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Arabole Shaila
Research Scholar, Department of Agronomy, Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur, Maharashtra, India

Renuka Shinde
Associate Professor, Department of Agronomy, Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur, Maharashtra, India

Gaikwad Vaibhav
Assistant Professor, Department of Agronomy, College of Agriculture, Phaltan (Affiliated to Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Patil Ranjeet
Assistant Professor, Department of Agricultural Entomology, Dr. D.Y. Patil College of Agriculture, Talsande, Kolhapur (Affiliated to Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Corresponding Author:
Arabole Shaila
Research Scholar, Department of Agronomy, Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur, Maharashtra, India

Effect of the zinc nutrition on yield, nutrient content and uptake of direct seeded rice (*Oryza sativa* L.)

Arabole Shaila, Renuka Shinde, Gaikwad Vaibhav and Patil Ranjeet

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Abstract
The investigation on "Response of direct seeded rice (*Oryza sativa* L.) to zinc nutrition in sub-montane zone of Maharashtra comprise of filed experiment which was carried out at Agronomy Farm in Survey No.359 and Plot No.22C at Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur (M.S.), India during the *kharif* 2021. is situated on an elevation of 545.59 meters above the mean sea level on $16^0$41'30" North latitude and 74^0 14'00" East longitude and agro-climatically comes under the Sub-Montane Zone of Maharashtra under NARP, Kolhapur. The minimum temperature varied from 15.1 °C to 18.6°C, while maximum temperature was in the range of 26°C to 32.3°C, respectively. The relative humidity ranged between 75 to 91 per cent and 58 to 88 per cent during morning and evening respectively. The total rainfall received during experimentation period was 1304.6 mm during the experimentation from 23rd to 48th meteorological weeks. The maximum evaporation was recorded 4.6 mm day-1 and lowest being 1.9 mm day-1 in 23rd and 37th meteorological weeks, respectively. The layout of the experimentation was randomized block design with three replications and eleven treatments. On the basis of findings, it is concluded that the treatment T_{11}: RDF (100:50:50 kg NPK kg ha^{-1} + Vermicompost @ 2.5 t ha^{-1}) + Soil application of $ZnSO_4$ @ 20 kg ha^{-1}+ Foliar application of 0.2 % EDTA Zn best result on yield studies**,** Nutrient (NPK & Zn) Content (%) in Grains and Straw of DSR and Uptake of Nutrients by Rice Plant (kg ha^{-1}). The minimum yield studies, Nutrient (NPK & Zn) Content (%) in Grains and Straw of DSR and Uptake of Nutrients by Rice Plant (kg ha^{-1}) was recorded under the treatment T_1 absolute control.

Keywords: Zinc, direct seeded rice, micronutrient, yield, vermicompost

Introduction
Rice (*Oryza sativa* L.) is the world's leading staple food grains and premier cereal crop for above 60 per cent world's population, belonging to family Poaceae. It is a short-day, self-pollinating plant that is native to South- Eastern Asia. Carbohydrate present in the form of starch, which makes up around 72–75 per cent of the overall grain content, is the primary nutrient found in paddy. Roughly 7-8 per cent of the protein in rice is glutamine, also known as Oryzenin, which has a higher digestibility rating and less crude fiber and fat (1-2%). Due to its distinctive perfume and exceptional quality, scented rice commands a significant premium in both the domestic and international markets. 2-Acetyl-1-pyrroline is main fragrance component found in *Indrayani* rice. Rice crop is widely farmed in tropical and subtropics, provides 40 per cent of the global population with a great source of calories (Virdia and Mehta, 2009). India will have the most acreage planted with rice and the second-highest output of rice in the world in 2020–21, after China (Anonymous, 2021[a]) [1]. China was the world largest rice producer country with 146.7 million metric tonnes. In 2020–21, rice production will reach a record 122 million metric tonnes, up from 118.9 million metric tonnes the year before (Anonymous, 2021[b]) [2].
India has over 45 million hectares of land devoted to rice farming in the year 2021. Rice is the food grain that is most widely cultivated in South Asian Nations (Anonymous, 2022[a]) [1]. Next to China, India is the world's second-largest producer and consumer of rice. West Bengal, Uttar Pradesh and Punjab are the three main rice-producing states in India. The direct seeding is time and labour saving method, constitutes both wet and dry seeding. The upland paddy is mostly dry- seeded and found in parts of Bihar, Assam, Chhattisgarh, Gujarat, Kerala, Karnataka, West Bengal, Uttar Pradesh and Maharashtra. The upland rice grown in India is about 13 per cent of

area under cultivation; it helps in feeding numbers of poor farmer from its limited resources in India.

Direct seeded rice (DSR) reduces 11.2 per cent of the total cost of production over the transplanting method (Dongarwar *et al*., 2018) [4]. In DSR, the input requirements and total investment are much less than transplanted rice. Kumar and Ladha (2011) [7] recorded higher benefit cost ratio in direct seeded rice as compared to manual transplanted rice. Integrated use of synthetic fertilizers with organic sources of nutrients helps in maintaining higher productivity and greater stability in crop production. Application of vermicompost is considered good to safe supply of all micronutrients for the crop production. Vermicompost can be used in crop production as a integrated nutrient management component and as single source of essential nutrients. All nutrients (Macro and Micro) present in vermicompost are in readily available form, thereby, increasing nutrients uptake by the plants (Banik and Sharma., 2009). Micronutrients are crucial for the growth and development of plants as well as for boosting crop productivity. Zinc is the micronutrient that is most deficient in soils across the world, zinc insufficiency is one of the primary agricultural issues that threatens regional and global food security. In the world more than 30 per cent of the cultivated soils are zinc deficient and about 50 per cent of the soils used for cereal crop production are low in available zinc. Nearly half of the world population suffers from zinc deficiency (Cakmak, 2008) [3]. In India, about 26 per cent populations and about 54 per cent childrens are suffering from Zn deficiency (Verma *et al*., 2015) [13]. The most economic way to alleviate zinc deficiency in the rice is application of zinc fertilizers and improves productivity and zinc concentration in grains. In addition to specific zinc fertilizers, organic manures are good source of zinc and other nutrients.

Therefore, adopting direct seeded rice in zinc-deficient soil and performing well under adequate zinc nutrient supplies coupled with vermicompost become equally significant to farmers. As a result, this study may be helpful to evaluate the nutritional value of zinc and the effectiveness of its use in rice grain and straw when various zinc sources are combined with RDF

Materials and Methods

The field layout for paddy during *kharif* season was set out at Agronomy Farm in Survey No.359 and Plot No.22C at Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur (M.S.), India. The soil of experimental field has smooth and uniform leveled topography the experimental plot was sandy clay loam soil. The pH and electrical conductivity values were 7.80 (slightly alkaline in reaction) and 0.45 dSm^{-1} (normal-low saline), respectively. The status of soil organic carbon content (0.51%) was medium. The plot was low in available N (168.27 kg ha^{-1}), relatively very high in available P_2O_5 (30.02 kg ha^{-1}), medium in available K_2O (339.88 kg ha^{-1}) and deficient in available Zn (0.25 ppm). The available N, P_2O_5, K_2O and organic carbon content were classified based on a three-tier system, the calcium carbonate content in soil at initial was 8.2 per cent and the results were interpreted accordingly.

The weather parameters were recorded during the period of field experimentation minimum temperature varied from 15.1°C to 18.6°C, while maximum temperature was in the range of 26°C to 32.3°C, respectively. The relative humidity ranged between 75 to 91 per cent and 58 to 88 per cent during morning and evening respectively. The total rainfall received during experimentation period was 1304.6 mm during the experimentation from 23rd to 48th meteorological weeks. The maximum evaporation was recorded 4.6 mm day^{-1} and lowest being 1.9 mm day^{-1} in 23rd and 37th meteorological weeks, respectively. The layout of the experimentation was randomized block design with three replications and eleven treatments done during *kharif*, 2021. The details of the treatment combinations given as below,

T_1: Absolute control, T_2: RDF (100:50:50 kg NPK kg ha^{-1})., T_3: RDF (100:50:50 kg NPK kg ha^{-1} + Vermicompost @ 2.5 t ha^{-1})., T_4: RDF (100:50:50 kg NPK kg ha^{-1} + Vermicompost @ 2.5 t ha^{-1}) + Soil application of $ZnSO_4$ @ 10 kg ha^{-1}., T_5: RDF (100:50:50 kg NPK kg ha^{-1} + Vermicompost @ 2.5 t ha^{-1}) + Soil application of $ZnSO_4$ @ 20 kg ha^{-1}., T_6: RDF (100:50:50 kg NPK kg ha^{-1} + Vermicompost @ 2.5 t ha^{-1}) + Foliar application of 0.1 % EDTA Zn., T_7: RDF (100:50:50 kg NPK kg ha^{-1} + Vermicompost @ 2.5 t ha^{-1}) + Foliar application of 0.2 % EDTA Zn., T_8: RDF (100:50:50 kg NPK kg ha^{-1} + Vermicompost @ 2.5 t ha^{-1}) + Soil application of $ZnSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.1 % EDTA Zn., T_9: RDF (100:50:50 kg NPK kg ha^{-1}+ Vermicompost @ 2.5 t ha^{-1}) + Soil application of $ZnSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.2 % EDTA Zn., T_{10}: RDF (100:50:50 kg NPK kg ha^{-1}+ Vermicompost @ 2.5 t ha^{-1}) + Soil application of $ZnSO_4$ @ 20 kg ha^{-1}+ Foliar application of 0.1 % EDTA Zn., T_{11}: RDF (100:50:50 kg NPK kg ha^{-1} +Vermicompost @ 2.5 t ha^{-1}) + Soil application of $ZnSO_4$ @ 20 kg ha^{-1}+ Foliar application of 0.2 % EDTA Zn

Table 1: Physical and chemical properties of soil of the experimental plot

Sr. No.	Characteristics	Composition	Method used
A)	Physical properties		
1.	Sand (%)	50.42	International pipette method (Piper, 1966)
2.	Silt (%)	14.27	
3.	Clay (%)	35.31	
4.	Textural class	Sandy clay loam	Triangular diagram (Prescott, Taylor and Marshall, 1934)
B)	Chemical properties		
1.	pH	7.80	Potentiometric method (Jackson, 1973)
2.	EC (dSm^{-1})	0.45	Conductometric method (Jackson, 1973)
3.	Organic carbon (%)	0.51	Walkley and Black's rapid titration method (Jackson, 1973)
4.	Available N (kg ha^{-1})	168.27	Alkaline $KMnO_4$ method (Subbiah and Asija, 1956)
5.	Available P_2O_5 (kg ha^{-1})	30.02	Olsen method (Olsen,1954)
6.	Available K_2O (kg ha^{-1})	339.88	Flame photometer method (Jackson, 1973)
7.	Available Zn (ppm)	0.25	Atomic absorption spectroscopy(Lindsay and Norvell, 1978)

Result and Discussion

The details of results obtained from the present investigation have been presented and discussed appropriate heading and subheading.

Yield and harvest index

Mean grain yield, straw yield, biological yield and harvest index ha^{-1} as influenced by various treatments is presented in Table 2. Grain, straw, biological yield (q ha^{-1}) and harvest index of DSR as influenced by various treatments.

1. Yield studies

Among various zinc nutrition treatments (Table 2) soil application of ZnSO4 @ 20 kg ha-1+ foliar application of 0.2% EDTA Zn along with RDF (100:50:50 NPK kg ha-1) and Vermicompost @ 2.5 t ha-1 [T_{11}] recorded significantly the highest grain yield (48.97 q $ha^{-1)}$, maximum straw yield (69.71 q $ha^{-1)}$, highest biological yield (130.24 q ha^{-1}), biological yield (46.42 q $ha^{-1)}$ and harvest index (46.51) which was at par with the treatment of soil application of $ZnSO_4$ @ 20 kg ha^{-1} + foliar application of 0.1% EDTA zinc along with RDF (100:50:50 NPK kg ha^{-1}) and Vermicompost @ 2.5 t ha^{-1} [T_{10}]. The harvest index is reproductive efficiency of the plant. The mean value of harvest index was 46.48 per cent. The numerical value of highest harvest index (46.51) was noticed under [T_{11}] soil application of ZnSO4 @ 20 kg ha^{-1} + foliar application of 0.2% EDTA Zn and [T_5] soil application of ZnSO4 @ 20 kg ha^{-1}. However, [T_1] absolute control treatment was recorded lowest harvest index value of 46.42 per cent of direct seeded rice. Ghasal *et al.* (2015) [5] and Shivay *et al.* (2015) [10] reported similar results on harvest index. It might be due to combined method of application of zinc had favourable effect on root proliferation and there by plant nutrient uptake increasing from soil to aerial plant parts and ultimately enhancing vegetative plant growth parameters and yield attributing characters which finally makeup the yield.

2. Nutrient (NPK) Content (%) in Grains and Straw of DSR

The mean data on nitrogen content in grain and straw of direct seeded rice crop presented in Table 2 indicates that zinc nutrition significantly increased nitrogen phosphorus and potassium concentration in grain and straw of rice crop. In general, combined method of zinc application, (soil + foliar) was recorded significantly higher concentration of nitrogen in grain and straw as compare to only foliar application of zinc. Comparatively increased nitrogen content in grain (1.35 %) and in straw (0.83 %), phosphorus content was 0.21 per cent in grains and 0.14 per cent in straw, potassium concentration in grain and straw was 0.56 per cent and 1.25 per cent, respectively.

Comparatively increased nitrogen content in grain (1.35 %) and in straw (0.83 %) was recorded under soil application of $ZnSO_4$ @ 20 kg ha^{-1} + foliar application of 0.2% EDTA Zn along with RDF (100:50:50 NPK kg ha^{-1}) and Vermicompost @ 2.5 t ha^{-1} [T_{11}] due to effect of zinc on nitrogen concentration may be effect of dilution. The minimum nitrogen content in grain (1.09 %) and in straw (0.62 %) was observed under absolute control treatment [T_1] due to low availability of nutrients in soil. The treatment T_{11} was found significantly superior over foliar application of 0.1% EDTA Zn [T_6], RDF [T_2] and Vermicompost + RDF [T_3] and it was found at par with soil application of $ZnSO_4$ @ 10 kg ha^{-1} and 20 kg ha^{-1} as well as combine method of zinc application i.e. soil + foliar application. The concentration of nitrogen in rice grains was much higher as compared to straw. These results are similar with findings of Rana and Kashif (2014) [9], Shivay *et al*. (2015) [10] and Tharakan (2018) [12].

The treatment of soil application of $ZnSO_4$ @ 20 kg ha^{-1} + foliar application of 0.2% EDTA Zn along with RDF (100:50:50 NPK kg ha^{-1}) and Vermicompost @ 2.5 t ha^{-1} [T_{11}] resulted in higher phosphorus content and it was found superior over T_2, T_3 and T_6 treatments of only RDF application, RDF + Vermicompost and single foliar spray of 0.1 % EDTA Zn, respectively. Treatment T_{11} was at par with treatment T_4, T_5, T_7, T_8, T_9 and T_{10}. The application of zinc helps to supply more available phosphorus to plant and leads to greater 'P' absorption by rice plant. The lower phosphorus concentration in grain was 0.12 per cent and in straw 0.08 per cent found in absolute control treatment [T_1]. Combined method of zinc application (soil + foliar) recorded more concentration of phosphorous in grain and straw. Similar results were reported by Singh *et al.* (2013) [11] and Rana and Kashif (2014) [9].

Application of $ZnSO_4$ @ 20 kg ha^{-1} + foliar application of 0.2% EDTA Zn along with RDF (100:50:50 NPK kg ha^{-1}) and Vermicompost @ 2.5 t ha^{-1} (T_{11}) recorded highest potassium concentration in grain and straw and it was significantly superior and at par with T_4, T_5, T_7, T_8, T_9 and T_{10} except T_6 treatment which received only foliar application of 0.1% EDTA Zn, while minimum potassium content in grain (0.36 %) and in straw (0.92 %) were observed in absolute control [T_1] treatment. Direct seeded rice grains have significantly lower concentration of potassium as compared to straw. Increase in potassium concentration in grain and straw might be due to zinc nutrition. Similar results were noted by Rana and Kashif (2014) [9], Shivay *et al*. (2015) [10] and Ghasal *et al*. (2017) [6].

Table 2: Grain, straw, biological yield (q ha^{-1}) and harvest index of DSR as influenced by various treatments

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index
T_1 – Absolute control	21.55	24.87	46.42	46.42
T_2 – RDF (100:50:50 kg NPK ha^{-1})	34.70	39.96	74.66	46.48
T_3 – RDF + Vermicompost @ 2.5 t ha^{-1}	39.50	45.46	84.96	46.49
T_4 – (RDF + Vermicompost)+ Soil application of $ZnSO_4$ @ 10 kg ha^{-1}	51.42	59.16	110.58	46.50
T_5 – (RDF + Vermicompost)+ Soil application of $ZnSO_4$ @ 20 kg ha^{-1}	53.94	62.02	115.96	46.51
T_6 - (RDF + Vermicompost) + Foliar application of 0.1 % EDTA Zn	50.31	57.89	108.20	46.50
T_7 - (RDF + Vermicompost) + Foliar application of 0.2 % EDTA Zn	52.48	60.37	112.85	46.50
T_8 - (RDF + Vermicompost) + Soil application of $ZnSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.1 % EDTA Zn	56.61	65.29	121.90	46.44
T_9 – (RDF + Vermicompost) + Soil application of $ZnSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.2 % EDTA Zn	57.64	66.39	124.03	46.47
T_{10} – (RDF + Vermicompost) + Soil application of $ZnSO_4$ @ 20 kg ha^{-1}+ Foliar application of 0.1 % EDTA Zn	59.94	69.11	129.05	46.47
T_{11} – (RDF +Vermicompost) + Soil application of $ZnSO_4$ @ 20 kg ha^{-1}+ Foliar application of 0.2 % EDTA Zn	60.53	69.71	130.24	46.51
S.Em±	0.353	0.409	0.878	1.56
C. D. at 5%	1.043	1.208	2.593	NS
General mean	48.97	56.39	105.36	46.48

3. Uptake of Nutrients by Rice Plant (kg ha^{-1})

The data indicated that Table 3 mean nitrogen uptake in rice plant was 103.31 kg ha^{-1}. Among various zinc nutrition treatments the soil application of $ZnSO_4$ @ 20 kg ha^{-1} + foliar application of 0.2% EDTA Zn along with RDF (100:50:50 NPK kg ha^{-1}) and Vermicompost @ 2.5 t ha^{-1} [T_{11}] found significantly superior over rest of treatments except soil application of $ZnSO_4$ @ 20 kg ha^{-1} + foliar application of 0.1% EDTA Zn along with RDF (100:50:50 NPK kg ha^{-1}) and Vermicompost @ 2.5 t ha^{-1}[T_{10}], soil application of $ZnSO_4$ @ 10 kg ha^{-1} + foliar spray of 0.2% EDTA Zn along with RDF (100:50:50 NPK kg ha^{-1}) and Vermicompost @ 2.5 t ha^{-1} [T_9], and soil application of $ZnSO_4$ @ 10 kg ha^{-1} + foliar application of 0.1% EDTA Zn along with RDF (100:50:50 NPK kg ha^{-1}) and Vermicompost @ 2.5 t ha^{-1} [T_8]. Which was statistically indicating on par with it might be due to higher yield and availability of essential nutrients in soil, which up taken more amounts of nitrogen and it was recorded significantly highest amount of total nitrogen uptake 139.57 kg ha^{-1}. Whereas, lowest uptake of nitrogen 38.91 kg ha^{-1} was recorded in absolute control treatment [T_1] due to low yield and less amount of available nutrients. Increase in total nitrogen uptake could be attributed to synergistic effect between N and Zn. Similar traits were reported by Singh *et al.* (2013) [11], Shivay *et al.* (2015) [10] and Ghasal *et al.* (2017) [6] and Meena *et al.* (2018) [8].

Among all treatments of zinc nutrition, significantly higher amount of P uptake by grain, straw and total uptake by crop were recorded under soil application of $ZnSO_4$ @ 20 kg ha^{-1} + foliar application of 0.2% EDTA Zn along with RDF (100:50:50 NPK kg ha^{-1}) and Vermicompost @ 2.5 t ha^{-1} [T_{11}] and it was significantly superior over treatments T_7, T_6, T_5, T_4, T_3, T_2 and T_1 except soil application of $ZnSO_4$ @ 20 kg ha^{-1} + foliar application of 0.1% EDTA Zn along with RDF (100:50:50 NPK kg ha^{-1}) and Vermicompost @ 2.5 t ha^{-1} [T_{10}], soil application of $ZnSO_4$ @ 10 kg ha^{-1} + foliar application of 0.2% EDTA Zn along with RDF and Vermicompost [T_9] and soil application of $ZnSO_4$ @ 10 kg ha^{-1} + foliar application of 0.1% EDTA Zn along with RDF and Vermicompost [T_8], which were found at par with it might be due to more grain yield. Lowest amount of total uptake of P by crop 4.58 kg ha^{-1} was in absolute control treatment [T_1]. Higher uptake of phosphorous was recorded under soil + foliar application of zinc. Zinc nutrition had positive effect on phosphorus uptake by direct seeded rice in zinc deficient soil.

Amount of total K uptake by crop was recorded in treatment of soil application of $ZnSO_4$ @ 20 kg ha^{-1} + foliar application of 0.2% EDTA Zn along with RDF (100:50:50 NPK kg ha^{-1}) and Vermicompost @ 2.5 t ha^{-1} [T_{11}] and it was at par with soil application of $ZnSO_4$ @ 20 kg ha^{-1} + foliar application of 0.1% EDTA Zn along with RDF (100:50:50 NPK kg ha^{-1}) and Vermicompost @ 2.5 t ha^{-1}, [T_{10}], soil application of $ZnSO_4$ @ 10 kg ha^{-1} + foliar application of 0.2% EDTA Zn along with RDF and Vermicompost [T_9] and soil application of $ZnSO_4$ @ 10 kg ha^{-1} + foliar spray of 0.1% EDTA Zn [T_8] and except these treatments it was significantly superior (135.45 kg ha^{-1}) over remaining all treatments T_7, T_6, T_5, T_4, T_3, T_2 and T_1. The total potassium uptake was recorded very low (30.64 kg ha^{-1}) in absolute control [T1] treatment. Application of zinc significantly increased K uptake by crop due to synergistic effect of zinc on potassium uptake. Similar findings were reported by Shivay *et al.* (2015) [10] and Ghasal *et al.* (2017) [6]

Table 3: Mean NPK (%) in plant of DSR as influenced by various treatments

Treatments	Nitrogen (%)		Phosphorous (%)		Potassium (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1 – Absolute control	1.09	0.62	0.12	0.08	0.36	0.92
T_2 – RDF (100:50:50 kg NPK ha^{-1})	1.15	0.69	0.16	0.11	0.50	1.14
T_3 – RDF + Vermicompost @ 2.5 t ha^{-1}	1.16	0.70	0.17	0.12	0.51	1.19
T_4 – (RDF + Vermicompost) + Soil application of $ZnSO_4$ @ 10 kg ha^{-1}	1.22	0.72	0.21	0.14	0.56	1.28
T_5 – (RDF + Vermicompost)+ Soil application of $ZnSO_4$ @ 20 kg ha^{-1}	1.24	0.74	0.22	0.15	0.58	1.31
T_6 - (RDF + Vermicompost) + Foliar application of 0.1 % EDTA Zn	1.20	0.71	0.18	0.12	0.54	1.26
T_7 - (RDF + Vermicompost) + Foliar application of 0.2 % EDTA Zn	1.21	0.73	0.20	0.13	0.55	1.30
T_8 - (RDF + Vermicompost) + Soil application of $ZnSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.1 % EDTA Zn	1.29	0.77	0.23	0.16	0.61	1.32
T_9 – (RDF + Vermicompost) + Soil application of $ZnSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.2 % EDTA Zn	1.30	0.78	0.24	0.17	0.62	1.33
T_{10} – (RDF + Vermicompost) + Soil application of $ZnSO_4$ @ 20 kg ha^{-1}+ Foliar application of 0.1 % EDTA Zn	1.32	0.81	0.26	0.18	0.64	1.35
T_{11} – (RDF +Vermicompost) + Soil application of $ZnSO_4$ @ 20 kg ha^{-1}+ Foliar application of 0.2 % EDTA Zn	1.35	0.83	0.28	0.19	0.66	1.37
S.Em±	0.04	0.03	0.03	0.02	0.04	0.03
C. D. at 5%	0.13	0.10	0.09	0.06	0.11	0.10
General mean	1.23	0.74	0.21	0.14	0.56	1.25

Conclusion

On the basis of findings it is concluded that the treatment soil application of ZnSO4 @ 20 kg ha-1+ foliar application of 0.2% EDTA Zn along with RDF (100:50:50 NPK kg ha-1) and Vermicompost @ 2.5 t ha-1 [T_{11}] recorded significantly the highest grain yield (48.97 q $ha^{-1)}$, maximum straw yield (69.71 q $ha^{-1)}$, highest biological yield (130.24 q ha^{-1}), biological yield (46.42 q $ha^{-1)}$ and harvest index (46.51). Since the findings are based on the research done in one season further experiment more than one season will help in better to study the response of direct seeded rice (*Oryza sativa* L.) to zinc nutrition in sub-montane zone of Maharashtra. However, absolute control [T1] treatment was found inferior among all treatments of application zinc nutrition.

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