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Yield and economics in direct seeded rice using organic manures and micronutrients

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Abstract
A field experiment was conducted during 2014-15 and 2015-16 to study the effect of iron (FS 1% and SA 30 kg ha^{-1}), zinc (FS 0.5% and SA 25 kg ha^{-1}) and organic manures application (FYM 2.5,5.0 t ha^{-1} and vermicompost 1.5,3.0 t ha^{-1} and brown manure) on direct seeded dry rice in silty clay loam soil. Results revealed that vermicompost applied in conjunction with brown manure (RDF +BM + 1.5t VC) resulted in production of more dry matter, more number of effective tillers and higher grain yield, this treatment was found at par with combined foliar application of zinc and iron. Combined foliar application of iron and zinc (RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$) yielded more than their combined soil application than their sole application. Vermicompost combined with brown manure recorded higher gross returns while, combined foliar fertilization of zinc and iron registered with higher net return and benefit cost ratio.

Keywords: Vermicompost, Brown manure Zinc, Iron, Direct seeded rice, LAI, SPAD

1. Introduction

Abundance of oxygen influences the soil redox potential and pH these are the key factors that strongly influence the mobility of many nutrients in complex chemical and biological environments of rice soils (Gambrell and Patrick, 1978; Qian *et al*., 2004; Gao *et al*., 2006) [9, 19, 10]. These changes under aerobic soil environment regulate the dynamics of macro and micronutrients in the soil system and subsequently uptake by plant due to variable availability resulted constraint availability of several nutrients including N, P, S and micronutrients such as Zn and Fe (Ponnamperuma, 1972) [17].

Zinc plays an important role in different plant metabolism processes like development of cell wall, respiration, photosynthesis, chlorophyll formation, enzyme activity (Das, 2003) [3] while iron is a part of Ferrodoxins compounds that acts as redox system in photosyanthesis, nitrate reduction, sulphate reduction and N_2 assimilation (Marschner, 1995) [17] Under upland condition the availability of zinc reduced because of reduction of the water content of the soil may restrict Zn transport towards the root surface (Yoshida, 1981) [26] while iron converted into oxidized Fe^{3+}under upland condition that has a very low solubility (Yi *et al.*,1994) [27]. Supplementation of macro and micronutrients through organic manures application or direct micronutrients application along with macronutrients might be an option to overcome the deficiency of nutrients under direct seeded rice. Hence, it became imperative to study the effect of zinc, iron and organic manures on growth, yield and economics of direct seeded rice.

2. Material and Methods

A experiment was conducted at N. E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand) During *kharif* and *rabi* season of 2014-15 and 2015-16.The soil was silty clay loam in texture, slightly alkaline in reaction (pH 7.7) with low available nitrogen (236.5 kg ha^{-1}), medium in available phosphorus (19.6 kg ha^{-1}) and potassium (178.9 kg ha^{-1}). Fourteen treatments were laid out in randomized block design with three replications consisting of two micronutrients (zinc and iron) and three organic sources of nutrients (vermicompost, FYM and green manure) along with recommended dose of fertilizers. Farm yard manure (5.0 and 2.5 t ha^{-1}on dry weight basis) and vermicompost (3.0 and 1.5 t ha-^{1} on dry weight basis) were incorporated one week before sowing as per the treatments. Brown manuring was done alone and in combination of farm yard manure and vermicompost. For the brown manuring *Sesbania aculeate* is broadcasted at the time of rice sowing @ 30 kg ha-^{1} and allowed to grow for 30 days and was dried by spraying

2, 4-D ethyl ester. Zinc was applied in the form of zinc monohydrated ($ZnSO_4.H_2O$) and iron in the form of iron heptahydrate ($FeSO_4.7H_2O$). Three foliar spray of iron sulphate was done @1% at 20, 35 and 50 DAS by dissolving required quantity of iron sulphate in 500, 750 and 750 litres of water, respectively where as 0.5% zinc sulphate spray was done at 25 DAS by dissolving in 500 liters of water. Recommended dose of N, P and K was applied @ 120; 60:40 kg/ha. Rice variety NDR was used and line-seeding of rice direct seeded was done at a spacing of 20 cm x 5 cm, manually. Nursery for transplanting was raised at the seed rate 40 kg ha^{-1}, on the same day of direct seeding and transplanted on 20th day. Two to three healthy seedlings of 20 days age were transplanted per hill at the spacing of 20 x 10cm. Leaf area index (LAI) was computed by ceptometer (model Accu PAR LP-80, Decagon Devices, Pullman) uses radiation measurements and other parameters to accurately calculate leaf area index (LAI) non-destructively in real time. Chlorophyll meter (Model SPAD 502 of Minotta Co., Japan) was used to measure SPAD values. The leaf selected for measurement of SPAD reading was between fourth from base to leaf tip of the plant. The SPAD values were measured on 10 leaves in each plot and then mean value was calculated. The experimental data were analyzed using analysis of variance technique appropriate to randomized block design with the help of statistical programme OPSTAT

3. Result and discussion

3.1 Effect on plant growth and yield attributes

Application of vermicompost in conjunction with brown manure recorded higher number of effective tillers (308 m^{-2}) and higher dry matter accumulation (1267 g m^{-2}) which was found at par with RDF + BM + 2.5 t FYM and RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$ while, RDF + 1 FS of 0.5% $ZnSO_4$ remained at par with alone RDF (Table 1). Combined application of FYM and vermicompost was found superior over alone application of FYM and brown manure. Increased growth under organic source of nutrients might be due to organic manures not only supply essential nutrients to plant but also improves soil physical and biological health. These results corroborated the findings of Swarup and Yaduvanshi (2000) [24] and Yadana *et al*. (2009) [26].

Table 1: Plant growth pattern and yield attributes of direct seeded rice as influenced by different micronutrients and organic manures

Treatment	Effective panicle m^{-2}	Dry matter accumulation g m^{-2}	Leaf area index	SPAD value	Number of spikelet's per panicle	1000 grain weight
T_1- Absolute control	199	653	2.01	33.2	88	24.9
T_2- RDF120:60:40 (control)	236	947	3.73	35.9	100	25.6
T_3- RDF + SA of $ZnSO_4$ @ 25 kg ha^{-1}	280	1154	4.76	41.5	117	26.7
T_4- RDF + 1 FS of 0.5% $ZnSO_4$	248	1027	4.11	37.4	104	26.1
T_5- RDF + SA of $FeSO_4$@ 30 Kg ha^{-1}	265	1072	4.24	40.4	106	26.3
T_6- RDF + 3 FS of 1% $FeSO_4$	281	1177	4.75	40.5	118	26.6
T_7- RDF + SA of $ZnSO_4$ @ 25 Kg ha^{-1}+ SA of $FeSO_4$ @ 30 Kg ha^{-1}	284	1138	4.7	40.3	113	26.7
T_8- RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$	295	1211	4.84	41.8	124	27.1
T_9 - RDF+ 3.0 t VC	286	1177	4.53	37.6	123	26.7
T_{10}- RDF + 5.0 t FYM	266	1146	4.46	37.8	114	26.5
T_{11}- RDF + BM	275	1153	4.49	38.7	116	27.2
T_{12}- RDF +BM + 1.5t VC	308	1267	4.96	41.7	126	27.2
T_{13}- RDF + BM + 2.5 t FYM	294	1226	4.89	39.9	124	27
T_{14}- RDF + $ZnSO_4$ @ 25 Kg ha^{-1} (TPR)	251	1120	4.34	41.7	132	27.5
SEm±	11	36	0.14	0.5	4	0.2
CD (5%)	32	104	0.41	1.4	11	0.6

T_1 – T_{13} direct seeded rice, TPR- transplanting, RDF –Recommended dose of fertilizers, FS – foliar spray, SA- soil application, BM - Brown manuring, VM- vermicompost, FYM- farm yard manure, DAS- days after sowing.

In case of micronutrients treated plots foliar fertilization of iron and zinc had remarkable effect on plant growth parameter compared to soil application it might be due direct entry of nutrients in metabolic sites as zinc and iron both plays important role in various metabolic activity of plant growth. Gill and Walia (2013) [11] and Fageria *et al.* (2003) [8].

Leaf area index is an indicator of total source available to the plant for the production of photosynthates, which accumulate in the developing sink. RDF + BM + 1.5 t VC recorded higher LAI followed by RDF + BM + 2.5 t FYM and RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$. More LAI under organic manures might be attributed to the stimulating effect of vermicompost and brown manure that supplies plant with nutrients required for better yield (Roy *et al*., 2010; Dinesh *et al*., 2010) [22, 5] Significant effect of micronutrients on LAI might be due to their role in plant growth as iron is required for the synthesis of chlorophyll, which is essential pigment for photosynthesis. It also improves the root systems of rice, plant growth and leaf area of rice (Fageria, 2014) [8]. While Zn plays an important role in synthesis of tryptophan and IAA, which are responsible for increasing the leaf area. These results are in conformity with Misra and Abidi, 2007, Ali *et al*. (2003) [17, 1] and Johnson *et at* [1, 12] It is evident from the data given in Table 1 that micronutrient and organic manures were able to bring significant changes on SPAD values. Under micronutrient treatments, maximum SPAD value recorded with combined foliar application of zinc and iron sulphate RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$ and was found significantly superior to all the treatments except RDF + BM + 1.5 t VC, RDF + 3 FS of 1% $FeSO_4$ and RDF + $ZnSO_4$ @ 25 Kg ha^{-1} (TPR).

The maximum value of leaf chlorophyll content was recorded with combined iron and zinc application might be due to the fact that Fe is important in chlorophyll formation and development (Kobraee *et al*.,2011) [14] whereas zinc is also necessary for the chlorophyll synthesis and carbohydrate formation Vitosh *et al*. (1994) [25].

Table 2: Yield and economics of direct seeded rice as influenced by different micronutrients and organic manures

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index	Cost of cultivation $Rs.ha^{-1}$	Gross net return $Rs.ha^{-1}$	Net return $Rs.ha^{-1}$	Benefit: :cost ratio
T_1- Absolute control	2.84	3.65	43.68	23956	39386	10287	0.65
T_2- RDF120:60:40 (control)	4.64	5.10	47.67	29057	64360	23535	1.22
T_3- RDF + SA of $ZnSO_4$ @ 25 kg ha^{-1}	5.35	5.99	47.20	30307	74239	29288	1.46
T_4- RDF + 1 FS of 0.5% $ZnSO_4$	5.11	5.76	47.13	29182	71295	28076	1.45
T_5- RDF + SA of $FeSO_4$@ 30 Kg ha^{-1}	5.23	5.93	46.89	29507	72485	28652	1.47
T_6- RDF + 3 FS of 1% $FeSO_4$	5.48	6.2	46.82	29357	75766	30940	1.59
T_7- RDF + SA of $ZnSO_4$ @ 25 Kg ha^{-1}+ SA of $FeSO_4$ @30 Kg ha^{-1}	5.2	5.89	46.91	30757	72087	27554	1.35
T_8- RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$	5.83	6.63	46.82	29632	80821	34126	1.74
T_9 - RDF+ 3.0 t VC	5.61	6.39	46.72	44057	77633	22384	0.77
T_{10}- RDF + 5.0 t FYM	5.42	6.12	46.91	32807	75093	28191	1.30
T_{11}- RDF + BM	5.5	6.14	47.26	29227	76221	31330	1.61
T_{12}- RDF +BM + 1.5 t VC	6.1	6.95	46.74	37187	84551	31576	1.28
T_{13}- RDF + BM + 2.5 t FYM	5.9	6.68	46.87	31562	81823	33508	1.60
T_{14}- RDF + $ZnSO_4$ @ 25 Kg ha^{-1} (TPR)	5.53	5.94	48.22	40802	76655	23903	0.89
SEm±	0.17	0.23	0.43	-	2589	-	-
CD (5%)	0.5	0.65	1.24	-	7526	-	-
CV (%)	5.63	6.55	1.58	-	6	-	-

Higher number of spikelet per panicle was observed in case of transplanted method RDF + ZnSO4 @ 25 Kg ha-^{1} (TPR) however it did not vary with RDF + BM + 2.5 t FYM, RDF + 1 FS of 0.5% ZnSO4 + 3 FS of 1% FeSO4 and RDF+3.0 t VC.1000 seed weight was influenced significantly with different treatments higher 1000 seed weight was recorded with the RDF + ZnSO4 @ 25 Kg ha-^{1} (TPR) which remained at par with RDF + BM + 2.5 t FYM, RDF + 1 FS of 0.5% ZnSO4 + 3 FS of 1% FeSO4. RDF + BM, and RDF + 1 FS of 0.5% ZnSO4 + 3 FS of 1% FeSO4.More number of grains under transplanted rice might be due to better translocation of carbohydrates from source to sink. Prabhakarand Reddy (2010) [20] also reported similar results

3.2 Yield and economics

The data related to yield and economics of direct seeded rice supplied with micronutrients and organic manures were presented in Table 2. Treatments fertilized with either micronutrients or organics along with RDF, except foliar spray of zinc of 0.5% $ZnSO_4$ (T_4) recorded significantly higher grain yield over alone application of RDF. Brown manuring along with vermicompost and FYM application on rice had a significant positive effect than their sole application. The highest grain yield (6.10 t ha^{-1}) was obtained with the RDF + BM + 1.5 t VC which was statistically similar with RDF + BM + 2.5 t FYM, RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$ and RDF + 3.0 t VC it might be due the fact that application of FYM and vermicompost in rice yield might have promoted the vigorous growth of *Sesbania* that all together supplemented adequate amount of macro- and micronutrients to the soil in association with enhanced soil microbial activity. These results corroborated the findings of Bedi *et al.* (2009) [2] and Datt and Sharma (2006) [4].

Zinc and iron fertilization in direct seeded rice proved promising in enhancing the grain yield. RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$ produced 25.6 % higher grain yield over alone RDF and was found superior to soil application of iron sulphate(T_5) and combines soil application of zinc and iron (T_7). This could be due to the fact that in case of foliar application soil properties like pH, texture and presence of cations, did not interfere with the uptake of nutrient by the plants.

Rice grown through transplanting method, RDF + $ZnSO_4$ @ 25 kg ha^{-1}(TPR) yielded at par with DSR under same nutrient dose viz; RDF + SA of $ZnSO_4$ @ 25 kg ha^{-1} exhibited that both establishment methods remained at par with respect to grain yield. Liu *et al.* (2015) [15] also noted similar result. The highest straw yield compared to all treatments was obtained in the treatment that received RDF + BM + 1.5 t VC which was found statistically at par with the RDF + BM + 2.5 t FYM, RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$ and RDF + 3.0 t VC.

Highest harvest index (48.2%) was recorded with the RDF + $ZnSO_4$ @ 25 kg ha^{-1}(TPR), while the lowest value of harvest index was recorded in absolute control (43.6%). Higher harvest index under TPR might be due better sources to sink translocation of carbohydrates resulted in higher grain and less straw production. Similar findings were also made by Sharma *et al.* (1995) [23] owing to efficient translocation of the carbohydrates to the reproductive parts.

The total cost of cultivation was higher in case of vermicompost fertilization and transplanted method of rice establishment i.e. in RDF + 3.0 t VC and in RDF + $ZnSO_4$ @ 25 kg ha^{-1} (TPR) (44057 and 40802 Rs. ha^{-1}).Whereas, lowest cost of cultivation of system (29057) was associated with recommended dose of fertilizer (Fig.1). Maximum gross return (84551 Rs. ha^{-1}) was recorded with RDF + BM + 1.5 t VC and was found significantly superior to all the treatments being at par with RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$, RDF + 3.0 t VC and RDF + BM + 2.5 t FYM. The lowest gross return was observed in alone RDF.

The higher net returns (34126 Rs. ha^{-1}) registered in of case foliar fertilization i.e. RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$ followed by RDF + BM + 2.5 t FYM and RDF + BM (Fig.1). Foliar fertilization obtained higher net return because of lower cost of cultivation and higher productivity

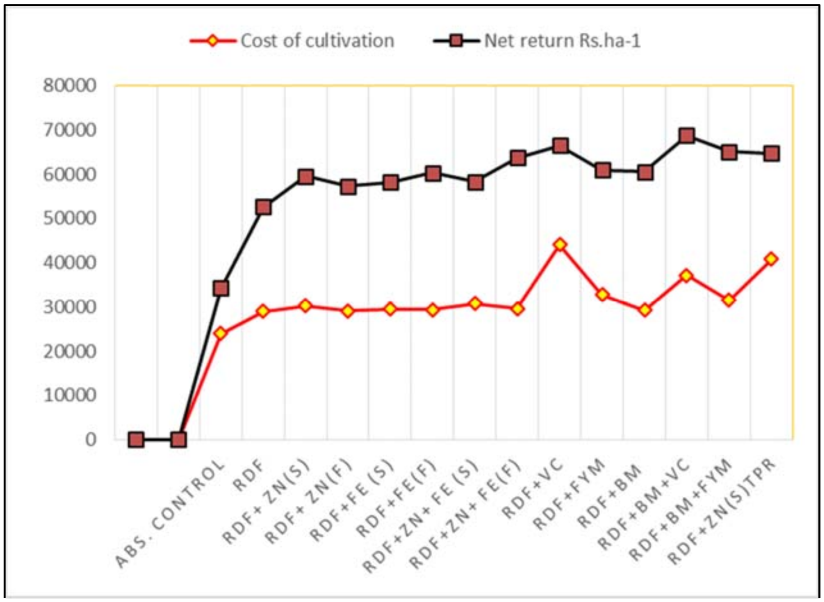

Fig 1: Graphical representation of cost of cultivation and net returns of treatments applied to direct seeded rice

The highest B: C ratio (1.74) was also found with foliar fertilization i.e. RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$ followed by RDF + BM and RDF + BM + 2.5 t FYM. Higher yield less cost of cultivation in case of foliar fertilization resulted in higher B: C ratio Duraisami and Mani (2001) [6] observed that the net return was higher in foliar spray than the soil application and control.

4. Conclusion

The present study has shown that under direct seeded rice grain can be effectively raised by application of vermicompost and brown manure alone with RDF or by foliar spray of iron sulphate along with zinc sulphate. Since, the cost of production was higher in case of organic manures application so foliar application might be better option to attain higher profit with less input cost.

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