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VARIETAL RESPONSE OF MAIZE TO NITROGEN AND ZINC FERTILIZER IN MINNA SOUTHERN GUINEA SAVANNA OF NIGERIA

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ABSTRACT

A field experiment was conducted in 2018 and 2019 seasons at the Teaching and Research Farm of the Federal University of Technology, Minna to determine the varietal response of maize to nitrogen and zinc fertilizer in Minna. The treatments included four levels of N: 0, 30, 60 and 90 kg ha^{-1}, three levels of Zn: 0, 2.5 and 5 kg ha^{-1} and two varieties of maize (Oba Super 2 and Suwan-1-SR). The experimental design was a 4×3×2 factorial design fitted in a randomized complete block design with three replications. The data collected were, plant height, number of leaves, cob weight, cob length, stover yield, grain yield and 1000 grain weight. All data collected were subjected to analysis of variance and the means were separated using Duncan Multiple Range Test. Highest plant height (43.69 and 44.37 cm) were obtained in 60 and 90 kg N ha^{-1} treatment application respectively in year 2018 at 3 Week After Sowing (WAS), these heights were significantly different from that of control (0 kg N ha^{-1}). Zinc (Zn) fertilization has no significant effect on maize height at all growth stage of maize in year 2018. Application of Zn produced significantly taller plants than those without Zn application at 3 and 9 WAS in 2019. The treatment 60 kg N ha^{-1} had significantly higher yield (27873.7 kg ha^{-1}) than others but similar to 90 kg N ha^{-1} (2512.4 kg ha^{-1}). Application of 60 kg N ha^{-1} increased with 12 % than the 0 kg N ha^{-1} on maize yield in 2019. There was response to Zn fertilization on stover and grain yields. The interaction effects were significant on stover yield. The nitrogen rate of 60 kg N ha^{-1} and the zinc rate of 2.5 kg were optimum for maize grain yield in Minna, both Oba Super 2 and Suwan-1-SR performed better in the study.

Keywords: Varietal, zinc, nitrogen, response, Minna

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INTRODUCTION

Maize is one of the most important grains in Nigeria based on its economic value. It was introduced into Nigeria in the 10th century by the Portuguese (Oladejo and Adetunji, 2012). It is the third most important cereal crop worldwide after wheat and rice (Oladejo and Adetunji, 2012). It is referred to as the cereal of the future for its valuable nutritional facts in human diet (Enyisi *et al.*, 2014).

Maize has been in the diet of Nigerians for centuries. Africans consume maize as a starchy-based food in a wide variety of porridges, pastes, grits, and beer (Eleweanya*et al*., 2005). Green maize (fresh on the cob) is eaten parched, baked, roasted or boiled; playing an important role in filling the hunger gap after the dry season (Olaniyan, 2015). Apart from food, maize is also useful as medicines and as raw materials for industries (Afzal *et al.,* 2009). There is high demand of maize yield due to high market demand for poultry feed. Maize is recognized as highly sensitive to Zn deficiency (Hossain *et al,* 2011). Zinc deficiency is a problem in food crops, causing decreased crop yields and nutritional quality (Cakmak, 2008).

Nitrogen is a vital plant nutrient and a major yield-determining factor required for maize production (Subedi and Ma, 2005). It is also a characteristic constituent element of proteins and also an integral component of many other compounds essential for plant growth processes including chlorophyll and many enzymes. Nitrogen and phosphorus are very essential for good vegetative growth and grain development in maize production.

Zinc is most crucial amongst the micronutrients that take part in plant growth and development due to its catalytic action in metabolism of almost all crops (George and Schmitt, 2002). Deficiency of Zn in soil causes deficiency in crops and altogether this has become problem all over the world with acute zinc deficiency ranges in arid to semi-arid regions of the world (Rashid and Ryan, 2004). Zn plays a major role in chlorophyll development and function, of which most important are the Zn-dependent activity of spp peptidase and the repair process of photo system II by turning over photo damaged D1 protein. (Hansch and Mendel, 2009). Deficiency of Zn reduces growth, tolerance to stress and chlorophy II synthesis (Kawachi, *et al*., 2009; Lee *et al*., 2010). The Zn that is available for plant uptake is in soil solution form, or is adsorbed in a labile form and thus, soil factors that affect its availability to plants are those which control the amount of Zn in soil solution and its sorption – desorption from / into the soil solution (Sharma *et al*., 2013). The objective of this study is to investigate the varietal response of maize to nitrogen and zinc fertilizer in Minna, Nigeria.

MATERIALS AND METHODS

Study Site

The study was conducted at the Teaching and Research Farm, Federal University of Technology Minna, located at latitude 9º 31′ 860′′ N; longitude 6º 27′ 244′′ E, its height is 207.8 m above sea level and is in the southern Guinea savanna of Nigeria. Climate of Minna is sub – humid, rainfall pattern is monomodal with the rainy season starting in April and ending in October. The physical features around Minna consist of gently undulating high plains developed on basement complex rocks made up of granites, migmatites, gneisses and schists. Inselbergs of Older Granites and low hills of schists rise conspicuously above the plains. Beneath the plains, bedrock is deeply weathered and constitutes the major soil parent material (saprolites) (Ojanuga 2006).

Field experiments

The experiments were conducted over two cropping seasons (2018 and 2019).

Treatments and experimental design

The experimental design was 4 x 3 × 2 factorial experiment fitted to a randomized complete block design (RCBD) and with three replications. Treatment comprises of four levels of N, 0, 30, 60, 90 kg Nha^{-1} and three levels of Zn 0, 2.5, 5, kg ha^{-1} with two maize varieties (Oba Super 2 and Suwan-1-SR) resulting in twenty-four treatment combination, each plot size was 4 m × 4 m, the net plot was 9 m^2.

Agronomic practices

The field was manually cleared and ridged at 75 cm apart. Maize variety, Oba super 2 was sowed (2 plants per stand) at 25 cm within the ridge, thinning was done to 1 plant per stand at 2 weeks after sowing (WAS). The N was supplied using NPK 15:15:15 fertilizer and urea and Zn was supplied using $ZnSO_4$ to the required plots. The N was applied in split dose, half at 2 WAS using NPK 15:15:15 while the remaining half was applied at 6 WAS using urea. The Zn was mixed thoroughly with NPK; Fertilizers were applied by side banding.

Soil sampling and analysis.

Surface soil (0–20 cm) samples were collected from eight points along four diagonal transects before the start of the experiment; they were bulked together to form a composite sample to characterize the field. Soil samples collected were air–dried, crushed and sieved with a sieve of 2 mm sieve. The samples were subjected to analysis using standard methods. Soil pH was determined in a 1: 2.5 (soil:water) ratio and 0.1 M $CaCl_2$ using a glass electrode pH meter. Particle size was determined by Bouyocous hydrometer method. Organic carbon was determined using Walkley-Black method (Nelson and Sommers, 1982). Determination of exchangeable bases was done by using ammonium acetate (NH_4OAc) displacement method. Na^+ and K^+ in the extract were determined by flame photometric method, while Ca^{2+} and Mg^{2+} by Na-EDTA titrimetric method. Exchangeable acidity (EA) was by KCl extraction method, the extract was determined by titrimetric method as described by Udol*et al.,* (2009). Available phosphorus extracted with the Bray P 1 method and P in extract determined using spectrophotometer. Total nitrogen was determined by micro-Kjeldhal method (Bremner, 1982). Zinc was extracted using the dilute HCl and Zn in solution was determined by atomic absorption spectrophotometer.

Growth and yield components analysis

Maize plant height: Plant heights were recorded at 3, 6, 9 and 12 WAS by measuring from the soil level of maize plants to the tips of the tallest leaf using meter rule.

Number of leaves: The numbers of leaves were recorded at 3, 6, 9 and 12 WAS by visual counting of the leaves.

Shoot biomass: The maize was cut above ground level in the net plot (9 m^2) at physiological maturity, dried and weighed using weighing balance and the weight was recorded

Cob length: The length of the harvested cobs was measured using meter rule.

Maize grain yield: Maize yield was carried out by harvesting maize ears in the net plot (8 m^2). These were shelled, air-dried and weighed.

Statistical analysis: Analysis of variance (ANOVA) was used to evaluate the treatment effects on data collected. Means separation was carried out where significant differences were observed using Duncan Multiple Range Test (DMRT) at 5 % level of probability using Statistical Analysis System (SAS).

RESULTS AND DISCUSSION

Some Physical and Chemical Properties of the Soil Prior to Planting

The results of the physical and chemical properties of the soil prior to land preparation in 2018 are shown in Table 1. The soil texture was sandy loam, pH was slightly acidic in H_2O, low in organic carbon, available P, total N and the extractable Zn (Esu, 1991). The pH was slightly acidic which was suitable for plant growth as most plant nutrients are available for plant uptake at pH 5.5-6.5 (Brady and Weil, 2002). The low organic carbon content of the soil might be partly attributed to the rapid organic matter mineralization. The extractable Zn was low (Esu, 1991) and below the critical range of 2.0 mg kg $^{-1}$ for extractable Zn established by Sims and Johnson (1991). And also, below the critical level of 2.20 mg kg^{-1} established for some savanna soils by Yusuf *et al* (2005).

Effect of Nitrogen, Zinc and Variety on the Growth of Maize in 2018 and 2019 Seasons

The main effect of N, Zn and variety on the plant height of maize were significant in 2018 and 2019 seasons. At 3 WAS in 2018, 60 and 90 kg N ha^{-1} produced the tallest plant 43.69 and 44.37 cm which was only significantly different from that of 0 kg N ha^{-1}. Application of N produced the taller plant at 6 WAS which was significantly different from others rates. The 30 and 60 kg N ha^{-1} where statistically similar 153.93 cm and 158.29 cm but significantly different from the 0 kg N ha^{-1} (126.49 cm) at 6WAS. The 60 (181.42 cm) and 90 (190.98 cm) kg N ha^{-1} produced the taller plant which were significantly different from the 0 kg N ha^{-1}. Similar result wasobserved at 12 WAS (Table 2). Application of N produced taller plants at 3, 6, 9 and 12 WAS in 2019 which were significantly taller than plants without N fertilization (Table 2). The maize effect of Zn fertilization on the height of maize was not significant at all the growth stages of maize in 2018. Application of Zn produced significantly taller plants than those without Zn application at 3 and 9 WAS in 2019, but at 6 WAS, plants with 5 kg Zn ha^{-1} produced the tallest plant with a height of 119.22 cm which was only significantly from the treatment with 0 kg Zn ha^{-1}. There was significantly different from the variety. The Suwan-1-SR produced tallest plant which was significantly different from Oba Super 2 at all stages of the growth of plant in both 2018 and 2019 except at 12 WAS in 2018 which was significantly similar to each other.

The interaction effect of N and Zn on growth of maize plant was only significant at 9 WAS in 2018 season. The application of Zn at 5 kg Zn ha^{-1}and 60 and 90 kg N ha^{-1} fertilization produced the tallest maize plants (Table 3). Plants with the shortest height of 144.85 cm was obtained with application of 0 kg Zn ha^{-1} and 0 kg N ha^{-1} which was not significantly different from those of 2.5 and 5kg Zn ha^{-1} + 0 kg N ha^{-1} and 30 kg N ha^{-1} + 5kg Zn ha^{-1} in 2018. There was interaction effect between the N and variety at 3 and 6 WAS in 2018 (Table 4). At 3 WAS application of 30 kg N ha^{-1} with Suwan-1-SR produced the taller plant which was significantly different from other combinations except the 90 kg N ha^{-1} with Oba Super 2 and 60 kg N ha^{-1} with Suwan-1-SR. At 6 WAS Application of N irrespective of seasons, the rate and variety were significant taller than 0 kg N ha^{-1} with either of the variety except the 90 kg N ha^{-1} with Oba Super 2 with 148.59 cm.

The main effect of N, Zn and variety on the number of maize leaves in 2018 and 2019 seasons was shown in Table 5. The 30 kg N ha^{-1} produced the highest number of leaves which was significantly different from others at 6 WAS in 2018, similar results was observed at 9 WAS but it is similar to application of 60 kg N ha^{-1}. There were no significantly different at 3 and 9 WAS in 2018. The N produced the highest leaves at 3, 6 and 12 WAS which were significantly different from the 0 kg N ha^{-1} in 2019 (Table 5). The maize effect of Zn fertilization on the number of maize leaves was not significant at all the growth stage of maize in both 2018 and 2019 seasons. The Suwan-1-SRwas significantly different from Oba Super 2 at 3 WAS in 2018 and 3, 6 WAS in 2019. There were no significantly different on number of leaves at 6, 9 and 12 in 2018 and 9 and 12 WAS in 2019.

The interaction effects of both N, Zn and variety on number of leaves was not significant in both years. Zinc has lesser role in the vegetative growth of plant while its requirement is more during reproductive phase in comparison to vegetative growth stage (Dileep, 2013). The same was observed during this experiment. Zinc application improves the growth because zinc is involved directly and indirectly as co-enzyme in photosynthetic process which provide substrate for growth and development (Vallee and Falchuk, 1998). It produced more tillers in similar crop like rice (Moussavi-Nik *et al*., 1997).

Effect of Nitrogen, Zinc and Variety on the Yield of Maize in 2018 and 2019 Seasons

The main effects of N, Zn and variety on the yields of maize in 2018 and 2019 seasons are shown in Table 6. The main effects of N and Zn on grain yield and stover yield of maize were significant in both seasons while cob weight was significant only in 2019 season. The treatment 60 kg N ha^{-1} had significantly higher yield (27873.7 kg ha^{-1}) than others but similar to 90 kg N ha^{-1} (2512.4 kg ha^{-1}). The 90 kg N ha^{-1} was statistically similar to 30 kg N ha^{-1}

(2308.4 kg ha^{-1}) Application of 60 kg N ha^{-1} increased with 12 % than the 0 kg N ha^{-1} on maize yield in 2019. There was similarity between the 30 kg N ha^{-1} and 90 kg N ha^{-1} on grain yield of maize. There was significantly different on the stover yield of maize. The highest rate of application produced significantly higher stover than others both season but similar to that of 60 kg N ha^{-1}. In 2019 maize cobs weight was significantly higher with the 90 kg N ha^{-1} than the 30 kg N ha^{-1} and 0 kg N ha^{-1}. There were no significant differences on cob length and 1000 grain weight in respect to N in both seasons.

Main effects of Zn on both stover and grain yields were only significant in both seasons while the cob weight was significant in 2019. There was response to Zn fertilization by both yields with the 0 kg Zn ha^{-1} treatment providing stover and yields of 2518.8 and 2007.5 kg ha^{-1} respectively in 2018 and 2477.71 and 1402.5 kg ha^{-1} in 2019 which were significantly different from that of those with Zn fertilization. The 5 kg Zn ha^{-1} produced higher cob weight than others in 2019. There was no significant difference on the variety used except in 2019 where the cob weight produced the heaviest weight with application of 5 kg Zn ha^{-1}.

There were interaction effects between the N and Zn, N and V, N, Zn and V on stover yield of maize in 2019.

The interaction effects of nitrogen and zinc on stover yield in 2019 season in Minna was shown in Table 7. Application of 90 kg N ha^{-1} and 5 kg Zn ha^{-1} produced the heaviest weight (4083.3 kg ha^{-1}) which was significantly different from other treatment combinations. The treatment combination of 90 kg N ha^{-1} + 2.5 kg Zn ha^{-1} were similar to 60 kg N ha^{-1} + 5 kg Zn ha^{-1} and 30 kg N ha^{-1} + 2.5 kg Zn ha^{-1}. The interaction effects of nitrogen and variety in 2019 was shown in Table 8. Application of 90 kg N ha^{-1} with Suwan-1-SR produced the stover yield of 3455.80 kg ha^{-1} which was significantly higher than 0 kg N ha^{-1} with either Oba Super 2 or Suwan-1-SR. The interaction effects of nitrogen, zinc and variety on stover yield in 2019 in Minna. The 90 kg N ha^{-1} + 5 kg Zn ha^{-1} with Suwan-1-SR produced significantly higher stover yield than other treatment combinations but similar to the 30 kg N ha^{-1} + 2.5 kg Zn ha^{-1} with Suwan-1-SR (Table 9). Grain yield increased with the application of Zn as reported by Morshedi and Farahbakhsh (2010) and Bashir *et al.,* (2012). They also attributed the superior yield attributes with the application of $ZnSO_4$ ha^{-1} and more translocation of photosynthate towards sink. The increase in these parameters might be due to involvement of zinc in various enzymatic processes which helps in catalyzing reaction for growth finally leading to development of more yield attributing character.

Sharma *et al.,* (1992) reported that the seed yield of maize increased by 11.4% up to Zn levels from 0 to 9 kg Zn/ha. Similar result was also reported by Cakmak*et al.* (1997) with other crops like rye, triticale, bread and durum wheats increase due to application of Zn.

There was clear evidence that N nutrition was a major constraint to maize production (Yusuf *et al*., 2009). Lawal *et al.,* (2013) reported that application of N fertilizer increased maize yield in the Guinea savanna. Adeboye*et al*., (2009) also reported that 90 kg N ha^{-1} to be optimum for maize in the area. In the West African savannas, 60 to 120 kg N ha^{-1} had been recommended by Carsky and Iwuafor (1999). Onasanya*et al.,* (2009) attributed an increase in the growth of the maize plant to N fertilizer application.

CONCLUSION

The result of this study established the response of maize to inorganic nitrogen and zinc fertilizer application. Nitrogen and zinc application to maize is therefore required for optimum yield. 90 kg N ha^{-1} improved the growth in both 2018 and 2019 seasons. Suwan-1-SR performed better in term of growth and 5 kg Zn ha^{-1} also increased the plant height in 2019. In addition, the nitrogen rate of 60 kg N ha^{-1} and the zinc rate of 2.5 kg were optimum for maize grain yield in Minna. Both Oba Super 2 and Suwan-1-SR performed better in the study.

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APPENDIX

Table 1: Some soil physical and chemical properties before sowing

Parameters	Values
Sand	768
Silt (g kg^{-1})	79
Clay (g kg^{-1})	153
Textural class	Sandy loam
Soil pH (H_2O)	5.22
Soil pH ($CaCl_2$)	4.27
Total nitrogen (g kg^{-1})	0.10
Organic carbon (g kg^{-1})	3.56
Available phosphorous (mg kg^{-1})	6
Exchangeable bases (cmol kg^{-1})	
Ca	1.68
Mg	0.03
K	0.31
Na	0.08
Exchangeable acidity (cmol kg^{-1})	0.12
ECEC	2.22
Zinc (mg kg^{-1})	1.34

Means for same column and factor followed by the same letter are not significantly different at 5 % level of probability.

Table 2: Effects of nitrogen zinc and variety on plant height of maize in 2018 and 2019

	2018				2019			
	3WAS	6 WAS	9 WAS	12 WAS	3WAS	6 WAS	9 WAS	12 WAS
Nitrogen (N)								
0	40.14b	126.49c	148.49c	164.77b	38.37b	81.45b	181.94b	209.49b
30	44.37a	153.93b	172.64b	200.82a	99.33a	123.67a	202.73a	226.04ab
60	41.14ab	158.29b	181.42ab	194.27a	103.51a	124.99a	209.84a	230.43a
90	44.37a	177.70a	190.98a	172.57b	104.92a	122.21a	214.17a	242.79a
SE±	1.25	6.19	4.85	6.00	4.36	5.45	6.89	6.65
Zinc (Z)								

0	41.67a	151.51a	172.44a	177.85a	80.54b	109.10b	199.28b	222.55a
2.5	42.06a	157.23a	174.48a	186.85a	91.71a	110.92ab	206.30a	233.81a
5	43.27a	153.57a	173.23a	185.49a	99.54a	119.22a	200.94a	225.20a
SE±	1.15	6.57	5.34	6.10	4.93	5.99	6.24	6.08
Variety (V)								
Oba Super 2	39.36b	147.49b	163.79b	178.04a	80.12b	96.23b	192.12b	217.57b
Suwan-1-SR	45.31a	160.71a	182.98a	188.54a	106.94a	129.93a	212.22a	236.81a
SE±	0.79	5.29	4.03	4.92	3.39	4.03	4.99	4.79
Interraction								
NxZ	NS	NS	*	NS	NS	NS	NS	NS
NxV	*	*	NS	NS	NS	NS	NS	NS
ZxV	NS	NS	NS	NS	NS	NS	NS	NS
NxZxV	NS	NS	NS	NS	NS	NS	NS	NS

WAS- Weeks After Sowing; * Significant at 5 % level of probability, NS- Not Significant

Table 3: Interaction effects of nitrogen and zinc on plant height in 2018 at 9 weeks after sowing season in Minna

	Zinc	Plant height (cm)
0	0	144.85e
0	2.5	154.30cde
0	5	146.33de
30	0	175.82abc
30	2.5	191.17ab
30	5	169.51bcde
60	0	170.62abcde
60	2.5	198.48a
60	5	193.77ab
90	0	183.30ab
90	2.5	193.77ab
90	5	179.87abc

Means in a column followed by the same letters are not significantly different at 5% level of probability.

Table 4: Interaction effects of nitrogen and variety on plant height at 3 and 6 weeks after sowing in Minna 2018

	3 weeks after sowing		6 weeks after sowing	
Nitrogen	Oba super 2	Suwan-1-SR	Oba super 2	Suwan-1-SR
0	37.20d	38.62cd	122.31d	130.66dc
30	40.12cd	45.79ab	168.45ab	186.96a
60	40.10cd	48.64a	158.25abc	158.32abc
90	45.07ab	42.44bc	148.59bcd	160.62ab

WAS- weeks after sowing

Means in a column or row followed by the same letters are not significantly different at 5% level of probability.

Table 5: Effects of nitrogen zinc and variety on number of leaves of maize in 2018 and 2019

	2018 Weeks after sowing				2019 Weeks after sowing			
	3	6	9	12	3	6	9	12
0	6.67a	10.21c	11.09c	11.86a	6.71b	8.61b	12.13a	12.82b
30	6.81a	12.16a	12.25a	12.67a	8.93a	10.50a	12.91a	13.23ab
60	6.76a	11.18b	11.84ab	12.25a	9.32a	10.86a	12.34a	14.22a
90	6.65a	10.60bc	11.33bc	11.86a	8.93a	10.91a	12.13a	14.25a
SE±	0.22	0.29	0.22	0.25	0.30	0.33	0.27	0.31
Zinc (Z)								
0	6.78a	11.00a	11.64a	12.28a	8.22a	10.31a	12.34a	13.54a
2.5	6.63a	11.37a	11.81a	12.32a	8.43a	10.32a	12.34a	13.81a
5	6.74a	10.75a	11.42a	11.98a	8.71a	10.52a	12.64a	14.00a
SE±	0.14	0.29	0.20	0.15	0.33	0.34	0.24	0.35
Variety(V)								
Oba Super 2	6.41b	11.26a	11.72a	12.31a	7.86b	9.39b	12.33a	13.62a
Suwan-1-SR	7.03a	10.81a	11.52a	12.07a	9.04a	10.96a	12.52a	14.00a
SE±	0.10	0.23	0.17	0.18	0.25	0.26	0.27	0.20
Interraction								
NxZ	NS	NS	NS	NS	NS	NS	NS	NS
NxV	NS	NS	NS	NS	NS	NS	NS	NS
ZxV	NS	NS	NS	NS	NS	NS	NS	NS
NxZxV	NS	NS	NS	NS	NS	NS	NS	NS

Means for same column and factor followed by the same letter are not significantly different at 5 % level of probability.

NS- Not Significant

Table 6: Effects of nitrogen zinc and variety on yield of maize in Minna in 2018 and 2019 seasons

	2018					2019				
	Cob Length (cm)	1000 grain weight (g)	Grain yield (kg/ha)	Cob weight (kg/ha)	Stover yield (kg/ha)	Cob Length (cm)	1000 grain weight (g)	Grain yield (kg/ha)	Cob weight (kg/ha)	Stover yield (kg/ha)
Nitrogen (N)										
0	12.94a	417.84a	1895.8c	379a	2302.1c	11.26a	397.15b	1747.20c	336b	1953.51c
30	12.57a	429.20a	2308.4b	383a	2654.2bc	13.39a	434.77a	2375.71b	391b	2737.31b
60	13.29a	436.18a	2783.7a	450a	2839.7ab	14.65a	443.80a	2867.11a	463ab	2904.12ab
90	24.15a	430.81a	2512.4ab	2933a	3145.8a	25.38a	438.46a	2593.2ab	1938.12a	3326.71a
SE±	3.10	12.63	144.39	652.62	170.71	3.08	12.61	144.60	25.76	170.82
Zinc (Z)										
0	13.22a	446.83a	2007.5b	2312a	2518.8b	13.48a	418.07a	1402.51b	399c	2477.71b
2.5	12.70a	417.60a	2426.6a	396a	2685.9b	13.23a	445.89a	2430.72a	406b	2660.13a
5	21.29a	421.09a	2441.2a	400a	3001.6a	21.82a	421.67a	2484.11a	1291.11a	2978.52a
SE±	3.00	10.65	135.79	647.03	155.03	3.07	11.22	152.04	21.27	171.58
Variety (V)										
Oba Super 2	18.62a	422.34a	2374.5a	400a	2616.7a	19.06a	422.38a	2345.21a	401.21b	2586.00a
Suwan-1-SR	12.85a	434.67a	2475.7a	1672a	2854.2a	13.28a	434.71a	2446.31a	1062.42a	2824.80a
SE±	2.90	8.85	109.95	643.26	129.00	2.96	9.24	122.73	19.18	142.38
Interraction										
NxZ	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
NxV	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
ZxV	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
NxZxV	NS	NS	NS	NS	NS	NS	NS	NS	NS	*

Means for same column and factor followed by the same subscript letters are not significantly different at 5 % level of probability.
NS- Not Significant

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Table 7: Interaction effects of nitrogen and zinc on stover yield in 2019 season in Minna

Nitrogen	Zinc	Stover yield (kg/ha)
0	0	1812.50d
0	2.5	1850.0d
0	5	2197.9cd
30	0	2701.5bcd
30	2.5	3248.4b
30	5	2762.1bcd
60	0	2695.8bcd
60	2.5	2645.80bcd
60	5	2870.8bc
90	0	2700.8bcd
90	2.5	2895.8bc
90	5	4083.3a
SE±		265.36

Means in a column followed by the same subscript letters are not significantly different at 5% level of probability.

Table 8: Interaction effects of nitrogen and variety on stover yield in 2019 season in Minna

Nitrogen	Variety	Stover yield (kg/ha)
0	Oba Super 2	1630.50c
0	Suwan-1-SR	2276.40bc
30	Oba Super 2	2803.50ab
30	Suwan-1-SR	3004.60ab
60	Oba Super 2	2912.50ab
60	Suwan-1-SR	2562.50b
90	Oba Super 2	2997.50ab
90	Suwan-1-SR	3455.80a
SE±		225.47

Means in a column followed by the same letters are not significantly different at 5% level of probability.

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Table 9: Interaction effects of nitrogen zinc and variety on stover yield in 2019 season in Minna

Nitrogen	Zinc	Variety	Stover yield (kg/ha)
0	0	Oba Super 2	1000.0h
0	2.5	Oba Super 2	1412.5gh
0	5	Oba Super 2	2479.1def
0	0	Suwan-1-SR	2625.0cdef
0	2.5	Suwan-1-SR	2287.5defg
0	5	Suwan-1-SR	1916.6fg
30	0	Oba Super 2	2773.0cdef
30	2.5	Oba Super 2	2562.5cdef
30	5	Oba Super 2	3075.0bcde
30	0	Suwan-1-SR	2630.0cdef
30	2.5	Suwan-1-SR	3934.7ab
30	5	Suwan-1-SR	2449.1def
60	0	Oba Super 2	3183.3bcde
60	2.5	Oba Super 2	2270.8defg
60	5	Oba Super 2	3283.3bcd
60	0	Suwan-1-SR	2208.3efg
60	2.5	Suwan-1-SR	3020.8bcde
60	5	Suwan-1-SR	2458.3def
90	0	Oba Super 2	2825.8cdef
90	2.5	Oba Super 2	2583.3cdef
90	5	Oba Super 2	3583.3bc
90	0	Suwan-1-SR	2575.8cdef
90	2.5	Suwan-1-SR	3208.3bcde
90	5	Suwan-1-SR	4583.3a
SE±			237.34

Means in a column followed by the same subscript letters are not significantly different at 5% level of probability.