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YIELD AND ECONOMICS OF RICE AS FORTIFICATION WITH ZINC AND IRON FERTILIZER

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Abstract

The field study were conducted to evaluate the effect of zinc and iron fertilizers application to soil alone and in combination with foliar application on yield, yield components and nutrient concentration. Field experiment were conducted during 2018 at agronomic research area, faculty of agriculture, Annamalai University. It consists of thirteen treatments, the basal dose of NPK at the rate of 150:50:50 kg ha-1 respectively,were applied to all treatments except control. The treatments were arranged in randomized block design (RBD) with three replications. Results were showed that soil along with foliar application of Zn and Fe produces significant impact on grain yield and yield attributing characters like productive tillers per metre square, number of grains per panicle, testweight. Maximum grain yieldof 6.08 t ha-1were recorded with treatment (T13)and lowest grain yield 1.91 t ha-1was observed with control treatment. Maximum Benefit Cost Ratio of 2.13and maximum net benefit of 52,228 Rs ha-1were recorded in the Soil Application of ZnSO4 @25 kg ha-1 + Soil Application of FeSO4 @30 kg ha-1 (T5).

Key words: Rice, Fortification, Zn-EDTA, Fe-EDTA, Yield attributes and Economics.

Introduction

Rice is the primary stable food for more than half of the world's population and together they directly supply more than 50 % of all calories consume by the entire human population (Jia-Yang *et al*., 2014).Total rice production is increased to 751.9 million tonnesworldwide (FAO, 2017)and among that 90 percent is produce and consume in developing countries.Over 2 billion people in Asia alone derive 80 % of their energy needs from rice, which contains 76-79 % carbohydrates, 6-9 % protein, 3 % fat and 3 % fibre. But unfortunately, about 870 million people are suffering from chronic under nourishment globally (Da silva *et al*., 2013) and vast majority of them are from developing countries where rice is closely associated with food security and political stability.

Zn and Fe deficiencies are widespread health problems. Iron deficiency is the most common nutritional disorder not only in the world and almost 1.6 billion people are suffering from iron deficiency (De Benoist *et al*., 2008). Iron deficiency anaemiais far the most wide spread micronutrient deficiency, and it results in impaired physical growth,mental development, and learning capacity (Bouis, 2003). Similarly, Zinc deficiency is equally serious and is ranked as the 5th leading risk factor for diseases in the developing world (Maret and sandstead, 2006). Numerous health problem link zinc deficiency to retarded growth, skeletal abnormalities, delayed wound healing, increased abortion risk and diarrhoea (Salgueiro *et al*., 2000). Approximately one third of the world population is suffering from zinc deficiency (Hotz and Brown, 2004). The situation is even more adverse in developing countries where more than half of the children and pregnant women are suffering from zinc and iron deficiencies (Seshadri, 2001). This situation is largely attributed to the high consumption of cereal based foods *viz*., rice,wheat and maize in these countries (Pfeiffer and McClafferty, 2007). Edible part of the modern cereal cultivars are inherently poor in iron and zinc. Increase of Zn, Fe concentration of rice grains, bioavailability of food crops, through bio fortification appears to be the most feasible, sustainable and economical approach among the different intervention to address Zn and Fe deficiency.

Materials and methods

The study was conducted in 2018 for the yield and economics of rice as fortification with zinc and iron fertilizerat agronomic research area, faculty of agriculture, Annamalai University situated at 11˚24' N latitude and 79˚41' E longitude at an altitude of +5.79 meters above mean sea level. The soil of the experimental field were clay and clay loamy in texture with available nitrogen (234 kg ha^{-1}), phosphorus (20.50 kg ha^{-1}) and potassium(305.7 kg ha^{-1}). The experiment comprised of thirteen treatments combination with ZnSO4, $FeSO_4$ and Zn-EDTA, Fe-EDTA which are laid out at Randomized block design with three replication. The $ZnSO_4$ and $FeSO_4$applied as basal and the Zn-EDTA, Fe-EDTA were foliar sprayed at active tillering, panicle initiation and milking stages. The test variety was co-47 and its spacing was 15 × 10 cm. Five plants were selected from each plot at random. Each plant marked with a small plastic white coloured ring and with wooden peg nearby for demarcation. The same five plants were observed at various stages of crop growth up to harvest for biometric observations. These five plants were harvested separately for post-harvest operations.

Results and Discussion

Productive tillers

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 maximum Productive tillers of 508.47. The increased in productive tillers might be due to combined soil and foliar application of Zn and Fe increased photo synthetic rate, excessive accumulation of sucrose, glucose and fructose in leaves which might have increased physiological parameters of the plant. 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. Similar results were also reported by Ravi kiran and Reddy (2004).

Panicle length

The data shown that highest panicle length of 23.23 cm were observed in the 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. It may be attributed to the increase in supply of photosynthates to sink due to higher chlorophyll content and photosynthesis due to more availability of micronutrients by foliar sprays at different intervals during growth period of the crop (Duraisamy and Mani, 2001).

No of grains per panicle

The data revealed that, highest no. of grains per panicle of 120 were observed in the 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. Foliar application of zinc has been reported to increase the viability of pollen grains, ultimately reducing sterility percentage. The results are agreement with the findings of Meena and shivay (2010), karim *et al*. (2012), khan *et al*. (2008), Asad and Rafique (2002), jat *et al*. (2011).

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 recorded the maximum grain yield of 6.08 t ha^{-1}. Higher grain yield due to Zn and Fe Fertilization is attributed to its involvement in many metabolic enzyme system, regulatory functions, auxin production and enhanced synthesis of carbohydrates and their transport to the site of grain production.

Zinc and Iron is an important component of various enzymes that are responsible for driving many metabolic reactions in all crops. Carbohydrates,protein and chlorophyll formation is significantly reduced in zinc-deficient plants. A constant and continuous supply of zinc is needed for optimum growth and maximum yield (Apurba K. Sutradhar *et al*., 2016).

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

Straw 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 obtained the maximum straw yield of 7.85 t ha^{-1}. Higher yield attributes ascribed to adequate supply of zinc that increased the uptake and availability of other essential nutrients, which results in improvement in plant metabolic process and finally increased the crop growth (Naik and Das, 2007). Application of Zn and Fe increased the growth parameters possibly due to inter relationship with auxin, an important growth parameter regulator and led the stem elongation.

Similar to the present experiment Suresh and Salakinkop (2016), also reported that combined soil and foliar application of $ZnSO_4$ and $FeSO_4$ recorded significantly higher grain yield, straw yield and yield attributing parameters.

Zn and Iron content in brown rice

Soil Application of $ZnSO_4$ @25 kg ha^{-1}+Foliar Application of Zn-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 Zinc EDTA, Iron 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 fertilizer whereas 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. The result is also supported by Debasish Barua and Mrinal Sakia (2018) reported that application of $ZnSO_4$ @ 25 kg ha^{-1} as basal + foliar @ 0.5% at three stages reveals significantally highest Zn content in grain and brown rice.

Zinc and iron content in rice grains were recorded maximum with their separate application and minimum under control, whereas combined and sequential application of Zn EDTA and Fe EDTA slightly decreased Zn and Fe concentration in grains as compared to their separate applications reported by Verma and Tripathi (1983). Result is supported with the findings of Kumar*et al*. (2016), Debasish Barua and Mrinal Saikia (2016) and Susmit Saha *et al*. (2017).

Economics

An economical analysis demonstrated that application of Soil Application of $ZnSO_4$ @25 kg ha^{-1} + Soil Application of $FeSO_4$@30 kg ha^{-1} produced the gross return of Rs. 98158 with benefit cost ratio (BCR) of 2.13 followed by the Soil Application of $ZnSO_4$@25 kg ha^{-1}+Foliar Application of Zn-EDTA@1%. The application of $FeSO_4$ significantly affected the cost of cultivation, net returns and benefit cost ratio of aerobic rice (Yadav, 2012). Even though the 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% were recorded the highest gross return of Rs.1,03,398 but the highest net return of Rs.52,228 were recorded with the Soil Application of $ZnSO_4$@25 kg ha^{-1}+ Soil Application of $FeSO_4$@30 kg ha^{-1}. It is because the high cost of Zinc and Iron chelated nutrients. So, it is obvious from the results that Soil Application of $ZnSO_4$ @25 kg ha^{-1} + Soil Application of $FeSO_4$ @30 kg ha^{-1} proved economical and cost-effective.

Table: Effect of fortification with zinc and iron fertilizer on economics of 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 with zinc and iron fertilizer on yield attributes of rice

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})	Fe content 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	3130	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	-	-

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