THE INFLUENCE OF DATE OF PLANTING AND FERTILIZER APPLICATION ON GROWTH COMPONENTS OF COLUMBUS GRASS (*SORGHUM ALMUM*)

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ABSTRACT

Trials were conducted at Gangara in the Northern Guinea Savanna ecological zone of Nigeria during the 1990 and 1991 rainy seasons. The effects of date of planting (4th, 14th, 24th June and 4th July) and levels of nitrogen fertilizer (0, 50, 100, 150 and 200 kg/ha) on growth components of *Sorghum alnum* were investigated. Planting in mid-June (14th June) in 1990 and early-July (4th July) in 1991 resulted in superior stand establishment and dry matter yields ($P < 0.05$) than other dates. In mid-June and early-July planting 14 days post-planting, plant densities were 7.0 and 9.0 culms/m² while plant heights were 20.4 and 11.3cm for the respective years. It had high tillering capacity and irrespective of date of planting (except for early-June planting) plant densities by 56 days post-planting (DPP) were greater than 100 culms/m². Plant heights at this stage were greater than 100 culm/m² and were generally above 200cm. Ninety DPP the pasture was at full bloom/hard dough stage. DM yields then ranged from 8.0 to 11.4 tDM/ha in 1990 and 9.6 to 14.7 tDM/ha in 1991. Similarly seed yield for the respective years were 894.7 and 836.3 kg/ha. Fertilizer application ($P < 0.05$) plant vigour, tillering and dry matter yield up to the highest N applied. In the first year's trial, plant density at 35 days post-planting ranged from 12.0 to 29.0 culms/m² while in the second year the range was 13.0 to 26.0 culms/m². The corresponding values at 56 DPP (i.e. 42 days following N application) were 32.0 to 81.0 and 45.0 to 101.0 culms/m². Dry matter yields rose steadily from 6.5 to 12.5 tDM/ha in 1990 and from 8.9 to 13.6

tDM/ha in 1991 as fertilizer was increased from 0 to 200 kgN/ha. Seed yield during the same period for the respective years varied from 416.0 to 753.0kg/ha. This study has shown that planting between mid-June and early-July with fertilizer application of 100 to 200 kgN/ha favour *S. alnum* establishment and production in the Northern Guinea Savanna of Nigeria.

Key Words: Columbus grass, planting date, fertilizer, plant density, height, seed yield, Guinea Savanna.

INTRODUCTION

One of the recent forage introductions into Nigeria is *Sorghum alnum* (Columbus grass). Preliminary investigations indicate that it is a dense, drought tolerant, perennial grass with promising performance in the semi arid areas where fodder availability is a major constraint (Muhammad *et al.*, 1994). The establishment of the grass is from seed either broadcast or drilled in rows and planting date is a critical factor for establishment and growth particularly in the year of establishment (Narayanam and Dabadghao, 1972).

Okeagu *et al.* (1989) at Shika, reported that *Brachiaria decumbens* (Stapf) pasture's productivity was positively related to its tillering characteristics and fertilizer nitrogen rates. Similarly, Akinola *et al.* (1971) observed that tiller production and dry matter yield were influenced by nitrogen rates in most grasses Singh *et al.* (1988) using *S. sudanense* reported increased number of shoots/m length of row, leaf area index, plant height and dry matter yield with increase N application.

The response of *S. alnum* to nitrogen fertilizer in terms of dry matter yield and

TABLE 1: CHEMICAL CHARACTERISTIC¹ OF THE SOIL AT THE EXPERIMENTAL SITE.

Soil depth (cm)	pH H ₂ O	pH CaCl ₂	%Org. Carbon	%O.M	N%	Meg/CEC
1990: Pre-trial						
0-10	5.18	4.72	0.88	1.51	0.07	7.60
10-20	4.94	4.72	0.69	0.82	0.06	7.62
1991: Pre-trial						
0-10	5.35	4.93	0.89	1.53	0.06	6.40
10-20	5.25	4.84	0.70	0.83	0.07	5.20
NFC (1988)	5.78	4.89	0.38	0.65	0.05	1.88

¹ Soil analysis was according to method described by Black (1965).

nutritive value is well documented in a number of countries (Narayanam and Dabadghao, 1972; Bodgan, 1977). This study was therefore designed to examine the effects of planting date and fertilizer application on growth components of *S. alnum* in Northern Nigeria.

MATERIALS AND METHODS

Description of the Study Area

The trial was conducted at Gangara during the 1990 and 1991 rainy seasons. The location of experimental site was 11° to 11° 12'N and 6° 55' to 7° 33'E, 33km north of the National Animal Production Research Institute (NAPRI), Shika, Nigeria, at an altitude of 610m above sea level in Northern Guinea Savanna zone of the country.

The soil of the study area is a clay loam with the chemical characteristics shown in Table 1. Meteorological data taken at Samaru weather station 43 m from the site of the experiment are shown in figure 1. The climate of the study area is characterised by a defined wet season which normally begins in April/May and ends in late September/early October. The dry season on the other hand lasts from October to April with a low relative humidity and a dry north-east wind. The total annual rainfall ranges from 727 to 1284 mm with an average of 1025 mm. The highest mean maximum air temperature of 36°C is recorded in April while the lowest mean minimum temperature of about 11.5°C occurs in December/January (Kowal and Knabe, 1972).

The trial site was previously planted to maize

and fertilized with NPK during the 1989 cropping season. Animals were night-kralled during the subsequent dry season period.

Experimental Design

The field on which the trial was conducted was initially ploughed and harrowed to provide a fine seed bed. Subsequently, 3 x 2m² plots were laid out in split-plot layout, completely randomised block design. Four planting dates (June 4th, 14th, 24th, and July 4th) constituted the main-plot and five fertilizer levels (0, 50, 100, 150 and 200 KgN/ha) were the sub-plot. The 20 treatment combinations were replicated 8 times.

The foundation seed stock was received from the National Livestock Projects Division (NLPD), Federal Ministry of Agriculture. Seeds multiplied in preliminary trials in the Forage Introduction Field of NAPRI, Shika were used in the trials. Pre-trial germination tests indicated mean seed viability of 82.5%. At planting, pure germinable seeds were drilled at the rate of 16.5 Kg/ha in rows 50cm apart. Weeding was carried out manually. Two weeks post planting and different levels of nitrogen in the form of urea were applied. Second weeding was done three weeks later (i.e, 5 weeks post-planting) to further control annual weeds which were mainly *Amaranthus spinosus* and *Eleusine indica*, *Brachiaria stigmatistata* and *Digitaria* spp.

Field Sampling

Field samplings were done to monitor pasture establishment and phenological

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development by measuring plant population and culm heights were monitored intervals. Plant population and culm heights were monitored fourteen days post-planting and thereafter at weekly intervals up to boot stage. Plant counts within a 50 x 50 cm² quadrat from three random locations per plot were used to determine plant population. Culm height was measured from the ground level without pulling the leaves upright from ten random locations per plot.

At full bloom stage (90 days after planting) the forage crop was harvested 15 cm above the ground level with sickles to determine dry matter yields. A sample was chopped into about 30 cm length to facilitate oven for drying. All samples were oven-dried at 70°C for 48 hours. Seed production was determined by harvested panicles. The sun dried, threshed seeds constituted the yield.

Statistical analysis of the data was done using the Statistical Analysis System SAS (1987) Statistical package.

RESULTS

Soil Characteristics

Pre-trial chemical characteristics of the soil

of the experimental sites for the 1990 and 1991 studies indicated a fairly acidic soil with low pH values at all horizons (Table 1). Percent organic carbon and organic matter were higher in the first 10 cm of the sub-surface soil while percent nitrogen and cation exchange capacity values were fairly similar in both horizons.

Figure 1 illustrates the mean monthly records of rainfall, temperature, relative humidity and sunshine hours during the study periods. In 1991 the annual rainfall of 888.2 was below the long term average of 1025 mm reported by Kowal and Knabe (1972) for the same location while in 1991 the rainfall started in March and the total rainfall was just about the given long term average. Mean maximum and minimum air temperature recorded during the study period were nearly the same as the values reported by Kowal and Knabe (1972).

Seedling Establishment, Growth and Development

Under field conditions it took 4 to 10 days for most seedlings to emerge. Seedling establishment in both years was influenced by date of planting up to 49 days post-planting (DPP) of the pasture growth with no significant changes ($P > 0.05$) thereafter (Table

TABLE 2. EFFECT OF DATE OF PLANTING ON PLANT DENSITY (CULMS/M²) OF S. ALMUM AT VARIOUS PLANT AGES (DAYS AFTER PLANTING) AT GANGARA DURING THE 1990 AND 1991 TRAILS.

Planting Date		Days after planting						
		14	21	28	35	42	49	56
1990								
4th	Jun	2.0 ^c	3.0 ^c	5.0 ^c	11.0 ^d	18.0 ^c	21.0 ^c	26.0 ^b
14th	Jun	7.0 ^a	9.0 ^a	28.0 ^a	47.0 ^b	96.0 ^a	127.0 ^a	127.0 ^a
24th	Jun	1.0 ^c	5.0 ^c	16.0 ^b	35.0 ^c	50.0 ^b	71.0 ^b	110.0 ^a
4th	Jul	4.0 ^b	3.0 ^b	27.0 ^a	60.0 ^a	92.0 ^a	110.0 ^a	120.0 ^a
S.E.D		1.7	2.6	4.0	9.0	9.5	24.7	33.6
1991								
4th	Jun	5.0 ^b	56.0 ^b	19.0 ^c	21.0 ^b	34.0 ^b	41.0 ^b	56.0 ^b
14th	Jun	5.0 ^b	8.0 ^b	30.0 ^b	43.0 ^a	95.0 ^a	121.0 ^a	124.0 ^a
24th	Jun	4.0 ^b	6.0 ^b	19.0 ^c	21.0 ^b	54.0 ^b	78.0 ^a	110.0 ^a
4th	Jul	9.0 ^a	19.0 ^a	46.0 ^a	59.0 ^a	102.0 ^a	110.0 ^a	125.0 ^a
S.E.D		3.3	11.1	16.9	22.0	30.2	32.1	33.3

Means within year with same letters in same column are not significantly different ($P > 0.05$)
S.E.D = Standard error of difference

TABLE 3: EFFECT OF PLANTING DATE ON CULM HEIGHT (CM) OF *S. ALMUM* AT VARIOUS STAGES OF DEVELOPMENT AT GANGARA DURING THE 1990 AND 1991 TRIALS.

Planting Date		Days Post Planting							
		14	21	28	35	42	49	56	63
1990									
4th	Jun	9.9 ^b	23.8 ^{ab}	48.0 ^{ab}	68.1 ^b	122.6 ^b	199.5 ^a	243.5 ^a	252.8 ^a
14	Jun	20.4 ^a	25.0 ^a	51.9 ^a	86.7 ^a	109.4 ^{ab}	192.1 ^a	240.1 ^a	252.1 ^a
24	Jun	9.1 ^b	16.3 ^c	33.2 ^c	73.1 ^{ab}	97.1 ^b	134.5 ^b	224.1 ^b	232.3 ^b
4th	Jul	10.4 ^b	21.0 ^b	40.6 ^{bc}	69.4 ^b	97.1 ^b	130.3 ^c	193.3 ^c	205.6 ^c
S.E.D		2.9	3.1	8.5	14.0	22.0	12.0	17.6	11.5
1991									
4th	Jun	8.4 ^b	17.9 ^b	31.7 ^a	63.6 ^c	91.9 ^b	149.1 ^b	220.9 ^b	226.5 ^b
14	Jun	12.4 ^a	22.0 ^a	53.9 ^a	81.5 ^a	139.7 ^a	193.3 ^a	236.2 ^a	239.1 ^a
4th	Jul	11.3 ^a	18.5 ^b	40.2 ^c	62.3 ^c	95.2 ^b	129.8 ^b	210.9 ^b	225.6 ^b
S.E.D		2.3	2.0	6.0	6.1	28.2	30.2	11.0	3.1

Means within year with same letters in same column are not significantly different ($P > 0.05$)
S.E.D = Standard error of difference

TABLE 4. EFFECT OF N FERTILIZER ON PLANT DENSITY (CULMS/M²) OF *S. ALMUM* AT VARIOUS STAGES OF DEVELOPMENT AT GANGARA DURING THE 1990 AND 1991 TRIALS.

Fertilizer Rate (KgN/ha)	Days Post Planting						
	14	21	28	35	42	49	56
1990							
0	1.0	9.0	10.0	12.0 ^c	14.0 ^c	23.0 ^c	32.0 ^d
50	5.0	7.0	10.0	13.0 ^c	16.0 ^c	23.0 ^c	45.0 ^{cd}
100	6.0	7.0	10.0	12.0 ^c	15.0 ^c	24.0 ^c	54.0 ^c
150	5.0	7.0	10.0	20.0 ^b	43.0 ^b	49.0 ^b	69.0 ^b
200	6.0	9.0	11.0	29.0 ^a	50.0 ^a	60.0 ^a	81.0 ^a
S.E.D	1.5	1.8	2.5	8.0	9.3	12.0	13.9
1991							
0	8.0	10.0	11.0	13.0 ^c	15.0 ^c	33.0 ^c	45.0 ^d
50	7.0	8.0	11.0	14.0 ^c	16.0 ^c	33.0 ^c	55.0 ^{cd}
100	7.0	8.0	11.0	13.0 ^c	15.0 ^c	34.0 ^c	64.0 ^c
150	6.0	7.0	9.0	23.0 ^b	44.0 ^b	54.0 ^b	79.0 ^b
200	9.0	11.0	13.0	26.0 ^a	59.0 ^a	71.0 ^a	101.0 ^a
S.E.D	3.0	3.7	3.8	4.2	9.3	10.2	12.5

Means within year with same letters in same column are not significantly different ($P > 0.05$)
S.E.D = Standard error of difference

2). Plant population at 14 days post-planting for example, varied from 1.0 to 9.0 culms/m². There was profused tillering and 56 DPP the values had increased and varied from 26 to 127 culms/m². Planting in mid-June in 1990 and early-July in 1991 resulted in higher seedling establishment with the lowest plant population from the early June planting.

Table 3 presents data on height of plant at 14 DPP which varied significantly ($P < 0.05$) from 9.1 cm to 20.4 cm in 1990, and from 8.4 cm in 1991 (Table 3) due to planting dates. By 63 DPP the variations were 205.6 to 252.8cm and 225.0 to 239.1 cm in the respective years.

Planting in mid-June in both years produced more robust taller growing plants than other planting dates.

Fertilizer application significantly ($P < 0.05$) affected plant population 21 days post application (i.e 35 DPP) with linear increase to 200 KgN/ha up to the 8th week of pasture establishment (Table 4). Increased levels of fertilizer resulted in higher tillering. The effect of fertilizer N on plant height is shown in Table 5. Significant differences ($P < 0.05$) were found as from 14 days following fertilizer application (i.e 28 DPP) in the second year's trial. Plant height increased with age within

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TABLE 5: EFFECT OF FERTILIZER LEVEL ON CULM HEIGHT (CM) OF *S. ALMUM* AT VARIOUS STAGES OF DEVELOPMENT AT GANGARA DURING THE 1990 AND 1991 TRIALS.

Fertilizer Rate (KgN/ha)	Days Post Planting							
	14	21	28	35	42	49	56	63
1990								
0	12.6	22.1	38.5	62.0	93.3bc	153.5b	191.0b	232.0b
50	14.0	21.0	39.0	67.4	79.0c	155.0b	192.1b	219.6c
100	11.5	20.7	40.1	73.0	107.2b	160.4b	197.8b	234.0b
150	11.6	20.3	43.2	72.8	115.8ab	161.7b	204.8ab	238.6ab
200	13.4	23.7	45.5	72.8	138.0a	177.7a	225.0a	254.0a
S.E.D.	3.7	3.7	11.0	16.7	26.0	15.0	21.0	14.7
1991								
0	10.1	20.5	39.7ab	57.2c	86.4c	110.8c	216.9ab	225.5b
50	11.0	18.1	28.7a	64.5c	72.2c	110.9c	202.3b	217.6b
100	10.3	19.4	43.1ab	65.5c	102.8b	143.6b	225.3ab	236.5b
150	9.5	20.2	43.0ab	90.3a	118.4b	165.1ab	210.7ab	229.5b
200	11.6	19.7	44.7a	77.0b	135.9a	191.7a	233.5a	244.0a
S.E.D	2.8	3.5	15.0	33.7	15.9	28.3	24.0	12.3

Means within year with same letters in same column are not significantly different ($P > 0.05$)
S.E.M = Standard error of difference

TABLE 6. EFFECTS OF PLANTING DATE AND N FERTILIZER ON DRY MATTER (DM) AND SEED YIELDS OF *S. ALMUM* PASTURE AT GANGARA DURING THE 1990 AND 1991 TRIALS (KG DM/HA).

Treatment	1990	1991	Mean
Planting date			
DM Yield			
4th Jun	8,033.7b	9,627.0b	8830.35d
14th Jun	11,140.9a	10,551.0b	10845.95b
24th Jun	8,111.1b	10,541.2b	9326.15c
4th Jul	8,166.1b	14,792.0a	11479.05a
S.E.D	301.5	393.3	347.40
Fertilizer rate			
KgN/ha			
DM Yield			
0	6,77.4 ^d	8,867.0 ^c	7672.2 ^e
50	7,674.8 ^c	8,882.0 ^c	8278.4 ^d
100	8,951.8 ^c	9,174.0 ^c	9062.9 ^c
150	9,037.4 ^b	11,074.0 ^b	10055.7 ^b
200	12,508.4 ^a	13,600.0 ^a	13054.2 ^a
S.E.D.	337.1	491.6	414.4
Seed Yield			
4th Jun	749.6c	729.0c	739.3b
14th Jun	894.7a	800.0b	847.5a
24th Jun	836.6b	810.2b	823.4a
4th Jul	863.3b	836.3a	849.8a
S.E.D	30.01	25.21	27.6
Fertilizer Rate			
(KgN/ha)			
Seed Yield			
0	416 ^c	528 ^d	472.0 ^d
50	482 ^d	599 ^c	540.5 ^{cd}
100	531 ^c	609 ^c	570.0 ^c
150	697 ^b	696 ^b	696.0 ^b
200	753 ^a	739 ^a	746.0 ^a
S.E.D	39.11	34.98	37.1

Means within the same column with different superscripts are significantly different ($P < 0.05$)
S.E.D. = Standard error of difference

fertilizer level ($P < 0.05$). Application of 200 KgN/ha resulted consistently in taller plants than those in other treatments.

Dry Matter and Seed Yields. Table 6 shows mean forage yields of pasture in response to date of planting and N application. Mid- June and early-July plantings in 1990 and 1991 respectively resulted in higher dry matter yields than other planting dates. Same trend was observed for seed yield (Table 6) N-fertilization increased significantly ($P < 0.05$). Application 200 KgN/ha almost doubled DM yield obtained from untreated plots. Seed yield followed the same trend (Table 6).

DISCUSSION

Seedling Establishment, Growth and Development

The soil pH values obtained in this study at all horizons were fairly similar to the values reported by NFC (1988) for soils of Northern Nigeria. NFC (1988) reported that with good soil management, soil acidity may not be a factor hindering crop production in this zone. The %N level obtained in this study were slightly above the NFC (1988) report. However, the %N level of soils of the Northern Guinea Savanna have been reported to be deficient for cereal crops (NFC, 1998) and had earlier been noted to limit the quantity and quality of rangeland forages (Haggar, 1975). While percent organic carbon and organic matter were slightly higher, the cation exchange capacity values obtained in this study were 2-4 times more than values reported by NFC (1988) indicating a higher capacity to hold ions.

Annual rainfall of 888.2 in 1990 was below the long term average of 1025 mm reported by Kowal and Knabe (1972) for the same location while in 1991 the rainfall started in March and the total rainfall was just about the given long term average. The indication was that variability in forage establishment, growth and development in the Northern Guinea savanna is strongly tied to the amount and distribution of rainfall (Kowal and Knabe 1972). Annual rainfall recorded in both years were in excess

of the 500 mm recommended by Narayanam and Dabandghao (1972) for Columbus grass production and should favour seedling establishment, growth and development. Mean maximum and minimum air temperatures recorded during the study period were nearly the same the value reported by Kowal and Knabe (1972).

Results of this trial indicated planting in mid-June in 1990 and early-July in 1991 proved superior to other planting dates. The rains were well established and seed drilling then coincided with adequate soil moisture to favour germination and seedling emergence, even establishment, tillering and robust growth resulting to high dry matter accumulation. Plantings made earlier in both years recorded poor seed germination and uneven pasture establishment, short drought spell and theft by ants. This observation was similar to findings reported earlier in Shika (Northern Guinea Savanna) with Rhodes grass (*Chloris gayana*) (Agishi, 1971); Gamba (*Andropogon gayanus*) (Kallah and Agishi, 1982) for which planting between late June and mid July was recommended for obtaining higher forage yields.

Fertilizer application improved plant density and also plant height. Both pasture parameters continuously increased even up to the highest N-applied which seemed to suggest the maximum N-response level has not been reached. Jung *et al.* (1964) reported that growth rate and tillering were greatly improved by increased level of N-fertilizer in sudan grass (*Sorghum sudanense*). Earlier, Okeagu *et al.* (1989) found increased number of tillers/m² and dry DM yield in response to increase application of N in *Brachiaria decumbense* due to increase N- application.

Dry Matter and Seed Yields

The high dry matter yield obtained in this study between mid-June to early-July seem to suggest that mid-June to early July is optimum time for establishing Sorghum alnum pasture in the savanna zones. This finding agrees with earlier work by Agishi (1977); Kallah and Agishi (1982) in Northern Guinea Savanna.

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A number of researchers working in the Northern Guinea Savanna had reported a consistently increasing trend of herbage production from forage grasses with increases in fertilizer up to the highest N-level, (Haggar, 1975; Akinola, 1982; Okeagu *et al.*, 1989; Aribu *et al.* 1987, Kallah and Nzamane, 1984). DM yield of Columbus grass in this study was found to compare well with the more familiar pasture grasses in Nigeria such as *Andropogon gayanus* (Haggar, 1975), *Pennisetum purpureum* var Ngala (Akinola, 1982), *Brachiaria decumbens* (Okeagu *et al.*, 1989).

Dry matter yield increase with incremental amounts of nitrogen fertilizer up to the highest N-level in both years of the study agree with work by Singh *et al.* (1988) who reported similar observations with sudan grass. The DM yield obtained at the highest N-rate (260 KgN/ha) -35 to 48% was higher than growing the crop without fertilizer.

In this study the seed yield of *S. alnum* was up to 0.86t/ha obtained from the mid-June to early July plantings. Application of N fertilizer improved seed yield by increasing tiller production hence number of flowering heads. This is an economic advantage in addition to its ease of establishment, robust growth and high DM production within the season of establishment that could be used in the promotion of the forage to farmers.

This study has shown that mid-June to early-July is the optimum period for the establishment of *S. alnum* in the Northern Guinea Savannah for high pasture establishment and vigorous growth in the season of sowing. The steady increase in dry matter with increase in levels of N-applied indicates that the maximum level of *S. alnum* response to N-application has not been attained suggesting the need for further studies to identify the optimum fertilizer requirement of this newly introduced forage material.

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