Effect Of Bio And Nano Zinc Fertilization On Nutrient Content And Yield Of Rice

P. Ponnmani , T. Muthukumararaja, M.V. Sriramachandrasekharan

Abstract: A field experiment was conducted in zinc deficient soil belonging to Padugai series (Typic Ustifluvent) at the farmer's holding during the Navarai season of year 2017. 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 with application of RDF+ soil application of bio zinc @ 30 kg ha-1and was on par with RDF + Foliar spray of 0.5 % ZnSO4. Similarly, the nutrient content (N, K and Zn) was recorded with application of RDF+ soil application of bio zinc @ 30 kg ha-1.But application of RDF (120: 40: 40 kg ha-1) alone registered the highest phosphorus content status at all stages of crop growth.

Key word: Zinc, organics, rice, yield, Nitrogen, Phosphorus, Potassium, Nano

1.INTRODUCTION

Among micronutrients, Zn deficiency is a widespread nutritional constraint throughout the world. Zinc is an essential micronutrient required for normal growth and development of living organisms including plant, animals and human beings[1]. Globally about two billion people are zinc deficient [2]. Zinc deficiency problem exists in both developed as well as developing countries [3]. One third of world population ranging from 4 to 73 per cent in different regions are affected by Zn deficiency [4]. The major reason is that cereals are mostly used as staple food for world population. According to an estimate, almost 50 per cent of the world's cereal growing soils are considered to be Zn deficient [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 ZnSO4 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 materials. 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 bio forms applied to soil and foliar application of these materials on rice crop under field conditions. With this background the present experiment entitled effect of bio and nano zinc fertilization on nutrient content and yield of rice.

2.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 KMnO4-N 275 kg ha-1, low in Olsen-P 10.4 kg ha-1, high in NH4OAc-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., T1 - Absolute control , T2 - NPK (RDF), T3 - RDF + ZnSO4 @ 25 kg ha-1 , T4 - RDF + Nano zinc (Granules @ 10 kg ha-1),T5 - RDF + Nano zinc (Granules @ 15 kg ha-1),T6 - RDF + Bio zinc (Granules @ 10 kg ha-1),T7 - RDF + Bio zinc (Granules @ 15 kg ha-1),T8 - RDF + Foliar spray of 0.5 % as ZnSO4 at T.S and P.I.,T9-RDF + Foliar spray of 1 ml L-1 as nano zinc at T.S and P.I. and T10- 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, P2O5, K2O ha-1 through urea, superphosphate and muriate of potash was added uniformly to all the plots. Nitrogen was applied in three split doses i.e., 50% as basal, 25% each at active tillering and 25% panicle initiation stages. The entire dose of P2O5 and K2O were 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 samples analysied and harvest stage grain and straw yield were recorded.

3.RESULTS AND DISCUSSION

3.1. Rice yield

A significant increase in grain and straw yield of rice was noticed due to application of various sources and methods of zinc application over control (Table 1).Grain and straw yield ranged from 3319 to 6070 and 4032 to 7068 kg ha-1. The highest grain and straw yield was obtained with RDF + soil application of bio zinc @ 30 kg ha-1 (6070 and 7068 kg ha-1) and was on par with RDF + foliar spray of 0.5 % ZnSO4 (5522 kg ha-1),T9.These treatments were significantly followed by T3 ,T10 and T6. The percentage increase in grain and straw yield (45 and 42) was noticed with RDF + soil application of bio zinc @ 30kg ha-1(T7) compared to over control (T1).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 ($Y = 3628 – 0.703x + 0.010x2, x2, R2 = 99^{**}$), numberof grains panicle-1 ($Y = 4688- 83.49 x – 9.322 x2, R2=99^{**}$), panicle length ($Y = -353.6 + 393.6x – 4.473 X2, R2= 0.99^{**}$) which showed that 99 per cent variation in grain yield are brought out by different yield attributes.[16] and [17] reported increase in grain yield due to improvement in yield components.

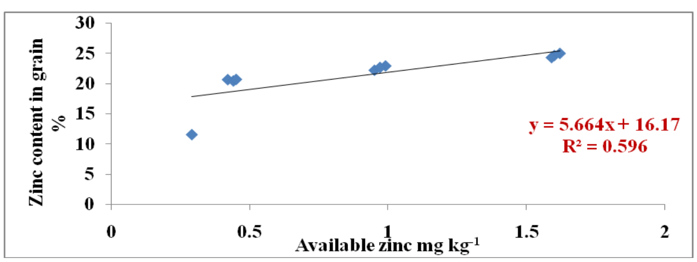
3.2.Nutrient content (N, P, K and Zinc)

Addition of various zinc sources and methods caused significant effect on nitrogen, phosphorus, potassium and zinc content at all stages of crop growth over control (Table 2,3,4 and 5).Nutrient content decreased with advancement of crop stage. At all stages of crop growth, combined application of RDF + soil application of bio zinc @ 30 kg ha-1(T7) registered the highest nitrogen, potassium and zinc content status (1.56, 1.17, 0.99 and 0.56 % ;1.89, 1.68, 0.55 and 1.29 % ; 45.37, 32.40, 24.93 and 37.33 mg kg-1). While, at all stages of crop growth, application of RDF (120: 40: 40 kg ha-1) alone T2 registered the highest phosphorus content status (0.56, 0.48, 0.26 and 0.21 %) at tillering, panicle initiation, grain and straw, respectively. This was followed by RDF + foliar spray of 0.5 % ZnSO4 (T8), RDF + foliar spray of 1 ml l-1 as nano zinc (T9) which were on par with each other. These treatments were followed by RDF + soil application of ZnSO4 @ 25 kg ha-1 (T3) .The lowest Nutrient content was recorded in the treatment absolute control which was followed by RDF @ 120: 40: 40 kg ha-1(T2) .Addition of different sources of zinc significantly improved concentration of N, P, K compared to control throughout the crop growth. Nutrient concentration decreased with advancement of crop growth probably due to dilution and increased DMP. In this study it was observed that the nitrogen content was found to increase with foliar and soil application of zinc at different growth stages of crop growth. The increase in the nitrogen content was observed by 18]. At harvest stage the nitrogen content in grain was higher as compared to that of straw. The higher nitrogen content in grain could be due to zinc application since zinc is essential for synthesis of DNA and RNA and for the metabolisms for production of carbohydrate, lipids and proteins. Further the results clearly indicated the nitrogen removal at different stages and at harvest both by grain and straw were increased with the application of zinc along with RDF. Thus results support the findings of [19]. Who stated that the increase could be attributed to synergistic effect between N and Zn which might be due to increase in enzymatic activity by Zn application. The phosphorus content at all stages both in grain and straw was found to decrease with the application of zinc. It might be due to the antagonistic effect of zinc on P absorption. Zinc was found to inhibit the translocation of P from root to top. The zinc has ability to control the rate of P absorption by roots through functional associations in the cell membrane. Excess zinc (high concentration of zinc) in plant tissue cause a decrease in expression of P transporter genes in plant roots. The origin of the interaction causes a reduction in translocation of P from root to top. The results are in agreement with the results obtained by [20].The content of potassium was found to be increasing with application of zinc. The maximum per cent increase of 18.51 and 52.53 at T.S, 27.32 and 49.17 at P.I.S, 32.72 and 63.21 in grain and 17.82 and 53.13 in straw was treatment over control. This might be due to the synergistic interaction between zinc and potassium, many zinc dependent enzymes are involved in carbohydrate metabolism in general and leaves in particular, impartment of K in stomata regulation, phloem export of assimilation from the source i.e., the leaves into the sink organs, maintained water balance in the soil- plant-atmosphere continuum. Zinc sufficiency is also associated with the marked increase in potassium efflux from roots, shoots into the growth medium. Zinc also facilitates the movement of K in guard cells of stomata [21]. Further it is also interesting to note that K content was higher in straw than grain of rice as compared to N and P in the present study, which indicates that rice straw is useful as a source of potassium. The massive increase in potassium uptake was due to the interaction of K and Zn by the improvement of enzymatic activity and metabolic processes of plant which might have ultimately facilitated the removal of potassium and consequently the yield. The results are in accordance with [22]. Addition of RDF + soil application of bio zinc @ 30 kg ha-1 T7recorded highest zinc concentration throughout the crop growth. However the results have clearly brought out the fact that application of bio zinc and nano zinc fertilizers both as soil and foliar application have resulted in obtaining the yields and on par with the conventional zinc application. One of the reasons that could be attributed in bio zinc which is encapsulated in the organic compounds i.e. either gluconates or lactates might have prevented the leaching losses of the zinc and made it available to the growth of the crop at the time of requirement by the crop[23]. Further zinc content in the plant is controlled by many factors such as amount of soil DTPA-Zn, transport of zinc to root surfaces and the interaction between Zn and other nutrients in the soil or within the plant [24]. Zinc fertilization in soil has been reported to cause a fourfold increase in zinc concentration in edible plant parts [25]. Increase in zinc concentration in grain and straw through soil Zn application were positively stimulated by increase in the soil N availability [26]. Nitrogen status in soil tended to affect endosperm Zn concentration to a greater extent than whole grain Zn concentration. The positive effect of high N on the endosperm Zn concentration have important implication in human nutrition because this part of the grain is the most commonly eaten part in many countries [27]. Zinc excerts an effect on carbohydrate metabolism through the effect on photosynthesis, sugar transformation and seed development. This increased zinc concentration in grain helps in production of bolder grains, thus increasing the grain yield [28]. Higher grain Zn concentration is a desirable quality factor which could increase the nutritional value of the grain for human [29]. [30] reported increase in Zn concentration and uptake on Zn addition. The foliar application of nano zinc was found to be on par with the soil application of bio zinc and the quantity of zinc applied in the form of nano zinc material is much less and hence is easily accessible for uptake by foliage. This was confirmed by significant positive correlation between Zn content in grain with available Zn at tillering stage (r = 0.7722**) at panicle initiation (r = 0.8683**) and at harvest stage (r = 0.9984**), zinc content in straw with available zinc at tillering stage (r = 0.9495**), at panicle initiation stage (r = 0.9342**) and harvest stage (r = 0.9054**). Regression analysis as shown (Fig.1) also showed very good combined between available zinc with zinc content at all stages. It indicated that 59 per cent, 75 per cent and 99 per cent variation in zinc content in grain at tillering, panicle initiation and harvest stage was accounted by available zinc.

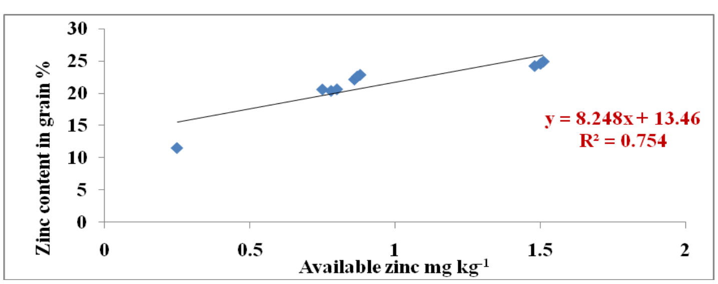
4.CONCLUSION

In conclusion, Bio zinc application to zinc deficient soil significantly increased Nutrient content 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 grain yield on soils affected with zinc deficient.

A.Tillering stage



B.Panicle initiation stage



C.Harvest stage

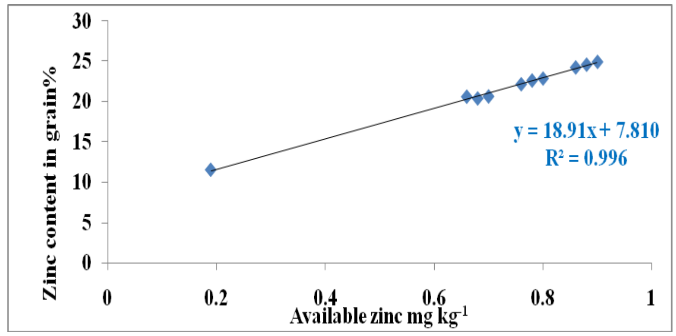


***Fig 1:** Linear relationship between available zinc and zinc content in grain*

***Table 1**. Effect of zinc sources and methods on grain and straw yield of rice*

Treatments	Grain Yield (kg ha-1)	Straw Yield (kg ha-1)
T1 – Absolute control	3319	4032
T2 – NPK (RDF)	4483	5365
T3 – RDF + Zn SO4 (25 kg/ha)	5522	6572
T4 –RDF + Nano Zinc (granules @ 10 kg /ha)	4657	5551
T5 –RDF + Nano Zinc (granules @ 15 kg /ha)	4758	5708
T6 – RDF + Bio zinc (granules @ 15 kg/ha)	5338	6377
T7 – RDF + Bio zinc (granules @ 30 kg/ha)	6070	7068
T8– RDF + Foliar spray of 0.5% Zn SO4@ TS and PIS	5983	6980
T9- RDF + Foliar spray of 0.1% Nano Zinc @ TS and PIS	5962	6909
T10- 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

***Table 2.** Effect of zinc sources on nitrogen content (%) at different growth stages*

Treatments	Tillering stages	Panicle initiation stage	Grain	Straw
T1 -Absolute control	1.33	0.91	0.79	0.37
T2 - RDF (NPK)	1.42	1.01	0.84	0.41
T3 - RDF + Zn SO4 @ 25 kg ha-1	1.50	1.10	0.91	0.50
T4 -RDF + Nano Zinc granules @ 10 kg ha-1	1.43	1.02	0.84	0.42
T5 -RDF + Nano Zinc granules @ 15 kg ha-1	1.44	1.03	0.85	0.43
T6 - RDF + Bio zinc granules @ 15 kg ha-1	1.48	1.08	0.89	0.48
T7 - RDF + Biozinc granules @ 30 kg ha-1	1.56	1.17	0.99	0.56
T8- RDF + Foliar spray of 0.5% Zn SO4@ T.S. and P.I.S.	1.55	1.16	0.98	0.55

T9- RDF + Foliar spray of 1 ml Nano Zinc @ T.S. and P.I.S.	1.54	1.15	0.97	0.54
T10- RDF + Foliar spray of 1.5 ml Bio Zinc @ T.S. and P.I.S.	1.49	1.09	0.97	0.49
SEd	0.01	0.009	0.009	0.009
CD (P = 0.05)	0.03	0.02	0.02	0.02

Table 3. *Effect of zincsources on phosphorus content (%) at different growth stages*

Treatments	Tillering stages	Panicle initiation stage	Grain	Straw
T1 -Absolute control	0.33	0.29	0.11	0.06
T2 - RDF (NPK)	0.56	0.48	0.26	0.21
T3 - RDF + Zn SO4 @ 25 kg ha-1	0.42	0.34	0.16	0.10
T4 -RDF + Nano Zinc granules @ 10 kg ha-1	0.51	0.43	0.22	0.17
T5 -RDF + Nano Zinc granules @ 15 kg ha-1	0.49	0.41	0.20	0.15
T6 - RDF + Bio zinc granules @ 15 kg ha-1	0.47	0.39	0.18	0.13
T7 - RDF + Biozinc granules @ 30 kg ha-1	0.40	0.33	0.15	0.09
T8- RDF + Foliar spray of 0.5% Zn SO4@ T.S. and P.I.S.	0.52	0.44	0.23	0.18
T9- RDF + Foliar spray of 1 ml Nano Zinc @ T.S. and P.I.S.	0.48	0.40	0.19	0.14
T10- RDF + Foliar spray of 1.5 ml Bio Zinc @ T.S. and P.I.S.	0.50	0.42	0.21	0.16
SEd	0.01	0.009	0.004	0.004
CD (P = 0.05)	0.03	0.02	0.01	0.01

Table 4. *Effect of zinc sources on potassium content (%) at different growth stages*

Treatments	Tillering stages	Panicle initiation stage	Grain	Straw
T1 -Absolute control	1.54	1.22	0.37	1.06
T2 - RDF (NPK)	1.66	1.35	0.39	1.14
T3 - RDF + Zn SO4 @ 25 kg ha-1	1.80	1.52	0.49	1.23
T4 -RDF + Nano Zinc granules @ 10 kg ha-1	1.69	1.37	0.40	1.15
T5 -RDF + Nano Zinc granules @ 15 kg ha-1	1.71	1.40	0.41	1.16
T6 - RDF + Bio zinc granules @ 15 kg ha-1	1.76	1.47	0.47	1.21
T7 - RDF + Biozinc granules @ 30 kg ha-1	1.89	1.68	0.55	1.29
T8- RDF + Foliar spray of 0.5% Zn SO4@ T.S. and P.I.S.	1.87	1.63	0.54	1.28
T9- RDF + Foliar spray of 1 ml Nano Zinc @ T.S. and P.I.S.	1.85	1.60	0.53	1.27
T10- RDF + Foliar spray of 1.5 ml Bio Zinc @ T.S. and P.I.S.	1.78	1.50	0.48	1.22
SEd	0.01	0.02	0.004	0.009
CD (P = 0.05)	0.04	0.05	0.01	0.02

Table 5. *Effect of zinc sources on zinc content (mg kg-1) at different growth stages*

Treatments	Tillering stages	Panicle initiation stage	Grain	Straw
T1 -Absolute control	32.03	22.14	11.51	23.66
T2 - RDF (NPK)	36.18	25.76	20.60	28.01
T3 - RDF + Zn SO4 @ 25 kg ha-1	41.30	30.00	22.86	34.38
T4 -RDF + Nano Zinc granules @ 10 kg ha-1	37.00	26.10	20.38	28.82
T5 -RDF + Nano Zinc granules @ 15 kg ha-1	37.63	26.47	20.63	29.82
T6 - RDF + Bio zinc granules @ 15 kg ha-1	40.00	29.02	22.15	32.20
T7 - RDF + Biozinc granules @ 30 kg ha-1	45.37	32.40	24.93	37.33
T8- RDF + Foliar spray of 0.5% Zn SO4@ T.S. and P.I.S.	44.62	32.00	24.58	37.02
T9- RDF + Foliar spray of 1 ml Nano Zinc @ T.S. and P.I.S.	43.80	31.84	24.24	36.94
T10- RDF + Foliar spray of 1.5 ml Bio Zinc @ T.S. and P.I.S.	40.39	29.59	22.61	33.28
SEd	0.84	0.57	0.51.	0.61
CD (P = 0.05)	1.80	1.24	1.10	1.32

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