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Response of Transplanted Irrigated Rice (Faro, 44) to Applied Zinc by Nursery Enrichment of Fadama Soil in Adamawa State, Nigeria

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Abstract: Rice variety FARO 44(Sipi 692033) was evaluated under field condition for response to applied Zinc by nursery enrichment at Lake Gerio Irrigation Project within the savanna region of Nigeria. Rice nurseries (16 m^2) were prepared with bunds to maintain moisture and rice seed at the rate of 15kg ha^{-1} was broadcasted. Zinc fertilizer levels at the rate of 0, 5, 7.5and 10kg Zn ha^{-1} as $ZnSO_4 \bullet 7\ H_2O$ were applied mixed with 500g of river sand two weeks after emergence. The Zinc nursery enriched seedling stocks were transplanted at three seedlings per stand (20x15) two weeks after treatment in a randomized complete block design replicated three times. The results obtained were subjected to analysis of variance and means separated using Duncan's Multiple Range Test. It was observed that the number of rice tillers response to applied Zn was generally high (32) number of rice plant tillers with 5 Kg Zn ha^{-1} than with 7.5 and 10 Kg Zn ha^{-1}. The weight of 1000 grains (g) also response significantly at ($p < 0.05$) with the application of 5 Kg Zn ha^{-1}. Days to 50% heading was noted to reduce with the application of 5 Kg Zn ha^{-1}, while the control treatments has higher number of days to 50% heading-78 days than with 7.5 and 10 Kg Zn ha^{-1} applied. The number of leaves though shows a significant difference at ($p < 0.05$), the application of 5 and 7.5 Kg Zn ha^{-1} has the same response than 0 and 10 Kg Zn ha^{-1} applied. Number of panicle spike lets increased with the application of 5, 7.5 and 10 Kg Zn ha^{-1} than the control plot but 5 Kg Zn ha^{-1} applied has a higher number of panicle spike lets per stand than with 7.5 and 10 Kg Zn ha^{-1} applied. The plant girth was also significant with the application of 5 Kg Zn ha^{-1}. While increased in plant height was not affected by the application of Zn fertilizer, but rather shows a decreased in plant height with an increasing order of Zn fertilizer application. The influence of applied Zn on brown rice length (mm) was significant at 5, 7.5 and 10 Kg Zn ha^{-1}. Brown rice width (mm) of rice grain response significantly to 5 Kg Zn ha^{-1} than with 7.5 and 10 Kg Zn ha^{-1} applied. The response of paddy rice yield was significant at ($p < 0.05$) with the application of 5 Kg Zn ha^{-1}. It was observed that at 5kg Zn ha^{-1}grain yield of 10.3 tons was obtained for FARO 44. Almost all the responses were generally high with 5kg Zn ha^{-1} than with 0, 7.5 and 10 kg Zn ha^{-1} respectively.

Key words: Response · Transplanted Irrigated Rice · Applied Zinc · Fadama Soil

INTRODUCTION

Zinc (Zn) is an essential component of various enzyme systems for energy production, protein synthesis and growth regulation. Zinc-deficient plants also exhibit delayed maturity, [1]. This is the most common micronutrient fertilizer applied to rice (*Oryza sativa* L.) in the USA [2]. The application of Zn influences the biosynthesis of indole acetic acid (IAA) thus resulting in flowering and fruitening and also has a positive role in photosynthesis and nitrogen-metabolism. It is well known that a vast array of proteins use Zn for stabilizing their structures in a functional form [3]. Zinc (Zn) deficiency is a serious nutrient constraint to optimal rice productivity. Kanwar and Youngdahl [4] noted that Zn deficiency is the most serious deficiency and is becoming as important as deficiencies of N, P, K and S. In Nigeria, Sillanpaa [5] showed that low Zn contents were more typical in the northern States. Also in a study conducted by the National Special Programme for Food Security reveals that there was wide spread of Zinc deficiency in the north eastern part of Nigeria [6]. The Bureau of Soil

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and Water Management noted important results of soil analysis, primarily Zn deficiency found to be a major cause of low rice yields in the major rice producing provinces such as Iloilo, Cagayan Valley, Nueva Ecija, Bulacan, Camarines Sur and in flooded rice lands in Samar and Leyte, Bicol River Basin and CARAGA rice areas [7].

Fadama soils make up some of the productive agricultural soils in Adamawa State for irrigation agriculture [8]. The importance of these soils to irrigation agriculture and the current void of knowledge on Zinc application by nursery enrichment of Fadama soils in Adamawa State with respect to transplanted irrigated rice prompted this present study in order to enhance sustainable rice production in the Fadama soils. Though zinc sulfate field application is an effective cure for Zinc deficiency, its actual adoption remains sporadic because of genuine constraints on the part of resource-poor rice growers, [9].

The objective of this study is to assess the response of transplanted irrigated rice to applied zinc by nursery enrichment of Fadama soils of Lake Gerio Irrigation Project and to establish Zn nutrient level for optimum rice production in irrigated Fadama soils which is not only imperative but a requirement that will improve the productivity of rice. Rashid *et al.* [10] observed that Preparing Zinc enriched nursery is much easier than field application of Zn, as Zinc sulfate is broadcast applied to a much smaller piece of nursery area compared with much greater puddled rice field area. Also, Zn application to nursery area is 10-times economical compared with its field application because much lesser quantity of zinc sulfate is required per unit rice field area 30kg Zn per acre or 1.5kg Zn per 200m^2.

MATERIALS AND METHODS

Description of the Study Area: The study area was situated at the North-Western part of Jimeta, Yola in Adamawa State, Nigeria. It lies between longitude 12° and 12° 28′ East of Greenwich and Latitude 9°16′ and 9°19′ North of the equator. The area is between 150 and 180m above sea level. It is bounded in North-East by the River Benue, Jimeta in the South West and Namtari Forest Reserve on the West. The study site is under irrigation for crops such as rice, maize and vegetable [11]. The soil in the study site was classified as Typic Topaqual (USDA) or Gleyic Combisol (FAO). The soil geological formation was alluvium [12].

Soil Sampling: Prior to this study, twelve core soil samples were randomly collected from the 0-15cm top-soil and mixed inside a plastic bucket to form a composite and then taken to the laboratory for analysis.

Soil Analysis: The soil sample was air dried, crushed in wooden mortar and sieved with a mesh of 2mm diameter. All soil samples were analysed for pH (1:2.5) soil to water ratio using glass electrode pH meter as described by Bates [13], particle size using hydrometer method as described by Bouyoucos [14], Electrical conductivity, Soil organic carbon using chromic acid oxidation procedure of Walkley and Black [15], available Phosphorus was extracted with 1N NH_4F and 0.5N HCl [16] at the wavelength of 660nm. the Titrimetric method for the determination of Calcium and Magnesium in the soil as described by Black [17], the regular Macro-Kjeldahl Method as described by Black [17], was used for the determination of soil total Nitrogen, Potassium and Sodium was determined in 1N neutral NH_4OAc soil extract using Flame Photometry, Exchangeable acidity (The Titration Method) as described by Mclean [18]. The Diethylene triamine penta acetic acid (0.005M DTPA) [19] and 0.1N HCl [20] method of extracting available Zn in the soil were used concurrently for the determination of available Zn in the soil sample. The soil solution ratio was 1:10 and 1:2 for both HCl and DTPA, respectively. The contents were shaken for 30 minutes and two hours on an orbital shaker. The filtrate was analysed for Zn on an atomic absorption spectrophotometer 210 VG model. The important physical and chemical properties of Fadama soils are given in Table 2.

Field Experiment: Nursery beds was prepared and marked, each (4mx4m) with 0, 5, 7.5 and 10 Zn kgha^{-1} as Zn $So_4.7H_2O$ treatments applied two weeks after emergence. The experimental field was marked out, ploughed, harrowed and bunds constructed. Each experimental plot measured 6*5m. Butatex (herbicide) was applied at the rate of 3Lha^{-1} in order to control weed interference. The Zn nursery enriched seedlings were transplanted, at three seedlings per stand (20cmx15cm) two weeks after treatment in a randomized complete block design replicated three times. Two weeks after transplanting, D D. Force insecticide was applied at the rate of 2Lha^{-1} to control insect interference of the young seedlings. 110kg N ha^{-1}, 60 kg P ha^{-1} and 60 kg K ha^{-1} as NPK and Urea were applied at, early stage (20kg N ha^{-1}), active tillering (45kg N, 40kg P and K ha^{-1}) and panicle initiation (45kg N, 20kg P and K ha^{-1}), respectively.

Data Collection and Analysis: All plant samplings and measurements were confined to the inner rows, excluding the first three boarder rows. The following parameters were taken: number of tillers, number of leaves, plant height (cm), plant girth (mm), panicle, days to 50% heading, brown rice length (mm), brown rice width (mm), 1000grains weight (g) and yield per plot (kg). All the data collected were subjected to analysis of variance and means separated using Duncan's Multiple Range Test at 5% probability level [21].

RESULTS AND DISCUSSION

The effect of applied Zinc by nursery enrichment on the yield and yield components of transplanted irrigated rice is given in table 2 to 6. Transplanted irrigated rice (Faro 44) response to applied Zinc was significant at ($p < 0.05$). It was noted that the number of rice tillers response to applied Zinc was generally high with 5 kg Zn ha^{-1} than with 0, 7.5 and 10 kg Zn ha^{-1}. Table 2 is the result for the effects of treatment on tiller number and 1000 grain weight (g) of rice. It was observed that the results obtained are agreement with those obtained by Chude [22] who noted that the application of Algifol with inorganic fertilizer enhances the number of rice tillers effectively. Although, the number of tillers was enhanced by the application of 5 kg Zn ha^{-1} high rate of dose applied 7.5 and 10 kg Zn ha^{-1} leads to decrease number of tillers in a reverse order, implying that this particular cultivar requires 5kg Zn ha^{-1} for attainment of economic production. It is therefore important to note that Faro 44 respond positively to 5kg Zn ha^{-1} fertilizer rate used in this study.

1000 grain weight (g) response to applied Zinc was significant with the application of 5kg Zn ha^{-1} table 2. This was higher than the 20.5g 1000 grain weight obtained by Chude [22]. Hacisalihoglu and Kochian [23] reviewed the evidence from studies conducted in a range of crops and concluded that efficient Zn utilization in the shoot was of higher importance than rhizosphere processes. Dobermann and Fairhurst [24] maintained that preventing Zn deficiency is an intricate part of general crop management and these could involve broadcasting $ZnSO_4$ in nursery seedbed, Dipping seedlings or presoaking seeds in a 2-4% ZnO suspension (e.g., 20-40 g ZnO L^{-1} H_2O) and maintaining pH 6.5-8.0 - good-quality water. The effect of applied Zinc on days to 50% heading (Table 3) indicates that the application of 5kg Zn ha^{-1} has the tendency of lowering the number of days to heading of this rice variety. The number of leaves was enhanced by the application of 5 and 7.5kg Zn ha^{-1} indicating that

Table 1: Distribution of DTPA/HCl Extractable Zn and other soil properties of Gerio Irrigation Project in Yola North Eastern Nigeria

Properties	Values
DTPA (mg/kg)	2.4
0.1N HCl (mg/kg)	9.1
pH (1:2.5) In H_2O	6.6
Organic Carbon (%)	2.0
%N	0.0448
Bray P (mg/kg)	5.0
ECEC (Meq/100g)	20.2
EC (ms/cm)	0.31
Textural Class	Silty Clay Loam

Table 2: Effects of applied Zn on no. of tillers, 1000 grains weight (g) of rice

	No. of tillers		1000 grains weight (g)	
Kg Zn ha^{-1}	Mean	SE	Mean	SE
0	24.3c	±0.33	24.6c	±0.31
5	31.7a	±0.33	29.5a	±0.33
7.5	29.0b	±0.58	27.2b	±0.60
10	28.0b	±0.58	28.0ab	±0.64
Significance	*		*	

Note: Means with the same letter are not significantly different (Duncan's Multiple Test at P< 0.05)

*: Significant SE: Standard Error

Table 3: Effects of applied Zn on Days to 50% heading and No. of leaves of rice

	Days to 50% heading		No. of leaves	
Kg Zn ha^{-1}	Mean	SE	Mean	SE
0	78a	±0.33	6b	±0.33
5	72c	±0.33	8a	±0.33
7.5	74b	±0.00	8a	±0.33
10	74b	±0.33	6b	±0.33
Significance	*		*	

Note: Means with the same letter are not significantly different (Duncan's Multiple Test at P< 0.05)

*: Significant SE: Standard Error

Table 4: Effects of applied Zn on panicle and plant height, of rice

	Panicle		Plant height (cm)	
Kg Zn ha^{-1}	Mean	SE	Mean	SE
0	10b	±0.33	97a	±0.58
5	13a	±0.33	91.7c	±0.33
7.5	12a	±0.58	94b	±0.58
10	12a	±0.58	96a	±0.58
Significance	*		*	

Note: Means with the same letter are not significantly different (Duncan's Multiple Test at P< 0.05)

*: Significant SE: Standard Error

Table 5: Effects of applied Zn on brown rice length and brown rice width (mm) of rice

	Brown rice length (mm)		Brown rice width (mm)	
Kg Zn ha^{-1}	Mean	SE	Mean	SE
0	7.1b	±0.29	3.3b	±0.18
5	9.8a	±0.15	4.9a	±0.54
7.5	8.7a	±0.22	3.9b	±0.09
10	8.9a	±0.49	3.9b	±0.03
Significance	*		*	

Note: Means with the same letter are not significantly different (Duncan's Multiple Test at P< 0.05)

*: Significant SE: Standard Error

Table 6: Effects of applied Zn on plant girth (mm) yield per plot (kg) of rice

	Plant girth (mm)		Yield per plot (Kg)	
Kg Zn ha^{-1}	Mean	SE	Mean	SE
0	2.3b	±0.06	24.8c	±0.33
5	2.7a	±0.06	30.8a	±0.69
7.5	2.2b	±0.00	28.6b	±0.78
10	2.4b	±0.09	27.9b	±0.29
Significance	*		*	

Note: Means with the same letter are not significantly different (Duncan's Multiple Test at P< 0.05)

*: Significant SE: Standard Error

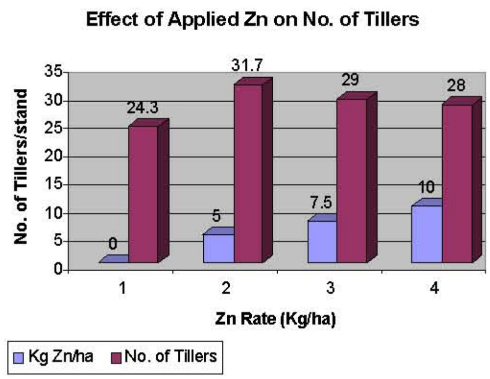
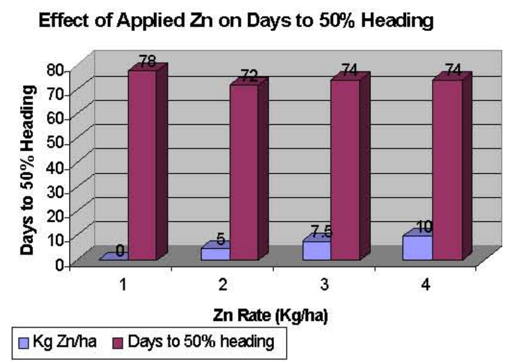


Fig. 1:



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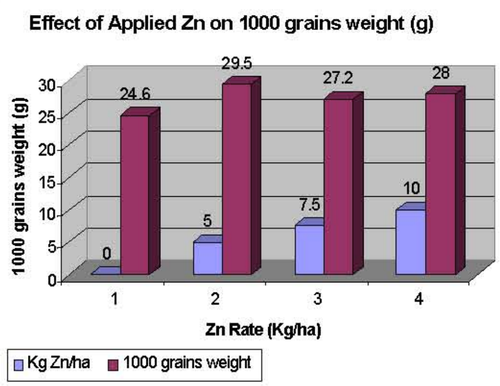

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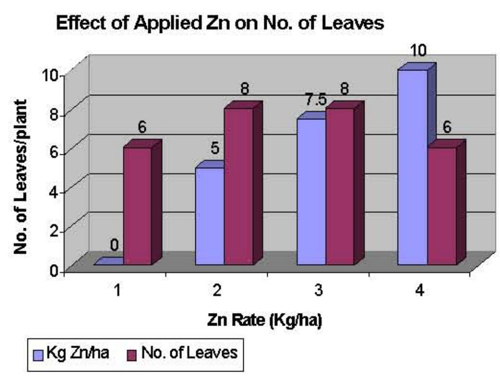


Fig. 4:

the increase in the number of leaves which improves the vegetative growth could enhance the photosynthetic ability of rice leading to high yield. The plant girth was also significant with the application of 5kg Zn ha^{-1}. Increased in plant height was not affected by the application of Zinc fertilizer, but rather shows a decrease in plant height with an increasing order of application (Table 4). The panicle was significant at ($p < 0.05$) with the application of 5kg Zn ha^{-1}. The influence of applied Zinc on brown rice length and width (mm) was noted with the application of 5kg Zn ha^{-1}.

Yield response of rice to applied Zinc was significant at ($p < 0.05$) with the application of 5kg Zn ha^{-1}. The yield response to applied Zinc followed a decreasing pattern with high rate of applied kg Zn ha^{-1}. The soils, though moderate in Zn content, showed an increase in yield and yield components of transplanted irrigated rice (FARO, 44) with applied Zn. Rice grain yield in this study was good (10.3 tons ha^{-1}) in marked contrast to yields of (4.7-5.9 and 6.9-7.5 tons ha^{-1}) reported by Dobermann and Fairhurst [24] and Slaton *et al.* [2] of the same cultivar. In a previous studies, conducted by

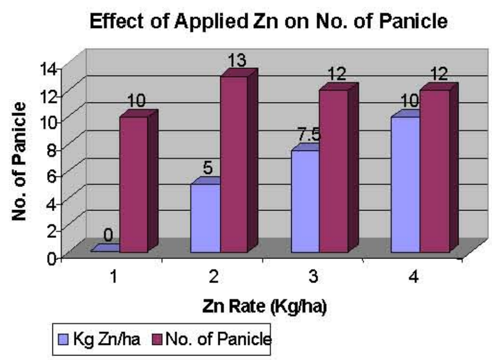
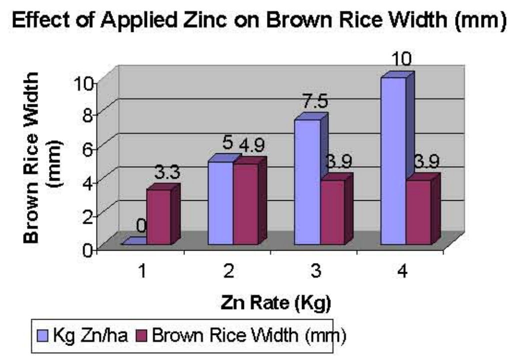


Fig. 5:



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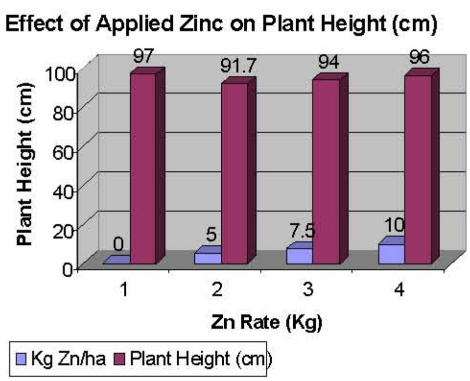
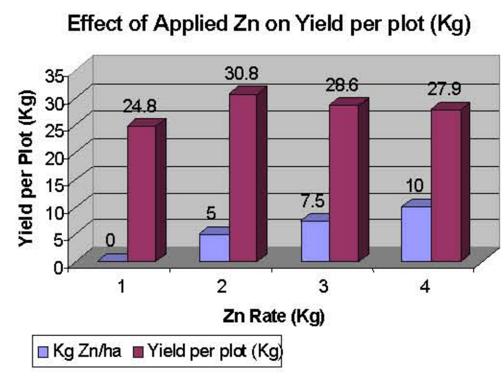


Fig. 6:



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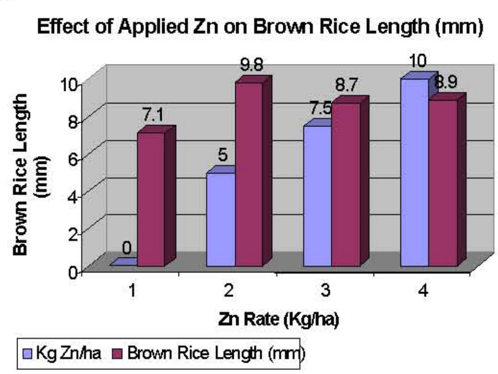

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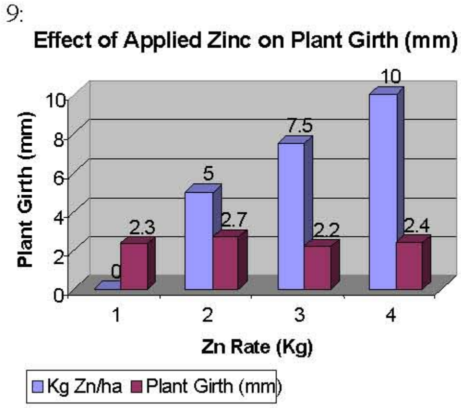

Fig. 10:

Jamala [25], Rashid *et al.* [10]; Slaton *et al.* [2] and, optimum Zinc levels of 30 kg per acre as Zinc sulphate, 1.1 to 2.2 kg Zn ha^{-1} as Zinc spray solutions, 11.2 kg Zn ha^{-1} dry granular Zinc fertilizers broadcast and 5 kg Zn ha^{-1} Zn $So_4.7H_2O$ were reported respectively. The significant increases in grain yield and other yield components due to Zinc application further confirm Zinc as important requirement that affects the productivity of rice, [3, 7, 2].

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