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## Growth and yield response of streak virus resistant maize (TZESR-W) to different nitrogen rates on a sandy loam soil of semi-arid region of Nigeria

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### Abstract

Field experiments were conducted at Abubakar Tafawa Balewa University Research Farm, Bauchi during the 1992 and 1993 cropping seasons to investigate the “Growth and yield response of streak virus resistant maize (TZESR-W) to different N rates on a sandy loam soil of semi-arid region of Nigeria”. Experimental treatments consisted of seven rates of N (0, 50, 100, 150, 200, 250 and 300 KgN/ha) and optimum levels of P (17.5 Kg/ha) and K (50 Kg/ha) applied as base rates. These were tested in a randomized complete block design with 3 replications. N was split applied by side dressing in two equal doses: half at two weeks after sowing and the other half at 5 weeks after sowing. Experimental results revealed that the application of N fertilizer up to 100 KgN/ha significantly increased the maize plant height, number of cobs, cob length, cob girth, cob weight, grain yield, stover yield and percent N in grain and stover over the absolute control in both 1992 and 1993 cropping seasons. In other words, the application of N fertilizer beyond 100 KgN/ha was not significant when compared with the absolute control. On the other hand, shelling percentage, 1000-grain weight and N uptake by stover were not significantly affected by N fertilizer application. This study therefore suggested that maize (TZESR-W) could be grown on a sandy loam soil of semi-arid region of Nigeria with the application of 100 KgN/ha, 17.5 KgP/ha and 50 KgK/ha. Application of N fertilizer beyond 100 KgN/ha on TZESR-W is a waste of resources.

**Keywords:** Maize; Nitrogen; Soil; Arid

### 1. Introduction

Nitrogen is one of the main limiting factors of maize production in the savanna zones of Nigeria. Normally, maize do well on deep, well drained loamy soils which are rich in organic matter and nitrogen. Effect of N during vegetative growth appears to be more pronounced on maize stalk and final plant height is normally reduced in the absence of N. [1] (Kaltungo, 1995). [2] Balasubramanian *et al*, (1978) observed that maize crop failed to produce worthwhile grain in the absence of N fertilization in Samaru, Nigeria. They also observed that maize is a potentially high yielding crop especially under optimum management conditions; its demand for N is therefore higher than other cereals.

Work on nitrogen fertilization of maize carried out in the past indicated that maize cultivation in the savanna zones of Nigeria requires the application of 120 KgN/ha to 150 KgN/ha [3] (Olugunde 1981) but with the development of new early maturing varieties especially streak virus resistant, it has become pertinent to work out agronomic and nutritional requirements of maize in the savanna zone of Nigeria. In view of the above, the present study was undertaken as a first step to work out the N requirement of new streak virus resistant variety of maize under optimum level of applied P and K [1].

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## 2. Material and methods

Field experiments were conducted during the 1992 and 1993 raining seasons (June to October) at Abubakar Tafawa Balewa University Research Farm at Bauchi, Nigeria. There were 7 levels of N (0, 50,100,150,200,250 and 300 KgN/ha) and an absolute control plot arranged in a randomized complete block design with 3 replications.

After ploughing and harrowing, the field was marked out into plots of 26.25m<sup>2</sup> (5.25mx5.0m) each. Before harrowing the field, a uniform does of P and K at the rate of 17.5 KgP and 50 KgK/ha respectively were applied to all the plots with the exception of the absolute control plots. Maize variety TZESR-W (an improved white maize variety) was sown on 10<sup>th</sup> and 2<sup>nd</sup> July in 1992 and 1993 wet seasons respectively following a row to row and plant to plant spacing of 75cm and 25cm respectively. No cropping activity was done in between the two maize seasons.

Nitrogen through urea was applied in two equal split doses: one at 2 weeks after sowing and the second at 5 weeks after sowing as side dressing. Normal weeding and hoeing were carried out manually to keep the field free of weeds. Before applying fertilizer, composite soil samples at 0-15cm and 15-30cm depths were collected randomly from the experimental fields in both 1992 and 1993 to find out the initial soil test values. Soil samples so collected were analyzed for physico-chemical properties following the conventional methods of soil analysis.

Data on plant growth such as plant height was taken at different intervals [35, 65 and 102 days after sowing (DAS)] and increase in plant height per day was calculated.

Yield data and other characteristics such as cob length, cob girth, cob weight, shelling percentage and 1000-grain weight were measured and calculated from the samples taken from the net harvested area of 12m<sup>2</sup>. Cob length and cob girth were measured using venire calipers. Shelling % was calculated by dividing the grain weight by cob weight and the product is multiplied by 100.

Grain and stover yields were calculated and recorded from the net plot harvested for each treatment. Samples of grain and stover were taken in 1993 only for the analysis of N and N uptake. Nitrogen in grain and stover was determined using microkjeldahl distillation procedure.

## 3. Results and discussion

### 3.1. Soil characteristics

**Table 1** Physico-chemical Properties of the Soils of the Experimental site during 1992 and 1993 Cropping seasons at Bauchi, Nigeria.

Soil Parameters	1992		1993	
	Soil Depth (cm)		Soil Depth (cm)	
	0-15	15-30	0-15	15-30
<b>Mechanical Analysis</b>				
Sand (%)	74	71	67	65
Silt (%)	11	12	14	16
Clay (%)	15	17	19	19
<b>Textural class</b>	<b>Sandy -Loam</b>		<b>Sandy -Loam</b>	
<b>Chemical analysis</b>				
PH(1:1 Soil: water suspension)	6.0	6.30	6.72	6.19
Organic Carbon(%)	0.68	0.24	0.54	0.40
Total-N(%)	0.053	0.035	0.099	0.088
C/N ration	12.83	6.85	5.46	4.55
Available-P(ppm)(Bray-1	4.51	4.53	9.15	9.03
<b>Exchangeable cations(meq/100g)</b>				
Ca	3.49	4.15	3.19	3.76
Mg	0.93	1.17	0.95	1.05
K	0.24	0.19	0.21	0.15
Na	0.11	0.18	0.15	0.13
CEC(Meq/100g)	4.77	5.69	4.50	5.09

Soil of the experimental site is sandy loam in texture with no marked differences in sand, silt and clay content in between 0-15 and 15-30 cm depths (Table 1). Soil reaction (pH) is 7.2 with low organic carbon and total nitrogen content. Available P during 1992 season was lower than in 1993. Relatively high level of available P in the experimental plot of 1993 (Table1) is primarily due to the high levels of P fertilization from soybean crop previously grown in the area. Cation exchange capacity of the soil is low; the dominant Cation in both the soil depths is calcium (Table1).

### 3.2. Plant Height

Plant Height as influenced by N fertilizer application is presented in Table 2. The result indicated that plant height of maize was significantly affected by N fertilizer application at all stages of sampling (35, 63 and 102 days after sowing) when compared with the absolute control in both 1992 and 1993 seasons. Moreover, the result showed that the application of N fertilizer up to 100KgN/ha with 17.5KgP/ha and 50KgK/ha resulted in taller plants when compared with the absolute control. It was also observed that plant heights of the maize plant increased with the age of the plant, as plant height at 102 DAS was taller than at 63 DAS. Similarly, plant height at 63 DAS was taller than plant height at 35 DAS.

The study went further to calculate increased in plant height per day. Thus, it was observed that increase in plant height per day as influenced by N fertilizer application, was more pronounced between 35 and 63 DAS and low between 63 and 102 DAS. This observation indicated that vegetative growth was maximum up to 63 DAS and later on it slowed down and nutrients absorbed were utilized for reproductive phase of development. Results obtained by [4]El-Sharkaway *et al*, (1976) and [5] Adetiloye *et al*, (1984) indicated that plant heights consistently reduced in the absence of applied N and that N is required mostly in the early part of the plant life cycle.

**Table 2** Effects of N on Plant Height (cm) and increase in Plant Height per day (cm) at various stages of Maize Growth during 1992 and 1993 Cropping Seasons

Treatment (Kg/ha)	Plant Height(cm) 1992			Plant Height(cm) 1993		
	35 DAS	63 DAS	102 DAS (Harvest)	35 DAS	63 DAS	102 DAS (Harvest)
T <sub>0</sub> -Absolute Control (no N,P and K)	0.63 (1.80)	1.69	1.72	0.40 (1.14)	1.19	1.83
T <sub>1</sub> - Control (only P and K)	0.68 (1.94)	1.95	2.21	0.51 (1.46)	1.39	2.09
T <sub>2</sub> -N <sub>50</sub> +T <sub>1</sub>	0.82 (2.34)	2.20	2.56	0.65 (1.86)	2.03	2.60
T <sub>3</sub> -N <sub>100</sub> +T <sub>1</sub>	0.84 (2.40)	2.35	2.75	0.79 (2.26)	2.13	2.88
T <sub>4</sub> -N <sub>150</sub> +T <sub>1</sub>	0.81 (2.31)	2.09	2.51	0.72 (2.06)	1.94	2.53
T <sub>5</sub> -N <sub>200</sub> +T <sub>1</sub>	0.83 (2.37)	2.34	2.60	0.74 (2.11)	1.98	2.49
T <sub>6</sub> -N <sub>250</sub> +T <sub>1</sub>	0.88 (2.51)	2.47	2.56	0.79 (2.26)	1.96	2.50
T <sub>7</sub> -N <sub>300</sub> +T <sub>1</sub>	0.86 (2.41)	2.42	2.50	0.80 (2.29)	1.92	2.61
SE	0.06	0.13	0.11	0.15	0.14	0.13
LSD(0.05)	0.18	0.36	0.32	0.43	0.39	0.37

Figures in parenthesis are increase in height in cm per day

### 3.3. Cob Length and Cob Girth

Data on cob length and cob girth of maize is presented in Table 3. The data indicated that cob length and cob girth of maize was significantly increased with the application of N fertilizers over the absolute control. The result also indicated that the application of N fertilizer up to 100KgN/ha significantly increased the length and girth of maize in 1992; beyond this level, the increase was not significant.[6] Nimje and Seth (1988) and [7] Bataev *et al*, (1991) had earlier reported increase in cob size with the application of N levels.

**Table 3** Effect of N on Cob Length and Cob Girth during 1992 and 1993 Cropping Seasons

Treatment (Kg/ha)	Mean Cob Length(cm)		Mean Cob Girth(cm)	
	1992	1993	1992	1993
To-Absolute Control (no N,P and K)	10.8	8.7	10.6	8.9
T1-Control (only P and K)	12.8	9.3	12.9	7.9
T2-N50+T1	14.7	14.4	13.9	12.9
T3-N100+T1	16.7	12.6	14.6	12.3
T4-N150+T1	15.4	12.2	13.9	11.9
T5-N200+T1	16.1	11.9	13.6	11.6
T6-N250+T1	17.1	14.3	14.6	13.0
T7-N300+T1	16.5	14.5	14.4	12.5
SE	0.74	1.41	0.59	1.41
LSD(0.05)	2.05	4.00	1.60	4.10

T<sub>1</sub>=17.5 KgP+50 KgK/ha

### 3.4. Cob Weight, Shelling Percentage and 1000-grain weight

Table 4 is data on cob weight, shelling percentage and 1000-grain weight of maize in 1992 and 1993. The data indicated that the application of N fertilizer up to 100 kgN/ha significantly increased the cob weight of maize (TZESR-W) when compared with the no N control. The application of N beyond 100kgN/ha on cob weight was not significant. The earlier study of [4] El-Sharkaway *et al*, (1976) and [8] Gagro (1977) revealed that application of N beyond 150 KgN/ha will not increase cob weight significantly.

**Table 4** Effect of N on Cob Weight, Shelling Percentage and 1000-Grain Weight during 1992 and 1993 Cropping Seasons.

Treatment (Kg/ha)	Cob Weight (Kg/ha)		Shelling Percent (%)		1000-Grain Weight (g)	
	1992	1993	1992	1993	1992	1993
To-Absolute Control (no N,P and K)	1667	1667	87.7	73.2	138.7	173.8
T1-Control (only P and K)	1833	1916	79.2	68.2	211.6	193.8
T2-N50+T1	2750	3250	87.5	208.9	208.9	193.9
T3-N100+T1	4667	4833	79.1	73.6	222.4	206.8
T4-N150+T1	4250	4750	87.2	68.2	212.9	109.7
T5-N200+T1	5767	4417	801.1	65.0	234.4	217.4
T6-N250+T1	5333	4750	87.3	80.4	229.2	203.5
T7-N300+T1	5416	4917	85.2	81.7	217.4	209.1
SE	468	101	3.5	5.8	8.0	12.3
LSD(0.05)	1298	303	10.3	16.0	22.6	36.1

T<sub>1</sub>=17.5 KgP+50 KgK/ha

Shelling percentage was not affected significantly with the application of fertilizer (Table 4). The application of N fertilizer with basal amounts of P and K resulted to increase in 1000-grain weight over the absolute control, but statistical analysis has shown that the increase was not significant (Table 4). On the contrary, it was observed [4] that 1000-grain weight of maize increased significantly with the increase levels of N.

### 3.5. Grain and Stover Yield

Result of grains and stover yield presented in table 5 indicated that there was significant increase in grain yield due to N application over no N application as well as over the absolute control. The increase in grain yield was significant only up to 100 KgN/ha in both 1992 and 1993, beyond this level of N, the increase in yield of grain was no significant. Similarly, the application of N fertilizer increased stover yield significantly up to 50 KgN/ha in 1992 and 150 KgN/ha in 1993. However, [9] Subhan (1997) reported a significant stover yield increase with the application of 300 KgN/ha. The result of this study therefore indicated that N fertilizer application is necessary if maize is grown for grain or stover, and that maximum grain yield of maize could be obtained at 100 KgN/ha in the semi- arid region of Nigeria. It is worthwhile to mentioned that N fertilizer recommendation for maize production in the savanna zone of Nigeria was 100 KgN/ha [10] (IAR, 1983), but there has been reports that sole maize crop will respond significantly up to 120-150 KgN/ha in Northern Nigeria [3].

**Table 5** Effect of N on Grain and Stover Yield of Maize during 1992 and 1993 Cropping Seasons

Treatment (Kg/ha)	Grain Yield (Kg/ha)		Stover Yield (Kg/ha)	
	1992	1993	1992	1993
To-Absolute Control (no N,P and K)	1455	750	3750	2917
T1-Control (only P and K)	1483	1833	4583	4583
T2-N50+T1	2383	2417	6417	5416
T3-N100+T1	3592	3583	7500	6017
T4-N150+T1	3975	3600	7139	6119
T5-N200+T1	4208	3983	7083	6250
T6-N250+T1	4692	3833	7000	6250
T7-N300+T1	4608	4000	6667	5667
SE	570	347	620	440
LSD(0.05)	1580	1123	1719	1220

T<sub>1</sub>=17.5 KgP+50 KgK/ha

### 3.6. Nitrogen Uptake by Grain and Stover of Maize

Data on N percent in grain and Stover and total N uptake is presented in Table 6. Statistical analysis of the data indicated that there was significant increase in grain N with the application of N up to 150 KgN/ha when compared with the no N application. The result of this study supports the result of the experiments of [11] Rhoads and Stanley (1981) who reported that N concentration in grains tended to increase with increases in rates of N application. The result of this experiment also agreed with the reports of [12] Thiraporn *et al*, (1992) who stated that grain N increased in response to N fertilization up to 160 KgN/ha.

The result this study has shown that application of N fertilizer did not increased significantly the N content of Maize Stover (Table 6). The study also indicated that about one-third of N was present in the stover whereas the remaining two-third was present in the grain. Earlier reports of [13] Singh and Balasubramanian (1983) revealed that about 25% N was present in the stover, 50% in the grain and the remaining 25% in the root system.

The study has therefore revealed that any time chemical fertilizer is applied to the soil some quantity is removed from the soil by plant roots and translocated to the plant for vegetative growth and grain formation. From this study, one-third of N was removed from the soil and stored in the Stover, and about two-third of N was stored in the grain. This means that more N is needed in grain formation than in vegetative growth phase of maize. Moreover, since N uptake by maize has revealed that certain quantity of N is found in the Stover, the return of this Stover to the soil during land preparation means the return of N to the soil from the Stover after its mineralization.

**Table 6** Effect of N on percent N content in Grain and Stover of maize and total uptake (kg/ha) during 1993 growing seasons

Treatment (Kg/ha)	Percent N		N Uptake(Kg/ha)		Total N uptake(Kg/ha)
	Grain	Stover	Grain	Stover	(grain + stover)
To-Absolute Control (no N,P and K)	0.61	0.47	4.6	13.7	18.3
T1- Control (only P and K)	1.60	0.58	29.3	26.6	55.9
T2-N50+T1	1.66	0.49	40.1	26.5	66.6
T3-N100+T1	1.70	0.56	60.9	31.3	92.2
T4-N150+T1	1.81	0.58	65.2	34.9	100.1
T5-N200+T1	1.63	0.58	65.0	36.3	101.3
T6-N250+T1	1.65	0.53	63.2	33.1	96.3
T7-N300+T1	1.35	0.51	59.0	28.9	82.9
SE	0.04	0.06	4.6	5.6	6.7
LSD(0.05)	0.13	0.17	22.5	14.2	35.4

T<sub>1</sub>=17.5 KgP+50 KgK/ha

### 3 Conclusion

The use of nitrogen fertilizer application for optimum yields of maize in the savanna zone of Nigeria has become necessary because the continuous cropping system practice in the savanna has rendered the soil less productive when no fertilizers are applied. Previous study on N nutrition of maize in the savanna zone of Nigeria had reported that maize requires about 120-150 KgN/ha but with the release of improved varieties of maize particularly TZESR-W, it has become pertinent to work out its N requirement in the semi-arid region of Nigeria. The result of this investigation therefore revealed that the maize crop, TZESR-W, responded to N fertilizer application up to 100 Kg N/ha resulting in significant increase in maize plant height (at all stages of sampling), cob length, cob girth, grain yield and dry cob weight (after harvest) when compared with the absolute control in both 1992 and 1993. Furthermore, stover yield of maize and nutrient concentration in grain were also significantly affected by N application. In conclusion, this study revealed that N fertilization is imperative for maize cultivation in the semi- arid region. Thus, any maize cultivation that does not include the application of N would result to a decrease in vegetative growth and subsequently the final yield of maize grain and stover.

### Compliance with ethical standards

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#### Disclosure of conflict of interest

There is no conflict of interest among the authors.

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