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Zinc Accounting for Lowland Rice (*Oryza sativa* L.) Under Different Methods of Zinc Application with Green Leaf Manuring

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Abstract

Zinc is the common micronutrient; its availability is reduced under lowland rice cultivation. Field investigation was carried out at during winter (*Rabi*) season of 2016-17 at Agricultural College and Research Institute, killikulam, Tamil Nadu Agricultural University. The zinc use efficiencies were positively influenced the by the application of zinc as basal and foliar spray at critical stages of rice. The higher physiological efficiency recorded by zinc applied as basal with green leaf manuring. The zinc induced nitrogen use efficiency was noted higher at zinc applied as soil plus foliar application with green leaf manuring. The agronomic efficiency, partial factor productivity and zinc recovery fraction (apparent recovery) was higher under application of zinc as foliar spray twice with green leaf manuring. Incorporation of green leaf manure of *Glricidia maculate* was favorable influence of increasing use efficiency of applied zinc.

Keywords: Lowland rice; Zinc; Green leaf manure; Zinc use efficiency

Introduction

Rice (*Oryza sativa* L.) is a staple food for more than 50% of the world's population, including regions of high population density and rapid growth. The global population is 7.55 billion presently and is expected to reach 9.77 billion by the year 2050. Human consumption accounts for 85 percent of total production for rice, compared with 72 percent for wheat and 19 percent for maize. Among the Asian countries, India and china is leading in rice area, production and productivity. Even though the production is higher due to escalating of world population, need to produce more food grain to meet out the requirement. At present rice production alone consumes nearly 24.7 Mt. of fertilizer ($N+P_2O_5+K_2O$) which accounts for approximately 14.0% of the total global fertilizer consumption in a year and in India it accounts for 31.8% of the total fertilizer consumption [1].

Chemical fertilizer and organic manure application provide sufficient nutrient for better growth and development. Among them, micronutrients plays key role in production of rice in particularly zinc. Zinc is the macro micronutrient; it involves various metabolic activities of rice growth. Increasing the use efficiency applied zinc, various agronomic methods are helpful and application of zinc as a basal and foliar spray gives better use efficiency in turn which minimizes the nutrient loses to the environment.

Nearly 50% of cultivated soils in India are low in plant available Zn and these soils are under intensive cultivation of wheat and rice with no or little application of Zn fertilizers. Mosier et al. described four agronomic indices commonly used to describe nutrient efficiency: partial factor productivity, which is kg crop yield per kg nutrient, applied; agronomic efficiency, which is crop yield increase per kg nutrient applied; apparent recovery efficiency, which is kg nutrient taken up per kg nutrient applied and physiological efficiency, which is kg yield increase per kg nutrient taken up [2].

In addition to the chemical fertilizer, application organic manure like green leaf manure decomposition produce the organic acids and makes available to the applied zinc fertilizer in the soil. Therefore, the application of zinc with green leaf manure gives better result of growth and yield also increases the use efficiencies lie apparent recover, agronomic efficiency, physiological efficiency and zinc induced nitrogen efficiency.

Materials and Methods

A field investigation was carried out at rabi season of 2016-17, agriculture college and research institute, killiulam, Tamil Nadu Agricultural University. The farm is geographically located in the southern part of Tamil Nadu at 8°46' N latitude and 77°42' E longitude at an altitude of 40 m above mean sea level.

The experimental site is situated in semi-arid tropical region. The mean annual rainfall is 786.6 mm received in 40 rainy days. The mean maximum and minimum temperature of the location were 33.4°C and 23.6°C respectively. The soil of the experimental field is sandy clay loam in texture. The fertility status was low in available nitrogen (237 kg ha^{-1}), medium in available phosphorus (18 kg ha^{-1}), medium in available potassium (240 kg ha^{-1}), Organic carbon (0.64%), pH (1:2 soil water suspension) (7.4) and diethylene triamine penta acetic acid (DTPA) extractable Zn in soil was 0.8 mg kg^{-1} of soil.

The experiment was laid out in completely randomized block design, replicated thrice using ADT (R) 45 as the test variety. The objective the study is different methods of application zinc on use efficiencies of lowland rice with addition green leaf manure to fulfill the objective, the experiment was carried out with the following treatments i.e., 100% RDF alone (T_1) and it was in combination with $ZnSO_4$ @25.0 kg ha^{-1} as basal (T_2), 37.5 kg ha^{-1} as basal (T_3), $ZnSO_4$ @

0.5% as foliar spray (T_4), 1.0% as foliar spray (T_5). The treatment T_6 to T_8 consist of 100% RDF+GLM @ 6.25 t ha^{-1}+$ZnSO_4$ @ 12.5 kg ha^{-1} as basal (T_6), 25.0 kg ha^{-1} as basal (T_7) and 37.5 kg ha^{-1} as basal (T_8). For treatment T_9 and T_{10} instead of basal application, the $ZnSO_4$ was given as 0.5% foliar spray (T_9) and 1.0% foliar spray (T_{10}) with 100% RDF +GLM @ 6.25 t ha^{-1}. The treatment T_{11} and T_{12} consist of all combination in 100% RDF+GLM @ 6.25 t ha^{-1}+$ZnSO_4$ @ 12.5 kg ha^{-1} as basal+0.5% $ZnSO_4$ as foliar spray (T_{11}) and 1.0% foliar spray (T_{12}).

The recommended dose of fertilizer viz., 150:50:50 kg NPK ha^{-1} was applied to all the plots. In the form of DAP (18% N and 46% P_2O_5). The N fertilizer was applied in the form of urea (46% N) the basal dose N was adjusted with N supplied by DAP. The K fertilizer was applied in the form of MOP (60% K_2O). N and K applied in four equal splits viz., one at basal and remaining at active tillering, panicle initiation and heading stages along with N.

Leaves and twigs of *Glyricidia maculata* @ 6.25 t ha^{-1} was collected from the farm and incorporated in the respective plots at ten days before transplanting. After incorporation the field was puddled two times and leveled two days prior to planting. Zinc sulphate 12.5, 25, 37.5 kg ha^{-1} was mixed with sand to uniform distribution and applied as basal before the transplanting to the respective plots as per the treatment. Zinc sulphate at 0.5 and 1% foliar spray was given in two times viz., at active tillering and panicle initiation. The estimated values of partial factor productivity (PFP), agronomic efficiency (AE), recovery efficiency (RE), physiological efficiency (PE) and of applied Zn were computed using the following expressions as suggested by Pooniya and Shivay [3].

$PFP=Y_t/Zn_a$

$AE=(Y_t-Y_{Ac})/Zn_a$

$RE=[(U_{Zn}-U_{Ac})/Zn_a] \times 100$

$PE=(Y_t-Y_{Ac})/(U_{Zn}-U_{Ac})$

Where, Y_t and U_{Zn} refer to the grain yield (kg/ha) and total Zn uptake (g/ha), respectively of different wheat varieties in Zn applied plots; Y_{Ac} and U_{Ac} refer to the grain yield (kg/ha) and total Zn uptake (g/ha), respectively of wheat in control (Zn_0) plots; Zn_a refers to the Zn applied (kg/ha); GU_{Zn} refers to Zn uptake (g/ha) in grain. The Zn induced nitrogen recovery efficiency (ZniNRE) was calculated as following the equation proposed by Prasad and Shivay:

ZniNRE=[N uptake (kg/ha) in Zn treatment-N uptake (kg/ha) in control plots (Zn_0)]/ N applied (kg/ha)

Results and Discussion

Nutrient uptake is a product of nutrient concentration and dry matter accumulation of the crop plant. Nutrient uptake determines the crop growth, development and yield of the crops. In the present investigation nutrient uptake has more significance with the application of 100% RDF+GLM @ 6.25 t/ha+$ZnSO_4$ @ 12.5 kg/ha as basal+1.0% foliar spray (Table 1). Soil plus foliar application of zinc with green leaf manure results in greater nutrient availability. The conjunctive use of green leaf manures and zinc which might have helped in gradual mineralization processes and the balanced supply of nutrients are the reason for the higher uptake of nutrient by the crop. This is corroborated with the earlier findings made by Turkhede et al. [4].

Treatments		Grain yield (kg ha^{-1})	Nutrient uptake		ZAR* (%)	ZnAE* (kg kg^{-1})	PFP* (kg kg^{-1})	PE*	ZnINE*
			N (kg ha^{-1})	Zn (g ha^{-1})					
T_1	100% RDF	5776	91.0	115.3	0.0	0	0.0	0.0	0.0
T_2	T_1+$ZnSO_4$ @ 25.0 kg ha^{-1} as basal	6166	98.9	442.4	1.4	16	247	1.1	5.7
T_3	T_1+$ZnSO_4$ @ 37.5 kg ha^{-1} as basal	6322	99.5	445	1	15	169	1.4	5.3
T_4	T_1+f.s. $ZnSO_4$ @ 0.5%	5888	92.6	400.2	11.4	45	2355	0.4	1.0
T_5	T_1+f.s. $ZnSO_4$ @ 1.0%	6009	94.4	405.9	5.8	47	1202	0.8	2.2
T_6	T_1+GLM @ 6.25 t ha^{-1}+$ZnSO_4$ @ 12.5 kg ha^{-1} as basal	6569	105.8	525.7	3.3	63	525	1.9	8.0
T_7	T_1+GLM @ 6.25 t ha^{-1}+$ZnSO_4$ @ 25.0 kg ha^{-1} as basal	6751	108.9	542.4	1.7	39	270	2.3	9.7
T_8	T_1+GLM @ 6.25 t ha^{-1}+$ZnSO_4$ @ 37.5 kg ha^{-1} as basal	6850	111.5	547	1.2	29	183	2.5	11.1
T_9	T_1+GLM @ 6.25 t ha^{-1}+f.s. $ZnSO_4$ @ 0.5%	6384	102.7	468.3	13.1	243	2554	1.8	6.3
T_{10}	T_1+GLM @ 6.25 t ha^{-1}+f.s. $ZnSO_4$ @ 1.0%	6410	103.5	493.1	6.6	127	1282	1.9	6.8
T_{11}	T_1 + GLM @ 6.25 t ha^{-1}+$ZnSO_4$ @ 12.5 kg ha^{-1} as basal+f.s. $ZnSO_4$ @ 0.5%	6991	114.7	553.9	2.9	81	466	2.8	12.9

T_{12}	T_1+GLM @ 6.25 t ha^{-1}+$ZnSO_4$ @ 12.5 kg ha^{-1} as basal+f.s. $ZnSO_4$ @ 1.0%	7105	119.6	567.9	2.6	76	406	2.9	15.5
SEd		217	2.5	11.0					
CD (P=005)		452	5.1	22.9					

Table 1: Effect of zinc nutrition with green leaf manuring on zinc use efficiency of lowland rice. *Data not statistically analyzed.

Rajkumar, observed that the green leaf manure to rice along with recommended N, P and K significantly enhanced the uptake of N [5]. The increased N uptake might be due to the fact that, initial high N requirement of rice crop was met by the fertilizer N and subsequent requirement was supplied by decomposition process, assuring the continuous N supply throughout the crop period which enhanced the uptake of N as well as other nutrient as evident from the higher DMP production. Addition of green leaf manure with zinc nutrition enhanced the uptake of zinc. These results were conformation with the findings of Yaseen et al. [6].

Zinc use efficiencies

Zinc use efficiency was calculated by zinc apparent recovery, zinc agronomic efficiency, Partial factor productivity, Physiological efficiency and Zinc induced nitrogen use efficiency. Application of zinc as basal and given as two foliar spray at tillering and panicle initiation with/without the prior incorporation of green leaf manure favorably enhanced the use efficiency of zinc. Agronomic efficiency can be defined as the nutrients accumulated in the above-ground part of the plant or the nutrients recovered within the entire soil-crop-root system [7].

The higher zinc agronomic efficiency (243) was recorded at zinc foliar spray of zinc with green leaf manuring. This might be due to the foliar application of zinc as two important critical stage of rice at tillering and panicle initiation had influence of higher agronomic se efficiency. The zinc apparent recovery indicates the efficiency of absorption of applied zinc. Zinc apparent recovery and partial factor productivity was higher in application of 100% RDF+GLM @ 6.25 t ha^{-1}+foliar spray of $ZnSO_4$ @ 0.5% had higher zinc apparent recovery of 13.1 per cent. This might be due to reduction in loss of applied zinc increased the availability through combined application green leaf manure and zinc nutrition. Contrary to this, the higher physiological efficiency was noted at soil plus foliar application of zinc with incorporation of green leaf manuring. The higher physiological efficiency might be due to incorporation of green leaf manure had influence on soil reactions in turn which increase the use efficiency and foliar spray of zinc also had greater impact on improving the physiological efficiency.

Zn fertilization improved zinc induced nitrogen recovery efficiency. Zinc nutrition with foliar spray plus soil application with addition of green leaf manure shows positive impact on the nitrogen recovery efficiency. The higher zinc induced nitrogen recovery efficiency was observed at application of NPK+green leaf manure incorporation with zinc fertilization of soil plus foliar spray had superior value of 15.5 percent compared to other treatments.

This might be due to higher growth and biomass production with the Zn application as higher Zn is available to plants and resulted in higher grain yield as compared to other treatments. Increase in grain yield with the application of Zn resulted into higher uptake of N and thereby higher recovery of N from soil. The increase in zinc use efficiency might be the reason of application of zinc as basal neither foliar spray and soil plus foliar spray.

Also, incorporation *Glyricidia maculate* green leaf manure during decomposition organic acids which increase the nutrient availability of the plant and increase the mineralization process in turn increased the availability of applied nutrients. Improvements of agronomic factors may influence chemical and physical processes in soils that influence the nutrient availability [8].

When soil temperature is low, mineralization of soil organic matter slows down resulting in less amount of Zn release in the soil. The application of green leaf manuring is one of the important practices for increasing organic matter and Zn content in the soil. The similar results were fond earlier work of Srinivasara and Rani [9]. Similarly, the foliar application of Zn is also a quick solution to plants growing in low Zn soil. These results corroborated with the previous finding of Rengel.

The increase in zinc use efficiency with application of zinc as foliar spray or soil plus foliar spray with green leaf manuring had greater impact on lowland rice cultivation. This similar result were more or less confirmed with the earlier findings of Fageria et al. [10], Pooniya and Shivay [3], Yadav et al. [11], Muthukumararaja and Sriramachandrasekharan [12,13] and Ghasal et al. [14].

Conclusion

From the above results it could be concluded that, lowland rice more responsive to applied zinc. In addition to incorporation green leaf manure enhanced the biological properties of soil in turn which increase the nutrient availability to the crop. Zinc nutrition either foliar spray or basal application with green leaf manuring can enhance the use efficiency of applied nutrients.

References

1. Nayak AK, Khanam R, Mohanty S, Chatterjee D, Bhaduri D, et al. (2018) Changing dimension of nutrient management in rice. 3rd ARRW International Symposium, Feb. 6-9, Cuttack, India, pp: 40-44.
2. Mosier AR, Syers KK, Freney JR (2004) Agri- culture and the nitrogen cycle. Assessing the impacts of fertilizer use on food production and the environment. Scope-65. Island Press, London.
3. Pooniya V, Shivay YS (2012) Summer green-manuring crops and zinc fertilization on productivity and economics of basmati rice (Oryza sativa L.). Archives of Agronomy and Soil Science 58: 593-616.
4. Turkhede AB, Choudhari BT, Chore CN, Kalpande HV, Jiotode DJ, et al. (1998) Effect of green manuring with glyricidia leaves and fertility levels on yield and physico-chemical properties of the soil in low land paddy. Crop Research-Hisar 16: 300-303.

5. Rajkumar C (2003) Study on the effect of different sources of nitrogen on growth and yield of rice. MSc (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore.

6. Yaseen M, Hussain T, Hakeem A, Ahmad S (1999) Integrated nutrient use including Zn for rice. Pak J Biol Sci 2: 614-616.

7. Roberts TL (2008) Improving nutrient use efficiency. Turkish Journal of Agriculture and Forestry 32: 177-182.

8. Pilbeam DJ (2015) Breeding crops for improved mineral nutrition under climate change conditions. Journal of Experimental Botany 66: 3511-3521.

9. Srinivasarao C, Sudha Rani Y (2013) Zinc deficiency: A productivity constraint in rainfed crop production. J SAT Agric Res 11: 1-11.

10. Fageria NK, Dos Santos AB, Cobucci T (2011) Zinc nutrition of lowland rice. Communications in Soil Science and Plant Analysis 42: 1719-1727.

11. Yadav B, Khamparia RS, Kumar R (2013) Effect of zinc and organic matter application on various zinc fractions under direct-seeded rice in vertisols. Journal of the Indian Society of Soil Science 61: 128-134.

12. Muthukumararaja TM, Sriramachandrasekharan MV (2012) Effect of zinc on yield, zinc nutrition and zinc use efficiency of lowland rice. Journal of Agricultural Technology 8: 551-561.

13. Muthukumararaja TM, Sriramachandrasekharan MV (2014) Enhancing rice productivity through integration of organics and zinc in a zinc deficient soil. Journal of International Academic Research for Multidisciplinary 2: 359-368.

14. Ghasal PC, Shivay YS, Pooniya V, Choudhary M, Verma RK (2017) Zinc accounting for different varieties of wheat (Triticum aestivum) under different source and methods of application. Indian Journal of Agricultural Sciences 87: 1111-1116.