EFFECT OF DIFFERENT SPLIT APPLICATIONS OF NPK FERTILIZER ON GROWTH AND YIELD OF MAIZE, AND ECONOMIC RETURNS.

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ABSTRACT

Declining inherent soil nutrient, poor grain yield of maize, delayed supply and high cost of inorganic fertilizer, call for proper timing of application, to optimize the use of this scarce resource in maize production in Nigeria. A field experiment was carried out in the 2007 and 2008 cropping seasons in the University of Agriculture, Abeokuta to investigate the effect of different split applications of NPK fertilizer 20:10:10 on growth and yield of maize. Six treatments laid out in Randomized complete Block Design (RCBD) consisted of 600 kg/ha of NPK 20:10:10 in 2007 and 300 kg/ha in 2008, applied at 2 and 6 WAP (Week after planting), 2 and 8 WAP, 4 and 6 WAP, 4 and 8 WAP, 6 and 8 WAP and no fertilizer (control). Plant height, grain yield, cob length, cob girth, hundred grain weight were all significantly affected ($p < 0.05$) by different split application. Fertilizer application increased grain yield by 135 260% and 67 191% in 2007 and 2008 respectively. Application of fertilizer at 2 and 8 WAP consistently gave the highest significant grain yield. In 2008, delaying first dose of fertilizer till 6 WAP increased grain yield but was not economical. Split application of 300 kg/ha fertilizer, at 2 and 8 WAP gave higher economic return than application of 600 kg/ha at 4 and 6 WAP or 4 and 8 WAP. It was concluded that maize grain yield can be maximized if fertilizer is applied at 2 and 8 WAP, while delayed application of 300 kg/ha of fertilizer till 6 WAP could lead to economic loss.

KEYWORDS: Fertilizer, split application, maize

INTRODUCTION

In sub-Sahara Africa, maize is a staple food for an estimated 50% of the population. It is important source of carbohydrates, protein, iron Vitamin B and minerals (IITA).

No other crop is distributed over so large an area and none occupies a larger hectarage than maize in Nigeria. This wide coverage does not however translate directly into increased production as the total output per hectare of maize in Nigeria stood at 1.3 tons in 1999, this figure was about 25% of the World total output per hectare (RMRDC, 2004). The current production is not sufficient to meet the food need of Nigerians. In spite of this challenge, the area devoted to maize production has continued to decline.

Many of the resource poor maize farmers have drifted from maize production because of its high fertilizer requirements to other cereals like sorghum and millet. This is so due to unavailability and high prices of fertilizers (RMRDC, 2004).

Use of nitrogenous fertilizers and declining soil fertility have been reported to be the problems for maize production in sub-Sahara Africa (IITA, 2005). N, P and K are the major nutrients limiting maize production in Nigeria (Kayode, 1985, 1986). These chemical fertilizers are often imported, they are thus scarce and expensive (Nottidge et al, 2005). The present relatively high recommended rates of NPK fertilizers such as 120-60-60 (Balasubraimarian *et al.,* 1978), apart from being unaffordable by poor farmers, do not give corresponding high yield increase in some instances (Uyovbisere *et al.,* 2000). Since nutrients are also released from natural sources such as N-fixation, weathering and organic matter mineralization. Odedina (2005) recommended a lower rate of 50-40-60 kg/ha NPK, he did not however take cognizance of time of application as all fertilizer treatments were applied two weeks after planting.

Determining the optimum time to apply N for corn has been the subject of considerable research during the last 30 years (Randall *et al.,* 2003). The general conclusion among researchers have been that N should be applied

nearest to the time it is needed by the crop (Keeney, 1982, Aldrich, 1984, Fox *et al.,* 1986).
Split applications (application of the same fertilizer more than once to the crop) are widely used when nitrogen containing fertilizers are applied to maize and other crops which have been shown to benefit from extra nitrogen at a particular stage in their development (Ahn, 1993). Crop response to N fertilizer application varies with rate and timing of N application in relation to plant development (Mossedaq and Smith, 1984).
NPK 20:10:10 is a common fertilizer in Nigeria often patronized by maize growers, since the ratio of N, P and K in it favors the ratio of fertilizer recommendation for maize without addition of any other straight fertilizer. The aim of this study was therefore to evaluate the effect of different split application of NPK 20:10:10 on the growth and yield of maize. The objectives were to obtain the best split application for maize and the economic returns from different split application, hence the profitability or otherwise of different split application.

MATERIALS AND METHODS

A field experiment was conducted at the University of Agriculture, Abeokuta (7^0 15'N, 3^0 25'E) in the growing season of 2007 and 2008. The area receives an annual rainfall of about 1000mm with a mean temperature of 19.9 27.2^{0}C. Six treatments were arranged in a randomized complete block design (RCBD) replicated three times. The treatments were made up of different splits application of 600kg/ha or 300kg/ha of compound fertilizer N. P.K (20:10:10) in 2007 and 2008 respectively. Application was made at 2 and 6 WAP (weeks after planting) that is at V2 and V12 growth stage; 2 and 8 WAP (V2 and V16); 4 and 6 WAP (V6and V12); 4 and 8 WAP (V6 and V16); 6 and 8 WAP (V12 and V16) and no fertilizer control.
Composite soil sample of the experimental site was taken from 20cm soil depth before planting, for routine soil analysis. The experimental site was manually cleared at the commencement of the experiment in 2007 having been mechanically cleared and sown to maize the previous years, while planting was done after mechanical ploughing and harrowing in 2008. Maize variety SWAN 1 Y was planted at spacing of 75 x 50cm and maintained at 2 plants per stand to give a population of 53, 333 plants per hectare. Planting was done on flat in both years. Weeds were removed manually by the use of hoe weeding. Fertilizer treatments were applied using band placement method and covered at different time as defined above.
Plant height was measured fortnightly from five plants per plot commencing from 2 WAP to 10 WAP. Days to 50% tasselling was obtained by counting as the number of days from planting till the time 50% of plant in each plot tasselled. Grain yield was obtained by harvesting 56 plants from the net plot and at stable weight of about 13 % moisture content. Cob length and cob girth were measured by using a tape rule. Five cobs from the harvested cobs were sampled for these. Hundred grain weight was obtained by counting hundred grains from each shelled maize, while shelling percentage was the ratio of the shelled grain to the unshelled grain on the cobs multiplied by hundred.
Data collected were subjected to analysis of variance procedures. Where effects were significant at the 0.05 probability level, means separation was done by using Duncan's Multiple Range Test DMRT.

RESULTS

Effect of different split applications of NPK fertilizer on growth of maize.

Different split applications of NPK fertilizer had significant effect ($P<0.05$) on plant height of maize in year 2007 and 2008 (Table 1). The shortest plant of maize for both years was recorded in the no fertilized (control) plots. Delaying first dose of fertilizer application till 6 weeks after planting gave the shortest plants amongst the fertilized treatments, but taller than the control plots in both years. Split application of fertilizer at 4 and 6 WAP gave the tallest plant in 2007. In 2008, application of first dose of fertilizer at 2 or 4 WAP (V2 or V6) produced plants that ranked same; while delaying fertilizer application till 6 WAP (V12) produced plants that were not significantly different from the control plants in height, even though taller. Plant height generally reduced across all treatments in 2008 relative to 2007; the exceptions were when applications was made at 4 and 8 and 6 and 8 WAP where similar values were recorded.

Effect of NPK split application on maize yield

Table 1: Soil Physical and Chemical Properties of the experimental site before planting

Property	Value
Sand (%)	86.6
Silt (%)	5.4
Clay (%)	8.0
pH (H_2O)	6.3
N (%)	0.17
P (ppm)	15.95
K (meg/100g)	0.27
Ca (Meq/100g)	2.29
Mg (Meg/100g)	0.94

Maize included in maizdataTable

Table 2: Effect of different split applications of inorganic fertilizer on plant height of maize

Time of application	Growth stage	Final Plant height of maize 10WAP (cm)	
		2007	2008
Control (No fertilizer)		145d	136b
2 and 6 WAP	V_2 and V_{12}	177abc	170a
2 and 8 WAP	V_2 and V_{16}	186ab	168a
4 and 6 WAP	V_6 and V_{12}	195a	165a
4 and 8 WAP	V_6 and V_{16}	160bcd	161a
6 and 8 WAP	V_{12} and V_{16}	152cd	152b
S.E		8.57	6.97

[a,b,c,d] Means followed by the same letters are not significantly different ($P \leq 0.05$).
WAP = Weeks after planting

Effect of split applications of NPK fertilizer on days to 50% tasselling
Different split applications had no significant ($p > 0.05$) on days to 50% tasselling of maize in both years of this study (Table 2). Fertilizer application however led to between 2 5 and 2 4 days early flowering in 2007 and 2008 respectively.

Table 3: Effect of different split applications of NPK fertilizer on days to 50% tasselling of maize

Time of application	Growth stage	Days to 50% Tasselling	
		2007	2008
Control		61	60
2 and 6 WAP	V_2 and V_{12}	57	58
2 and 8 WAP	V_2 and V_{16}	56	56
4 and 6 WAP	V_6 and V_{12}	57	58
4 and 8 WAP	V_6 and V_{16}	59	57
6 and 8 WAP	V_{12} and V_{16}	59	58

Effect of split applications of NPK fertilizer on grain yield of maize
Grain yield of maize was significantly affected ($p < 0.05$) by different split application of maize in this study (Table 3). A similar trend was observed in 2007 and 2008; the highest ($p < 0.05$) grain yield was obtained in the plots that received inorganic fertilizer, while the least ($p < 0.05$) was from the control no fertilizer plots. Grain yield was higher across all treatments in 2007 compared with 2008. In 2007, grain yield of maize ranked same

when fertilizer was applied at 2 and 6, 2 and 8 and 4 and 6 WAP. This was higher ($p<0.05$) than when application was made at 4 and 8 and 6 and 8 WAP, which also ranked same. In 2008, grain yield varied significantly ($p<0.05$) amongst all treatments. The grain yield pattern was such that highest grain yield ($p<0.05$) was obtained by applying fertilizer at 2 and 8 WAP, while the least ($p<0.05$) grain yield value amongst the fertilizer treated plots, was obtained when fertilizer was applied at 6 and 8 WAP, which was only higher than the control no fertilizer plots.

Table 4: Effect of different split applications of NPK fertilizer on grain yield of maize

Time of application	Growth stage	Grain (Kg/ha)	
		2007	2008
Control		943c	754d
2 and 6 WAP	V_2 and V_{12}	3,395a	1,967ab
2 and 8 WAP	V_2 and V_{16}	3,574a	2,197a
4 and 6 WAP	V_6 and V_{12}	3,388a	1,681abc
4 and 8 WAP	V_6 and V_{16}	2,589b	1,628bc
6 and 8 WAP	V_{12} and V_{16}	2.215b	1,258cd
S.E		242.7	168

[a,b,c,d,] Means followed by the same letters are not significantly different ($P\leq0.05$).
WAP Weeks after planting

Effect of split application of NPK fertilizer on shelling percentage of maize.
Shelling percentage of maize was not significantly affected by different split application of fertilizer in 2007 and 2008. In general, a similar pattern was observed in both years. Shelling percentage across all treatments was higher in 2007 than 2008.

Table 5: Effect of different split applications of NPK fertilizer on shelling percentage and 100 grain weight of maize

Time of application	Growth Stage	Shelling percentage		100 grain weight (g)	
		2007	2008	2007	2008
Control		82.2	79.6	21.3c	21.9c
2 and 6 WAP	V_2 and V_{12}	84.8	81.2	26.4ab	26.3a
2 and 8 WAP	V_2 and V_{16}	84.7	81.4	24.6bc	25.7a
4 and 6 WAP	V_6 and V_{12}	82.9	79.9	28.3a	24.1b
4 and 8 WAP	V_6 and V_{16}	82.4	80.2	25.8ab	24.4b
6 and 8 WAP	V_{12} and V_{16}	81.8	81.3	23.7bc	23.7b
S.E				1.08	0.30

[A,b,c,d] Means followed by the same letters are not significantly different ($P\leq0.05$).

Effect of different split applications on hundred-grain weight of maize
Split application of maize significantly affected hundred-grain weight of maize in 2007 and 2008 (Table 4). The least grain weight for both years was from the control plot. Similarly for both years the least grain weight amongst the treatments that received fertilizer was obtained when first application was delayed till 6 WAP. In 2008, treatments that received first dose of fertilizer at 2 WAP gave significantly bigger grains than that obtained when application of first dose was made at 4 or 6 WAP

Effect of NPK split application on maize yield

Effect split applications of NPK Fertilizer on cob length on cob girth.

Cob length of maize was significantly affected by different split application of maize in 2007 and 2008 (Table 5). The shortest ($p < 0.05$) cobs for both years were obtained from the control plots. Longer cobs were obtained across all treatments in 2007 relative to 2008. In both years early fertilizer application gave longer cobs. Cob girth of maize is shown in Table 5. In 2007 all fertilizer treated plots ranked same and better than the control, while in 2008 application of fertilizer at 2 and 6 WAP gave the fattest cob; while delaying first dose till 6 WAP gave cobs which were similar to those obtained from the control plots.

Table 6: Effect of different split applications of NPK fertilizer on cob length and cob girth of maize

Time of application	Growth Stage	Shelling percentage		100 grain weight (g)	
		2007	2008	2007	2008
Control		10.6c	10.7b	13.0b	13.8b
2 and 6 WAP	V_2 and V_{12}	15.0ab	14.0a	15.4a	15.2a
2 and 8 WAP	V_2 and V_{16}	15.1ab	14.9a	15.0a	14.6ab
4 and 6 WAP	V_6 and V_{12}	15.9a	13.5a	15.5a	14.5ab
4 and 8 WAP	V_6 and V_{16}	14.0b	13.1ab	14.5a	14.6ab
6 and 8 WAP	V_{12} and V_{16}	14.1b	12.4ab	14.7a	13.5b
S.E		0.49	0.76	0.44	0.34

[a,b,c,d,] Means followed by the same letters are not significantly different ($P \leq 0.05$).

Effect of different split applications of NPK on costs and returns

Table 6 shows the costs and returns as well as the benefit/cost ratio of different split application of NPK. In both years the return on investments was less than the cost incurred in the control (no fertilizer) plots. There were 8% and 23% loss in 2007 and 2008 respectively. In plots that received NPK fertilizer, there were positive returns on investments, which ranged from 27 110% in 2007. In 2008 however, split applications at 6 and 8 WAP (V_{12} and V_{16}) led to 8% loss on investment, while for other splits application, return on investment were positive and ranged from 12 61%.

DISCUSSION

The results of the physiochemical properties of the soil show that both P and K are adequate for maize production. The results of this study are thus discussed with respect to Nitrogen which was inadequate, since according to Liebig's law of minimum, the most limiting factor determines yield potential.

Significant response of plant height to application of fertilizer, varying response to different split applications of NPK and response to both early (2WAP) and late (6 and 8WAP) fertilizer application in both years suggest that the inherent soil nutrient was not sufficient for the vegetative stage of the crop. Applying N at side dress (V_8 V_{10}) has been suggested as one of the best ways of supplying N to meet this high demand, however highly deficient maize would be able to respond to N applied late in the season (Binder *et al.,* 2000).

Delayed development as revealed in days to 50% tasselling even though not significant, can also be attributed to negative effect of nutrient deficiency in the development of maize. Delayed in tasselling of maize due to competition for nutrient has been reported (Chui and Shibles, 1984).

Low grain yield obtained in the control plots in 2007 and 2008 was partly due to reduction in stand count. In both years, stand count of the control plots was only 57% of the fertilizer treated plots (data not shown). Shortage of N during the period of stem elongation of wheat and during subsequent shoot development was reported to have led to increased shoot mortality and smaller spike size which further limit the final number of Kernels produced per unit area (Mossedaq and Smith, 1994). The low grain yield in the control plot can also be attributed to impaired growth as evident in the final plant height value. This suggests reduced photosynthetic activity and reduction in assimilate partitioned for grain production. Significant reduction in one hundred grain weight, cob length and cob girth value in the control plots also confirmed this.

Higher grain yield in 2007 relative to 2008 was due to 50% reduction in the rate of fertilizer applied in 2008. Crop response to N fertilizer application varies with rate and timing of N application in relation to plant development (Mossedaq and Smith, 1994).

Split application of NPK at 2 and 8 WAP (V2 and V16) consistently gave higher grain yield in both years. However, the current recommendations for the forest zone in Nigeria is that all the NPK be applied at planting or at 2 3 WAP or split application of the N at planting and 5 6 WAP (Sobulo, 1986). The general practice in the forest-savannah transition zone, where this study was carried out is split application at 2WAP and 4 6 WAP. The present results however suggest exhaustion of nutrient (probably due to leaching) before the completion of the reproductive phase when second dose of fertilizer was applied at 6 WAP or V12. Application of high N rate at anthesis produced grain yields higher than those of controls; indicating the importance of adequate N nutrition during late developmental stages (Morris and Paulsen, 1985).

The significant response of grain yield to varying split application at lower rate of NPK in 2008 contradicts earlier report by Elemo (1996) that where only 56kg N/ha was applied, its time of application made very little difference to yield, and that only at the highest rate did split application give any appreciable increase over an un-split application. Alofe and Okeleye (1990) also reported a non-significant yield response between maize that received all N at planting and maize that received its nitrogen in splits. The present results can be attributed to high nutrient deficiency in the soil. It has been observed that that the greater the N deficiency, the earlier N must be applied to obtain maximum grain yields (Binder *et al.,* 2000).

The significant response of grain yield to NPK fertilizer application, even when the first dose was applied at 6WAP (V_{12}) in both years is also as a result of low inherent soil nutrient. Binder *et al.,* (2000) observed that highly deficient maize would be able to respond to N applied late in the season and lack of N response by maize when applied at the V8 stage has been attributed to high soil residual nitrate (Jokela and Randall, 1989). The relative effectiveness of nitrogen fertilizer applications is largely determined by soil characteristics (Randall *et al.,* 2003).

This study revealed a yield increase of 1, 272 2,452 kg in fertilizer treated plots over the control plots in 2007, and 504 1,443 kg in 2008. These wide ranges indicate that while there could be positive response of grain yield to late NPK fertilizer application, delayed application could lead to as much as 50% or more reduction in yield depending on the soil residual N and rate of fertilizer applied. Binder *et al.* (2000) observed that the soil N status would affect how late N application could be delayed without reducing yield.

The costs and returns analysis revealed that although fertilizer application increased total costs of production by 46 and 34% in 2007 and 2008 respectively, positive returns (66.8 260%)were only guaranteed by fertilizer application. This implies that majority of poor resource farmers that constitutes greater percentage of maize producer in Nigeria would have been operating at a loss. Such farmers have continued to produce probably because adequate economic analysis is seldom carried out, and often times family labor is employed from land preparation to harvest, which is often unaccounted for. Negative returns recorded when first dose of fertilizer was delayed till 6WAP (V12 and V16) in 2008, revealed that low rate as well as delayed fertilizer application could produce a yield response but the response might not be economical. In 2007 however, application of fertilizer as late as V12 and V6 (6 and 8 WAP) resulted in higher and economical grain yield production. This can be attributed to the higher rate applied. A cut off date for N application has been given as the VT or R_1 stage, or on or before R 1.5 for maize that would have otherwise developed N deficiency during grain fill (Ruselle *et al.,* 1983, Binder *et al.,* 2000). The economic analysis also shows that economic returns from maize from split application of fertilizer at 2 and 8 WAP (V2 and V12) in 2008 was higher that the returns from application made at 4 and 8 WAP or 6 and 8 WAP (V6 and V16 or V1 and V16 respectively) in 2007; even though lower rate (50%) was applied in 2008. This shows that early application of lower rate of fertilizer could lead to higher returns than application of higher rate at later date.

CONCLUSION

Different splits application of NPK fertilizer had significant effect on maize growth and yield both at the recommended and 50% of the recommended rate. Highest grain yield was obtained from split application of NPK at 2 and 8 WAP (V2 and V16). Fertilizer application increased production cost by 46 and 34% and increased grain yield by 135 260% and 67 191% in 2007 and 2008 respectively. Grain yield from application of 300 kg/ha of NPK 20:10:10 at 2 and 8 WAP (V2 and V12) compared favourably with yield from 600 kg/ha of same fertilizer at 6 and 8 WAP (V12 and V16). Higher economic returns were obtained from application of 300 kg/ha NPK 20:10:10 at 2 and 8 WAP or 2 and 6 WAP relative to returns from application of 600 kg/ha of same fertilizer at 4 and 8 WAP or 6 and 8 WAP. Delaying application of low rate of NPK fertilizer till 6 WAP will lead to economic loss in a deficient soil.

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