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Studies on fly ash, lime and vermicompost incorporation on rice yield in an acid soil

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Abstract
The field investigation entitled "Studies on fly ash, lime and vermicompost incorporation on rice yield in an acid soil*"* was conducted during *Kharif* 2020-2021 and 2021-2022 in an *Inceptisol* at KVK, Katghora, Korba, (Chhattisgarh). The experiment conducted with twelve treatments with three replications in randomized block design (RBD). The addition of 75% RDF + 40 t/ha Fly ash + 2 t/ha Lime + 2 t/ha Vermicompost (T_{12}) enhanced the yield attributes of rice with yield increases of 27 and 57 percent in grain and straw respectively over control.

Keywords: Fly ash, lime, vermicompost, yield, rice

Introduction
Indian electricity generation is majorly dependent on thermal energy by burning the coal producing large amount of fly ash as by-product. Dumping and disposal of fly ash in ponds and land is a routine practice which raises various environmental concerns. Hence, the Ministry of Environment, Forest and Climate Change (MoEFCC), Govt. of India has made continuous efforts for proper utilisation and disposal of fly ash. This by-product's rich nutrient content has opened doors for its utilisation in agriculture rising a tremendous potential in improving crop productivity and soil health. Besides its nutrient efficiency, fly ash treatment showed a significant result in agricultural insect-pest control. However, agricultural use of fly ash is quite limited in comparison to other sectors of India.
In India more than 70% of total energy consumed is shared by thermal power. It is the biggest source of power in India. Chhattisgarh is major fly-ash generating state in India because it has a large amount of coal reserves as there are 15 major thermal power plant. The state generates over 20 million tonnes of ash and utilises a meagre 6-8 million tonnes a year.
India is one of the leading producers of rice around the world. Rice crop is grown all over the country in which FA is used as an amendment (Korcak 1995; Brown and Chaney 2000) [3, 2]. In India rice production was estimated about 102.36 million tonnes in *kharif* season of 2020-21 on the back of good monsoon rains and acreage, according to government data. Rice production stood at 101.98 MT in the kharif (summer-sown) season of the 2019-20 crop year. Paddy is the principal crop and the central plains of Chhattisgarh are known as rice bowl of central India. In the present investigation paddy (*Oryza sativum*) is taken as test crop as it is grown in many parts of our state. It may be quite worthy to evaluate the effect of fly ash, lime and vermicompost application on soil properties

Materials and Methods
In *Kharif* 2020, the current experiment was adopted. Using auger, representative soil samples were obtained from 0-15 cm depth and composite samples were prepared before the experiment was laid out. The soil samples were air dried, passed through a 2 mm sieve and used for different physical-chemical analysis.
The soil of the experimental field was Inceptisol, which was also locally called as Matasi (in Chhattisgarh plain) and Gader (in Northen hills).

1. Tested variety
Rice cultivar Indira Aerobic-1 (Swarna x IR 42253) was taken as a test crop. It has a semi dwarf and excellent grain quality. The cultivar has deep rooted system, drought tolerance, vigorous growth habitat. It has been tolerant to neck blast, sheath rot, semi tolerant to leaf blight and sheath blight. The crop matures in about 115-120 days.

Treatment Details

Treatment no.	Treatment name
T_1	Control
T_2	100% RDF
T_3	75% RDF + 2 t/ha Lime
T_4	75% RDF + 2 t/ha Vermicompost
T_5	75% RDF + 20 t/ha Fly ash
T_6	75% RDF + 20 t/ha Fly ash + 2 t/ha Lime
T_7	75% RDF + 20 t/ha Fly ash + 2 t/ha Vermicompost
T_8	75% RDF + 20 t/ha Fly ash + 2 t/ha Lime + 2 t/ha Vermicompost
T_9	75% RDF + 40 t/ha Fly ash
T_{10}	75% RDF + 40 t/ha Fly ash + 2 t/ha Lime
T_{11}	75% RDF + 40 t/ha Fly ash + 2 t/ha Vermicompost
T_{12} :	75% RDF + 40 t/ha Fly ash + 2 t/ha Lime + 2 t/ha Vermicompost

N, P and K nutrients were applied through Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP), respectively. One-third ($1/3^{rd}$) of Urea and recommended doses of P and K were applied at the time of transplanting. The remaining equal two splits ($2/3^{rd}$ of Urea) were given at tillering and panicle initiation stage of rice.

2. Cultivation Details

a) Field preparation

Field was prepared to obtain strong tilth for better germination and growth with tractor drawn cultivator followed by rotavator and leveler after the treatment combinations were applied according to layout schedule.

The fly ash was applied as per the treatments before transplanting and showing of crop in a prepared field.

b) Transplanting

The rice seedlings that were 24 days old were planted in prepared fields. Seedlings have been carefully uprooted and transplanted from the nursery. The planting method was carried out at a distance of 20 x 10 cm.

c) Manure application

Organic manures in the form of vermicompost were applied as per the treatments. Manure was applied uniformly in plots using broadcasting method. The composition of vermicompost was N (Nitrogen 0.69%), P (Phosphorus 0.47%) and K (Potassium 0.71%).

d) Harvesting

The heads of rice were harvested from the net plot and border field separately when the central grain in the head had fully matured. With the help of a sickle, the stalk was harvested 4-5 cm from the ground level. After sun drying, crops were manually threshed and winnowed and yield per plot was recorded.

e) Soil reaction

Soil pH was determined in 2.5:1 water-soil suspension after stirring for 30 minutes, with a glass electrode pH meter as suggested by Piper (1966) [7].

f) Electrical conductivity (EC)

The soil sample used for pH determination was allowed to settle down overnight, and then Solu-bridge determined the conductivity of the supernatant liquid as described by Wakley and Black (1934) [10].

g) Organic carbon (OC)

Organic carbon was determined by Walkley and Black rapid titration method (1934) [10].

Results and Discussion

The yield of rice in an experiment by the application of Fly ash, lime, vermicompost and fertilizer is discussed below

Grain and stover yield of paddy

Application of the different levels of fly ash along with lime, vermicompost and fertilizers showed significant differences in the grain and straw yield of rice crop (Table 1 and Figure 1). Higher grain yield was obtained in the T_{12}: 75% RDF + 40 t/ha FA + 2 t/ha Lime + 2 t/ha Vermicompost (38.24, 39.08, 38.66 q ha^{-1}) and which was on par with T_8: 75% RDF + 20 t/ha FA + 2 t/ha Lime + 2 t/ha Vermicompost (37.83, 37.47, 37.65 q ha^{-1}) and followed by T_{10}: 75% RDF + 40 t/ha FA + 2 t/ha Lime (35.58, 36.71, 36.15 q ha^{-1}) in 2020, 2021 and pooled data respectively. Significantly lower grain yield was noticed in the control treatment (22.30, 21.24, 21.77 q ha^{-1}) during 2020, 2021 and pooled data respectively.

The trend of straw yield followed a similar pattern as that of grain yield (Table 1 and Figure 2). The straw yield differed significantly due to higher levels of fly ash application along with and without lime, vermicompost and fertilizers. Among different treatments, treatment T_{12}: 75% RDF + 40 t/ha FA + 2 t/ha Lime + 2 t/ha Vermicompost was recorded significantly higher straw yield (59.40, 60.75, 60.07 q ha^{-1}) and found on par with T_8: 75% RDF + 20 t/ha FA + 2 t/ha Lime + 2 t/ha Vermicompost (56.36, 56.44, 56.40 q ha^{-1}) and followed by T_{10} : 75% RDF + 40 t/ha FA + 2 t/ha Lime (55.11, 56.51, 55.81 q ha^{-1}) and significantly lower straw yield (29.13, 28.00, 28.57 q ha^{-1}) was noticed in the control treatment during 2020, 2021 and pooled data respectively.

Higher grain and straw yields in rice could also be attributed to better total uptake of essential nutrients. Similar results were reported by Mulla *et al.* (2000) [4]. Selvakumari *et al.* (2000) [6] also reported the highest yield in rice when fly ash was applied in combination with compost, fertilizer and Azospirillum. Matte and Kene, 1995 [6] evaluated that application of fly ash helps in better aeration, root activity and nutrient absorption and the consequent complementary effect would have resulted in higher grain and straw yield in rice. Similar finding was reported by, Ramteke *et al.*, (2016) [7], Mandel *et al.*, (2021) [5], Bhavaya *et al.*, (2022) [1].

Table 1: Effect of fly ash, lime, vermicompost and fertilizer on grain and straw yield of rice.

Treatment details	Grain (q ha^{-1})			Straw (q ha^{-1})		
	2020	2021	Pooled	2020	2021	Pooled
T_1 : Control	22.30	21.24	21.77	29.13	28.00	28.57
T_2 : 100% RDF	33.15	34.17	33.66	53.58	53.24	53.41
T_3 : 75% RDF + 2 t/ha Lime	28.11	28.40	28.26	41.92	42.27	42.10
T_4 : 75% RDF + 2 t/ha Vermicompost	26.69	26.19	26.44	38.02	36.25	37.14
T_5 : 75% RDF + 20 t/ha Fly ash	28.26	28.26	28.26	42.82	42.31	42.57
T_6 : 75% RDF + 20 t/ha Fly ash + 2 t/ha Lime	34.10	34.47	34.29	54.24	53.44	53.84
T_7 : 75% RDF + 20 t/ha Fly ash + 2 t/ha Vermicompost	29.47	28.64	29.06	43.51	42.24	42.88
T_8 : 75% RDF + 20 t/ha Fly ash + 2 t/ha Lime+ 2 t/ha Vermicompost	37.83	37.47	37.65	56.36	56.44	56.40
T_9 : 75% RDF + 40 t/ha Fly ash	30.07	30.11	30.09	45.75	45.61	45.68
T_{10} : 75% RDF + 40 t/ha Fly ash + 2 t/ha Lime	35.58	36.71	36.15	55.11	58.51	56.81
T_{11} : 75% RDF + 40 t/ha Fly ash + 2 t/ha Vermicompost	32.94	32.58	32.76	53.33	53.56	53.45
T_{12} : 75% RDF + 40 t/ha Fly ash + 2 t/ha Lime + 2 t/ha Vermicompost	38.24	39.08	38.66	59.40	60.75	60.08
SEM±	0.67	0.89	0.61	1.35	1.41	1.39
CD (p = 0.05)	1.97	1.62	1.80	3.96	4.12	4.07

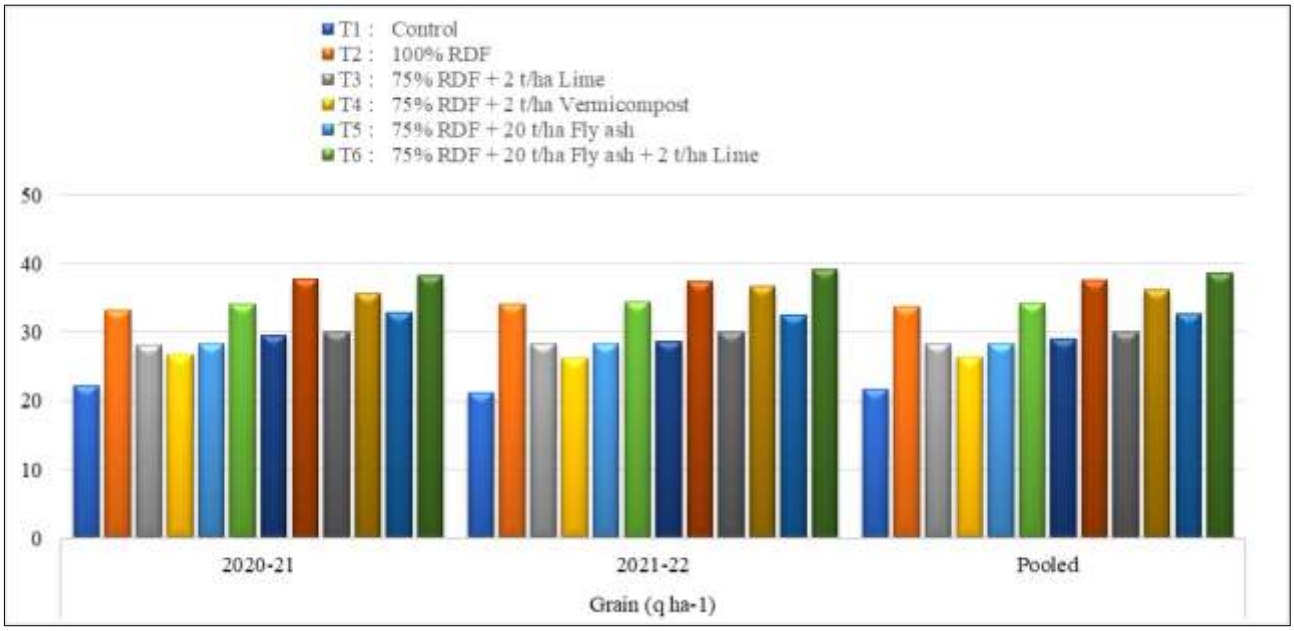

Fig 1: Effect of fly ash, lime, vermicompost and fertilizer on grain yield of rice

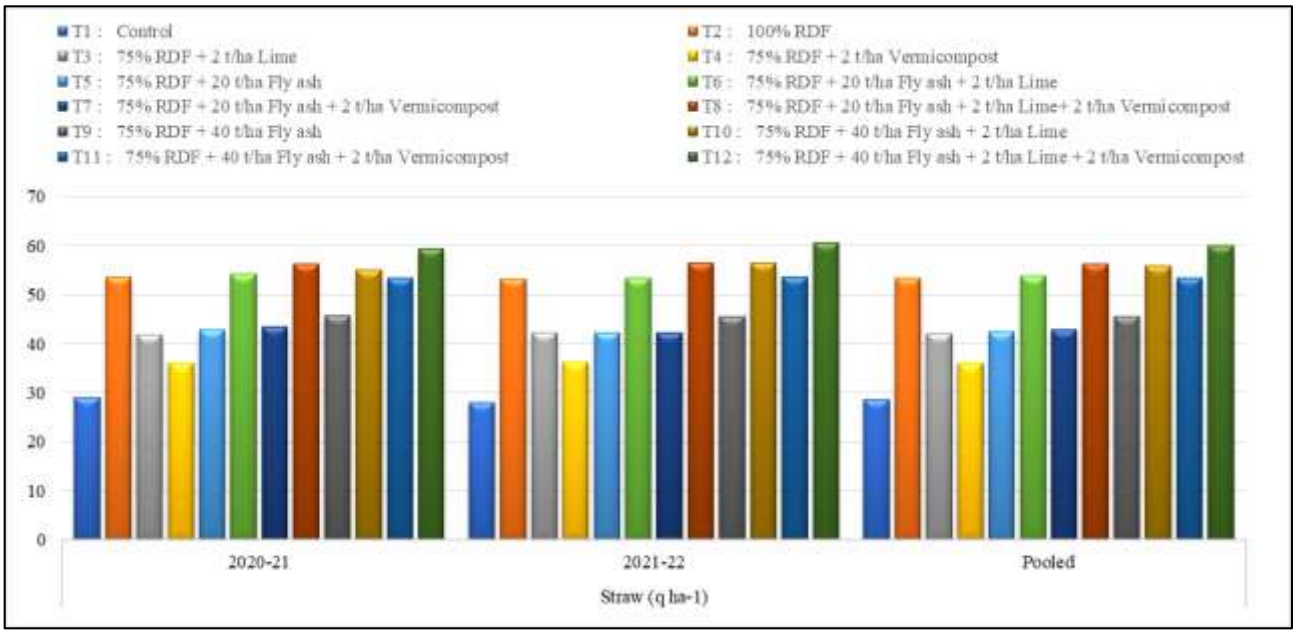

Fig 2: Effect of fly ash, lime, vermicompost and fertilizer on straw yield of rice

Conclusions

Significantly higher grain and straw yield were obtained due to the combined application i.e., 75% RDF + 40 t/ha Fly ash + 2 t/ha Lime + 2 t/ha Vermicompost (T_{12}) grain (38.24, 39.08, 38.66 q ha^{-1}) and straw (59.40, 60.75, 60.07 q ha^{-1}) compared to control. The maximum yield was recorded in treatment 75% RDF + 40 t/ha Fly ash + 2 t/ha Lime + 2 t/ha Vermicompost followed by 75% RDF + 20 t/ha Fly ash + 2 t/ha Lime+ 2 t/ha Vermicompost.

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