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RESEARCH

Effect of Enriched FYM, Paper Mill Fly Ash on Soil Properties and Growth of Rice on Degraded soil

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ABSTRACT
Paper Mill is a wood based power plant which generates a huge amount of fly ash. The application of fly ash in degraded land may reduce the problem of disposal to some extent. A field study was carried out on a sandy loam soil at the KVK farm 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 application of different treatment FA combinations increased paddy yield compared to 100% GRD. However the control treatment failed to produce the yield in degraded land. Among the treatments, the 75% GRD +60t FAha^{-1}+5t FYMha^{-1} gave highest paddy yield than all other treatments. The straw yield was not significantly influenced by FA treatments, but the beneficial effect of enriched fly ash on higher rice straw yield was observed. Application of 75% GRD + fly ash@ 60 t ha^{-1} + FYM @ 5 t ha^{-1} recorded the highest soil available phosphorus, potassium and zinc compared to other treatments and soil available N was highest in application of 75% GRD + fly ash@ 40 t ha^{-1} + FYM @ 5 t ha^{-1}. The soil available Cu, Mn and Fe content were not significantly influenced by different combination of FYM, FA and Fertilizers. The treatment 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) was the maximum available chromium and Nickel, Lead and Cobalt as not influenced by the different doses of fly ash.

Key words: Fly ash, FYM, Heavy metals, Rice, fertilizers.

Abbreviations: N – Nitrogen; P – Phosphorous; K – Potash; Fe – Iron; Mn – Manganese; Zn – Zinc; Cu – Copper ; Cr – Chromium; Ni –Nickel; Pb – Lead ; ppm - Parts per million; kg – kilogram; ha – Hector ; q – Quintal; %- percent; mg kg $^{-1}$ – milli gram per kilogram(ppm).

1. INTRODUCTION

In Chhattisgarh major area comes under the rainfed condition, where rice cultivation is depends on south-west monsoon inspite of that state is popularly known as “rice bawl of India” because maximum area is under rice cultivation during *kharif* and contribute major share in national rice production. Chhattisgarh awarded by “krishi karmanya award” for record growth in productivity of rice in 2010-11 and 2012-13 by GOI. It has area about 83741.6 thousand ha, production is 62.46 lakh tonnes and productivity is 2372 kg/ha of 2012-13 (Anonymous 2013).

In India and most country major source of electrical energy is coal based thermal power plants, which produce 175 million tonnes, which would require about 40,000 hectares of land for the construction of ash ponds (Lal *et al.*, 2012). The ash production in India is expected to reach about 225 million tonnes per annum by 2017. 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 tonnes respectively (Kanungo., 2013). The fly ash utilization in the country is estimated to be about 59% only (Kanungo., 2013). Fly ash an amorphous ferroalumino silicate, Physically fly ash occurs as fine particles (60-70%) which has a size below 0.075 mm is a by-product of pulverized coal fired thermal power station and has low to medium bulk density, high surface area and very light texture with pH varying from 4.5 to 12 depending upon S content in the coal (Lal *et al*., 2012). Being a vegetative fossil fly ash consist of mineral matter which plant have up taken from the soil. 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). 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).

Kharif:

Kharif crops are usually sown with the beginning of the first rains in July, during the south-west monsoon season starts on 15 June and lasts until 15 November in Chhattisgarh. In India, the kharif season varies by crop and state.

Heavy metals:

Heavy metals have included density, atomic weight, atomic number, aqueous chemistry or periodic table position. Density range from above 3.5 g/cm^3 to above 7 g/cm^3. Atomic weight starts at greater than sodium (22.98) to greater than 40 or 200 or more. Atomic numbers generally given as greater than 20.

2. STUDY AREA

2.1 Geographical situation

Geographically, Janjgir-Champa is situated in north Mahanadi and the centre of Chhattisgarh and lies between 21.06 to 22.04 North latitude and 82.03 to 83.02 East longitude with an altitude of 294.4 meters above the mean sea level.

2.2 Experimental site

The experiment was conducted at the KVK Research Farm, Janjgir - Champa (C.G.). The site selected for experiment was ideal, since it has assured irrigation and drainage facilities. The upper 30 cm soil was removed to develop the field bunds.

3. MATERIALS AND METHODS

3.1 Collection of Fly Ash Sample

The fly ash was collected from Madhya Bharat Paper Ltd. Village – Birgahni Champa Dist.- Janjgir Champa , Chhattisgarh . The fly ash samples were air dried then the parameters like nitrogen, potash, phosphorous, micronutrients Fe , Mn, zn , Cu and heavy metals like Pb, Cr, Cd, Mn were analyzed.

Table 1

Chemical characteristics of fly ash

No	Particulars	Value
1.	**Total Major Nutrients**	
	Nitrogen (%)	0.084
	Phosphorus (%)	0.043
	Potassium (%)	0.33
2.	**Total Micronutrients**	
	Iron (%)	0.73
	Manganese (%)	0.016
	Zinc (%)	0.007
	Copper (%)	0.003
3.	**Total Heavy Metals**	
	Nickel (mg kg^{-1})	23.1
	Cobalt (mg kg^{-1})	9.6
	Lead (mg kg^{-1})	21.5
	Chromium (mg kg^{-1})	34.2

Enriched FYM:
FYM is *rich* in nutrients. A small portion of N is directly available to the plants while a larger portion is made available as and when the *FYM* decomposes. When cow dung and urine are mixed, a balanced nutrition is made available to the plants.

3.2 Field Experiment

A field experiment was conducted in a sandy loam soil at the KVK Research Farm, Janjgir Champa, 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.

Table 2
Pre harvest characterization of the experimental soil

No	Particulars	Value
8	Available nitrogen (kg ha^{-1})	107.4
9	Available phosphorus (kg ha^{-1})	0.80
10	Available potassium (kg ha^{-1})	549.81
11	Available Fe (mg kg^{-1})	8.09
12	Available Mn (mg kg^{-1})	9.72
13	Available Zn (mg kg^{-1})	0.67
14	Available Cu (mg kg^{-1})	0.43
15	Available Pb (mg kg^{-1})	4.5
16	Available Cr (mg kg^{-1})	10.8
17	Available Ni (mg kg^{-1})	0.22
18	Available Co (mg kg^{-1})	0.14

Available nitrogen was determined by alkaline permanganate method as described by Subbiah and Asija (1956). Available phosphorus was extracted using $NaHCO_3$ (pH 8.5) by the method described by Olsen *et al.* (1954) and the amount of available phosphorus was determined by ascorbic acid method described by Watnabe and Olsen (1965) using spectrophotometer. Available potassium was extracted by neutral normal ammonium acetate (pH-7) and determined with the help of Flame photometer as described by Jackson (1967). Micronutrients i.e. Fe, Mn, Cu and Zn 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 the concentrations of the nutrients in the filtrate were analyzed by atomic absorption spectrophotometer (Lindsay and Norvell, 1978). Heavy metals, 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).

Atomic Absorption Spectrophotometer:
In the analysis employing atomic absorption spectrophotometer (AAS) the sample in the form of a homogeneous liquid is aspirated into a flame where free atoms of the elements to be analysed are created. A light source (hallow cathode lamp) is used to excite the free atoms formed in the flame by the absorption of the electromagnetic radiation. The decrease in energy (absorption) is then measured which follows the Lambert – Beer law, i.e. the absorbance is proportional to the number of free atoms in the ground state.

4. RESULT AND DISCUSSIONS

4.1 Effect of enriched fly ash on the available major nutrients at harvest.

4.1.1 Available Nitrogen in soil

The results on soil available nitrogen as influenced by treatments is presented in (Table 3), indicated that the application of fly ash in combination with or without FYM and GRD increased soil available nitrogen significantly over control, Slight increase in soil N status in the treatments was associated with the addition of chemical fertilizers along with the mineralization of organic nitrogen from fly ash and organic manure, which is a slow process and provides all the major and micro-nutrients during the crop requirement at later stage . Das *et al.* (2013)

also observed increase availability of nitrogen with application of fly ash and FYM. Similar results related to N availability in soil by application of fly ash and FYM were also concluded by Yadav (2006) and Jala (2005).

Table 3

Effect of enriched fly ash on the available major nutrients at harvest

Treatments	Available Nitrogen (Kg ha^{-1})	Available Phosphorus (Kg ha^{-1})	Available Potassium (Kg ha^{-1})
T_1 Control	109	0.74	550.36
T_2 100% GRD(100:60:40)	135.89	1.16	580.49
T_3 75% GRD + 20t FA ha^{-1}	135.89	1.28	562.01
T_4 75% GRD + 40t FA ha^{-1}	137.98	1.43	576.57
T_5 75% GRD + 60t FA ha^{-1}	133.80	1.22	565.37
T_6 75% GRD + 20t FA ha^{-1}+5t FYM ha^{-1}	137.98	1.28	569.93
T_7 75% GRD + 40t FA ha^{-1} +5t FYM ha^{-1}	139.89	1.37	600.06
T_8 75% GRD + 60t FA ha^{-1} +5t FYM ha^{-1}	137.80	1.52	616.09
SEm±	**2.13**	**0.043**	**12.03**
CD (P = 0.05)	**6.46**	**0.13**	**36.5**

4.1.2 Available Phosphorus in soil

The data on soil available phosphorus as influenced by the different treatments indicated that the increase in application of GRD, Fly ash doses with and without FYM significantly increased the available soil phosphorus status over control (Table 3). The available phosphorus significantly increased by application of 75% GRD + 40 t FA ha^{-1} (T_4) , 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 than 100% GRD of chemical fertilizer. The treatment 75% GRD + 60 t FA ha^{-1} + 5 t FYM ha^{-1} (T_8) gave highest soil available phosphorus. Jabeen *et al.* (2012) also observed that the increase in phosphorus content with increase in fly ash in the present study may be attributed to the available phosphorus present in coal fly ash which was found to be higher in comparison to the experimental soil. The increase may be due to the hydrolysis of iron, aluminium and magnesium compound in fly ash and released inorganic acid by fly ash. The liberated acids might have helped in the release of available phosphate from the unavailable form without affecting the pH as organic matter present in the soil has a buffering capacity in maintaining the pH, Similar finding was also reported by Yadav (2006) and Onwuka (2011).

4.1.3 Available Potassium in soil

Data on available soil potassium presented in the (Table 3) revealed that in the levels of different combination of fertilizer, fly ash with and without FYM increased the available potassium content over control. The treatment 75% GRD + 60 t FA ha^{-1} + 5 t FYM ha^{-1} (T_8) recorded the highest available potassium and was comparable to that 100% GRD , 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) treatments. Increase in exchangeable potassium with application of fly ash, was mainly because of higher content of exchangeable potassium in fly ash. The increase availability of potassium with application of fly ash, FYM and fertilizer also reported by Das *et al.* (2013). Similar results were also found by Jabeen *et al*. (2012) and Jala (2005).

4.2 Effect of enriched fly ash on the available micro nutrients at harvest

Table 4

Effect of enriched fly ash on the available micro nutrients at harvest

Treatments	Available Iron (mg kg^{-1})	Available Manganese (mg kg^{-1})	Available Zinc (mg kg^{-1})	Available Copper (mg kg^{-1})
T_1 Control	7.63	8.35	0.70	0.38
T_2 100% GRD(100:60:40)	8.63	9.11	0.74	0.39
T_3 75% GRD + 20t FA ha^{-1}	9.43	10.61	0.82	0.56
T_4 75% GRD + 40t FA ha^{-1}	9.86	10.94	1.21	0.82
T_5 75% GRD + 60t FA ha^{-1}	8.74	10.20	1.13	0.52

T_6 75% GRD + 20t FA ha^{-1}+5t FYM ha^{-1}	9.63	9.71	1.24	0.62
T_7 75% GRD + 40t FA ha^{-1}+5t FYM ha^{-1}	10.07	11.77	1.30	0.90
T_8 75% GRD + 60t FA ha^{-1}+5t FYM ha^{-1}	11.02	12.75	1.42	0.92
SEm±	**0.8**	**1.04**	**0.12**	**0.14**
CD (P = 0.05)	**NS**	**NS**	**0.38**	**NS**

The application increases in the level of fly ash with and without FYM significantly influence the zinc content in the soil (Table 4). The application of fly ash with and without FYM had significantly higher available soil zinc as compare to control and 100% GRD. The applications of different doses of fly ash applied with or without FYM were almost comparable. The application of 75% GRD + 60 t FA ha^{-1} + 5 t FYM ha^{-1} (T_8) showed the highest amount of available soil zinc. The minimum available zinc in soil was recorded in control and the application of different combinations of fly ash, with and without FYM and GRD did not influence the available iron, manganese and copper over control.

Availability of the micronutrients in soil increased with increasing doses of fly ash and its integration with fertilizer. The increase in available micronutrients status of soil different doses of fly ash application might be attributed due to the two reasons; firstly, the direct addition of nutrients to soil through different doses of fly ash or FYM, secondly, due to favorable soil conditions associated with application of fly ash and FYM. Reddy *et al*. (2010) also reported increased availability of micronutrients in soil by the application of fly ash and FYM, similar results found by Chitdeshwari *et al*. (2007) and Yadav (2006).

4.3 Effect of enriched fly ash on the available heavy metals

Effect of different treatment combinations on available chromium was significantly (Table 5). The treatment 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) was the maximum available chromium as compare to 100% GRD and control , while lowest was in control.

Table 5

Effect of enriched fly ash on the available heavy metals in soil at harvest

Treatments	Available Chromium (mg kg^{-1})	Available Lead (mg kg^{-1})	Available Cobalt (mg kg^{-1})	Available Nickel (mg kg^{-1})
T_1 Control	10.78	4.56	0.16	0.23
T_2 100% GRD(100:60:40)	10.89	4.76	0.21	0.25
T_3 75% GRD + 20t FA ha^{-1}	13.02	5.32	0.24	0.44
T_4 75% GRD + 40t FA ha^{-1}	13.78	5.0	0.27	0.49
T_5 75% GRD + 60t FA ha^{-1}	12.92	5.03	0.25	0.37
T_6 75% GRD + 20t FA ha^{-1}+5t FYM ha^{-1}	13.93	5.33	0.23	0.34
T_7 75% GRD + 40t FA ha^{-1}+5t FYM ha^{-1}	14.02	4.8	0.21	0.47
T_8 75% GRD + 60t FA ha^{-1}+5t FYM ha^{-1}	13.98	4.84	0.17	0.32
SEm±	**0.26**	**0.29**	**0.037**	**0.09**
CD (P = 0.05)	**0.80**	**NS**	**NS**	**NS**

The Nickel, Lead and Cobalt as not influenced by the different doses of fly ash and fertilizers with and without FYM. Dey *et al.* (2012) reported that the application of different doses of fly ash also increase the chromium content in soil due fly ash has high chromium.

4.4 Effect of enriched fly ash on the yield attributing characters

4.4.1 Yield attributes

The data related to the total number of tillers per plant are presented in (Table 6 & fig 1). The application of 75% GRD + 60 t FA ha^{-1} + 5 t FYM ha^{-1} (T_8) produced significantly highest number of total tiller. Among all the treatments of fly ash with and without FYM, 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) recorded significantly higher number of total tiller compared to GRD. The similar trend of total tillers was observed in case of effective tillers, panicle length and total filled grain (Table 5). The control treatments plants did not produce the tillers due to removal of top surface fertile soil and plants suffered the acute deficiency of nutrients (Table 2).

The higher yield attributes of rice in 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 were due to experimental soil was poor in organic matter. Hence organic enrichment of the soil with fly ash and FYM proved advantageous improvement on soil physico-chemical and biological properties contributed to better crop growth, root and shoot development of rice plant reported by Karmakar *et al*. (2010). Similar results concluded by Khan *et al*. (2008) and Yavarzadeh *et al*. (2012).

Table 5

Effect of enriched fly ash on the performance of yield attributes of rice

Treatments	Total Tillers plant^{-1} (Numbers)	Effective Tillers plant^{-1} (Numbers)	Panicle length (cm)	Total filled grain panicle^{-1} (Numbers)	Test weight (g)
T_1 Control	0.00	0.00	0.00	0.00	0.00
T_2 100% GRD(100:60:40)	6.80	6.53	19.42	70.00	25.85
T_3 75% GRD + 20t FA ha^{-1}	6.67	6.27	20.03	78.73	24.94
T_4 75% GRD + 40t FA ha^{-1}	6.47	5.93	20.15	79.80	25.16
T_5 75% GRD + 60t FA ha^{-1}	5.80	5.47	19.76	72.60	25.02
T_6 75% GRD + 20t FA ha^{-1}+5t FYM ha^{-1}	6.80	6.53	21.09	76.87	25.43
T_7 75% GRD + 40t FA ha^{-1}+5t FYM ha^{-1}	7.73	7.20	21.12	81.67	24.98
T_8 75% GRD + 60t FA ha^{-1}+5t FYM ha^{-1}	8.07	7.53	20.24	80.20	25.04
SEm±	**0.48**	**0.45**	**0.56**	**4.2**	**0.43**
CD (P = 0.05)	**1.45**	**1.38**	**1.70**	**12.73**	**1.31**

4.4.2 Grain Yield

The grain yield was significantly influenced due to application of fly ash with FYM (Table 6 & fig 1) over 100% GRD and control. The 75% GRD + 60 t FA ha^{-1} + 5 t FYM ha^{-1} (T_8) produced the significantly higher grain yield , which was at par to that 75% GRD + 40 t FA ha^{-1} + 5 t FYM ha^{-1} (T_7) . There was failed to produce grain yield of rice due to removal of top surface soil (fig.1).

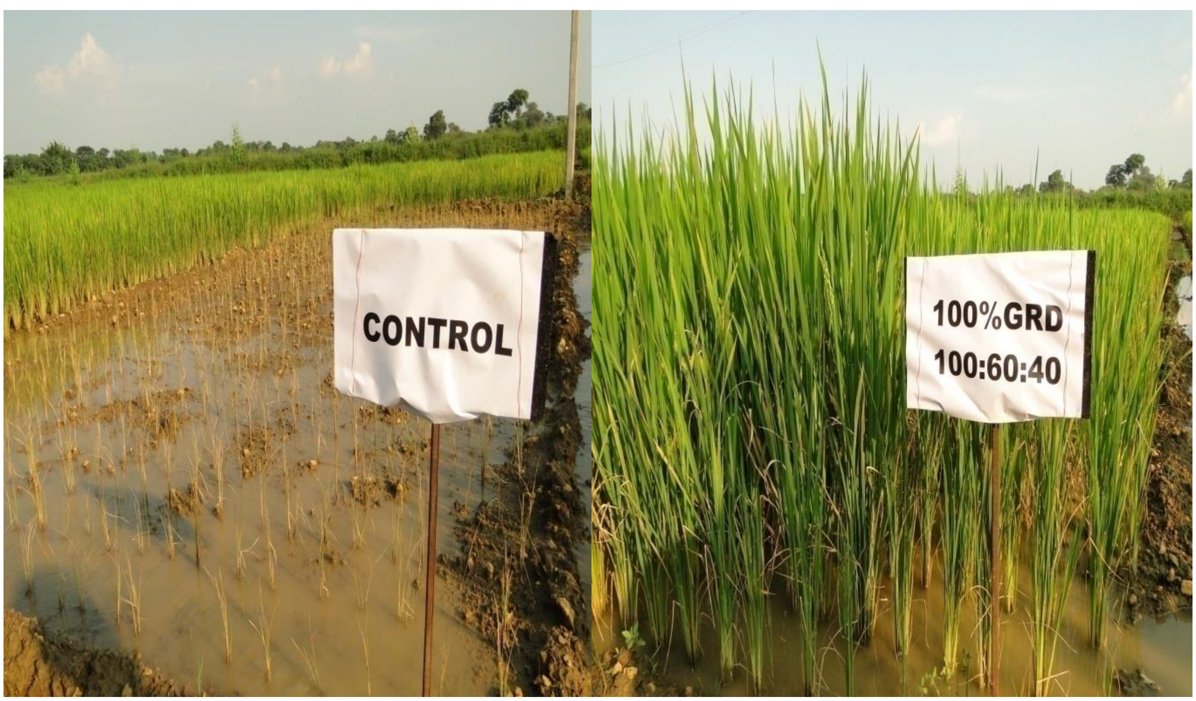

Figure 1
Effect of different fly ash treatments on crop growth

Table 6
Effect of enriched fly ash on the grain and straw yield of rice

Treatments	Grain Yield (q ha^{-1})	Straw Yield (q ha^{-1})
T_1 Control	0.0	10
T_2 100% GRD(100:60:40)	31.67	47.5
T_3 75% GRD + 20t FA ha^{-1}	26.83	44.83
T_4 75% GRD + 40t FA ha^{-1}	33.67	46.33
T_5 75% GRD + 60t FA ha^{-1}	31.83	41.50
T_6 75% GRD + 20t FA ha^{-1}+5t FYM ha^{-1}	28.0	47.0
T_7 75% GRD + 40t FA ha^{-1} +5t FYM ha^{-1}	37.67	49.42
T_8 75% GRD + 60t FA ha^{-1} +5t FYM ha^{-1}	42.67	51.50
SEm±	**2.05**	**1.75**
CD (P = 0.05)	**6.23**	**5.30**

4.4.3 Straw Yield

The data on straw yield as influenced by different doses of fly ash and FYM treatments are presented in (Table 6) .The treatment 75% GRD + 60 t FA ha^{-1} + 5 t FYM ha^{-1} (T_8) was produced significantly higher straw yield as compare to others , However it was comparable to that obtained under treatment 100% GRD, 75% GRD + 40 t FA ha^{-1} (T_4) , 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) . The lowest straw yield was recorded under control (T_1) treatment.

The supply of nutrients, conducive physical environment leading to better aeration, increase in soil moisture holding capacity, root activity and nutrient absorption and the consequent complementary effect in fly ash and FYM treated plots increased total tillers, effective tillers, panicle length and total filled grain would have resulted in higher straw and grain yield of rice this finding are in conformity with that of

Reddy *et al*. (2010). The beneficial effect of fly ash on yield was also reported by Aggarwal *et al.* (2009) in wheat and sorghum and by Arivazhagan *et al*. (2011) in rice, wheat, maize, ragi.

Degraded soil:
Degraded soils have a health status such, that they do not provide the normal goods and services of the particular soil in its ecosystem.

5. CONCLUSION

From the above results and discussion of present study it is concluded that there is broad scope for utilization of paper mill fly ash and organic manure for improving soil fertility and plant productivity. It improves the soil available nitrogen, phosphorus and potash and micronutrients. Fly ash can be used as a potential nutrient supplement for degraded soils for which the solid waste disposal problem reduced to some extent. Such utilization of fly ash in an integrated manner added advantage of minimizing environment pollution.

SUMMARY OF RESEARCH

1. *Rice* crops were been cultivated in eight different treatment combinations.
2. In the present study, soil before cultivation, after cultivation, yield attributes, grain and straw yield were recorded.
3. Combined application of fly ash, FYM and fertilizers improved grain and straw yield than control treatment.

FUTURE ISSUES

Fly ash can be used as a potential nutrient supplement for degraded soils for which the solid waste disposal problem reduced to some extent. Such utilization of fly ash in an integrated manner improved soil physical, chemical and biological properties and found beneficial for soil and crop.

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