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Influence of Zinc Source on Yield and Zn Uptake of Hybrid rice

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Abstract

A field experiment was carried out at the Main Rice Research Centre, Soil and Water Management Research Unit, Navsari Agricultural University, Navsari, Gujarat during *kharif* seasons of 2019-2021 to study the influence of zinc source on yield of hybrid rice and Zn uptake by rice plant in response to zinc sulphate ($ZnSO_4$) and zn-ethylene diamine tetra acetate (Zn-EDTA) as Zn source carried out in randomized block design with four replications. The experiment consists of eight treatments *viz.,* Z_1: control, Z_2: application of Zn as per soil test based through $ZnSO_4$, Z_3:100% soil application ($ZnSO_4$ @ 25 kg ha^{-1}), Z_4: spray 0.05% $ZnSO_4$ at tillering +panicle initiation (PI) stage, Z_5: spray 0.1% $ZnSO_4$ at tillering + PI stage, Z_6: spray 0.05% Zn -at tillering + PI stage, Z_7: spray 0.1 % Zn-EDTA at tillering stage + PI stage and Z_8: application of Zn as per soil test based through Zn-EDTA. The results revealed that yield attributes and yield of rice was significantly enhanced on addition of zinc sources over control. The maximum panicle length, panicle weight, grain and straw yield were recorded with the application of zinc as per soil test based application through Zn-EDTA and was on par with spraying of 0.05 and 0.1 % Zn-EDTA at tillering and panicle initiation stage. Application of zinc in the form of Zn-EDTA resulted in grater values for these parameters as compared to zinc sulphate source. Application of both zinc sources failed to produce any remarkable changes in zinc content in rice grain. However, zinc content in rice straw and zinc uptake by rice plant was recorded higher with the application of Zn-EDTA. Thus, Zn-EDTA proved to be efficient sources as foliar spray @ 0.05 % for rice production and Zn uptake by rice plant.

Keywords: Hybrid rice, zinc sulphate, Zn-EDTA, foliar spray, yield, uptake

Introduction

Rice is generally grown under submerged condition and consequently depletion and toxicity of the micronutrient is encountered in many parts of India. Rice is one of sensitive crops to zinc deficiency which may limits its growth and yield. Zinc is one of the most important micronutrients essential for plant growth especially for rice. It acts as an essential component of many enzymes and controls several biochemical processes in the plants required for growth (IRRI, 2000). Its deficiency in rice has been reported in lowland rice of India (Mandal *et al*., 2000). In India, among micro-nutrients, Zn deficiency is the most widespread under the area of high yielding crop varieties particularly in low land rice (Singh and Ram, 2010). In high rice consuming areas, zinc deficiency caused yield reduction and Zn malnutrition in humans (Tiong *et al*., 2014). Zinc deficiency continues to be one of the key factors in determining rice production in several parts of the country (Chaudhary *et al*., 2007). Zinc deficiency in plant is noticed when the supply of zinc to the rice plant is inadequate. Among the several factors which influence zinc supply to the plants include pH, concentration of zinc, iron, manganese and phosphorus in soil solution are very important. Zinc deficiency is usually corrected by application of zinc sulphate and response of rice to zinc under flooded condition has been reported by many workers (Mollah *et al*., and Fageria *et al*., 2011). Moreover, Zn chelates, such as Zinc ethylene diamine tetra acetic acid (Zn-EDTA), which supply significant amount of Zn to the plant without interacting with soil components may also found beneficial. High cost of Zn containing fertilizers, limit its use for checking its deficiency (Mustafa *et al*., 2011). Soil application of micronutrients can be costly. The macro and micronutrients added to the soil and their availability will be affected by the soil environmental factors. Amongst different methods, foliar spraying, as a particular practice to supply these nutrients could avoid these factors and results in rapid absorption. This method is generally more effective and less costly and may enhance crop productivity. Further, to meet the increasing global demand of rice, hybrids can out yield other varieties to close the yield gap evident in many areas. It also raises yield potential. Keeping in view the importance of zinc nutrition; its use efficiency in rice and to mitigate zinc deficiency, the study was taken to know the influence of zinc source applied through soil or foliar method on hybrid rice.

Materials and Methods

Field experiments were conducted at Main Rice Research Centre, Navsari Agricultural University, Navsari (Gujarat) during *kharif* 2019-2021. The soil of experimental field was clayey in texture, medium in organic carbon, low in nitrogen, medium in phosphorus, higher in potassium, medium in zinc and slightly alkaline in reaction. The different treatment of zinc sources and application methods involved Z_1: control, Z_2: application of Zn as per soil test based through $ZnSO_4$, Z_3:100% soil application ($ZnSO_4$ @ 25 kg ha^{-1}), Z_4: spray 0.05% $ZnSO_4$ at tillering +panicle initiation (PI) stage, Z_5: spray 0.1% $ZnSo_4$ at tillering + PI stage, Z_6: spray 0.05% Zn-EDTA at tillering + PI stage, Z_7: spray 0.1 % Zn-EDTA at tillering stage + PI stage and Z_8: application of Zn as per soil test based through Zn-EDTA. The experiment was laid out in randomized block design and replicated for four times. The hybrid rice variety GRH-2 was planted on a spacing 20 cm x 15 cm by transplanting using 25 kg ha^{-1} seed material in *kharif* season. Recommended dose of fertilizer for hybrid rice 120:37.5:00 NPK kg ha^{-1} was applied in two split *viz.,* 50% dose of nitrogen and 50% of nitrogen through urea at tillering and grain filling stage. Full dose of phosphorus through SSP were applied as basal dose. Zinc was applied as per treatments. The other cultural operation, irrigations and plant protection measures were given as common practices as per the recommendation for the rice. Yield attributes were measured from a sample of 5 panicles drawn at random from each plot at harvesting. The net plot was harvested and sun dried followed by weighing the biological yield. Threshing was done manually and weighing of grain was done at about 14 % moisture content. All the data recorded during the study period were statistically analysed by using standard methods as suggested by Panse and Sukhatme (1967).

Results and Discussion

The pooled results revealed that the effect of zinc was found to be significant on different growth and yield and its attributes **(Table 1)**. Significantly higher panicle length (29.08 cm), panicle/m^2 (192) and panicle weight (4.5 gm) were counted with application of Zn as per soil test based application through Zn-EDTA (Z_8) and at par with almost all the soil applied and foliar spray of zinc over control. Increase in productive tillers might be due to adequate supply of zinc which might increase the uptake and availability of other nutrients that improve plant metabolic processes and resulted in increased plant growth. Adequate supply of zinc produced more number of productive tillers per m^2 (Naik and Das, 2007). Zn-EDTA spray at maximum tillering and at booting stage increased number of panicle/m^2 (Saha *et al*., 2020). The overall increase in these parameters of rice could be attributed to overcoming the hidden deficiency of Zn nutrient through its application under low to marginal available Zn containing soil. Application of Zn to marginal soil, improved their availability which also substantiates the beneficial effects of their application on rice crop. Rana and Saifur (2014) also reported that application of $ZnSO_4$ and Zn-EDTA improved the growth and yield attributes of rice crop. Patel and Singh (2010) also found the beneficial effects of multi-micronutrients could be the balanced nutrition of the crops and thereby improved crop growth as well as yield. Grain and straw yield were significantly influenced due to different zinc application treatments. Significantly higher grain yield was recorded with soil test based applied Zn-EDTA (Z_8) and found at par with foliar spray of 0.05 % and 0.1 % Zn-EDTA at tillering and panicle initiation stage; straw yield was also noticed significantly higher with treatment Z_8 and on par with almost all the zinc applied methods except soil test based applied $ZnSO_4$ (Z_2) and control plot. The higher rice yield due to zinc is attributed to its involvement in many metallic enzymes system, regulatory function and auxin production (Hacisalihoglu, 2002), enhanced synthesis of carbohydrates and their transport to the site of grain production (Pedda Babu *et al*., 2007). Fageria *et al*., (2011) reported 97% increase in rice yield due to zinc fertilization. The favourable influence of applied Zn on yield may be due to its catalytic or stimulatory effect on most of the physiological and metabolic processes of plants (Mandal *et al*., 2009). Alvarez *et al*., (2001) reported that when Zn was added as Zn-EDTA, the amounts of the most labile fractions (water soluble plus exchangeable and organically complexed Zn) increased throughout the entire soil profile column, which enhanced the root-cell membrane function. Chhabra and kumar (2018) also reported that soil and foliar applications of zinc enhance the rice yield. Karak *et al*., (2006) revealed that the use of different sources of Zn (Zn-EDTA, and $ZnSO_4.7H_2O$) gave significantly increase in both rice grain (4.56 t ha^{-1}) and straw (6.88 t ha-^{1}) yield during 2-year experiment where 1.0 kg Zn applied as Zn-EDTA. Naik and Das (2008) examined the relative performance of chelated Zn-EDTA and $ZnSO_4$. Initial incorporation of chelated Zn showed pronounced effect on growth over single basal application of $ZnSO_4$. The highest rice grain and straw yield were recorded due to application of 1 kg Zn ha^{-1} as Zn-EDTA as basal with highest mean filled grain percentage, thousands grain weight, and number of panicle/m^2.

Table 1: Yield and its attributes influenced by different zinc treatments (pooled)

Treatments	Panicle length (cm)	Number of panicle / m^2	Panicle weight (gm)	Grain yield (kg/ha)	Straw yield (kg/ha)
Z_1	26.34	128	3.88	5093	6147
Z_2	26.37	141	4.18	5492	6490
Z_3	26.96	136	4.22	5421	6558
Z_4	26.80	138	4.29	5587	6574
Z_5	26.59	151	4.42	5554	6695
Z_6	26.58	156	4.48	5914	6778
Z_7	26.98	177	4.22	5983	6876
Z_8	29.08	192	4.5	6286	7300
S.Em.±	0.90	7.03	0.16	219	282
C.D. 5%	2.55	19.87	0.44	618	797

Application of soil test based applied Zn-EDTA (Z_8) was increased Zn content in grain however it was found non-significant **(Table 2)**. The zinc content in rice straw was recorded maximum with spraying of 0.1 % Zn-EDTA at tillering stage + PI stage (Z_7) and found at par with the treatment spraying of 0.1% $ZnSO_4$ (Z_5) and 0.05% Zn-EDTA (Z_6) at tillering + PI stage and with soil test based applied Zn-EDTA (Z_8).

Yogi *et al*., (2023) also reported that application of Zn fertilizer (either as a foliar spray or into soil) increased Zn concentration than control treatment. Zn content in straw was significantly increased with the 0.5% Zn-EDTA treatment (Wang *et al*., 2020). Zn content in both grain and straw was significantly higher with the application of different levels and modes of Zn-EDTA as compared to $ZnSO_4$ application (Karak *et al*., 2005). It may be due to the foliar application of Zn which was effective in rice as Zn was directly absorbed by rice plant leaves and finally accumulated in grain. Zn uptake by rice plant was recorded significantly higher with the treatment Z_8 and found at par with treatment foliar spray of Zn application at both the sources and doses however Zn uptake in straw was remained at par with 100 % soil application (Z_3). Kulhare *et al*., (2017) reported that the Zn uptake by grain was significantly increased with Zn-EDTA found superior to $ZnCl_2$. Karak *et al*., (2005) also found almost similar results. It may be due to higher efficiency of Zn-EDTA for the absorption of Zn by rice grain and straw as higher content of Zn in plant due to Zn-EDTA. Further, foliar application of zinc efficiently promotes zinc uptake by plant root, which increased zinc absorption.

Table 2: Zn content in rice and uptake in grain and straw influenced by different zinc treatments (pooled)

Treatments	Zn content in grain (ppm)	Zn content in straw (ppm)	Zn uptake by rice grain (g/ha)	Zn uptake (g/ha) by rice straw
Z_1	14.68	21.72	74.98	139.36
Z_2	15.00	20.79	82.69	137.40
Z_3	15.69	22.38	85.37	150.93
Z_4	16.21	21.61	91.06	144.12
Z_5	16.27	22.50	91.16	153.84
Z_6	15.79	22.32	93.44	154.33
Z_7	15.62	24.52	93.52	173.40
Z_8	16.28	23.76	102.44	176.22
S.Em.±	0.61	0.79	4.92	9.01
C.D. 5%	NS	2.24	13.91	25.47

The present investigation concluded that application of Zn as per soil test based through Zn-EDTA recorded significantly higher grain yield. Further, foliar spraying of 0.05 % and 0.1 % Zn-EDTA at tillering and panicle initiation stage was also found equally effective as soil test based Zn-EDTA application. Thus, it is recommended that Zn-EDTA applied in rice will prove to be an efficient sources as foliar spray @ 0.05 % at tillering and panicle initiation stage for rice production and Zn uptake by rice.

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