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INFLUENCE OF ZINC USE EFFICIENCY AND RICE YIELD THROUGH ZINC ENRICHED FYM UNDER STRESSED SOIL

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Abstract

An experiment was conducted to study the enhancement of zinc use efficiency and yield through zinc enriched FYM under stressed soil during Rabi 2017 at experimental farm, Faculty of Agriculture, Annamalai University. The experiment was conducted with eight treatments and three replications laid out in randomized block design viz., T_1 - Control (RDF) 100 %, T_2 - RDF + FYM @ 500 kg ha^{-1}, T_3 - RDF + Zinc @ 2.5 kg ha^{-1}, T_4 - RDF + Zinc @ 5.0 kg ha^{-1},T_5 - RDF + Zinc @ 7.5 kg ha^{-1} , T_6 - RDF + 2.5 kg Zn enriched FYM @ 500 kg ha^{-1},T_7 - RDF + 5.0 kg Zn enriched FYM @ 500 kg ha^{-1}, T_8 - RDF + 7.5 kg Zn enriched FYM @ 500 kg ha^{-1}). The result of experiment revealed that addition of zinc or zinc enriched farmyard manure favourably influenced the ZnUE and yield of rice over control. Grain and straw yield was higher with Zn-EFYM compared to zinc alone at all levels. The highest grain yield (7692 kg ha^{-1}) and straw yield (8942 kg ha^{-1}) was noticed with RDF + 5.0 kg Zn enriched FYM @ 500 kg ha^{-1}. This treatment on an average caused 56 per cent increase over control.Zinc use efficiency increased in the presence of zinc alone and the maximum ZnUE was noticed with RDF + zinc @ 2.5 kg ha^{-1}.Further ZnUE was highest at RDF + 2.5 kg Zn enriched FYM @ 500 kg $ha^{-1}$and declined with loading of zinc.

***Keyword*:** Zinc, FYM, rice, yield, ZnUE.

Introduction

Rice (*Oryza sativa* L.) is one of the major stables, feeding more than half of the world population. It is grown in more than 100 countries, predominantly in Asia. Rice provides 21% of energy and 15% of protein requirement of human populations globally (Depar *et al*., 2011). Among the rice growing countries India ranks first in area(43.8 million ha) and second in production (157.2 million tonnes), next only to China. However, the average productivity of rice in India is only 3.62 tha^{-1} against the global average of 4.52 tha^{-1} (FAO, 2014). Increasing productivity and production are essential to meet the food requirement of the burgeoning population. In order to attain the desired yield potential through agronomic manipulations and adopting appropriate management practices for raising not only the yield but also improvement of quality characteristics of rice is an area of research, which needs immediate attention. The productivity and quality of rice depends on environmental conditions and agronomic management practices of the area (Singh *et al*., 1998). In TamilNadu, rice cultivation spreads over an area of 21 lakh hectares with a total production of 93 lakh Mt (Anonymus, 2015). Among micronutrients, Zn deficiency is a wide spread nutritional constraint through out the world. Zinc is an essential micronutrient required for normal growth and development of living organisms including plant, animals and human beings(Kabata-Pendias,2000). Zinc plays an important role in many biochemical functions with in plants. *Viz.,* auxin production, preferential accumulation of chlorophyll, protein synthesis and starch metabolism Therefore, deficiency of zinc in soil adversely affects the growth and development of plants. Rice crop requires high amount of Zn (Bradyand Weil, 2007; Havlin *et al*., 2007), under deficient condition of Zn in soil, therefore Zn deficiency becomes in the rice plants, than plant growth is restricted and quality of rice grain deteriorate and human health is also adversely affected (Pathak *et al*., 2008; Singh, 2010). To ameliorate zinc deficiency in the zinc deficient soils, the zinc fertilizers are being used but the zinc availability is less to the plants due to very high zinc fixation in soil. Organic manures provide major as well as micronutrients and improve soil health by improving physical condition of soil. The combined use of inorganic fertilizers with organic manures namely, farm yard manure (FYM), green manure, poultry manure, pig manure increased the rice yield, Nitrogen, Phosphorus and Potassium uptake, use efficiency of nutrients and available nutrient status of soil (Laxminarayana, 2006). The effect of combined application of FYM and zinc on soil parameters and plant factors was well documented (Ram Sakal, 2001). However, information on the response of rice to zinc enriched FYM on soil characteristics is limited. Hence, keeping the above said point in view study the enhancement of zinc use efficiency and yield through zinc enriched FYM under stressed soil.

Materials and Methods

Field experiments were conducted during Navarai season of year 2017. Before imposition of treatments, the soil used in the experiment had the following properties viz., pH-7.78, EC-0.84 dSm^{-1}, organic carbon-3.9 g kg^{-1}, CEC-23.21 c mol(p^+) kg^{-1},$CaCO_3$- 1.52%, $KMnO_4$-N- 275 kg ha^{-1}, Olsen-P- 10.4 kg ha^{-1}, NH_4OAc-K- 294 kg ha^{-1} and DTPA-Zn-0.68 $mgkg^{-1}$. The treatments consisted ofeight treatments viz.,T_1 - Control (RDF) 100 %, T_2 - RDF + FYM @ 500 kg ha^{-1}, T_3 - RDF + Zinc @ 2.5 kg ha^{-1}, T_4 - RDF + Zinc @ 5.0 kg ha^{-1},T_5 - RDF + Zinc @ 7.5 kg ha^{-1} , T_6 - RDF + 2.5 kg Zn enriched FYM @ 500 kg ha^{-1},T_7 - RDF + 5.0 kg Zn enriched FYM @ 500 kg ha^{-1}, T_8 - RDF + 7.5 kg Zn enriched FYM @ 500 kg ha^{-1}). The design was FRBD with three replications. Twenty seven days old rice seedling var CO 51 was transplanted in the main field. All the plots received uniform dose of 150 kg N ha^{-1}, 50 kg P_2O_5 ha^{-1} and 50 kg K_2O ha^{-1} applied through urea, SSP and muriate of potash respectively. The zinc was applied through analytical grade zinc sulphate ($ZnSO_4.7H_2O$).The zinc sulphate contains 21 percent Zn. Calculated quantities of zinc, FYM and Zn Enriched FYM were applied as per the treatment schedule in soil. Grain and straw yield was recorded at harvest and expressed as kg ha^{-1}. The plant samples were analyzed for zinc following standard procedure and uptake was computed. Soil was analyzed for DTPA zinc (Lindsay and Norwell, 1978). Zinc use efficiency was calculated following the formula proposed by Fageria (2009).

i) Partial Factor Productivity (PFP)

$$PFP = \frac{Y}{P}$$

ii) Agronomic Efficiency (AE)

$$AE = \frac{(Y - Y_0)}{F}$$

iii) Partial Nutrient Balance (PNB)

$$PNB = \frac{U_H}{F}$$

iv) Apparent Recovery Efficiency by difference

$$RE = \frac{(U - U_0)}{F}$$

Where

- Y : Yield of harvested portion of crop with nutrient applied
- Y_0 : Yield with not nutrient applied
- F : Amount of nutrient applied
- U_H : Nutrient content of harvested portion of the crop
- U : Total nutrient uptake in above ground crop biomass with nutrient applied
- U_0 : Nutrient uptake in above group crop biomass with no nutrient applied

Results and Discussion

Rice yield

A significant increase in grain and straw yield of rice was noticed due to application of different levels of zinc and Zn-eFYM (zinc enriched FYM) over control (Table 1). However, the response was more evident in the treatments of Zn-eFYM as compared to Zn application as ($ZnSO_4.7H_2O$). The highest grain and straw yield was obtained with combined application of RDF + 5.0 kg Zn-eFYM @ 500 kg ha^{-1} T_7 (7692 and 8942 kg ha^{-1}). It was significantly on par with T_8 and significantly followed by T_6. The percentage increase in grain and straw yield (36 and 24: 33 and 22) was noticed with combined application of RDF + 5.0 kg Zn-eFYM @ 500 kg ha^{-1} (T_7) and RDF+ zinc @ 5.0 kg ha^{-1} (T_4) compared to over control (T_1). With respect to zinc sulphate alone application of RDF+ zinc @ 5.0 kg ha^{-1} (T_4) recorded maximum grain and straw yield but superior to rest of zinc levels treatments. The lowest grain and straw yield (4926 and 5964 kg ha^{-1}) was observed in the absence of Zn and Zn-eFYM (T_1). Enhanced grain and straw yield could be due to supply of nutrients especially macro and micronutrients which induced cell division, expansion of cell wall, meristematic activity, photosynthetic efficiency, regulation of water to cells, conducive physical environment, facilitating to better aeration, root activity and nutrient absorption leading to higher rice yield (Singh and Sharma 2014). In the present study, RDF + 5.0 kg Zn-eFYM @ 500 kg ha^{-1} amended soil showing maximum nutrients. Higher rice yield due to combined application of organics and zinc could be due to the fact that micronutrient availability was expected to enhance through complication or chelation thereby prevent fixation in soil (Latha *et al.,* 2001). This was ably confirmed by significant positive correlation between grain yield with available N (r = 0.961**), available P (r = 0.954**), available K (r = 0.994**) and available Zn (r = 0.770**). Application of zinc has been reported to correct the efficiency of different Zn requiring enzymes leading to higher yield (Hacisalihoglu and Kochian 2003). In the present study, higher grain yield is due to better utilization of N and P for grain production through metabolic activity and also improvement in metallo enzymes system regulators function and growth promoting by auxin production from zinc. Khan *et al.* (2012) reported maximum yield at 9.0 kg Zn ha^{-1} and reduced at 12 and 15 kg Zn ha^{-1}.

Zinc use efficiency

Analysis of variance on zinc use efficiency showed that addition of zinc, Zn-eFYM significantly improved various zinc use efficiency parameters over control (Fig. 1). Zinc use efficiency decrease with increase in Zn levels. Agronomic efficiency ranged from 63.8 to 175.0 kg kg^{-1}, partial nutrient balance ranged from 0.60 to 1.94kg kg^{-1}, partial factor productivity ranged from 168.6 to 569.1 kg kg^{-1}, apparent recovery efficiency of zinc ranged from 1.62 to 7.25 per cent in respectively. Application of RDF + 2.5 kg Zn-eFYM @ 500 kg ha^{-1} (T_6) recorded the maximum agronomic efficiency (175.0 kg kg^{-1}), apparent recovery efficiency of zinc (7.25 per cent), partial nutrient balance (1.94 kg kg^{-1}),partial factor productivity (569.1 kg kg^{-1}) in respectively. It was significantly superior to rest of Zn-eFYM levels. With respect to zinc levels, addition of RDF + zinc @ 2.5 kg ha^{-1} (T_3) recorded the maximum agronomic efficiency (79.4 kg kg^{-1}), apparent recovery efficiency of zinc (3.16 per cent) partial nutrient balance(1.65 kg kg^{-1}), partial factor productivity (473.4 kg kg^{-1}) in respectively. Nutrient use efficiency has been extensively used as a measure of the capacity of a plant to acquire and utilize nutrients for biological and grain yield (Gill *et al.,* 2004). The flexibility in biomass production, root morphology and root distribution patterns has been found to be important adaptive mechanism for acquiring nutrients (Lynch *et al.,* 2007; Yang *et al.,* 2007). Greater NUE at lower levels is common because of efficient utilization of nutrients at lower level (Fageria, 1992). The decrease in Zn use efficiency with increasing rate of Zn is also related to progressive decrease in DMP or grain yield with increasing Zn rate in Zn deficient soils (Fageria and Baligar, 2001). Higher Zn use efficiency at lower level of Zn was reported by Rathod *et al.* (2012) in rice. Our results are agreement with Rathod *et al.* (2012) they also reported that zinc use efficiency due to Zn-enrichment of organics at 2.5 kg ha^{-1} improved over its, application as zinc sulphate in both wheat and maize crops.

Table 1 : Effect of zinc and zinc enriched FYM on grain and straw yield of rice (kg ha^{-1})

Treatments	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})
T_1 - Control (RDF)	4926	5964
T_2 -RDF + FYM @ 500 kg ha^{-1}	5436	6500
T_3 - RDF + Zinc @ 2.5 kg ha^{-1}	5918	7014
T_4 - RDF + Zinc @ 5.0 kg ha^{-1}	6522	7668
T_5 - RDF + Zinc @ 7.5 kg ha^{-1}	6323	7468
T_6 - RDF + 2.5 kg Zn enriched FYM @ 500 kg ha^{-1}	7114	8327
T_7 - RDF + 5.0 kg Zn enriched FYM @ 500 kg ha^{-1}	7692	8942
T_8 - RDF + 7.5 kg Zn enriched FYM @ 500 kg ha^{-1}	7532	8784
SEd	134.86	158.9
CD (P = 0.05)	289.29	340.10

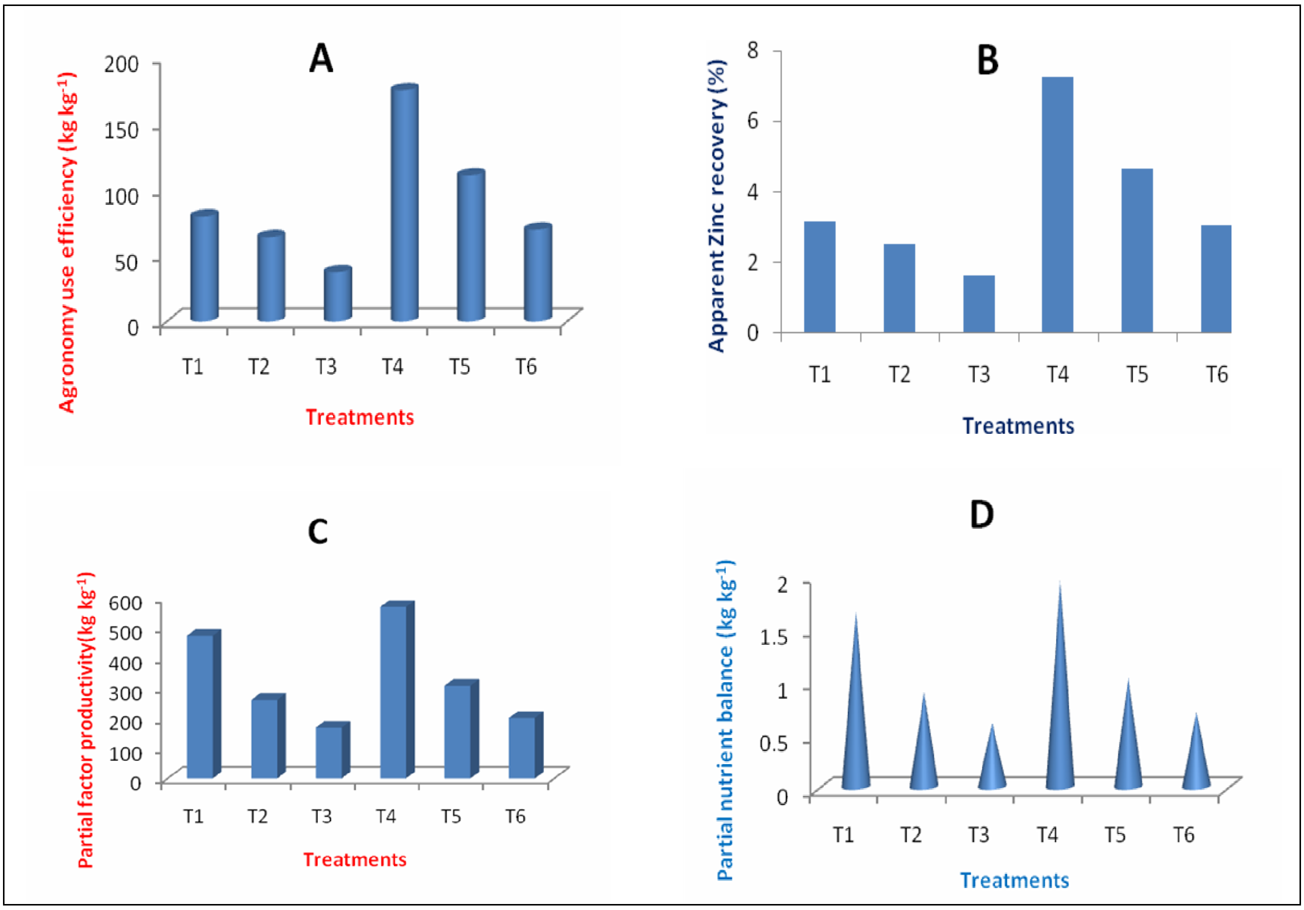

Fig. 1 : Effect of zinc and zinc enriched FYM application on Zinc use efficiency
A) Agronomic efficiency, B) Apparent recovery efficiency, C) Partial factor productivity, D) Partial nutrient balance

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