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Influence of Bio and Nano Zinc Fertilization on Growth and Yield of Rice

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ABSTRACT

Zinc is the essential plant micronutrients and their importance for crop productivity is similar to that of major nutrients.The field experiment was conducted in zinc deficient soil belonging to Padugai series (VerticUstropept) at the farmer's holding during the Navarai season of year 2017.The treatments consists of viz., T_1 - Absolute control , T_2 - NPK (RDF), T_3 - RDF + $ZnSO_4$ @ 25 kg ha^{-1} , T_4 - RDF + Nano zinc (Granules @ 10 kg ha^{-1}),T_5 - RDF + Nano zinc (Granules @ 15 kg ha^{-1}),T_6 - RDF + Bio zinc (Granules @ 10 kg ha^{-1}),T_7 - RDF + Bio zinc (Granules @ 15 kg ha^{-1}),T_8 - RDF + Foliar spray of 0.5 % as $ZnSO_4$ at T.S and P.I.,T_9-RDF + Foliar spray of 1 ml L^{-1} as nano zinc at T.S and P.I. and T_{10}- RDF + Foliar spray of 1.5 ml L^{-1} as bio zinc at T.S and P.I.. The test crop was rice var.CO 51. The results revealed that grain and straw yield was significantly enhanced on addition of different sources of zinc over control. The grain and straw yield was maximum (6070 and 7068 kg ha^{-1}) with application of RDF+ soil application of bio zinc @ 30 kg $ha^{-1}$and was on par with RDF + Foliar spray of 0.5 % $ZnSO_4$ (5983 and 6980 kg ha^{-1}).Similarly, the plant height and DMP was recorded with application of RDF+ soil application of bio zinc @ 30 kg ha^{-1}.

KEY WORD: Zinc, organics, rice, yield, Plant height, DMP.

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INTRODUCTION

Micronutrient deficiencies such as limited zinc (Zn) availability are one of the main problems limiting agricultural productivity, especially in alkaline calcareous soils. Therefore, Zn is often included in macronutrient fertilizers to improve crop quality and productivity[1]Zinc is an essential element that plays many important roles in various physiological and metabolic processes in plant. This trace element plays vital function in structural molecules such as DNA and activates different metabolic and regulatory enzymes. It has been reported that nearly 925 proteins in humans and over 500 proteins in plant contain zinc.[2]It also plays a role in photosynthesis, protein synthesis, cell division, maintaining integrity of the membrane structure[3], resistance against the pathogen infection[4] and add sexual reproduction through affecting production and shape of pollen and changes in the stigma. Plants also may develop symptoms such as interveinal chlorosis, bronzing of leaves, abnormally shaped leaves, stunting or resetting which can effectively reduce crop production and health[5].According to the World Health Organization, the average prevalence of zinc deficiency in the world population is 31 per cent which may range from 4 per cent to 73 per cent in different countries[6]. Agricultural systems are the main pathway from which nutrients including zinc enter the human food chain. Therefore, zinc malnutrition must be directly dependant on the inability of cropping systems to deliver enough zinc to the food crops[7].

In India, zinc is considered as the fourth important yield limiting nutrient after nitrogen, phosphorus and potassium respectively. Zinc deficiency affects one third of the world's population. In India, 47 per cent of the soils are zinc deficient. Critical limit of a nutrient in soils refers to a level below which the crops will redily respond to its application. This critical limit varies with soil, crops and varieties. Critical limit of zinc for rice was 0.74 ± 0.18 ppm across the soils and indifferent agro-ecological regions of India[8]. The analysis of DTPA extractable zinc in soils has shown the 40 per cent of soil samples were potentially zinc deficient[9]. It has been postulated that the zinc deficiency is likely to increase from 49- 63 per cent by the year 2025 as most of the marginal soils brought under cultivation are showing the symptoms of zinc deficiency[10].Rice (*Oryza sativa L.*) is an important stable food crop among all the cereals.About 90 per cent of rice grown and consumed in South and South East Asia. In some parts of the world consumption of rice is a high as 990 g per person per day[11]. India ranks first in the world in terms of area of rice cultivation with 44.6 m ha and second in productivity of 2.96 t ha^{-1}. In Tamil Nadu has produced 79.14 lakh tones of rice from an 18.3 lakh hectares in 2014 -2015[12]. The efficiency of applied $ZnSO_4$ is only 1 to 4% and most of the applied zinc is rendered unavailable to plants due to many factors such as leaching, fixation[13]. Hence it is essential to minimize the nutrient losses in fertilizer application, increase the crop yield through the exploitation of new applications with the help of nano technology and nano meterials.The overview of green synthesis is easily understood when the precursor is added to the leaf extract it changes the color which indicates the formation of nano catalyst[14,15]. Literally very little information exist on the application of nano zinc both in chemical and bioforms applied to soil and foliar application of these materials on rice crop under fieldconditions.With this background the present experiment entitled influence of bio and nano zinc fertilization on growth and yield of rice.

MATERIALS AND METHODS

With a view to study the response of growth and yield of rice to bio and nano zinc in deficient soil, The field experiment was conducted in zinc deficient soil belonging to Padugai series (Typic Ustifluvents) at the farmer's holding during the Navarai season of year 2017.The experimental soil was clay loam in texture with pH 7.78, EC 0.84 dS m^{-1}, organic carbon 3.9 g kg^{-1} (low), low in $KMnO_4$-N 275 kg ha^{-1}, low in Olsen-P 10.4 kg ha^{-1}, high in NH_4OAc-K 294 kg ha^{-1} and low in available DTPA-Zn 0.68 mg kg^{-1}.The experiment was laid out in randomized block design. The treatments consists of eight treatments viz., T_1 - Absolute control , T_2 - NPK (RDF), T_3 - RDF + $ZnSO_4$ @ 25 kg ha^{-1} , T_4 - RDF + Nano zinc (Granules @ 10 kg ha^{-1}),T_5 - RDF + Nano zinc (Granules @ 15 kg ha^{-1}),T_6 - RDF + Bio zinc (Granules @ 10 kg ha^{-1}),T_7 - RDF + Bio zinc (Granules @ 15 kg ha^{-1}),T_8 - RDF + Foliar spray of 0.5 % as $ZnSO_4$ at T.S and P.I.,T_9-RDF + Foliar spray of 1 ml L^{-1} as nano zinc at T.S and P.I. and T_{10}- RDF + Foliar spray of 1.5 ml L^{-1} as bio zinc at T.S and P.I.The recommended dose of 150:50:50 N, P_2O_5, K_2O ha^{-1}through urea, superphosphate and muriate of potash was added uniformly to all theplots. Nitrogen was applied in three split doses i.e., 50% as basal, 25% each atactive tillering and 25% panicle initiation stages. The entire dose of P_2O_5 and K_2Owere applied basally as per the treatment schedule. The test crop rice CO 51. The zinc was applied through bio and nano zinc formulations. At different stages of crop growth plant height and DMP and harvest stage grain and straw yield were recorded.

RESULTS AND DISCUSSION

Plant height

Analysis of variance on plant height furnished in (Table 1) showed that application of sources and methods caused significant improvement on plant height at all stages over control. Plant height ranged from 36.5to 56.8 cm at tillering stage, 68.4 to 89.4 cm at panicle initiation stage and 88.1 to 107.2 cm at harvest stage respectively. Plant height at all stage was highest with RDF + soil application of bio zinc @ 30kg ha^{-1} compared to rest of the treatments. Among the treatments, tallest plant (56.8, 89.4 and 107.2 cm) at tillering, panicle initiation and harvest stage was noticed with application of RDF + soil application of bio zinc @ 30kg ha^{-1}(T_7) and was on par with T_8,T_9 and significantly followed by T_3.At harvest stage application of RDF + soil application of bio zinc @ 30kg ha^{-1}produced 17 % of taller plants as compared to control. Compared to all the treatments the lowest plant height was recorded in the treatment receiving RDF @ 120: 50: 50 kg ha^{-1}(101.2 cm) followed by control(88.1 cm) at harvest stage.This could be attributed to adequate supply of zinc which accelerates the activity of enzymes and auxin metabolism in plants.It could also be attributed to the increased growth of internodal portion with higher synthesis of IAA and metabolizing gibberellic acid[16]. Zinc is known for precursor of growth as they play greater and crucial role during early phase of the plant life. Zinc is precursor of tryptophan, which is supposed to play a decisive role in the synthesis of auxin, the main factor behind apical dominance, growth and development, which is involved in cell division and internode elongation[17]. The result obtained in the present study was confirmed by the significant positive correlation between plant height with DTPA-Zn (r=0.972**),zinc concentration (r=0.992**) and Zn uptake (r=0.987**).

Dry matter production (DMP)

Addition of zinc sources and methods caused significant effect on dry matter production at all stages of crop growth over NPK alone (Table 2).DMP at all stage was highest with RDF + soil application of bio zinc @ 30kg ha^{-1} compared to rest of the treatments. The DMP ranged from 1708 to 2929 kg ha^{-1} at tillering stage and 4061to 5802kg ha^{-1} at panicle initiation stage respectively.Among the treatments, the treatment receiving RDF + soil application of bio zinc @ 30kg ha^{-1} recorded significantly highest dry matter production at tillering stage (2929 kg ha^{-1}) and panicle initiation stage (5802 kg ha^{-1}) respectively.This was followed by RDF + foliar spray of 0.5 % Zn SO_4 (T_8), RDF + foliar spray of 0.1% nano zinc (T_9) which were on par with each other. These treatments were followed by RDF + soil application of Zn SO_4 @ 25 kg ha^{-1}.The lowest dry matter was recorded in the treatment absolute control and was followed by the treatment receiving RDF @ 150: 50: 50 kg ha^{-1}.Increase in DMP due to zinc might be due to role of zinc for the activities of various types of enzymes such as those required for CO_2 assimilation pathway and chlorophyll biosynthesis[18]. This was confirmed by significant positive correlation between DMP with DTPA-Zn (r=0.90**; r=0.87**) and Zn uptake (r=0.94**; r=0.95**) at tillering and panicle initiation stages respectively. Increase in DMP due to zinc was reported by earlier workers [19,20,21].

Rice yield

A significant increase in grain and straw yield of rice was noticed due to application of varioussources and methodsof zinc application over control(Table 3).Grain and straw yield ranged from 3319 to 6070 and 4032 to 7068 kg ha^{-1}. The highest grain andstraw yield was obtained with RDF + soil application of bio zinc @ 30kg ha^{-1}(6070 and 7068 kg ha^{-1}) and was on par with RDF + foliar spray of 0.5 % $ZnSO_4$(5522 kg ha^{-1}),T_9.These treatments were significantly followed by T_3,T_{10} and

T_6. The percentage increase in grain and straw yield (45 and 42) was noticed with RDF + soil application of bio zinc @ 30kg ha^{-1}(T_7) compared to over control (T_1).The lowest grain and straw yield was recorded in the treatment receiving RDF @150: 50: 50 kg ha^{-1} followed by control(3319 and 4032 kg ha^{-1}).Increase in grain yield due to zinc was the logical result due to increase in yield components. In the present study, number of panicles m^{-2}, number of grains $panicle^{-1}$, panicle length and 1000 grain weight increased with Zn levels and highest value was obtained with RDF + soil application of bio zinc @ 30kg ha^{-1}.The above argument was ably supported by linear relationship between grain yield with number of panicles m^{-2} ($Y = 3628 – 0.703x + 0.010x^2$, x^2, $R^2 = 99^{**}$), numberof grains $panicle^{-1}$ ($Y = 4688- 83.49 x – 9.322 x^2$, $R^2=99^{**}$), panicle length ($Y = -353.6 + 393.6x – 4.473 X^2$, $R^2= 0.99^{**}$) which showed that 99 per cent variation in grain yield are brought out by different yield attributes. [22,23]reported increase in grain yield due to improvement in yield components.

CONCLUSION

In conclusion, Bio zinc application to zinc deficient soil significantly increased plant height, DMP and grain yield of rice. Application of Bio zinc proved better over application of alone zinc sulphate ($ZnSO_4$) indicating the positive role of organic matter in increasing plant height, DMP and grain yield on soils affected with zinc deficient.

Table 1. Effect of zinc sources and methods on plant height (cm) at different growth stage.

Treatments	**Tillering stage**	**Panicle initiation stage**	**Harvest stage**
T_1 -Absolute control	36.5	68.4	88.1
T_2 - NPK (RDF)	41.5	74.0	93.0
T_3 - RDF + Zn SO_4 (25 kg/ha)	50.10	83.6	101.4
T_4 -RDF + Nano Zinc (granules @ 10 kg /ha)	43.1	75.6	94.4
T_5 -RDF + Nano Zinc (granules @ 15 kg /ha)	44.5	76.8	95.7
T_6 - RDF + Bio zinc (granules @ 15 kg/ha)	48.0	80.5	98.8
T_7 - RDF + Biozinc (granules @ 30 kg/ha)	56.8	89.4	107.2
T_8- RDF + Foliar spray of 0.5% Zn SO_4@ TS and PIS	55.1	88.7	106.4
T_9- RDF + Foliar spray of 0.1% Nano Zinc @ TS and PIS	53.5	87.6	104.8
T_{10}- RDF + Foliar spray of 0.15% Bio Zinc @ TS and PIS	49.2	82.1	100.3
SEd	1.25	1.09	1.28
CD (P = 0.05)	2.64	2.29	2.70

Table 2. Effect of zincsources and methods on DMP (kg ha^{-1}) at different growth stages

Treatments	Tillering stage	Panicle initiation stage
T_1 – Absolute control	1708	4061
T_2 – NPK (RDF)	1937	4600
T_3 – RDF + Zn SO_4 (25 kg/ha)	2487	5304
T_4 –RDF + Nano Zinc (granules @ 10 kg /ha)	2034	4800
T_5 –RDF + Nano Zinc (granules @ 15 kg /ha)	2122	4891
T_6 – RDF + Bio zinc (granules @ 15 kg/ha)	2323	5206
T_7 – RDF + Biozinc (granules @ 30 kg/ha)	2929	5802
T_8– RDF + Foliar spray of 0.5% Zn SO_4@ TS and PIS	2854	5706
T_9- RDF + Foliar spray of 0.1% Nano Zinc @ TS and PIS	2765	5601
T_{10}- RDF + Foliar spray of 0.15% Bio Zinc @ TS and PIS	2412	5303
SEd	55.42	73.35
CD (P = 0.05)	116.43	154.11

Table 3. Effect of zinc sources and methods on grain and straw yield of rice (kg ha^{-1})

Treatments	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})
T_1 – Absolute control	3319	4032
T_2 – NPK (RDF)	4483	5365
T_3 – RDF + Zn SO_4 (25 kg/ha)	5522	6572
T_4 –RDF + Nano Zinc (granules @ 10 kg /ha)	4657	5551
T_5 –RDF + Nano Zinc (granules @ 15 kg /ha)	4758	5708
T_6 – RDF + Bio zinc (granules @ 15 kg/ha)	5338	6377
T_7 – RDF + Biozinc (granules @ 30 kg/ha)	6070	7068
T_8– RDF + Foliar spray of 0.5% Zn SO_4@ TS and PIS	5983	6980
T_9- RDF + Foliar spray of 0.1% Nano Zinc @ TS and PIS	5962	6909
T_{10}- RDF + Foliar spray of 0.15% Bio Zinc @ TS and PIS	5455	6459
SEd	131.17	106.23
CD (P = 0.05)	281.88	223.19

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