Agrosearch (2006) 8 No. 1 13 - 25

COMPARATIVE LEAF GROWTH AND GRAIN YIELD RESPONSES OF HYBRID AND OPEN-POLLINATED MAIZE GENOTYPES TO NITROGEN FERTILIZER APPLICATION

ABAYOMI, Y. A ARIJENJA-GEORGE A. and KOLAWOLE, I. A.
Department of Agronomy, University of Ilorin, Ilorin. Nigeria

ABSTRACT:

Field experiment was conducted at the Teaching and Research Farm of the Faculty of Agriculture, University of Ilorin, Bolorunduro (8^o 29'N, 4^o 35'E) in the southern Guinea savanna of Nigeria, to compare the leaf growth and grain yield responses of hybrid and open-pollinated maize genotypes to nitrogen fertilizer application. Extension growth of leaves at nodes 5 to 15 on the plant was measured at 4 day intervals from emergence until maximum length of each was attained. Rates and duration of leaf extension at each node were determined from linear regression of leaf length against the chronological time in days after planting. Grain yield and yield components were determined at maturity. Application of N fertilizer had greater effects on leaf growth and hence on grain yield than the genotype effects. Grain yield increased with increasing N application due to enhanced leaf growth in both the hybrid and open-pollinated maize cultivars, thereby confirming the importance of leaf growth on grain yield of cereal. Positive correlation was obtained between grain yield and leaf extension rate (LER) and the final leaf length, while extension duration showed inverse relationship with grain yield. The results of this study therefore suggest that for the full advantage of hybrid over the open-pollinated to be achieved, leaf growth of the hybrid maize has to be improved.

KEY WORDS: Leaf growth, grain yield responses, nitrogen application, maize genotypes.

INTRODUCTION:

Maize (*Zea mays*, L) is a principal component of cropping system in Nigeria. Maize is very important and useful as human food, livestock feed and raw material in a number of industries. Despite the enormous importance of this crop, the production level is low resulting in importation of the crop (Fajemisin, 1986). It has been observed that the major factor limiting maize production is the low grain yield, which depends on the amount of dry matter produced and translocated to grains after anthesis ((Moll *et al.*, 1987).

Leaf growth is important in influencing light interception, crop growth and yield in cereals (Gallagher and Biscoe, 1978). The final yield of dry matter has been shown to be proportional to the total amount of radiation intercepted by crop during growth (Scott and Jaggard, 1978) and light interception is largely determined by leaf area index (LAI) (Milford *et. al.* 1985). In a much earlier study, Watson (1947) reported that leaf area and leaf area duration were the main causes of yield differences in plants rather than the rate of photosynthesis or net assimilation rate. Thus, low yield of most tropical maize has been attributed to low leaf area index resulting from low fertility of tropical soils.

Greater efforts have been devoted to the production of hybrid maize varieties with the hope of increasing grain yield (Kim, 1987; International Institute of Tropical Agriculture (IITA), 1992). Nevertheless, the desired yield advantage of hybrid over the open-pollinated varieties has not been obtained in Nigeria, especially in the southern Guinea savanna zone. Adedoyin (2000) reported a yield advantage of only 1.7 percent of hybrid over open-pollinated maize varieties in the southern

Guinea savanna zone. Similarly in an earlier study, Agbaje (1999) also reported a yield advantage of 10.5 percent of hybrid over the open-pollinated maize in the forest ecological zone of the country. These yields were considerably lower than the values reported in the U.S.A (Tollenaar, 1991; Tollenaar *et al.* 1992). It has been reported that the improvement in grain yield of hybrid over the open-pollinated in the U.S.A was due to improved leaf growth. The extended leaf area duration (LAD) in the new maize at Ontario, U.S.A has contributed significantly to increased grain yield of modern maize (Tollenaar, 1989). Crosbie (1982) and Davic (1992) have also reported that longer retention of effective leaf area in hybrid maize has contributed significantly to its increased yield over the open-pollinated maize. Maize grain yield can be increased by improving leaf growth (Pendleton *et al.* 1968) which can be manipulated by using agronomic practices such as fertilizer application. Recent studies in Nigeria (Alabi, 1999; Mustapha, 1999; Adedoyin, 2000; Arijenja-George, 2001; Kolawole, 2001; Abayomi and Adedoyin, 2004) have also shown the importance of leaf growth in grain yield of maize in response to N application. Nevertheless, information on comparative responses of leaf growth to N application in hybrid and open-pollinated maize cultivars is scanty. This study was therefore conducted to determine the optimum N required for good leaf growth for optimum grain yield and the comparative responses of hybrid and open-pollinated maize cultivars to N fertilizer application.

Materials and Methods:

The study was conducted at the University of Ilorin Teaching and Research Farm, Bolorunduro (8° 29'N, 4° 35'E) in the southern Guinea savanna zone of Nigeria. The physical and chemical characteristics of the soil of the experimental site are presented in Table 1. The study was designed as a 2 x 2 x 5 factorial experiment and laid out in split-split-plot made up of two maize types (hybrid and open-pollinated) as the main plots, two cultivars each of the hybrid (Oba super 1 and Oba super 2) and open-pollinated (SWAN-1-SR and DMRSR-Y) maize types as the sub-plots and five nitrogen levels (0, 40, 80, 120 and 160 kg N ha^{-1}) as the sub-sub-plots. Land was ploughed, harrowed before ridges were made 1.5m apart and 5m long. Plot size was $45m^2$ consisting of 7 ridges. Seeds treated with Apron Plus 50 DS were planted at a rate of 4 seeds per hole at an intra-row spacing of 30 cm, and later thinned to two plants per stand to give a plant population density of 53,333 plants per hectare. Weed control was achieved by spraying a tank mixture of premextra (330 g l-1 metolachlor and 170 g l-1 atrazine a.i.) and stomp (pendimenthalin 500 g l-1 a.i) immediately after planting at a rate of 5 litres of product per hectare. This was later supplemented by hand weeding at 7 weeks after planting (WAP). Fertilizer application was made in form of NPK (20-10-10) at two equal split applications at 2 WAP and at taselling (7 WAP) at rates stated above.

Data collection included leaf growth measurement using a metre rule at leaf nodes 5 to 15 on a plant. Leaf length was measured from the ligule of the last fully expanded leaf to the tip of the newly emerging leaf. Measurements were taken at 4 day intervals starting as soon as leaf in each node appeared and continued until the last two readings were the same. From the data collected, leaf extension rate (LER, cm d^{-1}) and leaf extension duration (LED, days) were calculated for each plot by fitting a linear regression of leaf length against the chronological time in days after planting (Abayomi, 1992). The regression equation was in form $y = mx + c$, where y = leaf length, m = LER, x = days and c = constant. LED was calculated by interpolating $y = 0$ and y = final leaf length into the equation. At harvest, 10 cobs were randomly selected from each plot for the determination of yield components including cob length, cob circumference, kernel row number, kernel number per cob, 100 seed weight and shelling percentage. Grain yield in each plot was also recorded after adjustment to 14 % moisture content.

All data collected were subjected to analysis of variance using the split-splitplot model and correlation analysis with GENSTAT statistical package. Significant means were separated using the Duncan's Multiple Range Test at 5 % probability level.

Results:

The results of the main effects of maize type, cultivars and N application on leaf extension rate (LER, $cm^2\ d^{-1}$) are presented in Table 2. The results show that LER was consistently slightly higher in hybrid than in the open-pollinated (OP) cultivars at all leaf nodes with significant differences in most nodes except nodes 9, 12, 14 and 15. Oba super 1 (hybrid) showed consistently higher LER than the other cultivars with significant differences at most nodes. Application of N fertilizer at any rate significantly increased LER at all leaf nodes when compared with no application. There were no significant differences in LER between the N levels.

In contrast to the results on LER, leaf extension duration (LED, days) (Table 3) was longer in the open-pollinated cultivars than in the hybrids, although the differences were not significant ($p > 0.05$) except at nodes 6, 7, 10 and 13. LED was significantly ($p < 0.05$) shorter in Oba super 1 than in the other cultivars. Application of N fertilizer resulted in significant decrease in LED at all leaf nodes. Final leaf length (Table 4) was also slightly longer in the hybrid than the open-pollinated maize genotypes at all leaf nodes, although the differences were generally not significant. Oba super 1 showed significantly ($p < 0.01$) longer leaves than the other cultivars. Application of N fertilizer at any rate significantly increased final leaf length from nodes 7 to 15.

Most yield components and grain yield were slightly higher in the hybrid than in the open-pollinated maize type, although the differences were not significant ($p > 0.05$) for most components and grain yield (Table 5). Oba super 1 (hybrid) has significantly higher grain yield than in the other cultivars including Oba super 2 (hybrid) which has similar grain yield as SWAN-1-SR (OP), while grain yield was lowest with DMRSR-Y (OP). Application of N fertilizer resulted in significant increases in all yield components and grain yield. Application of 160 kg N ha^{-1} gave the highest yield which was significantly better than at 40 and 120 kg N ha^{-1}.

The results of the simple linear correlation coefficients of leaf growth parameters and grain yield (Table 6) showed significant positive relationship of LER and final leaf length with grain yield at all leaf nodes, while LED was significantly inversely related to grain yield at most nodes. The results of the simple linear correlation matrix (Table 7) show that all yield components are positively related to grain yield and to one another with the exception of shelling percentage which was not significantly associated with grain yield and other yield components.

Discussion:

Results of the present study show that the effect of nitrogen fertilizer application was higher on leaf growth than the effect of maize type resulting in significant increases in grain yield due to N application while there were no significant differences between hybrid and open-pollinated maize types. Application of N fertilizer significantly increased LER and consequently the final leaf length at all nodes. This was in line with the reports of other workers who showed that LER is proportional to leaf N content up to 2.5 mg/ leaf which resulted in faster LER and are associated with shorter LED in sugar beet (Milford *et al.* 1985) and rye grass (Thomas, 1983). Other workers had also reported that inadequate nitrogen resulted in substantially depressed leaf area in maize, even though the number of leaves was relatively unaffected (Lemcoff and Loomis, 1986; Muchow, 1988). The results of increased leaf length due to N application was in line with the reports of Dale *et al,* (1983) and Uhart and Andrade (1995) who showed that nitrogen has significant effect on leaf length. Similarly, McCullough *et al,* (1994) and Kemp and Blacklow (1982) showed greater effects of N application on the final length of leaves.

Leaf extension rate and the final leaf length showed ontogenetic trends irrespective of maize type, cultivar and N application, increasing with leaf positions up to leaf 12, then decreased thereafter. This was in agreement with the report of Muchow and Sinclair (1994) who showed that there appears to be a genetically determined upper limit to the size of a leaf at any node. Thus, size is governed by ontogeny but can be modified by environmental factors. Ontogenetic response of LER has been reported by other workers for wheat (Gallagher, 1979) and barley (Maan *et al,* 1989).

The results also showed positive increase in grain yield as a result of enhanced leaf growth by N application, suggesting that N shortage reduces leaf growth resulting in reduced percent of radiation intercepted, radiation use efficiency and dry matter partitioning to reproductive sink as reported by Andrade and Uhart (1995). Grain number, cob length, cob circumference showed positive and significant responses to increasing N application, hence increase in grain yield. Results of this study showed highly significant relationships between grain yield and its components. Longer and thicker cobs with many kernel rows contributed to increased yield. This is in harmony with the report of Cross (1991) who showed that grain yield is positively correlated with kernel row and seed weight.

Lack of significant difference in leaf growth at all nodes may be responsible for the insignificant yield differences between hybrid and OP obtained in this study (Table 5), and those earlier reported by Agbaje (1999) and Adedoyin (2000). Leaf growth has been reported to be an important factor influencing light interception, crop growth rate and grain yield in cereal crops (Gallagher and Biscoe, 1978). Crosbie (1982) and Davic (1992) have reported that longer retention of effective leaf area in hybrid maize contributed to its increased yield over the OPs. Similarly, it has been reported that the extended leaf area duration in the new maize at Ontario, U.S.A. have contributed significantly to the increased yield of the modern maize (Tollenaar, 1989). Varietal differences in grain yield of maize due to differences in leaf area index have been reported by Okeleye and Alofe (1995), who showed that a relatively low leaf area index exhibited by three OP cultivars was found to limit their grain yields. Low yield of most tropical maize has been reported to be caused by low leaf area resulting from low fertility of most tropical soil (Duncan, 1969). It was reported that increased LAI of crop increases the yield by increasing the total canopy photosynthesis (Fitter and Hay, 1987). It can therefore be concluded from this study that application of N at a rate between 80 and 120kg N/ha will give good leaf growth and grain yield. Moreover for the expected yield advantage of hybrid over the OPs to be achieved, leaf growth in hybrid has to be significantly improved.

REFERENCES:

Abayomi, Y.A. (1992). Comparative effects of water stress on wheat and sugar beet. ***Ph.D Thesis,*** University of Wales, U.K.

Abayomi, Y.A. and Adedoyin, G. A. (2004). Effects of planting dates and nitrogen fertilizer application on growth and yield of contrasting genotypes of maize (*Zea mays* L.) I: Leaf growth and its relationship with grain yield. ***J. Agric. Res. & Dev.*** 3:83-97.

Adedoyin, G.A. (2000). Effects of planting date and nitrogen application on leaf growth of hybrid and open-pollinated maize (*Zea mays,* L). ***Ph.D Thesis,*** University of Ilorin, Ilorin. Nigeria.

Agbaje, G.O. (1999). Contributions of morpho-physiological traits to grain yield in hybrid and open-pollinated varieties of maize (*Zea mays,* L). ***Ph.D Thesis,*** University of Ilorin, Ilorin. Nigeria.

Alabi, J.O. (1999). Effect of nitrogen fertilizer application on leaf growth and its relationship with grain yield. ***B.Agric. Project,*** University of Ilorin, Nigeria.

Andrade, F.H. and Uhart, S.A. (1995). Nitrogen deficiency in maize 1. Effect on crop growth, development, dry matter partitioning and kernel set. ***Crop Science*** 35: 1376-1383.

Arijenja-George, A. (2001). The effect of nitrogen application on leaf growth and grain yield of two contrasting hybrid maize genotypes. ***B.Agric. Project,*** University of Ilorin, Nigeria.

Cross, H. Z. (1991). Leaf expansion rate effects on yield and yield components in early maturity maize. ***Crop Science*** 31:579-583.

Crossbie, T. M. (1982). Changes in physiological traits associated with long term breeding effects to improve grain yield of maize in H. Loden and D. Wilkinson (eds) ***Proc. 37th Ann. Corn and Sorghum Res. Conf. Chicago, Il Amer. Seed Trade Association, Washinton D. C.*** pp.206-223.

Dale, R. F.; Coelho, D.T. and Gallo K. P. (1983). Prediction of daily green leaf index for corn. ***Agron. J.*** 72: 99-1005.

Davic, D.N. (1992). Genetic contributions to yield of maize. ***Maydica*** 37: 67-79.

Duncan, W.G. (1969). The relationship between corn population and yield. ***Agron. J.*** 50:82-84.

Fajemisin, J.M. (1986). An overview of maize improvement programmes of the National Cereals Research Institute. ***Annual Report, NCRI, Morre Plantation, Ibadan.*** Pp. 7-11.

Fitter, A.H. and Hay, R.K.M. (1987). ***Environmental Physiology of Plants. (2nd ed).*** Academy Press, London. 423pp.

Gallagher, J.N. (1979). Field studies on cereal leaf growth. ***J. Expt. Botany*** 30:625-636.

Gallagher, J.N. and Biscoe, P. V. (1978). A physiological analysis of cereal yield 2.Partitioning of dry matter. ***Agric Progress*** 53:51-70.

IITA (1992). Sustainable food production in sub-Sahara Africa 1. ***IITA's contributions. IITA, Ibadan, Nigeria.*** 208pp.

Kemp, D.R. and Blacklow, W.M. (1982). The responsiveness to temperature of the extension rates of leaves of wheat growing in the field under different levels of nitrogen fertilizer. ***J. Exptl. Botany*** 33: 29-36.

Kim, S.K. (1987). Breeding for hybrid varieties of maize. In Feistrizer, W. P. And Kelly, A.F. (eds). Hybrid seed production of selected cereal, oil and vegetable crops. ***FAO Plant Production and Protection*** 82: 55-81.

Kolawole, I. A.(2001). Effects of nitrogen application on leaf growth and grain yield of two contrasting open-pollinated maize genotypes. ***B.Agric. Project, University of Ilorin, Nigeria.***

Lemcoff, J.H. and Loomis R. S. (1986). Nitrogen influences and yield determination in maize. ***Crop Science*** 26: 1017-1022.

Maan, A.A.S; Wright, D. and Alcode, M.B. (1989). Effects of sowing dates, sowing density and nitrogen supply on leaf extension in Spring barley. ***J. Agric. Sci. Camb.*** 113: 305-315.

McCullough, D.E; Girardin, P.H.; Mihajlovic, M.; Aquilera, A. and Tollenaar, M. (1994). Influence of N supply on development and dry matter accumulation of an old and new maize hybrid. ***Can. J. Plant Sci..*** 74:471-477.

Milford, G.E.J.; Pocock, T.O. and J. Riley (1985). An analysis of leaf growth in sugar beet II. Leaf appearance in field crop. ***Ann. Appl. Biol.*** : 173-185.

Moll, R. E.; Kamprath, E.J. and Jackson, W.A. (1987). Development of nitrogen efficient prolific hybrid of maize. ***Crop Science*** 27: 181- 186.

Muchow, R.C. (1988). Effects of nitrogen supply on the comparative productivity of maize and sorghum in a semi-arid tropical environment I: Leaf growth and leaf nitrogen. ***Field Crop Res.*** 18: 1-16.

Muchow, R. C. and Sinclair T. C. (1994). Nitrogen response of leaf photosynthesis and crop radiation use efficiency in field-grown maize and sorghum. ***Crop Science*** 34: 721 727.

Mustapha, W. O. (1999). Effects of nitrogen supply on leaf growth and yield of two field-grown maize varieties. ***B.Agric. Project, University of Ilorin, Nigeria.***

Okeleye, K.A. and Alofe, C.O. (1995). Effect of nitrogen fertilizer source on dry matter accumulation and grain yields of open-pollinated maize (*Zea mays*, L). ***Samaru J. Agric.*** 12: 87-98.

Pendleton, J. W. ; Smith, G. E.; Winter, S. R. and Johnston, R. J. (1968). Investigation of the relationships of leaf angle in corn (*Zea mays* L.) to grain yield and apparent photosynthesis. ***Agron. J.*** 60:422-424.

Scott, R.K. and Jaggard, K.W. (1978). Theoretical Criteria for Maximum Yield. Proceedings of the 41st Winter ***Congress of the International Institute for sugar beet Research, Brussels.*** Pp. 179-198.

Thomas, H. (1983). Analysis of the nitrogen responses of leaf extension in *Lolium tenulentum* seedling, **Annals of Botany** 51:363-371.

Tollenaar, M. (1989). Genetic improvement in grain yield of commercial maize hybrid grown in Ontario from 1959-1988. ***Crop Science*** 29:1365-1371.

Tollenaar, M. (1991). Physiological basis of genetic improvement of maize hybrid in Ontario from 1950 to 1988. ***Crop Science*** 31 : 119 124.

Tollenaar, M.; Dwyer, L. M. and Stewart, D. W. (1992). Ear and kernel formation in hybrids representing three decades of grain yield improvement in Ontario. ***Crop Science*** 32 (2) : 432 438.

Uhart, S.A.and Andrade, F.H. (1995). Nitrogen deficiency in maize I: Effect on crop growh, development dry matter partitioning and kernel set. ***Crop Science***. 35: 1376-1383.

Watson, D.J. (1947). Comparative physiological studies on the growth of field crops II: The effect of varying nutrient supply on net assimilation rate and leaf area. ***Annals of Botany*** 11 : 375-407.

Table 1 . Physical and chemical properties of the soil of Bolorunduro (8 29'N,^{0}4^{0} 35'E).

Sand (g kg^{-1})	819
Silt (g kg^{-1})	105
Clay (g kg^{-1})	76
pH (H_2O)	6.3
Organic matter (g kg^{-1})	80.60
Available P (mg kg^{-1})	5.70
Calcium (cmols kg^{-1})	1.7
Magnesium (cmols kg^{-1})	1.0
Potassium (cmols kg^{-1})	0.18
Sodium (cmol kg^{-1})	0.12
Total acidity (cmols kg^{-1})	1.32
Total nitrogen (g kg^{-1})	3.28

Table 2. Effects of maize type, cultivar and nitrogen fertilizer application on leaf extension rate (LER, cm d^{-1})

	Leaf Node										
Treatments	5	6	7	8	9	10	11	12	13	14	15
Maize type											
Hybrid	1.65a	3.69a	5.02a	5.90a	5.83a	6.96a	7.17a	6.98a	6.90a	6.35a	6.25a
Open-pollinated	1.21b	2.73b	4.35b	5.28b	5.62a	6.31b	6.74b	6.77a	6.61b	6.35a	6.12a
S.E	0.174	0.113	0.076	0.259	0.158	0.207	0.191	0.187	0.136	0.161	0.222
Cultivar											
Oba super 1	1.88a	4.18a	5.51a	6.28a	5.87a	6.91a	7.30a	7.04a	6.92a	6.48a	6.50a
Oba super 2	1.42b	3.20b	4.53b	5.53a	5.78a	7.01a	7.04ab	6.92a	6.89ab	6.22a	5.99a
SWAN-1-SR	1.32bc	2.97b	4.53b	5.33a	5.66a	6.33b	6.69b	6.62a	6.52b	6.34a	6.01a
DMRSR-Y	1.11c	2.48c	4.16c	5.24a	5.58a	6.29b	6.79b	6.92a	6.71ab	6.36a	6.23a
S.E.	0.138	0.204	0.146	0.155	0.173	0.108	0.228	0.220	0.193	0.152	0.153
Nitrogen level (kg ha^{-1}):											
0	0.96b	2.50c	3.83b	4.50b	4.57b	4.82b	4.85b	4.47b	4.45c	4.42b	4.64b
40	1.35ab	3.00bc	4.73a	5.70a	5.85a	6.88a	7.50a	7.36a	6.98b	6.47a	6.42a
80	1.75a	3.94a	5.15a	5.98a	6.01a	7.16a	7.23a	7.49a	7.35ab	7.03a	6.85a
120	1.48a	3.22b	5.02a	6.03a	6.20a	7.20a	7.55a	7.58a	7.60a	6.96a	6.74a
160	1.61a	3.38ab	4.67a	5.76a	6.00a	7.09a	7.64a	7.46a	7.40ab	6.86a	6.28a
S.E.	0.239	0.333	0.236	0.180	0.184	0.219	0.233	0.204	0.288	0.277	0.443

Values followed by the same letter(s) in each column are not significantly different by DMRT at 5% probability level.

Table 3. Effects of maize type, cultivar and nitrogen fertilizer application on leaf extension duration (LED, days)

Treatments	Leaf Node										
	5	6	7	8	9	10	11	12	13	14	15
Maize type											
Hybrid	40.2a	17.2b	14.1b	14.7a	16.8a	15.5b	15.9a	15.8a	15.3b	15.6a	14.4a
Open-pollinated	37.9a	20.7a	15.3a	15.5a	17.0a	16.9a	15.9a	16.3a	16.4a	15.5a	14.8a
S.E	6.40	1.63	0.44	0.52	0.18	0.12	0.22	0.62	0.49	0.85	0.97
Cultivar											
Oba super 1	28.9b	14.9b	13.4b	14.4b	17.4a	15.9b	15.4c	15.6b	14.9c	14.9c	13.6b
Oba super 2	51.5a	19.4a	14.7a	14.9b	16.2c	15.5c	16.4a	16.1ab	15.7b	16.4a	15.1a
SWAN-1-SR	35.5b	19.8a	15.3a	15.9a	17.2ab	17.0a	16.2ab	16.4a	16.3ab	15.0bc	14.9a
DMRSR-Y	40.3ab	21.6a	15.3a	15.1ab	16.8b	16.8a	15.6bc	16.2ab	16.6a	15.9ab	14.8a
S.E.	6.13	1.47	0.32	0.44	0.29	0.29	0.38	0.39	0.39	0.46	0.54
Nitrogen level (kg ha^{-1}):											
0	54.2a	22.8a	16.7a	16.8a	17.9a	18.2a	17.6a	18.2a	17.4a	15.5a	13.4a
40	35.7ab	18.3ab	13.7b	14.4b	16.5b	15.7b	15.3b	15.5b	15.7b	15.4a	14.8a
80	38.4ab	15.6b	13.9b	14.6b	16.9ab	15.8b	16.2ab	15.8b	15.6b	15.2a	14.3a
120	33.2b	19.2ab	14.0b	14.6b	16.6b	15.5b	15.2b	15.3b	14.9b	15.6a	15.2a
160	33.6b	18.7ab	15.1ab	15.2b	16.7b	15.8b	15.3b	15.6b	15.7b	16.0a	15.3a
S.E.	9.22	2.27	0.82	0.64	0.56	0.53	0.66	0.52	0.65	0.88	0.96

Values followed by the same letter(s) in each column are not significantly different by DMRT at 5% probability level.

Table 4. Effects of maize type, cultivar and nitrogen fertilizer application on final leaf length (cm)

	Leaf Node										
Treatments	5	6	7	8	9	10	11	12	13	14	15
Maize type											
Hybrid	43.55a	55.45a	67.03a	84.67a	97.03a	106.62a	111.55a	109.60a	104.00a	98.60a	87.20a
Open-pollinated	40.42b	52.50a	64.55a	82.10a	95.40a	104.25a	106. 65a	108.83a	106.60a	96.80a	89.60a
S.E	1.202	2.399	1.964	3.988	3.637	3.165	3.600	3.675	4.090	5.010	5.320
Cultivar											
Oba super 1	44.70a	57.20a	69.40a	88.05a	100.55a	108.45a	111.45ab	108.50a	101.7b	95.70ab	85.30b
Oba super 2	42.40b	53.70ab	64.65bc	81.30bc	93.50b	104.80ab	111 .65a	110.70a	106.40ab	101.40a	89.2ab
SWAN-1-SR	41.45bc	54.95a	67.45ab	84.80ab	97.05ab	105.15ab	106.45b	107.20a	103.70ab	94.80b	87.00ab
DMRSR-Y	39.40c	50.05b	61.65c	79.40c	93.75b	103.35b	106.85ab	110.45a	109.50a	99.00ab	92.70a
S.E.	1.001	1.881	1.827	1.799	2.352	2.303	2.376	2.712	3.140	3.020	3.340
Nitrogen level (kg ha^{-1}):											
0	40.50b	52.38b	60.31b	74.50b	83.06b	87.44b	83.50b	81.37b	76.70b	67. 70c	61.7b
40	39.69b	50.94b	63.69a	80.12ab	96.31a	107.81a	113.94a	113.62a	107.90a	98.7b	89.20a
80	42.31ab	54.31ab	67.25a	87.50a	100. 62a	112.00a	116.50a	118.15a	113.90a	105.8ab	95.90a
120	42.56ab	54.31ab	68.62a	87.44a	101.5a	109.87a	115.81a	115.44a	112.60a	107.7a	98.90a
160	44.88a	57.94a	69.06a	87.37a	99.56a	110.06a	115.75a	117.37a	115.40a	108.7a	96.40a
S.E.	1.894	2.461	2.846	3.131	3.057	2.974	3.002	3.114	3.560	4.120	4.780

Values followed by the same letter(s) in each column are not significantly different by DMRT at 5% probability level.

Table 5. Effects of maize type, cultivar and nitrogen fertilizer application on yield components and grain yield.

Treatments	Cob length (cm)	Cob circumference (cm)	Kernel row/cob (no)	Kernels/cob (no)	Seed weight (g)	Shelling %	Grain yield (t ha^{-1})
Maize type							
Hybrid	13.95a	13.43a	13.3b	425.1a	20.25a	79.1a	2.29a
OP	12.81b	13.00b	13.7a	342.1b	18.50b	75.7a	1.80a
S.E	0.386	0.168	0.06	6.43	0.248	2.03	0.258
Cultivar:							
Oba super 1	14.51	13.22a	13.1b	438.4a	29.24a	77.8ab	2.45a
Oba super 2	13.40b	13.47a	13.5ab	411.7a	19.26b	80.3a	2.12b
SWAN-1-SR	12.53c	13.20a	13.5ab	354.0b	19.17b	75.1b	2.01b
DMRSR-Y	13.09bc	12.80b	13.9a	330.2b	17.83c	76.3b	1.60c
S.E.	0.314	0.159	0.20	19.54	0.360	1.87	0.065
Nitrogen level (kg ha^{-1}):							
0	11.53d	12.10c	12.6b	305.9b	17.63b	75.5a	0.81d
40	13.03c	12.99b	13.5a	372.3a	19.62a	78.5a	1.84c
80	14.09ab	13.63a	13.9a	408.6a	19.61a	80.2a	2.49ab
120	13.66bc	13.40ab	13.8a	420.1a	19.12a	76.8a	2.33b
160	14.59a	13.74a	13.7a	411.0a	20.90a	75.7a	2.76a
S.E.	0.415	0.251	0.23	27.44	0.545	3.86	0.131

Values followed by the same letter(s) in each column are not significantly different by DMRT at 5 % probability level.

Table 6 Simple linear correlation coefficients of leaf growth parameters and grain yield

Leaf Node	Leaf extension rate (cm d^{-1})	Leaf extension duration (days)	Final length (cm)
5	0.317**	-0.218*	0.298**
6	0.495**	-0.329**	0.356**
7	0.491**	-0.296**	0.417**
8	0.660**	-0.245*	0.589**
9	0.612**	-0.092ns	0.594**
10	0.754**	-0.432**	0.691**
11	0.716**	-0.305**	0.706**
12	0.660**	-0.392**	0.670**
13	0.659**	-0.340**	0.621**
14	0.576**	-0.070ns	0.641**
15	0.328**	-0.181ns	0.495**

*, ** denote effects significant at 5 and 1 percent probability levels
ns denotes effect not significant.

Table 7. Simple linear correlation matrix of grain yield and yield components.

	Yield	Shelling %	Kernel row	Grains/Cob	Cob length	Cob circum	Seed weight
Yield	1.000						
Shelling %	0.063ns	1.000					
Kernel rows	0.351**	0.144ns	1.000				
Grains/Cob	0.300**	0.129ns	0.535**	1.000			
Cob length	0.323**	0.051ns	0.646**	0.646**	1.000		
Cob circumference	0.479**	0.151ns	0.634**	0.677**	0.797**	1.000	
Seed weight	0.226*	0.131ns	0.379**	0.406**	0.480**	0.487**	1.000

*, ** denote effects significant at 5 and 1 percent probability level respectively
ns denotes effects not significant