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Studies on fly ash, lime and vermicompost incorporation on urease and dehydrogenase activities in an acid soil under rice crop

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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 urease and dehydrogenase (DHA) activities in soil over control plot.

Keywords: Fly ash, lime, vermicompost, urease, dehydrogenase

Introduction

Fly ash is produced as a result of coal combustion in thermal power station. In, Indian electricity generation mainly dependent on thermal energy by burning the coal producing large amount of fly ash as by-product. 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.

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.

Material and Method

In *Kharif* 2020, the current experiment was adopted. The soil of the experimental field was *Inceptisol*, which was also locally called as Matasi (in Chhattisgarh plain) and Gader (in Northen hills).

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.

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 dose of P and K were applied at the time of transplanting. Remaining equal two splits ($2/3^{rd}$ of Urea) were given at tillering and panicle initiation stage of rice.

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

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, by glass electrode pH meter as suggested by Piper (1966).

f. **Electrical conductivity (EC):** The soil sample used for pH determination was allowed to settle down overnight, then Solu-bridge determined the conductivity of the supernatant liquid as described by Black (1965) [2].

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

Results and Discussion

The enzymes activities in rice crop in an experiment by the application Fly ash, lime, vermicompost and fertilizer are discussed below

Urease and Dehydrogenase activities

Application of fly ash with lime, vermicompost and fertilizers positively influenced the urease activity in the soil. The highest urease activity was noticed by the addition of T_{12}: 75% RDF + 40 t/ha Fly ash + 2 t/ha Lime + 2 t/ha Vermicompost (46.54, 48.56, 47.55 µg NH_4 -N g^{-1} of soil hr^{-1}) at par with T_{11}: 75% RDF + 40 t/ha Fly ash + 2 t/ha Lime (42.87, 44.76, 43.82 µg NH_4 -N g^{-1} of soil hr^{-1}) and followed by T_{11}: 75% RDF + 40 t/ha Fly ash + 2 t/ha Lime + 2 t/ha Vermicompost (41.24, 43.57, 42.41 µg NH_4 -N g^{-1} of soil hr^{-1}) in both the year (2020, 2021) and recorded in pooled data respectively. The control recorded the lowest activity (19.69, 21.91, 20.80 µg NH_4 -N g^{-1} of soil hr^{-1}) during both the year (2020, 2021) and noticed in pooled data also in fig 1. Increase in urease activity was found with fly ash application which increased in oxidative capacity of soil microorganisms and the hydrolysis reactions of urea. Similar results were observed by Lal *et al.*, (1996) [4], Chandrakar and Jena (2016) [3], and Bhavya *et al.*, (2022) [1].

Significantly higher dehydrogenase activity in soil was noticed in the treatments which received a combined application of fly ash, lime, vermicompost and fertilizer over the control treatment (T_1). The maximum dehydrogenase activity was recorded in the treatment T_{12}: 75% RDF + 40 t/ha Fly ash + 2 t/ha Lime + 2 t/ha Vermicompost (58.08, 61.20, 59.64 µg TPF g^{-1} 24 h^{-1}) which noticed at par with treatment T_8: 75% RDF + 20 t/ha Fly ash + 2 t/ha Lime + 2 t/ha Vermicompost (57.51, 60.08, 58.80 µg TPF g^{-1} 24 h^{-1}) and followed by T_6: 75% RDF + 20 t/ha Fly ash + 2 t/ha Lime (56.04, 58.78, 57.41 µg TPF g^{-1} 24 h^{-1}) in both the year (2020, 2021) and recorded in pooled data respectively. Significantly, the lower dehydrogenase activity was recorded in the treatment T_1 (31.25, 32.23, 31.74 µg TPF g^{-1} 24 h^{-1}) under control during both the year (2020, 2021) and in pooled data respectively in fig.2.

The increase in dehydrogenase activity with integrated use of fly ash, lime, vermicompost and fertilizer might be attributed to the increasing population of micro-organisms like bacteria, etc., which was influenced by lime, vermicompost. It might also due to favorable physical and chemical characteristics of the soil and increased availability of substrate through vermicompost. Krishna Kumar *et al.* (2005) [5] reported that there was a 2to 2.5 fold increase in enzyme activity in cropping treatments during the active growth stage of the crop. Bharat *et al.*, (2015) [11] studied that the highest dehydrogenase activity was recorded in 75 per cent RDF + 40 t FA ha^{-1} + 5 t FYM ha^{-1}. Similar results were also reported by Suresh and Murugaiyan (2013) [9], Lai *et al.*, (1999) [7] and Jala and Goel (2010) [6] and Bhavya *et al.*, (2022) [1].

Table 1: Effect of fly ash, lime, vermicompost and fertilizer on ureases and dehydrogenase activity in soil under rice.

Treatment details	Urease (µg NH4+ - N g -1 soil h-1)			Dehydrogenase (Ug/day/g soil)		
	2020	2021	Pooled	2020	2021	Pooled
T_1: Control	19.69	21.91	20.8	31.25	32.23	31.74
T_2: 100% RDF	24.78	25.23	25.01	34.37	33.89	34.13
T_3: 75% RDF + 2 t/ha Lime	35.07	35.25	35.16	41.87	42.89	42.38
T_4: 75% RDF + 2 t/ha Vermicompost	28.26	27.22	27.74	45.16	46.78	45.97
T_5: 75% RDF + 20 t/ha Fly ash	39.75	41.56	40.65	44.18	45.78	44.98
T_6: 75% RDF + 20 t/ha Fly ash + 2 t/ha Lime	39.44	42.21	40.83	56.04	58.78	57.41
T_7: 75% RDF + 20 t/ha Fly ash + 2 t/ha Vermicompost	38.92	39.79	39.36	54.21	56.23	55.22
T_8: 75% RDF + 20 t/ha Fly ash + 2 t/ha Lime+ 2 t/ha Vermicompost	39.57	43.23	41.4	57.51	60.08	58.80

T_9: 75% RDF + 40 t/ha Fly ash	40.56	42.94	41.75	41.80	42.61	42.21
T_{10}: 75% RDF + 40 t/ha Fly ash + 2 t/ha Lime	42.87	44.76	43.815	53.19	54.70	53.94
T_{11}: 75% RDF + 40 t/ha Fly ash + 2 t/ha Vermicompost	41.24	43.57	42.41	52.82	53.70	53.26
T_{12}: 75% RDF + 40 t/ha Fly ash + 2 t/ha Lime + 2 t/ha Vermicompost	46.54	48.56	47.55	58.08	61.20	59.64
S.Em ±	1.27	1.32	1.29	0.64	0.61	0.62
CD (P = 0.05)	3.73	3.87	3.8	1.88	1.78	1.78

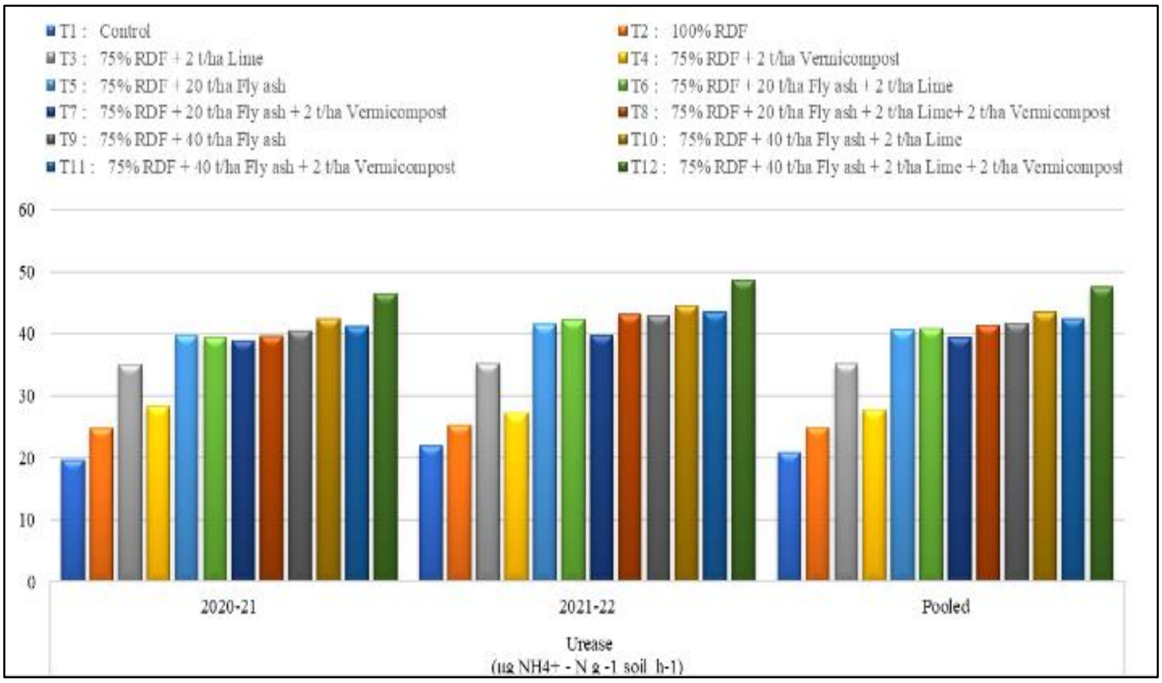

Fig 1: Effect of fly ash, lime, vermicompost and fertilizer in urease activity in soil

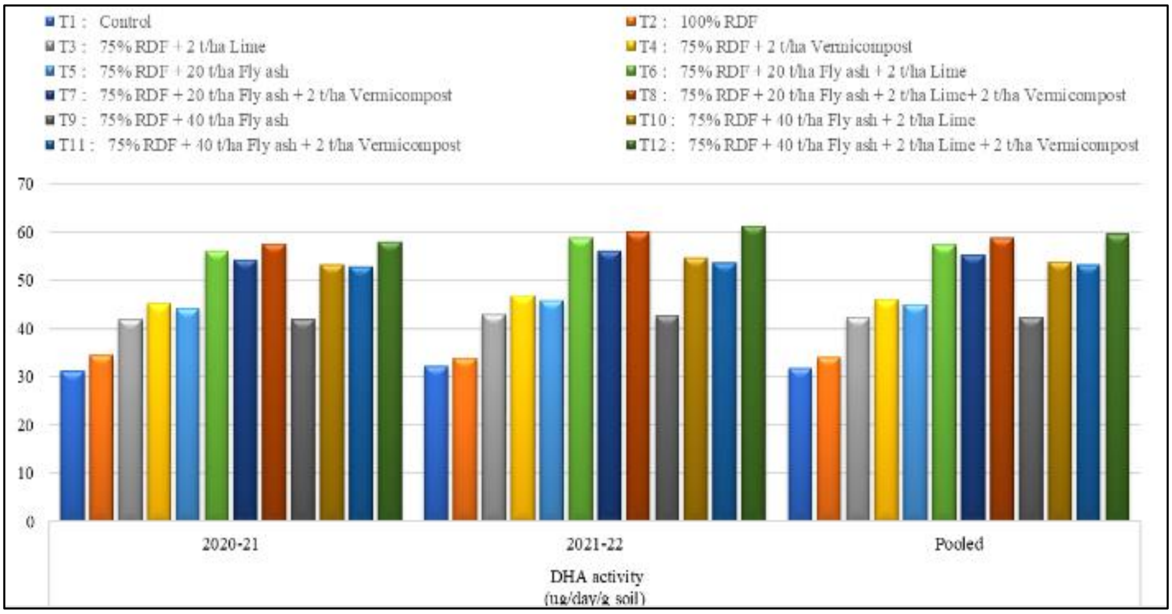

Fig 2: Effect of fly ash, lime, vermicompost and fertilizer on dehydrogenase activity in soil

Conclusions

Significantly higher urease and dehydrogenase activities 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}) urease enzyme (46.54,48.56,47.55 µg "NH_4^{+}-N" g^{-1} soil hr^{-1}), dehydrogenase enzyme (58.08, 61.2, 59.64 TPF µg 24 hr^{-1} g^{-1}. 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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