kg^{-1})	10.43
9.	DTPA Zn (mg kg^{-1})	0.88
10.	DTPA Cu (mg kg^{-1})	0.63

Table.3 Effect of fly ash and other liming materials on soil reaction (pH) of post-harvest soil

Treatment	pH
T1	4.76
T2	4.95
T3	6.05
T4	6.13
T5	5.58
T6	5.72
T7	5.83
T8	6.23
T9	6.90
T10	7.08
Mean	**5.92**
SEd	**0.34**
CD(p=0.05)	**0.72**

Table.4 Effect of fly ash and other liming materials on yield (t ha^{-1}) of rice crop

Treatments	grain (t ha^{-1})	straw (t ha^{-1})
T1	3.84	5.10
T2	4.09	5.27
T3	4.72	5.38
T4	4.97	5.34
T5	5.26	5.45
T6	5.45	5.63
T7	4.63	5.29
T8	4.47	5.20
T9	5.72	6.10
T10	5.93	6.32
Mean	4.9	5.5
SEd	**0.29**	**0.32**
CD (p=0.05)	**0.61**	**0.68**

Fig.1 Effect of fly ash and other liming materials on %OC of post-harvest soils

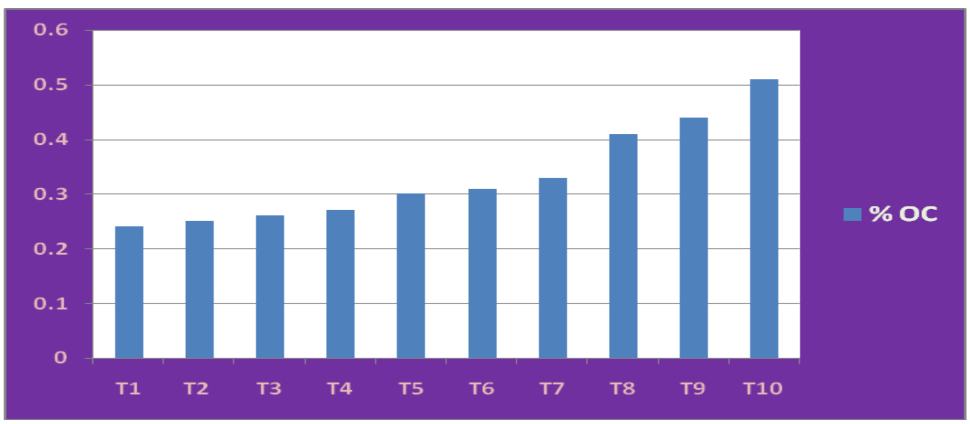
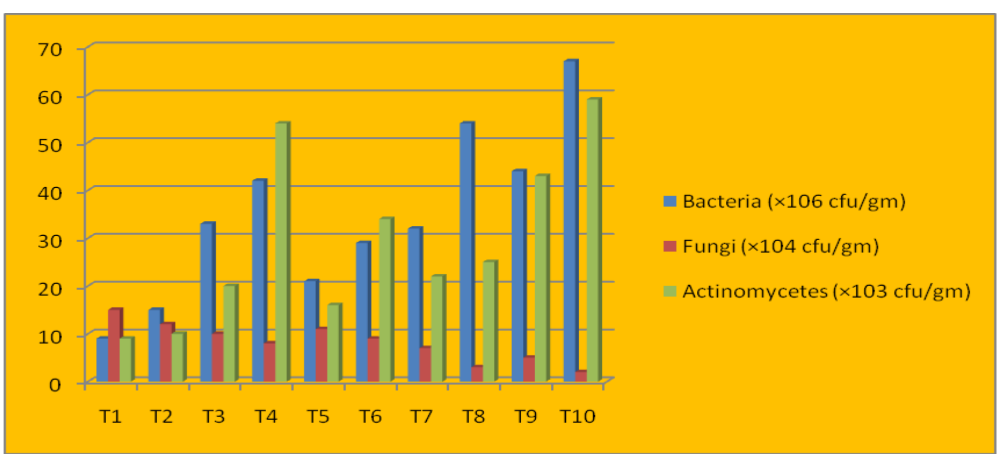


Fig.2 Effect of fly ash and other liming materials on microbial population (Cfu gm^{-1}) of post-harvest soil



The least counts were registered with the application of FA @ 40 t ha^{-1} + RDF and 50% dolomite + 50% FA + RDF which were on par with the values 3 and 2 x 10^4 cfu gm^{-1} soil respectively. On the whole, the fungal populations were low compared to that of bacterial population due to increase in soil pH which was in line with the findings of Chandrakar *et al.*, (2015).

Actinomycetes population

With regard to Actinomycetes population in post-harvest soil, application of 50% dolomite + 50% FA + RDF was highly significant over other treatments with 59 x 10^3 cfu gm^{-1} soil (Fig. 2). This was then followed by dolomite + RDF with 54 x 10^3 cfu gm^{-1} soil. The least count was shown by the application of 100% RDF alone (10 x 10^3 cfu gm^{-1} soil) which was on par with the control (9 x 10^3 cfu gm^{-1} soil). This is supported with the fact that the increased organic carbon in limed plots might have been conducive for the actinomycetes growth (Shah *et al.*, 1990).

Crop yield

The highest grain yield (5.93 t ha^{-1}) and straw yield (6.32 t ha^{-1}) were registered with 50% Dolomite + 50% FA + RDF which was then followed by 50% Lime + 50% FA + RDF (grain yield- 5.72 t ha^{-1} and straw yield- 6.10 t ha^{-1}) (Table 4). The higher yield with the application of 50% Dolomite + 50% FA + RDF might be due to the good bacterial and actinomycetal population in the concerned plot.

The lower crop yield with FA at higher levels might be due to formation of physical barrier for root elongation with compaction of FA particles at higher levels (Dwivedi *et al.*, 2007). But the yields for FA @ 30 and 40 t ha^{-1} + RDF were not lesser than the control plot and plot receiving 100% RDF alone.

From the present study it is inferred that the Fly ash by buffering soil pH can favour the growth of soil microbes in an acid soil. The application of 50% dolomite + 50% FA + RDF can be recommended to enhance soil bacterial and actinomycetes population whereas for fungal population Lime or Dolomite + RDF and FA @ 20 t ha^{-1}can be good.

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