Plant Archives Vol. 18, Special Issue (ICAAAS-2018), 2018 pp. 404-407 ***ISSN 0972-5210***

ENHANCE THE GROWTH AND DEVELOPMENT OF RICE BY THE FORTIFICATION OF ZINC AND IRON FERTILIZER

Balachandrakumar. V and G.B. Sudhagar Rao*

Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai nagar-608002, Tamil Nadu, India

Abstract

The field experiment on growth and development of rice as influenced by the Zinc and iron fertilizer were carried out at Annamalai university, Chidambaram during 2018. There are thirteen treatments with three replications were carried out in Randomized Block Design (RBD). Soil Application of $ZnSO_4$ @25 kg ha^{-1} + Fe SO_4 @35 kg ha^{-1} +Foliar Application of Zn EDTA@1% + Fe- EDTA @ 0.5% (T_{13}) recorded the highest plant height, LAI, No.of tillers, Test weight ,Grain yield of 6.08t $ha^{-1}$and Straw yield of 7.85 t ha^{-1}. Soil application of $ZnSO_4$@25 kg ha^{1}+foliar application of Zn EDTA@1% reveals significantly highest Zn content of 36.08 mg kg^{-1} in brown rice and soil application of $FeSO_4$ @ 30 kg ha^{-1}+ foliar application of Fe-EDTA @ 0.5% recorded the maximum Fe content of 32.65 mg kg^{-1}in brown rice.

***Key words*: Rice, Agronomic bio fortification, Zinc fertilization, Iron fertilization, Zn EDTA and Fe EDTA.**

Introduction

Rice (*Oryza sativa* L.) is a staple food for more than 60% of world population (Parthiban and Ravi, 2016) and it contributes 45 % to the total food grain production in India (Ram *et al*., 2013). Over 2 billion people in Asia alone derive 80 % of their energy needs from rice,which contains 80 % carbohydrates, 7-8 % protein, 3 % fat and 3 % fibre. Rice provides 23 % more than that provided by wheat and corn, of all the calories consumed by the world's population and even provides 50-80 % of the energy intake of people in developing countries but it does not provides enough essential micronutrients to eliminate Zinc and Iron deficiency (IRRI ,2006). Rice however is a poor source of many essential mineral nutrients especially Zn and Fe for human nutrition.The polished rice contains on an average only 12 mg kg^{-1} Zn and 2 mg kg^{-1} Fe, whereas the recommended dietary intake of Zn for people is 12-15 mg and that of Fe is 10-15 mg per day (Welch and Graham, 2004).Currently malnutrition of Zn and Fe afflicts more than 50 % of the world's population. Heavy and monotonous consumption of rice with low concentration of Zn and Fe has been considered a major reason for Fe and Zn malnutrition (Graham *et al*., 2001). So enrichment of rice grain with Zn and Fe will help to overcome these problems. With the ideas in view, a study were carried out with the method of agronomic bio fortification.

Materials and methods

A field experiment were carried out at the Annamalai University, Chidambaram during 2018. The treatment consists of thirteen treatment which are in combination with Zinc forms of fertilizer like $ZnSO_4$,Zn EDTA and Iron forms of fertilizer like $FeSO_4$and Fe EDTA.The $ZnSO_4$and $FeSO_4$was applied as basal and the Zn EDTA, Fe EDTA was foliar sprayed at Active tillering, Panicle initiation and milking stages. It was laid out in Randomized Block Design with three replication with an objective to identify the most effective Zinc and Iron fertilization schedule to increase Zinc and Iron concentration in rice grain. The soil of the experimental field was clay in texture, medium in available nitrogen, low in available phosphorus and medium in available potassium with organic carbon content of 0.46 % and pH value of 7.6.

Results and Discussion

Plant height

Soil Application of $ZnSO_4$@25 kg ha^{-1}+ Soil Application of $FeSO_4$@ 30 kg ha^{-1}+Foliar Application of Zn EDTA@1% + Foliar Application of Fe-EDTA @ 0.5 %(T_{13}) at active tillering, panicle initiation and milking stage with RDF increased the plant height was due to increase in protein synthesis and cell growth. The maximum height of the plant was 41.93 cm and 58.76 cmat 45DAT and 60 DAT respectively. This was closely followed by the soil application of $ZnSO_4$ @ 25 kg/ha and $FeSO_4$ @30 kg/ha (T_5) as basal recorded the highest plant height.

Increase in plant height might be due to zinc application and its interrelationship with auxin production, an important growth parameter regulating the stem elongation and cell enlargement khanda *et al*. (1997) and Sreenivasa Rao (2003). Iron has structural role in chlorophyll,energy transfer within the plant and enters in root cells also zinc increased the plant height *via* increasing the inter-nodal distance. Similar results was obtained by Ananda and Patil (2010).

Foliar application of micronutrients significantly increased the plant height which might be attributed to the adequate supply of micronutrients contributed to accelerate the enzymatic activity and auxin metabolism in plant (Sudha and Stalin 2015). Kandoliya *et al*., 2018 also reported that increased in plant height was observed with combined application of Zinc and Iron.

Leaf area index

The highest leaf area index of 18.99 and 13.74 at 45 DAT and 60 DAT respectively were recorded in Soil Application of $ZnSO_4$ @25 kg ha^{-1} + Soil Application of $FeSO_4$ @ 30 kg ha^{-1} +Foliar Application of Zn EDTA@1% + Foliar Application of Fe-EDTA @ 0.5% at active tillering, panicle initiation and milking stage with RDF (T_{13}).

Similar to the present experiment, Uma Shankar Ram *et al*. (2013) also reported that combined application of zinc as soil application through Zn EDTA @ 1.00 kg ha^{-1} followed by iron as foliar spray through Fe EDTA @ 0.5 kg ha^{-1} applied in two splits at 15 DAT and at 50 % panicle initiation produces significantly higher plant height, number of leaves per hill, leaf area index and number of productive tillers. Iron is required for the synthesis of chlorophyll, which is an essential pigment for photosynthesis. It also improves the root-system of rice and the growth and leaf areas of rice (Fageria, 2014). It was also observed in the higher amount of chlorophyll content in a treatment of zinc and iron, (kandoliya *et al*., 2018).

No. of tillers

The data revealed that highest no. of tillers 508.47 m^{-2} at harvest were recorded in Soil Application of $ZnSO_4$ @25 kg ha^{-1} + Soil Application of $FeSO_4$ @ 30 kg ha^{-1} +Foliar Application of Zn EDTA@1% + Foliar Application of Fe-EDTA @ 0.5% at active tillering, panicle initiation and milking stage with RDF (T_{13}). This was due to the availability of available quantity of micronutrients which facilitated more number of tillers at all the growth stages of the crop. Improvement in the plant growth might be due to proper nourishment of crop with nutrient supply and also increased activity of meristematic cells and cell elongation with combined soil and foliar application of Zn and Fe as they are known to have favourable effect on metabolic activity (Pooniya and Shivay, 2013). Suresh and Salakinkop (2016) also reported that increased in no. of tillers with response to combined soil and foliar application of Zn and Fe.

Test weight

Among these, the treatment that significantly influenced on the highest test weight of 19.88 gm were recorded in Soil Application of $ZnSO_4$@25 kg ha^{-1}+ Soil Application of $FeSO_4$ @ 30 kg ha^{-1} +Foliar Application of Zn EDTA@1% + Foliar Application of Fe-EDTA @ 0.5% (T_{13}) at active tillering, panicle initiation and milking stage with RDF.

The result is supported by Jat *et al.* (2011) reported that higher grain weight in rice was obtained with Zinc, copper, iron, manganese and boron which were applied in combination.Increase in test weight due to foliar application of Zn was also reported by Khan *et al.* (2009), Asad and Rafique (2000).

Grain yield

Soil Application of $ZnSO_4$@25 kg ha^{-1}+ Soil Application of $FeSO_4$@ 30 kg ha^{-1}+Foliar Application of Zn EDTA@1% + Foliar Application of Fe-EDTA @ 0.5% (T_{13}) at active tillering, panicle initiation and milking stage with RDF resulted in increased yield of 6.08 t ha^{-1}due to Zn and Fe application was attributed to better performance of growth and yield parameters through adequate availability of major and micro nutrients in soil, which in turn favourably influenced physiological processes and built up of photosynthates (Tabassum *et al*., 2013).

Iron as a constituent of the electron transport enzymes like cytochrome and ferridoxin are actively involved in photosynthesis and mitochondrial respiration. It is also a constituent of the enzyme catalase and peroxidase, which catalyse the breakdown of H_2O_2 (peroxide released during respiration) in H_2O and O_2. O_2, preventing H_2O_2 toxicity. All these physiological process proved instrumental in increasing yield by the application of iron.

Zinc and iron plays a major role in biosynthesis of IAA and especially due to its role in initiation of primordial reproductive part and portioning of photosynthates towards them which promotes the yield (Barua and saika, 2018).

Straw yield

Zn and Fe provided in combination with RDF as soil application distribution of Fe and Zn with in the rice plant occurs through xylem and re-translocation in phloem which increase vegetative tissue formation resulted in improved photosynthetic activity which slows boosted growth of the plant parts and increment in dry matter (Nadim *et al*., 2012). Soil Application of $ZnSO_4$ @25 kg ha^{-1} + Soil Application of $FeSO_4$ @ 30 kg ha^{-1} +Foliar Application of Zn EDTA@1% + Foliar Application of Fe-EDTA @ 0.5% (T_{13}) at active tillering, panicle initiation and milking stage with RDF recorded the significantly higher straw yield of 7.85 t ha^{-1}.

Zayed *et al*. (2011) emphasized that combined soil application of zinc with micronutrients such as manganese and iron significantly increase the rice grain yield, straw yield and yield componenets. Application of micronutrients such as Zn, Fe and Mn their role in improving rice growth, photosynthesis, chlorophyll formation and cell elongation.

Zn and Iron content in brown rice

Soil Application of $ZnSO_4$ @25 kg ha^{-1}+Foliar Application of Fe-EDTA @ 0.5% recorded the highest Zn content of 36.08 mg kg^{-1} followed by combined Soil application of zinc sulphate @25 kg ha^{-1}, iron sulphate @30 kg ha^{-1} as basal and foliar application of Zinc EDTA 0.5%, Iron EDTA 1% (T_{13}) at active tillering, panicle initiation and milking stage with RDF recorded the Zn content of 35.65 mg kg^{-1}.

The highest Fe content of 32.65 mg kg^{-1} were observed in the Soil Application of $FeSO_4$@30 kg ha^{-1}+ Foliar Application of Fe-EDTA @ 0.5% followed by the combined Soil application of zinc sulphate, iron sulphate as basal and foliar application of Zn EDTA, Fe EDTA (T_{13}) at active tillering, panicle initiation and milking stage with RDF. The Zinc and iron content in rice grains were recorded maximum with their soil and foliar application of Zinc fertilizerwhereas combination with iron forms of fertilizer slightly decrease in their Zn and Fe content in brown rice as reported by Verma and Tripathi (1983). This indicated the antagonism between these two micronutrients when applied in combination.

Umashankar Ram *et al*. (2017)also concluded that Zn EDTA as soil and Fe EDTA as foliar applied in rice contributed marked increase in yield associated with grain micronutrient content (Zn and Fe) along with their uptake as compared to other combined application treatments. Result is supported with the findings of Gomez-Coronado *et al*., (2016), Kumar *et al*., (2016), Debasish Barua and Mrinal Saikia (2016) and Susmit Saha *et al*., (2017).

Table: Effect of fortification of zinc and iron fertilizer on yield attributes and Zn,Fe content in brown rice

Treatments	Cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net income (Rs ha^{-1})	BCR
T_1:Control	23000	24000	1000	1.04
T_2-RDF	40000	43831	3831	1.09
T_3-Soil Application of $ZnSO_4$ @25 kg ha^{-1}	41450	70187	28737	1.69
T_4-Soil Application of $FeSO_4$ @30 kg ha^{-1}	44480	64951	20471	1.46
T_5-Soil Application of $ZnSO_4$ @25 kg ha^{-1} + Soil Application of Fe SO_4 @30 kg ha^{-1}	45930	98158	52228	2.13
T_6-Foliar Application of Zn EDTA@1%	45500	53900	8400	1.18
T_7-Foliar Application of Fe EDTA @ 0.5 %	42750	47775	5025	1.11
T_8-Foliar Application of Zn EDTA@1% + Foliar Application of Fe EDTA @ 0.5 %	48250	59347	11097	1.22
T_9-Soil Application of $ZnSO_4$ @25 kg ha^{1}+Foliar Application of Zn EDTA@1%	46950	92531	45581	1.97
T_{10}-Soil Application of $ZnSO_4$ @25 kg ha^{-1} + Foliar Application of Fe EDTA @ 0.5 %	44200	81231	37031	1.83
T_{11}- Soil Application of $FeSO_4$ @30 kg ha^{-1} + Foliar Application of Zn EDTA@1%	49980	86847	36867	1.73
T_{12}- Soil Application of $FeSO_4$ @30 kg ha^{-1}+ Foliar Application ofFe EDTA @ 0.5 %	47230	75553	28323	1.59
T_{13}-Soil Application of $ZnSO_4$ @25 kg ha^{-1} + Soil Application of Fe SO_4 @30 kg ha^{-1} +Foliar Application of Zn EDTA@1% + Foliar Application of Fe EDTA @ 0.5 %	54180	103398	49218	1.90

Table: Effect of fortification of zinc and iron fertilizer on growth attributes

Treatments	No. of productive tillers m^{-2}	No. of grains panicle^{-1}	Panicle length	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Zn content in brown rice (mg kg^{-1})	Fecontent in brown rice (mg kg^{-1})
T_1	271.18	78	15.13	1.91	4.96	15.00	17.30
T_2	347.45	90	17.66	2.46	6.15	20.50	19.50
T_3	433.89	110	19.90	4.12	6.80	29.85	20.20
T_4	422.03	109	19.43	3.82	6.66	22.06	25.68
T_5	496.60	118	21.63	5.77	7.55	28.68	25.25
T_6	389.82	106	18.26	3.17	6.45	32.00	20.15
T_7	376.27	103	17.96	2.81	6.45	22.56	28.20
T_8	410.16	108	19.20	3.49	6.58	31.56	28.05
T_9	486.43	116	21.16	5.44	7.43	36.08	20.05
T_{10}	459.31	112	20.56	4.77	7.10	28.85	27.93
T_{11}	470.24	115	21.06	5.10	7.35	31.30	25.46
T_{12}	447.45	110	20.00	4.44	6.85	21.80	32.65
T_{13}	508.47	120	23.23	6.08	7.85	35.65	32.43
CD(0.05)	23.03	5.52	1.29	178.91	278.89	-	-
SEd	11.51	2.76	0.64	89.45	139.44	-	-

References

Ananda, N. and Patil, B.N. (2010). Effect of micronutrients (Zn and Fe) and time of nitrogen application on growth and yield of Durum Wheat. *Karnataka Journal of Agricultural Sciences*, 18(3).

Asad and R. Rafique (2000). Effect of zinc, copper, iron, manganese and boron on the yield and yield components of wheat crop in Tehsil Peshawar. *J. Pakistan Biol. Sci.*, **3:** 1615-1620.

Barua, D. and Saikia, M. (2018). Agronomic biofortification in rice varieties through zinc fertilization under aerobic condition. *Indian Journal of Agricultural Research*, 52(1).

Fageria, N.K. (2014). Mineral Nutrition of Rice. CRC Press, Tailor & Francis, ISBN-13: 978-1-4665-5807-6.

Gomez-Coronado, F., Poblaciones, M.J., Almeida, A.S. and Cakmak, I. (2016). Zinc (Zn) concentration of bread wheat grown under Mediterranean conditions as affected by genotype and soil/foliar Zn application. *Plant and Soil*, **401(1-2):** 331-346.

Graham, R.D., Welch, R.M. and Bouis, H.E. (2001). Addressing micronutrient malnutrition through enhancing the nutritional quality of staple foods: principles, perspectives and knowledge gaps. *Adv. Agron.*, **70:** 77-142.

IRRI (International Rice Research Institute) (2006). High-iron and zinc rice. (Online) Available: http://www.knowledgebank. Irri.org/Fact sheets/Other resources/Health and Nutrition/fs Fe and Zn.pdf.

Jat, S.L., Shivay, Y.S. and Parihar, C.M. (2011). Dual purpose summer legumes and zinc fertilization for improving productivity and zinc utilization in aromatic hybrid rice (*Oryza sativa*). *Indian Journal of Agronomy*, **56(4):** 328-333.

Kandoliya, R.U., Sakarvadiya, H.L. and BB, K. (2018). Effect of zinc and iron application on leaf chlorophyll, carotenoid, grain yield and quality of wheat in calcareous soil of Saurashtra region. *IJCS*, **6(4):** 2092-2096.

Khan, R., Gurmani, A.R., Khan, M.S. and Gurmani, A.H. (2009). Residual, direct and cumulative effect of zinc application on wheat and rice yield under rice-wheat system. *Soil Environ*, **28(1):** 24-28.

Khanda, C.N., Dixit, L. and Panda, S.C. (1997). Effect of zinc and graded levels of nitrogen on growth, yield and nutrient uptake of rice. *Oryza*, **34:** 43-46.

Kumar, A., Sen, A. and Kumar, R. (2016). Micronutrient fortification in crop to enhance growth, yield and quality of aromatic rice. *Journal of environmental biology*, **37(5):** 973.

Nadim, M.A., Awan, I.U., Baloch, M.S., Khan, E.A., Naveed, K. and Khan, M.A. (2012). Response of wheat (*Triticum aestivum L.*) to different micronutrients and their application methods. *J. Anim. Plant Sci*, **22(1):** 113-119.

Parthiban T and Ravi V (2016). Productivity of transplanted rice as influenced by weed control methods. **11(16):** 1445-1449.

Pooniya, V. and Shivay, Y.S. (2013). Enrichment of basmati rice grain and straw with zinc and nitrogen through ferti-fortification and summer green manuring under indo-gangetic plains of India. *Journal of plant nutrition*, **36(1):** 91-117.

Ram, U.S., Srivastava, V.K., Hemantaranjan, A., Sen, A., Singh, R.K., Bohra, J.S. and Shukla, U. (2013). Effect of Zn, Fe and FYM application on growth, yield and nutrient content of rice. *Oryza*, **50(4):** 351-357.

Ram, U.S., Srivastava, V.K., Singh, S.K., Yadav, M.K. and Sen, A. (2013). Agronomic biofortification of rice with special reference to Zn and Fe nutrition. *International Journal of Current Microbiology and Applied Sciences*, **2(11):** 384-387.

Rao, N.S. (2003). Rice *(Oryza Sativa L.)* Response to Time and Method of Zinc Application (Doctoral dissertation, ANGRAU ACB: AGRONOMY).

Saha, S., Chakraborty, M., Padhan, D., Saha, B., Murmu, S., Batabyal, K., Seth, A., Hazra, G.C., Mandal, B. and Bell, R.W. (2017). Agronomic biofortification of zinc in rice: Influence of cultivars and zinc application methods on grain yield and zinc bioavailability. *Field Crops Research*, **210:** 52-60.

Sudha, S. and Stalin, P. (2015). Effect of zinc on yield, quality and grain zinc content of rice genotypes. *International Journal of Farm Sciences*, **5(3):** 17-27.

Suresh, S. and Salakinkop, S.R. (2016). Growth and yield of rice as influenced by biofortification of zinc and iron. *J. Farm Sci*, **29(4):** 443-448.

Tabassum S, Khamparia RS, Singh S (2013). Effect of zinc and organic manures on yield attributes and yield of rice. *Bioinfolet*., **10(3A):** 879-881.

Uma Shankar Ram, S.K. Singh,V.K. Srivastava and J.S. Bohra. (2017). Effect of Zn, Fe and FYM on interaction between Zn and Fe on nutrient content,uptake and yield of different varieties of rice (*Oryza sativa* L.). *Int. J. Curr. Microbial. App. Sci.*, **6(2):** 874-890.

Verma, T.S. and Tripathi, B.R. (1983). Zinc and iron interaction in submerged paddy. *Plant and Soil*, **72(1):** 107-116.

Welch, R.M. and Graham, R.D. (2004). Breeding for micronutrients in staple food crops from a human nutrition perspective. *Journal of experimental botany*, **55(396):** 353-364.

Zayed, B.A., Salem, A.K.M. and El Sharkawy, H.M. (2011). Effect of different micronutrient treatments on rice (Oriza sativa L.) growth and yield under saline soil conditions. *World J. Agric. Sci.*, **7(2):** 179-184.