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Response of Inorganic Fertilizers in Conjunction with Organic Sources on Performance of Drought Tolerant Direct Seeded Rice (*Oryza sativa* L.) in Central India

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ABSTRACT: Rice is the major source of carbohydrate in the human nutrient which is consumed by 75 % of the global population. Crop needs a balanced supply of nutrients for its optimum growth. In context of current climate change scenario, lowering negative impact of inorganic fertilizer on soil health, use of organic fertilizer along with biofertilizer is essential to provide optimum yields. Supplementing soil with organic sources of nutrients requires large amount of manures, also it takes time to release nutrients in the soil. in the present study combining the inorganic fertilizers with organic fertilizer could support to achieve sustainable production with optimum yield. A field experiment was conducted during the rainy season of 2019-20 under all India coordinated project for dryland agriculture at Kuthlia farm, Rewa, JNKVV, (M.P.). Nine treatment combinations were laid out in randomized block design with three replications. The results indicated that the treatment T_9; 50% RDN through fertilizer + 50% RDN through compost + Seed treated with Azotobacter @ 10g kg^{-1} seed registered maximum plant height (66 cm), no. of tillers (370.33 m^{-2}). The yield attributes *viz*., number of productive tillers m^{-2}, total number of grains $panicle^{-1}$, panicle weight, grain yield $panicle^{-1}$ and test weight were observed a strong and positive correlation with the grain yield of rice. The regression analysis, concluded strong, positive linear relationship of growth and yield attributes with grain yield of rice. The grain yield (3.80 t ha^{-1}) and harvested index (0.37) were maximum in the treatment T_9 however, straw yield (6.50 t ha^{-1}) was maximum under T_2; 100% recommended dose of NPK through fertilizer (100 kg N+40 kg P_2O_5 +40 kg K_2O ha^{-1}). The treatment T_9 fetched maximum economic returns. The investigation concludes that the treatment T_9 increased growth and yield of rice. Furthermore, adoption of INM has a positive impact on soil health and sustaining optimum crop productivity.

Keywords: Drought tolerance rice, integrated nutrient management, compost, inorganic fertilizer, growth parameters, yield attributes.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal for millions in the world and provide food security to more than half of Indian population. About 70 % of world population has rice as the staple food and it provides 60-70% of energy to the Asia alone. In India, it is grown in an area of 45.07 M ha with the production of 112.27 Mt and average of yield 2713 kg ha^{-1} during *kharif* season. In Madhya Pradesh, rice is taken in an area of 2.39 Mha with the production of 4.49 Mt and the 1880.46 kg ha^{-1} (Directorate of economics statistics, DA & FW 2020-21). It is majorly produced and consumed in all over the country except Central and Western part of India. In context of present scenario, even after rice being more important crop for our nation, the interest of farmer is decreasing due to its lower production. The main causes of its low production is changing climatic condition, variation in rain fall pattern and more water demand (1 ha cm day^{-1}) than other crops, forcing the farmer to adopt other crop for rainy season. Rising of nursery, puddling and keep water stagnation during the crop cycle is a major problems of transplanted rice (TPR) which require excessive amount of water and give approximate same amount of yield than other methods of rice production like direct seeded rice (DSR). Furthermore, its covers 30-40% of production cost (Rani and Jayakiran 2010). DSR is very effective and perfect option for current problems of rice production. DSR acquires 26% of total rice area in South Asia and is increasing day by day (Gupta *et al.*, 2006). It lowers the dependency on labor, thereby reduces production cost, also, it reduces the time duration by 7-10 days with comparable grain yield as that of TPR (Sharma *et al.*, 2005). Hence, DSR is water, time and energy saving technology that reduce the overall demand of rice production management and gives optimum yield. DSR production technology is very effective against aberrant weather conditions like late onset of monsoon, erratic distribution of rainfall (Singh *et al*., 2006). Apart from these, it is also helpful for crop intensification by saving time between harvesting of previous crop and sowing of next crop in the cropping system (Singh *et al.*, 2008). After green revolution, drastic increase and dependency on chemical fertilizer on the race of higher production even after more price of fertilizer in the market, its consumption remains unchanged and even increased due to its easy applications and quick response by the crop. Increasing the grain yield by the application of chemical fertilizer up to a certain limit and now it is stagnant. Imbalanced use of fertilizer has declined soil fertility and increased soil pollution. At present increased chemical fertilizer use not only deteriorate soil health but also increased many heavy metal health hazards. By the continuous application of major nutrient by readymade fertilizer increased the demand for micronutrient by crop. These negative impact of chemical fertilizers sparked the interest towards organic farming. Inclusion of organic sources of nutrient in conjunction with inorganic fertilizer will not only enhance crop production but also solve many problems of chemical based inorganic farming like minimize the dependency on chemicals fertilizer and reduce the soil pollution. Further, it will also bring down the dependency on fertilizer import thereby save nation's currency. Biofertilizers, improves the soil quality and availability of nitrogen in the rhizosphere. It promotes the development of plant by colonizing the rhizosphere of plant and provide essential nutrients or phytohormones (Amrutha *et al*., 2022). Hence, there is urgent need to lower higher consumption of chemical fertilizer to by combining the use of organic sources. Furthermore, benefits of compost in conjunction with inorganic fertilizer and biofertilizer need to be explored in direct seeded rice. The moderate use of chemical fertilizer with organic manures need to be studied. Also, its relation with growth and yield attributes to obtain optimum yields is required. Hence, it is necessary to use suitable combination of inorganic fertilizer with organic manures and biofertilizer. Therefore, in order maintain soil health, there is a need to use inorganic fertilizers with organic and biofertilizers. Thus, present investigation was undertaken to study the response of inorganic fertilizer in conjunction with organic sources on performance of drought tolerant direct seeded rice (*Oryza sativa* L.) in Central India.

MATERIAL AND METHODS

The field experiment was carried out during the rainy season of 2019-20 at College of Agriculture, Rewa, JNKVV, Jabalpur (24° 30′ N, 81° 25′ E and 365.7 m above the mean sea level). The site of the experiment was silt-clay loam in texture, medium in organic content (0.46%), low in available N (105.6 kg ha^{-1}), P_2O_5 (8.8 kg ha^{-1}) and high in K_2O (245.61 kg ha^{-1}). A combination of 9 treatments *viz*., T_1; Control, T_2; 100% recommended dose of NPK through fertilizer (100 kg N+40 kg P_2O_5 + 40 kg K_2O ha^{-1}), T_3; 100% RDN Through compost, T_4; 50% RDN through fertilizer + 50% RDN through compost, T_5; 50% RDN through fertilizer + 25% RDN through compost, T_6; 25% RDN through fertilizer + 50% RDN through compost, T_7; 50% RDN through fertilizer + 25% RDN through compost + Seed treated with Azotobacter @ 10g kg^{-1} seed, T_8; 25% RDN through fertilizer + 50% RDN through compost + Seed treated with Azotobacter @ 10g kg^{-1} seed, T_9; 50% RDN through fertilizer + 50% RDN through compost + Seed treated with Azotobacter @ 10g kg^{-1} seed was laid out in randomized block design in three replications. The drought tolerant rice variety 'DRR Dhan42 (DRT-42)' was selected for the experimental trial. The field was ploughed with tractor-drawn plough followed by two disking. All the weeds and stubbles of previous crops were removed. Seeds were sown with row spacing of 25 cm after placing fertilizer, after that it was covered with the soil. The recommended dose of fertilizer; nitrogen (100 kg ha^{-1}), P_2O_5 (40 kg ha^{-1}) and K_2O (40 kg ha^{-1}) was given in each plot except control via different proportions of compost, Urea (46% N), Diammonium phosphate (18% N and 46% P_2O_5), Single super phosphate (16% P_2O_5) and Muriate of potash (60% K_2O) on ha^{-1} basis as basal application except urea which was applied in splits doses, 50% as basal and remaining 50% in two splits, first 25% at tillering second 25% at panicle initiation stage. The weeds were managed by hand weeding at 25 DAS. There was no serious insect pest incidence during the trial. However, at milking stage some gundhi bug were observed which was controlled by the application of lambda cyhalothrin, 5 % SC @ 500 ml ha^{-1} in 300 lit of water.

The data on growth attributes, *viz*., plant population m^{-2} at 15 DAS, plant height and no. of tillers at 60 DAS, leaf area index (LAI) at 40 and 60 DAS were recorded. The grain and straw yield, and harvest index (HI) were recorded and analyzed. The economics of the treatment, *viz*., gross returns, net returns, cost of cultivation and returns rupee^{-1} invested were recorded as per the treatments.

The data obtained were compiled and were subjected to statistical analysis using F-test (Gomez and Gomez 1984). Significant difference between treatments mean were compared with critical differences at 5% level of probability. Correlation between growth and yield attributes with grain yield were evaluated using Pearson's correlation coefficients.

RESULTS AND DISCUSSION

Growth parameters. The present investigation included plant population (m^{-2}), plant height (cm) and number of tillers m^{-2} is presented in Table 1. It is clear from the table that plant population at 15 DAS showed a non-significant difference among different nutrient combinations. In general, the growth pattern of rice revealed that plant height increased progressively up to 90 DAS irrespective of treatments (Fig. 1). Significantly tallest plant (66 cm) at 60 DAS were recorded in treatment T_9 imbedded with 50% RDN through fertilizer + 50% RDN through compost + Seed treated with Azotobacter @ 10g kg^{-1} seed which is followed by T_2, T_4, T_3, T_7, T_8. During the entire period of experiment, shortest plants were recorded in control where no treatments were applied. This might be because of nutrients availability at early stage of crop that boosted crop growth, while incorporation of compost slowly released nutrients in the soil and made available up to reproductive stage, thereby enhancing the growth of plant. Also incorporation of biofertilizer positively influenced plant growth and development. The results are in close line with Choudhary and Suri (2014) who also observed greatest magnitude of growth and development with the integrated nutrient management technology. Benerjee *et al*. (2018); Kumar and Das (2019) also reported similar results.

The numbers of tillers m^{-2} at 60 DAS is very much depended on nutrient availability, T_9 resulted in significantly more number of tillers m^{-2} as compared to its counterpart treatments. However, it was at par with T_2, T_4 and T_3. This might be because of improved soil health that resulted in more growth and development of plant as also observed by Choudhary and Suri (2014) were also observed more number of tillers in integrated nutrient management. Kumar and Das (2019); Meena *et al*. (2019); Ashwini *et al*. (2015) also reported more no. of tillers m^{-2} with the combine application of inorganic and organic sources of nutrients.

Table 1: Response of inorganic fertilizers in conjunction with organic sources on growth parameters of drought tolerant rice.

Treatments	Plant Population 15 DAS	Plant height (cm) 60 DAS	Number of Tillers m^{-2} 60 DAS
T_1- Control	90.66	53.73	327.66
T_2- 100% recommended dose of NPK through fertilizer (100 kg N+40 kg P_2O_5 +40 kg K_2O ha^{-1})	94.00	64.03	363.00
T_3- 100% RDN Through compost	92.66	61.06	354.33
T_4- 50% RDN through fertilizer + 50% RDN through compost	93.00	63.20	358.33
T_5- 50% RDN through fertilizer + 25% RDN through compost	91.00	56.80	340.00
T_6- 25% RDN through fertilizer + 50% RDN through compost	90.33	55.36	337.33
T_7- 50% RDN through fertilizer + 25% RDN through compost + Seed treated with Azotobacter @ 10g kg^{-1} seed	91.00	60.13	351.66
T_8- 25% RDN through fertilizer + 50% RDN through compost + Seed treated with Azotobacter @ 10g kg^{-1} seed	91.66	58.96	345.00
T_9- 50% RDN through fertilizer + 50% RDN through compost + Seed treated with Azotobacter @ 10g kg^{-1} seed	94.33	66.00	370.33
S.Em.±	**1.23**	**2.55**	**5.61**
C.D.5%	**NS**	**7.66**	**16.83**

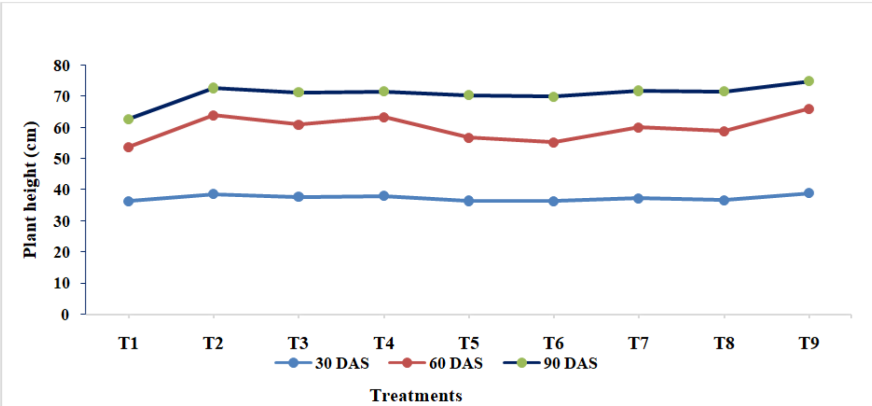

Fig. 1. Response of inorganic fertilizer in conjunction with organic source on plant height of drought tolerant rice.

Relationship between growth parameter and grain yield (t ha^{-1}). Relationship between growth parameter and yield showed a strong positive relationship between growth attributes and yield (Table 2, Fig. 2a and 2b). Correlation study revealed a strong positive correlation between grain yield and Leaf area Index (LAI) at 40 and 60 DAS (Fig. 2a and 2b). Regression analysis between grain yield with LAI revealed a linear increase with increase in LAI. This proves that with increase in LAI, grain yield also increase. The coefficient of determination showed 96 and 91%, at 40 and 60 DAS, respectively variation in grain yield. This might be because of more nutrient availability in INM practices that resulted in accumulation of more leaf area and yield. As also observed by Meena *et al.* (2019) with the combined use of organic and inorganic fertilizer owing to more LAI over RDF.

Table 2: Correlation matrix between grain yield and growth, and yield parameters of drought tolerant rice.

Parameters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Grain yield (t ha^{-1}) (X_1)	1								
Plant height (cm) 60 DAS (X_2)	0.9856	1							
No. of tillers m^{-2} 60 DAS (X_3)	0.9915	0.9932	1						
LAI 60 DAS (X_4)	0.9552	0.9752	0.9722	1					
Productive tillers m^{-2} (X_5)	0.9849	0.9824	0.9875	0.9703	1				
Panicle length (cm) (X_6)	0.8873	0.8531	0.8587	0.8797	0.8624	1			
Panicle weight (g) (X_7)	0.9830	0.9798	0.9801	0.9686	0.9914	0.8908	1		
Test weight (X_8)	0.8316	0.8094	0.8428	0.7608	0.8274	0.5644	0.7974	1	
Grain yield panicle^{-1} (g) (X_9)	0.9282	0.9125	0.9357	0.8709	0.9174	0.7041	0.8997	0.9758	1

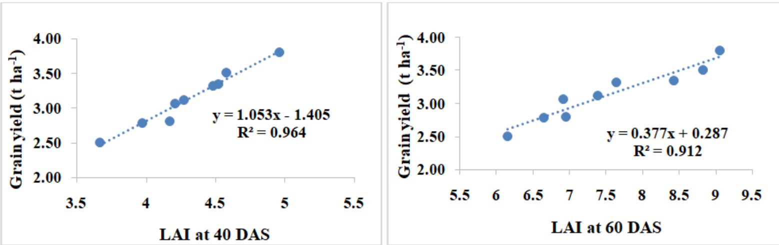

Fig. 2a and b. Relationship between LAI and grain yield (t ha^{-1}).

Yield attributes

Relationship between growth parameters and grain yield (t ha^{-1}). Among the various treatments yield attributes *viz*., number of productive tillers m^{-2}, total number of grains panicle^{-1}, panicle weight (g), grain yield panicle^{-1} (g) and test weight (g) showed a strong positive relationship (Table 2 and Fig. 2c-2g). It is evident form the table that there exist a strong significant correlation between grain yield and yield attributes. The gain in the grain yield was the final outcome of crop which usually relies on development of yield attributes. The regression analysis showed a very strong linear and positive relationship with number of productive tillers m^{-2} (97%), total no. of grains panicle^{-1} (85%), panicle weight (g) (96%), grain yield panicle^{-1} (g) (86%), and test weight (g) (69%) variation in grain yield.

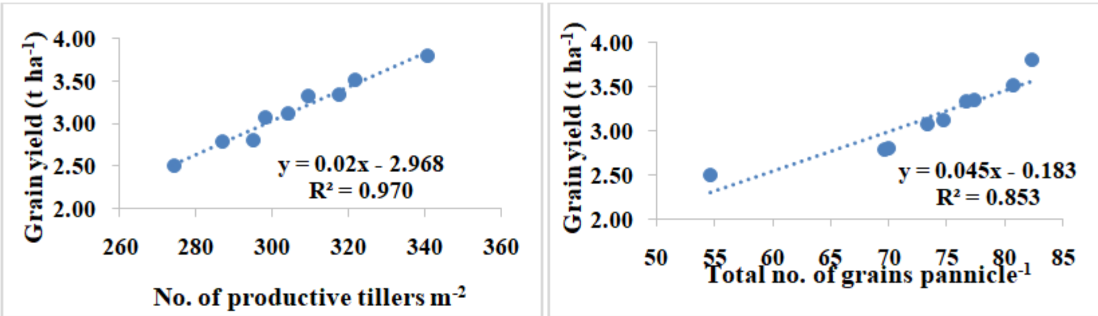

Fig. 2c and d. Relationship between number of productive tillers m^{-2} and Total no. of grains pannicle^{-1} with grain yield (t ha^{-1}).

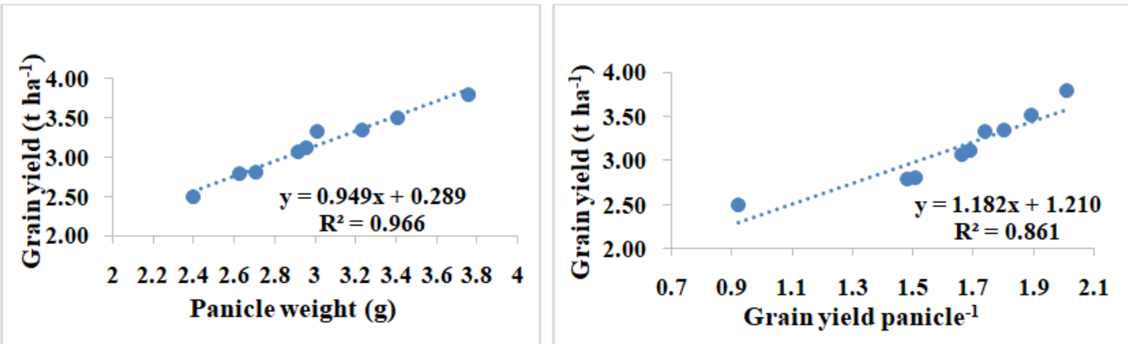

Fig. 2e and f. Relationship between Panicle weight (g) and Grain yield panicle^{-1} with grain yield (t ha^{-1}).

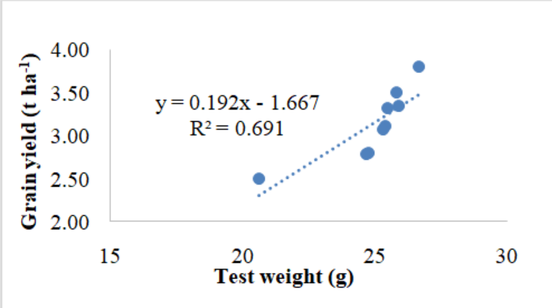

Fig. 2g. Relationship between Test weight (g) and grain yield (t ha^{-1}).

The increase in grain yield might be because of striking effect of 50% RDN through fertilizer + 50% RDN through compost + seed treated with Azotobacter @ 10g kg^{-1} on yield attributes that increased yield over the other treatment. The result agree with the findings of Mangaraj *et al.* (2022); Ofori *et al.* (2019) also reported higher yield and yield component with the combined application of compost and urea nitrogen.

Yield. Integrated nutrient management practices showed a significant effect effects on grain, straw yield and harvest index of drought tolerant rice (Table 3). Crop receiving 50% RDN through fertilizer + 50% RDN through compost + Seed treated with Azotobacter @ 10g kg^{-1} seed recorded highest grain yield (3.8 t ha^{-1}) which was significantly more over the other treatments. The crop with organic manuring along with inorganic fertilizer availed sufficient nutrient to the crop thereby enhancing grain yield. This suggests ability of supplying plant nutrient in accordance with the demand of crop that resulted in more grain yield. Furthermore, inoculation of biofertilizer showed a beneficial effect on plant growth throughout the life cycle. The results are in agreement with findings of Kalhapure *et al*. (2013); Khambhalkar *et al.* (2013). Significantly highest straw yield was recorded with the application of 100% RDF through conventional fertilizer which was more over the other treatments. The lowest values for grain and straw yield were obtained with the treatment where no nutrient were applied. This might be because of more nutrient availability during the initial crop growth stage that positively influenced vegetative growth resulting in more yield. This results corroborated with findings of Borah *et al*. (2015) produced higher grain and straw yield in INM.

Beneficial effect of 50% nutrient through inorganic and 50% through organic along with biofertilizer noted higher HI over the other treatments. The reason is that as the application of both inorganic and organic sources were efficiently utilized nutrients by plant thereby increasing accumulation of photosynthates which in turn transferred more photosynthates from sources to sink that leads to more yield of rice which finally resulted in variation in HI. Also synergistic effect of Azotobacter with the crop availed nutrient in one hand and propensity to improve biological property of the soil to achieve more productivity of rice under rainfed condition. A similar results suggested by Kumar *et al.* (2023).

Table 3: Response of inorganic fertilizer in conjunction with organic sources on yield and harvest index of drought tolerant rice.

Treatments	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})	Harvest Index
T_1- Control	2.50	6.01	0.29
T_2- 100% recommended dose of NPK through fertilizer (100 kg N+40 kg P_2O_5 +40 kg K_2O ha^{-1})	3.51	6.50	0.35
T_3- 100% RDN Through compost	3.33	6.41	0.34
T_4- 50% RDN through fertilizer + 50% RDN through compost	3.35	6.25	0.35
T_5- 50% RDN through fertilizer + 25% RDN through compost	2.81	5.69	0.33
T_6- 25% RDN through fertilizer + 50% RDN through compost	2.79	5.86	0.32
T_7- 50% RDN through fertilizer + 25% RDN through compost+ Seed treated with Azotobacter @ 10g kg^{-1} seed	3.12	6.04	0.34
T_8- 25% RDN through fertilizer + 50% RDN through compost+ Seed treated with Azotobacter @ 10g kg^{-1} seed	3.07	6.06	0.33
T_8- 50% RDN through fertilizer + 50% RDN through compost+ Seed treated with Azotobacter @ 10g kg^{-1} seed	3.80	6.44	0.37
S.Em. ±	**0.009**	**0.008**	**0.001**
C.D.5%	**0.027**	**0.024**	**0.003**

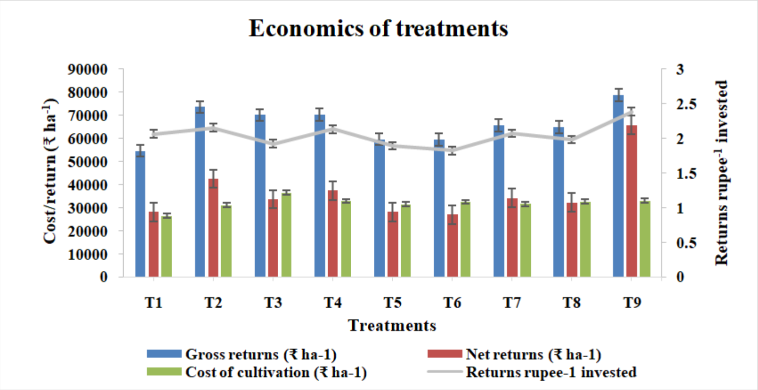

Fig. 3.

Economics of the treatment. Fig. 3. Clearly indicates significant difference among different treatment under study. T_9; 50% RDN through fertilizer + 50% RDN through compost + Seed treated with Azotobacter @ 10g kg^{-1} seed fetched maximum gross return (₹ ha^{-1}), net returns (₹ ha^{-1}), cost of cultivation (₹ ha^{-1}) with the maximum returns $rupee^{-1}$ invested. The highest returns $rupee^{-1}$ invested was worked out in the treatment in T_9 over the other treatment. This might be because of significant variation in grain yield that more net returns resulted in highest returns $rupee^{-1}$ invested in T_9. The result in close line with Borah *et al*., 2015; Meena *et al.*, 2019.

CONCLUSIONS

From the study it may be inferred that application of 50% RDN through fertilizer + 50% RDN through compost + Seed treated with Azotobacter @ 10g kg^{-1} seed resulted in more growth, yield attributes, yield, and economics of rice. A strong and positive relationship was observed between growth and yield attributes with grain yield. Integrated use of Inorganic fertilizer in combination with organic sources and biofertilizer can play a key role in improving fertility status of soil thereby a boon to improve yield and yield attributes of drought tolerant direct seeded rice.

Author contributions. Conceptualization and methodology by Mr. Narendra Kumar, Dr. B.K. Tiwari and Dr. R. K. Tiwari, Conceived and designed the analysis by Mr. Narendra Kumar and Miss. Mrinali Gajbhiye, Collected data and analysis by Mr. Narendra Kumar and Miss. Jyoti Kushawah and Miss. Mrinali Gajbhiye, Wrote the paper by Mr. Narendra Kumar and Miss. Mrinali Gajbhiye.

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Conflict of Interest. None.

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