EFFECTS OF PLANTING DATE AND MODE OF NITROGEN APPLICATION ON THE GRAIN AND NUTRIENT YIELDS OF SORGHUM SK5912 (*Sorghum bicolor* (L.) Moench) IN THE SOUTHERN GUINEA SAVANNA OF NIGERIA

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ABSTRACT

Timeliness of all crop management factors is essential for realizing the yield potential and maximum profit in sorghum production. A field experiment was conducted on an Alfisol in 2008 at the Old Teaching and Research Farm of the Federal University of Technology, Minna, to determine the appropriate planting date and mode of nitrogen (N) application for optimum grain and nutrient yield of sorghum (*Sorghum bicolor* L.) var. SK5912). The experiment was laid out in a 2 x 4 x 3 factorial fitted into a Randomized Complete Block Design (RCBD), consisting of two modes of N application ((i) 90 kg N ha applied at 2 weeks after planting (2 WAP), and (ii) 45 kg N ha applied at 2 and 4 WAP respectively) and four planting dates namely: T1 (25th April) and T2 (3rd May) after 1st and 2nd rainfall within the Nigerian Meterological Agency (NIMET) 2008 forecast of safe planting window for Minna area respectively, while T3(16th May) and T4 (9th June) were dates chosen after 1st and 2nd rainfall outside the NIMET safe window respectively. Results obtained showed that sorghum grain and N yield were significantly ($p < 0.05$) affected by planting date and mode of N application. In general, grain and grain N yield of *Sorghum* var. SK5912 were significantly higher when sown within the NIMET predicted safe planting window and at 90 kg N ha applied at 2WAP than when sown outside the NIMET windows under split N application. This study therefore suggests that, seeds of Sorghum var. SK5912 can be sown on the field between 25th April and 3rd May with an application of 90 kg N ha at 2WAP for optimum yield within the study area.

INTRODUCTION

Grain Sorghum (*Sorghum bicolor* (L.) Moench) is one of the most important cereal crops in the World. It is considered the fourth most important cereal crop after maize, wheat, and rice (Singh *et al*., 2003). It is grown in different part of the tropical and subtropical regions of the world. Sorghum locally called guinea corn is the most widely cultivated cereal crop and the most important food crop in the Savanna areas of Nigeria (NAERLS, 1996). Sorghum production in Nigeria span from the Derived Savanna in the Southwest and Southeast to the Southern Guinea into the Northern Guinea and Sudan ecologies (NAERLS, 1996). With the position of Sorghum and its importance, there is need for encouraging good growth of sorghum through appropriate management practices and good nutrition. Nitrogen is the most important nutrient required for high grain sorghum productivity (Eweis *et al*., 1998). Exposing sorghum plants to stress of nitrogen at any phase of its life cycle might lead to detrimental effect on growth, yield, and its components. Great efforts have been made by Scientists to improve sorghum productivity by new cultivars and increasing the efficiency of added fertilizers by controlling the release or minimizing the loss of nutrients. Therefore, mode of nitrogen fertilizer application becomes a critical decision if this improvement is will be feasible.

Planting date is one of the most important management decisions in producing high yielding small grains (McLeod *et al*., 1992; Dahlke *et al*., 1993). However, adverse weather may constraint planting into an unfavourable soil environment which may lead to poor stand establishment or replanting. Planting may be delayed long enough that choosing an early maturing hybrid may be required. Climate, which is the number one parameter in choosing an appropriate planting date for crops, is the most important variable in crop production even in high yield and high technology environments (Makadho, 1996). Despite technological advances in plant breeding, fertilizers and irrigation systems, climate is a key factor in agricultural production. In the 1980's, continued deterioration of food production in Africa was caused in part by extended drought and soil degradation (Makadho, 1996). In many areas, delay in planting after the optimum date reduces yield potential. Consequently, growers often reject nutrient placement options to avoid delays in planting, even when they may increase yield. Thus, growers' convenience in nutrient application is affected when planting date of crop is affected. Hence, nutrient placement decisions influence yield potential. Thus, effects of planting date and nutrient placement (mode of application) on yield must be evaluated. Many researches have been conducted to assess this scenario in Nigeria, but limited information is available especially in the guinea savanna region of this country. Therefore, this study was carried out to assess the grain and nutrient yields of sorghum SK5912 as affected by planting date and mode of nitrogen application in Minna, Guinea Savannah agro-ecological zone of Nigeria.

MATERIALS AND METHODS

Study area

The experiment was sited at the old Teaching and Research Farm of Federal University of Technology, Minna (Lat. 9°32'20.37" N and Long. 6° 27' 17.81" E at 232 m above sea level) located within Southern Guinea Savanna Vegetation Zone of Nigeria. The climate of Minna is sub-humid with mean annual rainfall of 1284 mm and a distinct dry season of about 5 months duration occurring from November to March (Ojanuga, 2006). The mean maximum temperature remains high throughout, about 32°C, particularly in March and June. Minna area lies within the Southern Guinea Savanna vegetation belt of Nigeria. The physical features around Minna consist of gently undulating high plains developed on basement complex rocks made up of granites, migmatites, gneisses and schists. Inselbergs of "Older Granites" and low hills of schists rise conspicuously above the plains. Beneath the plains, bedrock is deeply weathered and constitutes the major soil parent material (Ojanuga, 2006).

Treatment and experimental design

The experiment was laid out in a 2 x 4 factorial fitted into a randomized complete block design (RCBD), consisting of two modes of N application ((i) 90 kg N ha applied once at 2 weeks after planting (2 WAP), and (ii) 2 x 45 kg N ha split-applied at 2 and 4 WAP respectively) and four planting dates namely: T1 (25th April) and T2 (3rd May) after 1st and 2nd rainfall within the Nigerian Meterological Agency (NIMET) 2008 forecast of safe planting window for Minna area respectively, while T3 (16th May) and T4 (9th June) were dates chosen after 1st and 2nd rainfall outside the NIMET safe window respectively. The experiment was replicated three times giving a total of 24 plots.

Agronomic practices

The experimental plot (0.078 ha) was demarcated into 24 sub-plots of 3 replicates. The size of each sub- plot was 6.0m X 4.5m consisting of 6 ridges (6m long each), with the growth analysis sampling area (GASA) as the two outer ridges on both sides of a sub-plot and final harvesting area (FHA) as the two inner ridges of a sub-plot.SK5912 was the test crop used for this study. *Sorghum bicolor* L. Var. SK5912 is one of the improved sorghum varieties released by Institute for Agricultural Research (IAR) Samaru, developed for the Southern Guinea Savanna ecology. It is a long season, semi-tall and Striga tolerant variety. The maturity period is between 165 to 175 days with potential yield of about 2.5 – 3.5 t ha^{-1}. The colour of the seed is yellow. The sorghum seeds were sown at 5 seeds per hole and at a spacing of 75 cm and 50 cm between and within the ridges respectively during each planting date. Thinning was done manually at 2WAP to two plants per stand. Weeding was carried out at 2WAP and 6WAP with the use of hoe (manual weeding) and fertilizer applications were carried out at 2WAP and 4WAP respectively. Sources of N supplied were NPK 15:15:15 and Urea, whereas, a basal application of 45 kg P_2O_5, and 45 kg K_2O ha^{-1} (applied as NPK 15:15:15) was also applied to all plants at 2WAP.

Soil sampling and analysis

Soil sampling was done before clearing the land. Surface (0-15 cm) soil samples for chemical analysis were collected using an auger from four points on a diagonal transects across the field to give total of four samples. For soil bulk density and moisture content determinations, steel core sampler was used to collect samples besides the sampled points for chemical analysis from 0-15 cm depth also to give a total of four core samples. The soil samples for chemical analysis were air-dried and sieved using a 2 mm sieve and analyzed as described by International Institute of Tropical Agriculture (IITA, 1989). Particle size distribution was by Bouyoucos hydrometer method. Soil reaction was determined potentiometrically in a 1: 2.5 soil to water and $CaCl_2$ suspension with a glass electrode pH meter. Organic carbon was determined by Walkley and Black wet oxidation method. Available phosphorus was determined colorimetrically after Bray-P1 extraction. Exchangeable bases were extracted with neutral ammonium acetate. Calcium and Magnessium were determined by titrating with Na_2EDTA, while Potassium and Sodium was read with flame photometer. Total Nitrogen was determined by the micro Kjeldahl method. The steel core samples collected were used for evaluation of bulk density and gravimetric moisture content after placement in oven at 105°C for 24 hours. Total porosity was determined by calculation.

Data collection

The destructive sampling of the crop was done at 10WAS, 20WAS and at physiological maturity to obtain the fresh and dry weight of plant biomass at these growth stages from the growth analysis sampling area (GASA). This was done by cutting the above ground part of the plant; take their fresh weight and oven dried to a constant weight at about 70°C in the laboratory to obtain their dry weight. Other biomass assessment was carried out at harvest such as Stover and panicle weight on each plot. The Stover weight was determined by weighing the above ground portion at harvest and all the panicles on each plot within the Final Harvest Area (FHA) were gathered to obtain their weight. The number of plant per plot (FHA) was taken, the above ground portion was cut and panicles were separated from the main stem for each plot. The panicles harvested were taken to the laboratory after the Stover and panicle weight had been taken. The panicles from different plots were threshed separately to obtain their grain weight. Grain nitrogen and phosphorus were determined by multiplying the %N and %P in the grain with the grain yields (Kg ha^{-1}). Nitrogen in the grain was determined by using Kjeldahl digestion as described by IITA (IITA, 1989), while the grain phosphorus was determined using Vanado-molybdate colour method.

Statistical analysis

Data collected from both the field experiment and the laboratory analysis were subjected to analysis of variance (ANOVA) using a computer package MINITAB version 14 (MINITAB, 2000) to determine variations between the treatments. Where a significant treatment effect was found, the LSD (at 5% level of probability) was then used to separate the means.

RESULTS

The physico-chemical properties of soil

The physico-chemical properties of soil in the study area are shown in Table 1. The texture of the soil was clay loam with a moderately high amount of sand and clay contents. The bulk density of the soil was fairly high (1.80 g cm^{-3}) with total porosity of 32%. The soil is acidic in reaction and the difference between the pH in water and $CaCl_2$ was fairly high. The organic carbon was very low (3.22 g kg^{-1}) and the total nitrogen content of the so.. was medium, but the available phosphorus was very low. The exchangeable Ca is medium, while exchangeable Magnessium and Potassium are high in the soil. The exchangeable acidity was 3.75 cmol kg^{-1} and the CEC was 7.42 cmol kg^{-1}.

Table 1: Physico - chemical properties of the soil used for the experiment

Parameters	Mean values
Sand (g kg $^{-1}$)	560
Silt (g kg $^{-1}$)	150
Clay (g kg $^{-1}$)	290
Bulk density (g cm $^{-3}$)	1.80
Total porosity (%)	32
Textural Class	Clay loam
pH (H_2O)	5.0
pH ($CaCl_2$)	4.2
Organic Carbon (g kg $^{-1}$)	3.22
Total Nitrogen (g kg $^{-1}$)	2.10
Available Phosphorus (mg kg $^{-1}$)	2.0
Exchangeable cations (cmol kg $^{-1}$)	
Calcium	2.03
Magnessium	1.18
Potassium	0.36
Sodium	0.10
Exchangeable acidity (cmol kg $^{-1}$)	3.75
CEC (cmol Kg $^{-1}$)	7.42

Grain and biological yield

Data obtained for grain yield and 1000 grain weight are shown in Table 2. The result showed that grain yield of sorghum was significantly ($P < 0.05$) affected by planting date and mode of fertilizer N application. The interaction between planting date and Fertilizer N application was however, not significant. Planting early at 25th April and 3rd May favours higher grain yield (1803.65 and 2035.35 kg ha $^{-1}$ respectively) than late planting of 16th May and 9th June (590.65 and 520.90 kg ha $^{-1}$ respectively). Grain yield of plants supplied with the full N (90 kg N ha $^{-1}$) at 2WAP was significantly higher than those of plants that received split application of N (2 x 45 Kg N ha $^{-1}$). There was no significant difference in both the single effect of planting date, N application and their interaction on 1000 grain weight. Data on the Stover and panicle weight are shown in Table 4. The result showed that no significant effect was observed in planting date, Nitrogen application and their interaction on the panicle weight, but Stover weight was significantly affected by planting date. The plots planted on the first planting date (25th April) produced the highest (836.46 g plant $^{-1}$) weight, followed by those planted on 3rd May, while 16th May and 9th June gave the lowest.

Grain N and P yield

Data on grain N and P yield are contained in Table 3. The result showed that, grain N was significantly affected ($P < 0.05$) by the single effect of planting date, N application and their interaction. Full N dose (90 kg N ha $^{-1}$) applied at 2WAP gave a higher N yield than split N (2 x 45 kg N ha $^{-1}$) application. Although, high N yields were obtained in plots planted on 25th April and 3rd May, higher N yields (39.50 and 44.83 kg N ha $^{-1}$) were recorded compared to significantly low N yield that was obtained from split N application in all the planting dates. The grain P content was significantly ($P < 0.05$) affected by planting date alone. In the same manner, planting on 25th April and 3rd May favoured higher grain P content (53.64 and 49.53 kg P ha $^{-1}$) than 16th May and 9th June (17.38 and 14.86 kg P ha $^{-1}$) respectively.

Table 2: Grain yield and 1000 grain weight as affected by planting date and nitrogen application

Fertilizer	Planting date T1	T2	T3	T4	Mean
Grain yield (kg ha $^{-1}$)					
F1	2662.70	2900.10	418.50	498.80	1620.03
F2	944.60	1170.60	762.80	543.00	855.25
Mean	1803.65	2035.35	590.65	520.90	
1000 grain weight (g plant $^{-1}$)					
F1	42.17	39.40	40.97	38.23	40.19
F2	39.73	40.77	41.00	38.53	40.01
Mean	40.95	40.09	40.99	38.38	
LSD 5%		Grain yield	1000 grain weight		
Planting date (T)		791	NS		
Fertilizer (F)		559.3	NS		
Interaction (T * F)		NS	NS		

T1 = 25th April, T2 = 3rd May, T3 = 16th May, T4 = 9th June, F1 = 90 kg N ha applied at 2 Weeks After Planting (WAP), F2 = 45 kg N ha at 2 and 4WAP. NS = Not Significant at P<0.05

Table 3: **Panicle weight and Stover weight of Sorghum as affected by planting date and nitrogen application**

Fertilizer	Planting date T1	T2	T3	T4	Mean
Panicle weight (kg ha^{-1})					
F1	1.22	0.44	0.57	0.76	0.75
F2	1.22	0.62	1.08	1.03	0.99
Mean	1.22	0.53	0.83	0.90	
Stover weight (g plant^{-1})					
F1	758.75	594.17	372.02	291.25	504.06
F2	914.17	486.08	384.17	404.58	547.25
Mean	836.46	540.13	378.13	347.92	

LSD 5%	Panicle weight	Stover weight
Planting date (T)	NS	138.3
Fertilizer (F)	NS	NS
Interaction (T * F)	NS	NS

T1 = 25th April, T2 = 3rd May, T3 = 16th May, T4 = 9th June, F1 = 90 kg N ha applied at 2 Weeks After Planting (WAP), F2 = 45 kg N ha at 2 and 4WAP. NS = Not Significant at $P<0.05$

DISCUSSION

The results from this study showed that there was need for proper timing of N application as regard to adequate soil moisture availability, intensity and frequency of rainfall to meet the actual peak use period of sorghum (Var. SK5912) with little or no leaching losses. Observation of high grain yield when full N dose, 90 kg N ha^{-1} was applied at 2WAP may be due to vigorous seedling growth encouraged by efficient use of nutrients at plant emergence which is essential for obtaining the desired yield potential and maximizing profitability (Havlin *et al*., 2006). The low grain yield observed when split N application was done may be due not only to low N uptake at early growth stage to accumulate more dry matter and support initiation of the reproductive cycle, but also to high rainfall intensity at the time of top dressing of the remaining N dose. Losses of Nitrogen through leaching are pronounced in heavily fertilized soils and on fields where fertilizer application is poorly timed (Agbede, 2009).

Early planting between 25th April and 3rd May gave the highest grain yield which may be due to proper timing of nutrient placement and earlier planting date that favours high dry matter accumulation and grain filling. This is similar to the report of Johnson *et al*.,(1984) that grain sorghum yield decreased in the early June planting date compared to early May and April planting dates and when full N dose was applied at 25th April and 3rd May, it gave higher yield that expresses the yield potential of Var. SK 5912. Higher N yield observed when 90 kg N ha^{-1} was applied at earlier planting dates (25th April and 3rd May) may be due to low N mobility away from the root rhizosphere as a result of low rainfall intensity at the period. High yield of grain P observed in plots planted on 25th April and 3rd May planting dates may be due not only to good N nutrition that might have favoured high P uptake at the early growth stage but also to P redistribution at the seed formation when P from other plant parts moves to the seed, thus P content of seed is usually high (Agbede, 2009).

Table 3: Grain Nitrogen and Phosphorus as affected by planting date and Nitrogen application

	Planting Date				
Fertilizer	T1	T2	T3	T4	Mean
Grain Nitrogen (kg ha^{-1})					
F1	39.50	44.83	5.67	8.63	24.66
F2	16.16	15.42	13.92	8.98	13.62
Mean	27.83	30.13	9.80	8.81	
Grain Phosphorus (kg ha^{-1})					
F1	72.72	72.49	9.51	13.62	42.09
F2	34.55	26.56	25.25	16.10	25.62
Mean	53.64	49.53	17.38	14.86	
LSD 5%	Grain Nitrogen		Grain phosphorus		
Planting date (T)	9.7		21.6		
Fertilizer (F)	6.9		NS		
Interaction (T*F)	13.8		NS		

T1 = 25th April, T2 = 3rd May, T3 = 16th May, T4 = 9th June, F1 = 90 kg N ha applied at 2 Weeks After Planting (WAP), F2 = 45 kg N ha at 2 and 4WAP. NS = Not Significant at P<0.05

CONCLUSION

This study has shown that optimum grain and nutrients yield can be achieved within the study area, when *Sorghum* var. SK5912 is planted between 25th April and 3rd May with an application of 90 kg N ha^{-1} at 2WAP. Late planting of Sorghum in Minna longer than 3rd May will reduce Sorghum grain yield and nutrient uptake, more so without proper nutrient management to meet the peak use period of the crop. Also, split application since it did not increase grain yield and nutrient uptake is not encouraged.

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