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Effect of sources and methods of zinc application on growth and yield of Basmati rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted at Crop Research Centre of Sardar Vallabhbhai Patel university of Agriculture and Technology, Meerut, during Kharif season of 2017 with ten treatments viz control (T1), Seedling treatment with 1% ZnO solution (5 min.) (T2), 5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application (T3), 0.5 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application (T4), 7.5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application (T5), 1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application (T6), Foliar spray of $ZnSO_4$ with lime (0.1% Zn solution (T7), Foliar spray of $ZnSO_4$ with urea (0.1% Zn solution (T8), Foliar spray of $ZnSO_4$ with lime (0.15% Zn solution (T9) and Foliar spray of $ZnSO_4$ with urea (0.15% Zn solution (T10). Experiment was laid out in Randomized block Design with three replications. The soil of the experimental field was sandy loam is texture and slightly alkaline in nature and low in organic carbon, available nitrogen, available potassium and medium in available phosphorus. The basmati rice (PB-1) was transplanted on 20th July 2017. Plant height, number of tillers/m^2, dry matter accumulation, number of panicles/m^2, panicle length, grains/panicle and test weight and grain, straw and biological yield of rice crop was influenced by different sources and methods of zinc application and were recorded significantly highest with the application of 7.5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application (T5). Similarly, this treatment also gave maximum net return and benefit:cost ratio.

Keywords: Basmati rice, Zinc.

Introduction
Rice (*Oryza sativa* L.) is the most important food crop in the world. Cultivation of rice is important to food security of Asia, where more than 90% of the global rice is produced and consumed. India is the second largest producer and consumer of rice in the world after china. In India, the area, production and productivity of rice is 43.39 mha, 104.32 mt and 2.40 t/ha, respectively. However, Uttar Pradesh is the largest rice growing state after West Bengal but its productivity is low. Rice occupies an area of 5.87 mha, produces 12.51 mt rice with a productivity of 2.14 t/ha in UP, (Anonymous, 2016) [2]. In India, it accounts more than 40% of food grain production, providing direct employment to 70% people in rural areas. Being the staple food for more than 65% of the people, our national food security hinges on the growth and stability of rice production.
Zinc deficiency is a serious problem for rice grown under wet land soil conditions in Uttar Pradesh. To alleviate such deficiency, Zn is applied to the soil in the form of $ZnSO_4.7H_2O$. The recovery of applied Zn by rice is very low due to its transformation to different chemical forms. Crop plants utilize only 1-4% of the freshly applied Zinc and the rest goes in to the formation of different Zn compound of varying solubility and availability of Zn to plants. Recent estimates indicate that nearly half of world population suffers from Zn deficiency (Cakmak, 2008) [3]. Cereal crops play an important role in satisfying daily calorie intake in developing world, but are inherently very low in Zn concentrations in grain, particularly when grown on Zn- deficient soils. The reliance on cereal- based diets may induce Zn-deficiency related problems in humans, such as impairments in physical developments, immune system and brain function. Analysis of 25,000 plant samples collected from different states in India showed that 44% of the plant samples contained inadequate Zn (Singh, 2007) [14]. These values indicate that Zn deficiency in soils represents a particular constraint to crop yield and a major reason for the low dietary intake of Zn. Zinc can be directly applied to soil as both organic and inorganic compounds. Zinc sulfate ($ZnSO_4$) is the most widely applied inorganic source of Zn due to its high solubility and low cost. Zinc can also be applied to soils in form of ZnO, Zn-EDTA and Zn-oxysulfate.

Materials and Methods

A field experiment was conducted at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, during kharif season of 2017 with ten treatments viz control (T1), Seedling treatment with 1% ZnO solution (5 min.) (T2), 5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application (T3), 0.5 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application (T4), 7.5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application (T5), 1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application (T6), Foliar spray of $ZnSO_4$ with lime (0.1% Zn solution (T7), Foliar spray of $ZnSO_4$ with urea (0.1% Zn solution (T8), Foliar spray of $ZnSO_4$ with lime (0.15% Zn solution (T9) and Foliar spray of $ZnSO_4$ with urea (0.15% Zn solution (T10). Experiment was laidout in Randomized block Design with three replications. The soil of the experimental field was sandy loam in texture and slightly alkaline in nature and low in organic carbon, available nitrogen, available potassium and medium in available phosphorus. The basmati rice (PB-1) was transplanted on 20th July 2017. Rest of the cultural practices was followed as per recommendations.

Results and Discussion

Growth parameters

The maximum plant height was recorded in T_5 (7.5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application) which was significantly more as compared to all the treatments except T_3 and T_6 during the year of study (Table-1). Zinc application might has resulted in beneficial effect on cell division and cell elongation and it resulted in increased chlorophyll content and net photosynthetic rate which might be attributed to the increase in plant height with increase in zinc level. The similar results were also reported by Rupa *et al.,* (2003) [11] and Jat *et al.,* (2011) [8].

The maximum number of tillers and dry matter accumulation (Table-1) was observed with the application of T_5 (7.5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application). Dry matter accumulation is a function of total plant population, plant height, number of tillers hence all the characters will ultimately effect dry matter accumulation by crop indicates towards the photosynthesis left behind after respiration. In the present study the fact was further elucidated as more dry matter accumulation were recorded in all those treatment where zinc supply was more. In the initial stages, however, differences were less on account of very slow growth of plant. Similar result was obtained by Shivay *et al.,* (2008) [13].

Yield attributes

Panicle length is directly related to the number of grains panicle^{-1} and hence this is an important determinant of grain yield in cereal crops. The findings of experiment revealed that T_5 treatment (7.5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application) significantly increased panicle length over T_1 treatment during the year of study (Table 1). The panicle length might have increased with supply of photosynthates to sink due to higher chlorophyll content and photosynthesis may be due to more availability of micronutrients by foliar sprays at different growth stages of crop. Similar results were found by Varshney *et al.,* (2008) [17] and Singh and Tripathi, (2008) [15].

Number of panicles sq m^{-1} and number of grains panicle^{-1} are most important yield attributes. Treatment T_5 (7.5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application) gave significantly more number of panicles sq m^{-1} and number of grains panicle^{-1}during the year of study over control treatment (Table-1). This increase may be mainly due to the additional availability of macro and micronutrients until later growth stage of rice (Shaygany *et al.,* 2011 and Fang *et al.,* 2008) [12, 5].

1000 grain weight is a function of various production factors that given indication of grain development and filling patterns influenced by various factors. That inference of zinc sources and methods to rice was significant on 1000 grain weight when compared among different treatment of zinc but all treatments of zinc recorded higher 1000 grain weight as compared to control. These results confirm the findings of Cheema *et al.,* (2006) [4].

Table 1: Growth and yield attributes of basmati rice as influenced by sources and methods of zinc application.

Treatment	Plant height (cm)	Tillers/m^2	Dry matter accumulation (g/m^2)	Panicles/m^2	Panicle length (cm)	Grains/panicle	Test weight (g)
(T_1) Control	81.0	394	975.75	383	19.2	115	22.67
(T_2) Seedling treatment with 1% ZnO solution (5 min.).	86.0	425	1039.35	410	22.0	125	23.07
(T_3) 5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application.	101.8	496	1381.53	477	25.2	144	25.07
(T_4) 0.5 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application.	97.3	460	1137.22	445	22.1	138	23.95
(T_5) 7.5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application.	103.8	510	1487.87	491	25.9	150	25.73
(T_6) 1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application.	100.6	498	1335.72	480	24.5	141	25.20
(T_7) Foliar spray of $ZnSO_4$ with lime (0.1% Zn solution).	90.1	458	1216.88	439	22.3	127	23.07
(T_8) Foliar spray of $ZnSO_4$ with urea (0.1% Zn solution).	93.3	471	1257.25	451	22.9	136	23.60
(T_9) Foliar spray of $ZnSO_4$ with lime (0.15% Zn solution).	92.2	468	1272.53	448	22.7	137	23.44
(T_{10}) Foliar spray of $ZnSO_4$ with urea (0.15% Zn solution).	95.7	480	1316.13	465	23.4	140	23.96
SEm$\pm$	1.92	8.31	44.42	8.36	1.12	4.70	0.32
CD (P=0.05)	5.75	24.88	133.02	25.06	3.36	14.08	0.98

Yield

Among the various zinc sources and methods of zinc application T_5 (7.5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application) gave maximum grain, straw and biological yield (Table-2). Crop productivity is the rate at which a crop accumulate biomass which depends primarily on the photosynthesis and conversion of light energy into chemical energy by green plants. The yield of rice is composed of yield components like as number of panicles, panicle length and 1000 grain weight. Though, 1000 grain weight an influence on grain yield but its effect is lower than panicle length and number of grains panicle^{-1}. All sources and methods of zinc application differ significantly from each other except T_5 and T_3 and T_6. Positive effects of zinc application by soil and foliar sprays on grain yield of rice might be due to increase chlorophyll content of leaves of rice which might have increased photosynthesis and resulted in more dry matter accumulation and leaf area and hence lead to more capture of solar radiation that resulted in enhanced values of growth parameters and yield contributing characters and ultimately resulted in higher grain yield. These results are in line with Slaton *et al.* (2005) [16], Khattak *et al.* (2015) [9] and Ghoneim (2016) [7].

Table 2: Yield, harvest index and economics of basmati rice cultivation as influenced by sources and methods of zinc application.

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Benefit: cost ratio
(T_1) Control	40.87	56.65	97.52	41.91	28898	90237	61339	3.12
(T_2) Seedling treatment with 1% ZnO solution (5 min.).	44.87	61.92	106.79	42.04	30715	99028	68313	3.22
(T_3) 5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application.	52.50	68.30	120.80	43.46	29898	115245	85347	3.85
(T_4)0.5 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application.	46.54	64.68	111.22	41.84	31058	102775	71717	3.31
(T_5) 7.5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application.	53.30	69.35	122.65	43.50	30398	117003	86605	3.85
(T_6) 1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application.	51.90	68.00	119.90	43.29	33218	114000	80782	3.43
(T_7) Foliar spray of $ZnSO_4$ with lime (0.1% Zn solution).	47.60	63.01	110.61	43.06	29452	104652	75200	3.55
(T_8)Foliar spray of $ZnSO_4$ with urea (0.1% Zn solution).	48.27	63.02	111.29	43.37	29392	105987	76595	3.61
(T_9) Foliar spray of $ZnSO_4$ with lime (0.15% Zn solution).	48.67	64.09	112.75	43.18	29517	106946	77429	3.62
(T_{10}) Foliar spray of $ZnSO_4$ with urea (0.15% Zn solution).	49.17	64.14	113.31	43.41	29457	107962	78505	3.67
SEm$\pm$	0.90	2.31	2.68	-	-	-	-	-
CD (P=0.05)	2.69	6.93	8.04	-	-	-	-	-

Economics

Moreover, crop fertilized with zinc based nutrients application (T_5) **7**.5 kg Zn/ha through $ZnSO_4$ (21% Zn) as soil application gave more ruminative in terms of gross return (₹117003 ha^{-1}), net return (₹ 86605 ha^{-1}) and B:C ratio (3.85) over rest of the treatments (Table-2). It was mainly because of more increase in grain yield and gross income in comparison to increase in cost of cultivation (Kumar *et al*., 2017) [10]. Higher B:C ratio might have been attributed to dual advantage i.e. saving in inputs and additional returns due to higher yields (Ghasal *et al*., 2015) [6]. Whereas, maximum cost of cultivation (₹ 29517 ha^{-1}) was recorded with the application of (T_6) 1 kg Zn/ha through Chelated zinc (Zn EDTA) as soil application. It may be due to high cost of fertilizer (Abbas *et al*., 2010) [1].

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