JAAL 2(1): 108-118, June 2009

RESPONSE OF MAIZE GRAIN YIELDS TO RATES AND SPLIT APPLICATIONS OF NITROGEN AND NPK COMBINATIONS IN THE SOUTHERN GUINEA SAVANNA OF NIGERIA

Adeboye, M.K.A.*, Osunde, A.O., Tsado, P.A., Odofin, J.A., Bala, A., Adeyemi, R.A.1

Department of Soil Science, 1Department of Crop Production, School of Agriculture and Agricultural Technology, Federal University of Technology, P.M.B 65, Minna.

*Corresponding author, e mail: enilewu @yahoo.com

Running title - Maize yields response to rates and split application of fertilizer ....

ABSTRACT

...d experiments were conducted on the same field at Minna, southern Guinea savanna agro ...al zone to investigate the response of maize grain yields to different rates and split ...ions of nitrogen and NPK combinations. The two experiments had a split plot design fitted ...domized complete block with three replicates. The main plots in the two experiments were ...s at 30, 60, 90 and 120 kg ha-1 N and NPK. The subplots were the three methods of split ...ons, single, twice and three times. The soil of the site has inherent medium fertility status. ...s no response of grain yields to nitrogen fertilization. Application of full dose of nitrogen at ... time gave significantly (P<0.05) higher grain yield than three split applications. Grain ...574 kg ha-1was obtained with the application of 90 kg N ha-1in full while 5448 Kg ha- ...ained with 90 kg N-P-K ha-1which was significantly (P<0.05) higher than 3323 and 2906 ... produced by application of 30 and 60 kg NPK ha-1respectively. The rate of 90 kg N ha- ... to be the optimum for maize in the soil. Comparatively higher grain yields were produced by NPK combinations than nitrogen alone suggesting that maize respond more to nitrogen with adequate supply of phosphorus and potassium.

Key words: *Maize, yields, N rates, NPK, split application*

INTRODUCTION

Maize (Zea mays .L.) is one of the most important cereal crops in Nigeria. The importance of maize in human diet, livestock feed and as raw materials for industries has increased rapidly in the last two to three decades (Fakorede et al., 2003). The increased importance is such that in a survey of farmers in 27 villages studied in northern Nigeria by Smith et al. (1993), maize has evolved as a major food crop in 33 % of the villages in 1970 to a major food crop in 96 % and a major cash crop in 70 % of the villages in 1989. Thus, maize which was traditionally grown as a subsistence crop in small plots in home gardens has been transformed into a commercial and profitable crop in the farming systems of the different agro ecological zones of Nigeria. Per capital maize consumption has been reported to be growing at the rate of 0.3 % annually between 1983 to 1992 in West Africa (Adesina et al., 1999).

Maize has a high and relatively rapid nutrient requirement and the higher the yield; the more nutrients are exported from the field. A grain yield of 1 t ha-1 led to the removal of 25, 6 and 15 kg ha-1 of NPK respectively from the field while a grain yield of 7 t ha-1 resulted in the export of 128, 20 and 37 kg ha-1 of NPK respectively from the field (Sanchez, 1976). The high yielding improved maize varieties and hybrids that are cultivated by farmers nowadays will, therefore, result in high export of nutrients from the soil. There will therefore be the need for adequate fertilization of the crops to enable them attain their yield potentials. The inherently low fertility status of savanna soils (Tian et al., 1993) suggests that the soil inherent nutrients supply will not be adequate for high maize yield and external inputs of nutrients will be required. The current fertilizer recommendation for maize in the Nigerian savanna is 120-60-60 kg N, P205 and K20 (NPK) ha-1 respectively (Balasubramanian et al., 1978), though a lower rate of 80 kg N ha-1 has been proposed (Uyovbisere et al., 1990).

The timing of fertilizer application depends on the soil, climate, nutrients and crop (Tisdale et al., 1993). This is governed by basic considerations of making the nutrient available when the plant needs it and avoiding excess availability of nutrients especially of N, before and after the principal period of plant uptake (Brady and Weil, 1999).

The general recommendation of time of application of fertilizer nutrients in the savanna ecology of Nigeria is the supply of full dose of recommended phosphorus (P) and potassium (K) and half or one-third of N at planting time and the remaining N at 4 to 6 weeks after planting (WAP). Some studies have however, found no beneficial effect of split application of N on maize grain yield in the savanna. Remison (1980) found that split application of 80 kg N ha-1 in equal doses at planting and at six WAP was of no advantage over single application of the same amount of N in the savanna of Nigeria. In the same savanna, Balasubramanian and Singh (1982), reported no significant difference in maize yields with full and split N applications.

The twice application of N are tied to period of high N demand by the crop. But the maize plants have a third growth period, between seven to eleven WAP which coincides with the tasselling growth stage when there is high demand for N (Tisdale et al., 1993). The supply of N at this growth stage may also have a significant effect on the grain yield of maize.

In light of the aforementioned discussion, the objectives of this study was therefore conducted to determine the effects of different rates of N, P, and K as supplied by fertilizer sources and the split application of these nutrients based on the physiological growth stages of maize as it affects grain yield of maize in the southern Guinea savanna of Nigeria.

MATERIALS AND METHODS

Experimental Site Characteristics

The study was part of a long-term fertilizer trial established in 2008 at the Teaching and Research Farm of the School of Agriculture and Agricultural Technology of the Federal University of Technology, Minna (90 41' N; 60 31' E; Southern Guinea Savanna Ecology). Long-term mean annual rainfall at the experimental site is 1200 mm. Rainfall pattern is mono-modal with the rainy season starting in April or May and ending in October. Monthly rainfall during the period of study is shown in Table 1. The soil of the site is an Alfisol (USDA) with sandy clay loam surface soil texture. The field was left fallow for over five years prior to this study. The fallow vegetation consisted mainly of weeds, Tridax procumbens, Calopogonium muconides, Bracharia deflexa and Digitaria horizontalis.

Experimental Design and Treatments
The two experiments (1 and 2) were conducted on the same field. Experiment 1 had twelve treatments consisting of four levels of N, 30, 60, 90 and 120 kg N ha-1 supplied by urea fertilizer with each level applied in three ways (once all applied at 3 weeks after planting (WAP), twice - half applied at 3 WAP and the remaining half at 10-11 leaves growth stage of the plant and thrice one-third applied at 3 WAP, one-third applied at 10-11 leaves growth stage and the remaining applied at tasselling growth stage of the plant). Experiment 2 also had twelve treatments made up of 30, 60, 90 and 120 kg NPK ha-1 supplied by NPK, 15: 15: 15 compound fertilizer and each level applied the same way as in Experiment 1.

The two experiments had the same control (no fertilizer application). The treatments designation and description for Experiment 1 and 2 are shown in Tables 3 and 4 repectively. The two experiments had a split plot design fitted to a randomized complete block (RCB) with three replicates. The main plot treatments were the different levels of the nutrients and the subplots were the three methods of application. The field was divided into three blocks with each block representing a replicate of the main plots which measured 42 m x 30 m with a strip of 3 m separating them. The subplots were randomized within each main block to give a total of 75 experimental plots. The size of the subplot was 4.5 m x 6 m (27 m2) separated from one another by an alley of 1 m.

Land Preparation and Crop Management
The field was cleared manually of existing vegetation, mechanically ploughed and harrowed. Ridging was done manually. Maize variety, Oba-98, was planted on 12 July, using 3 seeds hill-1 at interplant spacing of 50 cm and 75 cm inter-row spacing. The seedlings were thinned to 2 seeds hill-1 2 WAP to give a total plant population of 53,000 plants ha-1. The plots receiving fertilizer application had their application at the appropriate times by single band about 5 cm deep, made along the ridge, 5 to 10 cm away from the plant stands. The fertilizers were incorporated. Weeds were controlled manually with hoe when necessary. All plots were remolded at the tasselling stage in place of last weeding as commonly practiced in the area.

SOIL SAMPLING AND ANALYSIS

At the initiation of the study, before land preparation, ten core soil samples were collected from five points along two diagonal transects on the field and bulked together to form a composite sample for analysis. Analyses were carried out using standard procedure as described by Anderson and Ingram (1993). Briefly, particle size distribution was by Bouyoucos hydrometer method. Soil reaction was determined potentiometrically in 1: 2.5 soil to 0.01 M CaCl2 suspension with the glass electrode pH meter. Organic carbon was determined by the wet dichromate oxidation method. Exchangeable bases were determined by extraction with neutral 1N NH4OAc. Potassium was determined with flame photometer while calcium (Ca) and magnesium (Mg) were determined using the atomic absorption spectrophotometer. Available P was extracted by the Bray P 1 method. The P concentration in the extract was determined colorimetrically using the spectronic 70 spectronic meter. Total N was determined by the Kjeldahl digestion method.

YIELD ANALYSIS

Maize grain yield analysis was carried out by harvesting maize ears in the two central rows leaving out border plants at both ends (net plot 4 9m^2), dried, shelled and weighed.
Statistical Analysis

Analysis of variance (ANOVA) was carried out using the GLM Procedure of SAS (SAS Inst., 2000). Means separation was done using Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Initial Soil Properties

The initial properties of the soil are shown in Table 2. The texture of the soil was sandy clay loam with moderately high amount of clay particles. The clay particles moderately high amount may inhibit leaching in the soil and hence the soil may not respond to split application of nitrogen (N). The soil was slightly acidic and low in organic carbon (7.46 g kg-1). The soil total N and exchangeable magnesium (Mg) were high, while the value of available phosphorus (P), exchangeable calcium (Ca) and potassium (K) were medium in the soil (Kparmwang et al., 2001). The soil is adequate in available P for maize cropping (Adeoye and Agboola, 1984; Aune and Lal, 1997). The inherently medium fertility status of the soil may be due to the long period of fallow of the soil. This might have accounted for low response to applied nutrients by crops growing in the soil.

Response to Different Rates and Split Application of Nitrogen

The effect of N rates on maize grain yield was not significant ($P>0.05$) (Table 5). The highest yield of 2912 kg ha-1 was obtained with application of 120 kg N ha-1. The lack of response to N may be partly attributed to the high soil total N content (5.11 g kg-1). Another reason could be due to the non-application of P and K. Several studies have reported that response to N is usually obtained with adequate fertilization with P and K (Odedina, 2005; Uyovbisere et al., 2000). The results seem to confirm the assertion by Uyovbisere et al., (2000) that the current recommended rate of 120 Kg N ha-1 may not be the most economical.

There was response to split application of N. The single application of the full dose of N resulted in a grain yield of 3606 kg ha-1, which was significantly ($P<0.05$) higher than the yield of 1904 kg ha-1 obtained when N was applied in equal doses three times (Table 5). These results were consistent with those of Remison (1980) and Balasubramanian and Singh (1982) who reported that split application of N in equal does has no advantage over single application. A report by IAR (1978), showed that split application of N three times has no additional yield advantage over two split applications. N is a mobile nutrient in the soil and subject to rapid leaching from the soil and this is why its split application is recommended so as to synchronize its supply with the period of greatest demand by maize and to minimize its loss by leaching (Brady and Weil, 1999). But the soil of the study site has a moderately high amount of clay particles which will minimize leaching of N from the soil thereby not allowing much of the applied N to be lost when applied in single dose at planting time. This may be another reason why the single application had higher grain yield then the three split applications and slightly higher yield than the two split applications.

The effect of different levels of N, P and K on grain yield was significant ($P<0.05$). The highest grain yield of 5448 kg ha-1 was obtained with the combination of 90 kg each of N,P and K ha-1 (Table 6). The lowest yield of 2906 kg ha-1 which was significantly ($P<0.05$) lower than other combinations was obtained with the 60 kg each of N, P and K ha-1. The relatively high yield of 3323 kg ha-1 obtained at 30 kg each of N, P and K ha-1 seems to indicate a high efficiency of N, P and K use at their low levels of application. Therefore, the current recommended rate of 120-60-60 kg N, P_2O_5 and K_2O (NPK) in the Nigeria Savanna (Balasubramanian et al., 1978) may not be considered optimum with all factors considered. The results were also an indication that N requirement by maize can be substantially reduced when K and P are applied in adequate amounts. Similar observation has been made by Odedina (2005).

There was no response to the split application of the N, P and K nutrients. The two times split application gave the highest grain yield of 4292 kg ha-1, which was not significantly (P>0.05) different from single and three split applications (Table 6). Split application of K has been reported to have no significant effect on the grain yield of maize at Mokwa in the same southern Guinea savanna (IAR, 1978). The results confirmed the general recommendation of application of full dose of P and K at planting in the savanna of Nigeria.

Interaction of Levels and Split Application of Nitrogen on Grain Yield

The interactive effects of the levels and split applications of N on grain yield of maize are shown in Table 7. Grain yield was relatively high, 3833 kg ha-1 where no N fertilizer was applied. The reason for this result could be due to the high total N and medium content of P and K in the soil. The soil available P is adequate for maize cropping (Adeoye and Agboola, 1984; Aune and Lal, 1997). Trials conducted at Mokwa showed no response by maize to K application (NCRL, 1987). The highest yield of 4574 kg ha-1 was obtained when the 90 kg N ha-1 was applied once without splitting. This is similar to the 80 kg N ha-1 economic optimum proposed by Uyovbisere et al., (1990) for the savanna of Nigeria.

In most cases, the three times split application gave the lowest grain yield confirming the appropriateness of the general recommendation of two split applications of N for the savanna zone. The application of 30 kg N ha-1 once and 60 kg N ha-1 in two split applications gave relatively high yield of 3945 and 3834 kg ha-1 respectively. These results indicate that at low levels of N application as practiced by majority of farmers, split application of N may not be necessary. But with moderate rate of 60 kg N ha-1, split application (twice) may be more appropriate

Interaction of Levels and Split Application of NPK on Grain Yield

The interactive effects of the levels and split application of NPK on grain yield of maize are shown in Table 8. Grain yields obtained ranged from 2182 to 6796 kg ha-1. These values were higher than the range of 1040 to 3850 kg ha-1 reported by Odedina (2005) in the humid southern part of Nigeria. The savanna zones of Nigeria have been reported to be the most suitable areas for maize (Jagtap, 1995) and yield potential is high compared to the humid environment (Kassam et al., 1975).

The highest grain yield of 6796 kg ha-1 was obtained with two split applications of 90 kg NPK ha-1 which was more than 54 % higher than the yield obtained with similar application of 120 kg NPK ha-1. Similar observation has been made by Odedina (2005) who opined that high application of K is inappropriate and may lead to imbalance nutrition in the crop. The high rate of N and K which were in excess amounts might have been leached by attendant high rainfall during the second application of the fertilizer.

At all levels of application, the two split applications gave consistently higher grain yield then the single or three split applications except at 120 kg N level. This is contrary to the general recommendation of application of full dose of P and K at once but agrees with the general recommendation for N in the savanna zone.

Comparatively, the application of NPK irrespective of the split application gave higher grain yield than the application of N alone (Tables 7 and 8). These results are consistent with the findings of other workers that the application of these nutrients, N, P and K are important for enhanced yield of maize in Nigeria (Adediran and Banjoko, 2003; Akintunde et al., 2000; Odedina, 2005) and response to N by maize is higher with adequate fertilization with P and K (Uyovbisere et al., 2000).

CONCLUSIONS

The conclusions from this study were that, response to N by maize is enhanced by adequate fertilization with P and K. Split applications of N, P and K two times in equal doses will lead to greater productivity of maize crop, but split applications will not enhance grain yield at lower than 60 kg N ha-1. Three split applications of NPK will not result in any significant yield advantage. The rate of about 90kg N ha-1 is the optimum rate for the maize crop. It is recommended that this study be conducted over long experimental period to have definitive conclusions.

ACKNOWLEDGEMENTS

The authors are grateful to Mallam Mohammed Abdulmalik of the Department of Soil Science, Federal University of Technology Minna for his technical assistance on the field and some 300 level (2008/2009) students of the School of Agriculture and Agricultural Technology of the same University for their assistance on the field.

REFERENCES

Adediran J.A and Banjoko, V.A. (2003). Comparative effectiveness of some compound fertilizer formulations for maize in Nigeria. Nigeria Journal of Soil Science, 13:42-48.

Adeoye, G.O and Agboola, A.A (1984). Critical levels for pH, available P,K and Mn and ear leaf content of P, Ca and Mn in sedimentary soils of southern Nigeria. Fertilizer Research, 6: 65-71.

Adesina, A.A., Coulibaly, O.N and Houndekon, V. (1999). Policy, devaluation and profitability of maize production in West and Central Africa: Comparative analysis of Cameroon, Benin and Mali. In. Badu Apraku, B., M.A.B Fakorede, M. Ouedraogo and I.M. Quinn (Eds).

Strategy for sustainable maize production in West and Central Africa. Proceedings of a Regional maize Workshop, IITA-Cotonou,Benin Republic, 21-25, April, 1997. WECAMAN/IITA Pp. 53-92.

Akintunde, A.Y., Obigbesan, G.O., Kim, S.K. and Akinrinde, E.A (2000). Effects of nitrogen rates on grain yield response of maize varieties in four ecological zones of Nigeria. Nigerian Journal of Soil Science, 12:35-44.

Anderson, J.M. and Ingram, J.S.I. (1993). Tropical Soil Biology and Fertility: A Handbook of Methods. 2nd Edition. C.A.B. International, Wallingford, UK 211pp.

Aune, J.B and Lal, R. (1997). Agricultural productivity in the tropics and critical limits of properties of Oxisols, Ultisols and Alfisols. Tropical Agriculture, 74:96-103.

Balasubramanian, V., Nnadi, L.A. and Mokwunye, A.U. (1978). Fertilizing sole crop

Maize for high yields. Samaru Miscellaneous Paper. 76-1-16.

Balasubramanian, V and Singh L. (1982). Efficiency of nitrogen fertilizer use under rainfed maize and irrigated wheat at Kadawa, northern Nigeria Fertilizer Research, 3:315-324.

Brady, N.C and Weil, R.R (1999). The nature and properties of soils. Prentice Hall, Inc., New Jersey. 881 pp.

Fakorode, M. A. B., Badu-Apraku, B., Kamara, A.Y., Menkir, A. and Ajala, S.O.(2003). Maize revolution in West and Central Africa: An overview. In, Badu-Apraku, B., M.A.B Fakorode, M. Ouedraogo, R.J. Carsky and A. Menkir (Eds). Maize , Revolution in West and Central Africa. Proceedings of a Regional maize Workshop, IITA-Colonou, Benin Republic, 14-18 May, 2001. WECAMAN/IITA Pp. 3-15

IAR (1978). Report to the Board of Government on the Institute work in 1977. Cereals improvement programme. IAR, Samaru, Zaria, Nigeria.

Jagtap, S.S. (1995). Handbook for use of resource information systems (IRSS). International Institute of Tropical Agriculture, Ibadan, Nigeria.

Kassam, A.H., Kowal, J. Dagg, M. and Harrison, M.N. (1975). Maize in West Africa and its potential in the savanna area. World Crops, 27 (1): 73-78

Lparnwang, T., Raji, B.A Odunze, A.C and Chude, V.O. (2001). Properties, classification and agricultural potentials of Ustults and Tropepts on a sedimentary toposequence in the Benue. Nigerian Journal of Soil Research, 2: 58-65.

NCRI (1987). NCRI Maize Programme Report. National Cereals Research Institute. Moor plantation, Ibadan.

Odedina, S.A (2005). Evaluation of NPK rate combinations for maize production in humid zones of Nigeria. Nigerian Journal of Soil Science, 15 (2): 111-116

Remison, S.V. (1980). Competitive effects of weeds on maize under varying N fertilization in the southern Guinea Savanna zone of Nigeria. African Journal of Agricultural Science, 7: 105-113.

Sanchez, P.A (1976) Properties and management of soils of the tropics. John Wiley and Sons, New York. 618pp.

SAS Institute (2000). SAS Users Guide. SAS Inst., Carry., N.C

Smith, J., Barau A.D., Goldman, A and Mareek, J.A. (1993). The role of technology in agricultural intensification: The evolution of maize production in the northern Guinea Savanna of Nigeria. In, K.A. Dvorak (Ed). Soil Science Research for Agricultural Technology Development: Spatial and Temporal Dimensions. CAB International, Wallingford, U.K.

Tian, G., Kang, B.T. and Brussard, L. (1993). Effect of plant residues with chemically contrasting composition on maize growth and nutrient concentration. Plant and Soil, 153:179-187.

Tisdale, S.L., Nelson, W.L., Beaton, J.D. and Havlin J.L. (1993). Soil fertility and fertilizers. Practice Hall Inc., New Jersey, U.S.A. 634pp.

Uyovbisere, E.O, Lombin, G. and Iwuafor, E.N.O. (1990). Comparative evaluation of selected fertilizer materials under field conditions in the subhumid Nigerian savanna:

I. Nitrogenous fertilizers. Samaru Journal of Agricultural Research, 7:85-95.
Uyovbisere, E.O., Chude, V.O. and Bationo, A.(2000). Promising nutrient ratios in fertilizer formulation for optimal performance of maize in the Nigeria savanna: The need for a review of current recommendation. Nigerian Journal of Soil Research. 1:29-34.

Table 1. Monthly rainfall during the period of study in 2008.

Month	Rainfall (mm)
January	0.0
February	0.0
March	0.0
April	25.0
May	97.0
June	66.1
July	216.2
August	300.6
September	264.2
October	100.1
November	0.0
December	0.0
Total	1086.6

Table 2. Selected physical and chemical properties of the soil before land preparation.

Properties	Value
Sand (gkg^{-1})	640
Silt (gkg^{-1})	90
Clay (gkg^{-1})	270
Textural class	Sandy clay loam
pH ($Cacl_2$)	5.5
Organic Carbon (gkg^{-1})	7,46
Total Nitrogen (gkg^{-1})	5.11
Bray PI (gkg^{-1})	11
Exchangeable Ca cmo $1kg^{-1}$)	2.40
Exchangeable Mg cmo $1kg^{-1}$)	1.18
Exchangeable Mg cmo $1kg^{-1}$)	0.26

Table3. Treatment designation and description of Experiment 1

S/No	Treatment designation	Treatment description
1	$A1_{30}$	30kgNha^{-1} Applied Once
2	$A2_{30}$	30kgNha^{-1} Applied Twice
3	$A3_{30}$	30kgNha^{-1} Applied Three
4	$B1_{60}$	60kgNha^{-1} Applied Once
5	B260	60kgNha^{-1} Applied Twice
6	$B3_{60}$	60kgNha^{-1} Applied Three
7	$C1_{90}$	90kgNha^{-1} Applied Once
8	$C2_{90}$	90kgNha^{-1} Applied Twice
9	$C3_{90}$	90kgNha^{-1} Applied Three
10	$D11_{20}$	120kgNha^{-1} Applied Once
11	$D21_{20}$	120kgNha^{-1} Applied Twice
12	$D31_{20}$	120kgNha^{-1} Applied Three

A, B, C, D-represent Urea fertilizer.

Table4. Treatment designation and description of Experiment 2

S/No	Treatment designation	Treatment description
1	$E1_{30}$	30kgNPKha^{-1} Applied Once
2	$E2_{30}$	30kgNPKha^{-1} Applied Twice
3	$E3_{30}$	30kgNPKha^{-1} Applied Three
4	$F1_{60}$	60kgNNPKha^{-1} Applied Once
5	$F2_{60}$	60kgNPKha^{-1} Applied Twice
6	$F3_{60}$	60kgNPKha^{-1} Applied Three
7	$G1_{90}$	90kgNPKha. Applied Once
8	$G2_{90}$	90kgNPKha^{-1} Applied Twice
9	$G3_{90}$	90kgNPKha^{-1} Applied Three
10	$H11_{20}$	120kgNPKha^{-1} Applied Once
11	$H21_{20}$	120kgNPKha^{-1}Applied Twice
12	$H31_{20}$	120kgNPKha^{-1} Applied Three

Table 5. Effects of different rates and split application of nitrogen on the grain yield of maize.

Treatment	Grain yield ($Kgha^{-1}$)
N levels ($Kg\ N\ ha^{-1}$) (N)	
30	2454a
60	2830a
90	2586a
120	2912a
LSD	1434
Significance	NS
Number of Applications (A)	
Once	3606a
Twice	2598ab
Thrice	1904b
LSD	1242
Significance	*

Means followed by the same letter(s) are statistically similar at $P<0.05$
* Significant at $P<0.05$
NS Not significant

Table 6. Effects of different rate and split application of nitrogen, phosphorus and potassium on the grain yield of maize.

Treatment	Grain yield ($Kgha^{-1}$)
NPK levels ($Kg\ N\ ha^{-1}$) (F)	
30	3323b
60	2906b
90	5448a
120	3644ab
LSD	1897
Significance	*
Number of Applications (N)	
Once	3715a
Twice	4292a
Thrice	3484a
LSD	1643
Significance	*

Means followed by the same letter (s) are statistically similar at $P< 0.05$
* Significant at $P<0.05$
NS Not significant

JAAT, 2(1): 108-118. June 2009

Table 7. Interactive response of maize grain yield (Kg ha-1) to different rates and split application of nitrogen.

Application rate (kg NPK ha^{-1})		Split Application			
		Once	Twice	Thrice	Mean
0	3833				
30		3945	1574	1933	2484
60		2454	3834	2202	2830
90		4574	1813	1370	2586
120		3453	3170	2111	2911
Mean		3607	2598	1904	
			1172		
LSD			2485		

Table 8. Interactive response of maize grain yield (Kg ha-1) to different rates and split application of NPK compound fertilizer.

Application rate (kg NPK ha^{-1})		Split Application			
		Once	Twice	Thrice	Mean
0	3833				
30		2944	3303	2722	2990
60		2592	3944	2182	2906
90		4623	6796	4926	5448
120		3700	3125	4106	3644
Mean		3465	4292	3484	
			1550		
LSD			3286		