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Dev Narayan
Ph.D., Scholar, Department of Agronomy, IGKV, Raipur, Chhattisgarh, India

GP Pali
Professor, Department of Agronomy, IGKV, Raipur, Chhattisgarh, India

Uttam Dewangan
Scientist, Department of Soil Science, IGKV, Raipur, Chhattisgarh, India

Biplab Choudhary
SRF, Department of Soil Science, IGKV, Raipur, Chhattisgarh, India

Nagendra Kumar Verma
Ph.D., Scholar, Department of Agronomy, IGKV, Raipur, Chhattisgarh, India

Dipendra Pankaj Porte
Ph.D., Scholar, Department of Agronomy, IGKV, Raipur, Chhattisgarh, India

Ravindra Kumar
Ph.D., Scholar, Department of Agronomy, IGKV, Raipur, Chhattisgarh, India

Ramnath
Ph.D., Scholar, Department of Agronomy, IGKV, Raipur, Chhattisgarh, India

Corresponding Author:
Dev Narayan
Ph.D., Scholar, Department of Agronomy, IGKV, Raipur, Chhattisgarh, India

Effect of fly ash in combination of farm yard manure, vermicompost on economics of rice

Dev Narayan, GP Pali, Uttam Dewangan, Biplab Choudhary, Nagendra Kumar Verma, Dipendra Pankaj Porte, Ravindra Kumar and Ramnath

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Abstract
The study was concluded that application of fly ash @ 30 t ha^{-1}+ 100% RDN + Vermicompost @ 2.5 t ha^{-1} proved to be best with respect of gross return, net return and B:C ratio but it was found to be comparable with treatment T_5 (100% RDN), T_9 (Fly ash @ 20 t ha^{-1}+ 100% RDN + Farm Yard Manure @ 5 t ha^{-1})' T_{10} (Fly ash @ 30 t ha^{-1}+ 100% RDN + Farm Yard Manure @ 5 t ha^{-1}), T_{13} (Fly ash @ 30 t ha^{-1}+ 100% RDN + Vermicompost @ 2.5 t ha^{-1}) and T_{14} (Fly ash @ 40 t ha^{-1}+ 100% RDN + Vermicompost @ 2.5 t ha^{-1}).

Keywords: Fym, rice, productivity, economics, fly ash, vermicompost

Introduction
Rice is a staple food for one-third of the world's population and occupies almost one fifth of the total land area covered under cereals. India is the second largest producer and consumer of rice, with a total rice crop area of 45768.96 thousand hectares. Chhattisgarh, known as the 'Rice bowl of India', has a population of 82% reliant on agriculture for their livelihood. Fly ash, a by-product of Thermal Power Stations, is an amorphous mixture of ferro aluminosilicate minerals generated from coal combustion. It is produced annually in India, with 197 major Thermal Power Plants and an estimated 187.81 million tons used annually. Chhattisgarh is a major fly-ash-generating state in India, with 29 main Thermal Power Plants producing 34.822 million tons of ash in 2019-2020. Fly ash is generally of silt loam texture, with a pH value of 6 to 11, electrical conductivity of 42 to 450 µ Scm^{-1}, and a bulk density of less than 1 g cm^{-3}. Fly ash amendment has been found to increase plant production by correcting nutrient deficiencies. A single application of fly ash can raise the pH of acid soils and improve plant nutrient status and water-holding capacity. The application of fly ash is influenced by the original pH of both ash and soil, with varying pH levels depending on the parent coal's Sulphur level. The addition of fly ash to soil boosts the pH of calcareous soil and improves soil strength. However, it is deficient in nitrogen and phosphorus, which can be overcome by adding organic substrates and growing leguminous crops. Fly ash amendment has inconsistent effects on macro and micronutrients, which is related to the source and quality of fly ash and the nutrient status of the soil being amended. The use of manures, organic and inorganic wastes is gaining acceptance to reduce input costs and sustain soil fertility. Further research is needed to improve the agricultural use of fly ash soil conditioner and its optimum use for different soil types and crops.

Methodology
Economics
Based on recent market prices of fertilizers, herbicide, market price of produce and prevailing wages of labour, economics of the treatment have been worked out.

Cost of cultivation (Rs ha^{-1})
Taking into consideration to the recent charges of agricultural operations and market price of inputs, the cost of cultivation was calculated from each treatment.

Gross returns (Rs ha^{-1})

It was computed by converting the harvest (Grain and straw) into monetary terms at the recent market price during the course of studies for each treatment.

Gross returns (Rs ha^{-1}) = Yield (q ha^{-1}) x Price of yield (Rs q^{-1})

Net returns (Rs ha^{-1})

It was computed by deducting cost of cultivation from gross returns.

Net returns (Rs ha^{-1}) = Gross returns (Rs ha^{-1}) - Cost of cultivation (Rs ha^{-1}).

Benefit cost ratio (%)

It was calculated by dividing the gross returns from cost of cultivation of respective treatment.

$$\text{Benefit: cost ratio} = \frac{\text{gross returns (Rs ha}^{-1})}{\text{Cost of cultivation (Rs ha}^{-1})} \times 100$$

Statistical analysis

All the pre and post-harvest observations recorded during different crop period, were subjected to statistical analysis as per the procedure laid down by Gomez and Gomez (1984). The significance of treatment effects was tested with variance ratio (F-Value). Appropriate standard errors and critical difference at 5 per cent probability level were taken to test the statistical significance of the result.

Result and Discussion

Economics

The data regarding economics (Cost of cultivation, gross return, net return and B: C ratio) as influenced by different treatment in the years 2022 and 2023 and on mean basis are presented in Table 1.

Cost of cultivation (Rs ha^{-1})

Several economics indices are available to evaluate the profitability of particular treatment like cost of cultivation, gross return, net return and B: C ratio. The cost of cultivation varied according to different treatment. It includes value of fertilizer, irrigation, seed, pesticides, herbicide and labour etc. The computations on cost of cultivation with respect to various fly ash in combination with farm yard manure, vermicompost and inorganic fertilizers, clearly indicated that, it was higher (Rs. 39730, 42397 and 41063 ha^{-1}, during 2022, 2023 and on mean basis, respectively) for T_{14} (Fly ash @ 40 t ha^{-1}+ 100% RDN + Vermicompost @ 2.5 t ha^{-1}), followed by T_{13} (Fly ash @ 30 t ha^{-1} + 100% RDN + Vermicompost @ 2.5 t ha^{-1}), (Rs. 39084, 41715 and 40399 ha^{-1} during 2022, 2023 and on mean basis, respectively) while the lowest cost of cultivation (Rs. 29079, 31566 and 30322 ha^{-1} during 2022, 2023 and on mean basis, respectively) was computed for T_6 (Fly ash @ 20 t ha^{-1}) during both the years of study and mean basis.

Gross return (Rs ha^{-1})

Gross return was found to be significantly affected because of application of various doses of fly-ash in combination with farm yard manure, vermicompost and inorganic fertilizers of rice as presented in Table 1. The results of analysis of variance made it clear that among treatment T_{13} (Fly ash @ 30 t ha^{-1}+ 100% RDN + Vermicompost @ 2.5 t ha^{-1}) reflected in the highest gross returns (Rs. 119620, 127403 and 123511 ha^{-1}, during 2022, 2023 and on mean basis, respectively) followed by T_{14} (Fly ash @ 40 t ha^{-1}+ 100% RDN + Vermicompost @ 2.5 t ha^{-1}).

Table 1: Effect of fly ash in combination of farm yard manure and vermicompost on economics of rice

	Treatment	Cost of cultivation (Rs. ha^{-1})			Gross Return (Rs. ha^{-1})			Net Return (Rs. ha^{-1})			B:C Ratio (%)		
		2022	2023	Mean	2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T_1	Farmers practices (N:P: K - 75:45:30 kg ha^{-1} + 1.5t ha^{-1} FYM)	32838	35307	34072	99594	104836	102215	66757	69529	68143	3.03	2.97	3.00
T_2	50% RDN (N:P: K - 50:30:20 kg ha^{-1})	30319	32752	31535	91181	92662	91922	60862	59910	60386	3.01	2.83	2.91
T_3	FYM @ 5 t ha^{-1}	29908	32297	31102	82341	83422	82881	52433	51125	51779	2.75	2.58	2.66
T_4	VC @ 2.5 t ha^{-1}	31433	33884	32658	82042	84185	83114	50609	50301	50455	2.61	2.48	2.54
T_5	100% RDN (N:P: K - 100:60:40 kg ha^{-1})	32831	35305	34068	114553	119907	117230	81721	84602	83162	2.98	3.02	3.00
T_6	FA @ 20 t ha^{-1}	29079	31566	30322	69533	71092	70313	40454	39526	39990	2.39	2.25	2.32
T_7	FA @ 30 t ha^{-1}	29725	32243	30984	72127	72130	72128	42402	39887	41144	2.43	2.24	2.33
T_8	FA @ 40 t ha^{-1}	30371	32930	31650	72491	72628	72559	42120	39698	40909	2.39	2.30	2.35
T_9	FA @ 20 t ha^{-1}+ 100% RDN + FYM @ 5 t ha^{-1}	36833	39446	38139	115559	122199	118879	78726	82753	80740	3.04	3.00	3.02
T_{10}	FA @ 30 t ha^{-1}+ 100% RDN + FYM @ 5 t ha^{-1}	37479	40128	38803	116978	123014	119996	79499	82886	81192	3.02	3.04	3.03
T_{11}	FA @ 40 t ha^{-1}+ 100% RDN + FYM @ 5 t ha^{-1}	38125	40810	39467	114917	121508	118213	76792	80698	78745	3.01	2.03	3.02
T_{12}	FA @ 20 t ha^{-1}+ 100% RDN + VC @ 2.5 t ha^{-1}	38438	41033	39735.	116028	121744	118886	77590	80711	79151	3.02	2.97	2.99
T_{13}	FA@ 30 t ha^{-1}+ 100% RDN + VC @ 2.5 t ha^{-1}	39084	41715	40399	119620	127403	123511	80536	85688	83112	3.06	3.05	3.06
T_{14}	FA @ 40 t ha^{-1}+ 100% RDN + VC @ 2.5 t ha^{-1}	39730	42397	41063	117906	125299	121602	78176	82902	80539	3.04	0.03	3.04
T_{15}	50% RDN + FYM @ 5 t ha^{-1}	32683	35188	33935	99791	104211	102001	67108	69023	68066	2.94	2.96	2.95
T_{16}	50% RDN + VC @ 2.5 t ha^{-1}	34288	36775	35531	101165	105453	103309	66877	68678	67777	2.95	2.87	2.91

Note: FA-Fly Ash, FYM-Farm Yard Manure, VC-Vermicompost, RDN-Recommended Dose of Nutrients

Net return (Rs ha^{-1})

Net return is significantly influenced by application of fly ash in combination with farm yard manure, vermicompost and inorganic fertilizers presented in Table 1.

The economics indicating net realization was influenced significantly by application of fly ash in combination with farm yard manure, vermicompost and inorganic fertilizers in both the years of investigation as well as their mean basis. The maximum net return (Rs. 80536, 85688 and 83112 ha^{-1}, during 2022, 2023 and on mean basis, respectively) was accrued with T_{13} (Fly ash @ 30 t ha^{-1}+ 100% RDN + Vermicompost @ 2.5 t ha^{-1}) which was significantly superior over T_1 (Farmers practices), T_2 (50% RDN), T_3 (Farm Yard Manure@ 5 t ha^{-1}), T_4 (Vermicompost @ 2.5 t ha$^{-1)}$, T_6 (Fly ash @ 20 t ha^{-1}), T_7 (Fly ash @ 30 t ha^{-1}), T_8 (Fly ash @ 40 t ha^{-1}), T_{15} (50% RDN + Farm Yard Manure @ 5 t ha^{-1}) and T_{16} (50% RDN + Vermicompost @ 2.5 t ha^{-1}) during both the year of investigations and on mean basis.

B: C ratio (%)
Significant difference in B: C ratio was observed due to different doses of fly ash alone as well as combination with farm yard manure, vermicompost and inorganic fertilizers in both the years of investigation i.e., 2022, 2023 and on mean basis (Table 1). Statistically the highest B: C ratio (3.06, 3.05 and 3.06 during 2022, 2023 and on mean basis, respectively) was obtained from T_{13} (Fly ash @ 30 t ha^{-1}+ 100% RDN + Vermicompost @ 2.5 t ha^{-1}) which were found significantly superior over T_3 (Farm Yard Manure@ 5 t ha^{-1}), T_4 (Vermicompost @ 2.5 t ha$^{-1)}$, T_6 (Fly ash @ 20 t ha^{-1}), T_7 (Fly ash @ 30 t ha^{-1}) and T_8 (Fly ash @ 40 t ha^{-1}) during both the of investigation and on mean basis, respectively. Whereas T_6 (Fly ash @ 20 t ha^{-1}) recorded significantly the lowest B: C ratio (1.39, 1.25 and 1.32 during 2022, 2023 and on mean basis, respectively).

Conclusion
The study demonstrates the significant potential of fly ash as a soil amendment for improving crop production, particularly rice. Chhattisgarh, being a major fly-ash-generating state, offers a valuable resource that can enhance soil fertility and crop yield when combined with organic and inorganic fertilizers. Among various treatments, the combination of fly ash (30 t ha^{-1}) with 100% RDN and vermicompost (2.5 t ha^{-1}) yielded the highest net returns and benefit-cost ratio, proving its economic viability. However, the variable effects of fly ash on soil nutrients highlight the need for careful selection and supplementation with organic materials. Further research is essential to optimize fly ash application across diverse soil types and crops, ensuring sustainable agricultural practices.

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