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Response of Two Groundnut (*Arachis hypogaea* L.) Varieties to Sowing Date and NPK Fertilizer Rate in a Semi-Arid Environment: Growth and Growth Attributes

[1,2]H.M.B. Bala, [1]V.B. Ogunlela, [1]B. Tanimu and [1]N.C. Kuchinda
[1]Department of Agronomy, Faculty of Agriculture, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria
[2]College of Agriculture, Hassan Usman Katsina Polytechnic, Katsina, Nigeria

Corresponding Author: V.B. Ogunlela, Department of Agronomy, Faculty of Agriculture, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria

ABSTRACT

The main objective of the present investigation was to determine the growth attributes of two groundnut varieties as influenced by sowing date and NPK compound fertilizer rate. Treatments were factorial combinations of three sowing dates (mid-June, end-June and mid-July), three fertilizer rates (10 kg N+13 kg P+13 kg K ha^{-1}, 20 kg N+26 kg P+26 kg K $ha^{-1}$and 30 kg N+39 kg P+39 kg K ha^{-1}) and two varieties (SAMNUT-22 and SAMNUT-23). Fertilizer rate x sowing date constituted the main plot, while varieties were assigned to the sub-plot as the experiment was laid out in split-plot design with four replications. Canopy spread at 9 Weeks After Sowing (WAS) declined with delay in sowing in 2005. Application of 20 kg N+26 kg P+26 kg K ha^{-1} increased canopy spread significantly. The widest canopy spread in 2005 resulted from the application of 30 kg N+39 kg P+39 kg K ha^{-1} to mid-June sown crop. Dry matter at 9 WAS in 2004 declined 21.2% when sown in mid-July while at 12 WAS it declined 25.1% and by 23.3% in 2005. Variety SAMNUT-23 accumulated 18.6% greater dry matter than var. SAMNUT-22. During the period 9-12 WAS crop growth rates were highest for the mid-June sown crop and 20 kg N+26 kg P+26 kg K ha^{-1} fertilizer rate, with a value that was 59.4 and 50.1% higher than those for the lowest and highest fertilizer rates, respectively. Delayed sowing delayed 50% flowering. Variety SAMNUT-22 flowered 8 days later than var. SAMNUT-23 and when sown early (in mid-June) and treated with 20 kg N+26 kg P+26 kg K ha^{-1} out-performed SAMNUT-23 in growth attributes.

Key words: Cultivars, fertilizer rate, groundnut, growth, growth attributes, semi-arid environment, sowing date

INTRODUCTION

Groundnut (*Arachis hypogaea* L.), an important oilseed crop in Nigeria, is widely grown in the tropics and sub-tropics (Nigam *et al.*, 1991). It is one of the most important crops that have the ability to thrive on newly reclaimed sandy soils as a legume of high nutritive value as well as being a source of edible oil (Desire *et al.*, 2010). Although groundnut is grown mainly for its seed, with some 40-50% oil content, all other plant parts are useful as food or animal feed (Ahmad *et al.*, 2007). Arslan (2005) considered groundnut haulm as the most important of its by-products that can be used to supply feed to livestock and its hay providing extra income to smallholder farmers.

Balanced use of fertihzers is said to play an important role in sustainable crop production (Afridi *et al.*, 2002). A good crop production would depend upon the time and appropriate amount of fertilization (Jan and Khan, 2000). One of the important factors influencing the production of crops in the tropics is soil fertility (Wandahwa *et al.*, 2006) such that soil productivity is hampered by the deficiencies of nutrients such as nitrogen, phosphorus and potassium. One of the important nutrients in groundnut production is phosphorus because of its large effects on seed oil content, and as such, phosphorus in excess or deficiency may reduce oil percentage (Afridi *et al.*, 2002).

Because nutrients are exported and lost during cropping, there is need for nutrient inputs from inorganic fertilizers to maintain a positive nutrient balance (Buah and Mwinkaara, 2009).

Consequently, strategies must be developed to restore soil fertility in order to increase crop production (Mafongoya *et al.*, 2006).

As a result of the great importance of groundnut as an oilseed crop, much research has been done on the crop in various groundnut-growing parts of the world. Apart from yield attributes, other aspects of the crop that have been studied include growth and growth attributes in relation to fertilizers and environmental effects. Also of interest are variations that exist among different cultivars of groundnut. In the farming systems of northern Nigeria, groundnut features as a rotation crop because it can fix atmospheric nitrogen, thereby improving soil fertility. However, constraints to its production include the fact that most farmers grow unimproved cultivars and use little or no fertilizers. In addition, variations in genotype susceptibility to nutrient deficiency have been reported. Calcium deficiency is an important problem in groundnut production, with lines from the sub-species *A. hypogaea* (Virginia type) being considered more susceptible to Ca deficiency than those of *A. hypogaea fastgata* (Spanish and Valencia types) (Zharare *et al.*, 2009).

The need to improve groundnut productivity has necessitated the breeding of varieties that can take the advantage of factors such as fertilizer level and sowing time. New groundnut varieties were recently developed and released at the Institute for Agricultural Research, Samaru, Nigeria but very little, if any, of the agronomic requirements of these varieties are yet known.

Similarly, the growth characteristics of the varieties and their growth response to agronomic factors are yet to be determined. It has therefore become imperative that the agronomic requirements of these varieties be determined through research. The main objective of the present investigation was to determine the growth attributes of two groundnut varieties as influenced by sowing date and NPK compound fertilizer rate.

MATERIALS AND METHODS

Site description: Field trials were conducted during the 2004 and 2005 cropping seasons at the Institute for Agricultural Research farm, Samaru (lat. 11° 11'N; long. 07°38'E; 686 m above sea level), in the northern Guinea savanna of Nigeria to study the response of growth attributes of two groundnut (*Arachis hypogaea* L.) varieties under varying sowing dates and NPK fertilizer rates. The long-term annual rainfall average at Samaru is about 1100 mm, spread over 110-140 days, and is usually adequate to produce a good groundnut crop (Harkness *et al.*, 1976). The soil of the experimental site was a well-drained ferruginous tropical soil. The composite soil samples from 0-30 cm depth of the experimental site were analyzed for physico-chemical properties using standard procedures (Black, 1965). The results of these are shown in Table 1.

Treatments and experimental design: The treatments tested consisted of factorial combinations of three sowing dates (mid-June, end-June and mid-July); three NPK compound fertilizer rates

Table 1: Physico-chemical properties of the soil taken from 0-30 cm depth of the experimental sites during the 2004 and 2005 cropping seasons at Samaru, Nigeria

Item	2004	2005
Chemical property		
pH in H_2O (1:1)	5.50	5.48
Organic carbon (g kg^{-1})	2.60	3.40
Total nitrogen (g kg^{-1})	6.20	10.00
Available P (mg kg^{-1})	5.25	4.46
Exchangeable cation (cmol kg^{-1})		
Ca	1.43	5.92
Mg	0.62	2.17
K	1.82	0.36
Na	5.00	5.65
CEC	6.60	10.00
Particle size distribntion (%)		
Sand	32.00	22.00
Silt	44.00	60.00
Clay	24.00	18.00
Textural class	Silt loam	Silt loam

(10 kg N+13 kg P+13 kg K, 20 kg N+26 kg P+20 kg K and 30 kg N+39 kg P+39 kg K ha^{-1}) and two varieties (SAMNUT-22 and SAMNUT-23). SAMNUT-22 is a high-yielding dual-purpose spreading line with a 110-120 days maturity period while SAMNUT-23 is an early maturing with 90-100 days maturity period. Both varieties are high yielding and rosette resistant. The treatments were replicated four times and laid out in split-plot design with combination of sowing date and compound fertilizer level assigned to the main plot and variety to the subplot.

Planting and cultural practices: The field was ridged 0.75 m apart with intra-row spacing of 0.20 m and planting was thinned down to two seedlings per hill three weeks after sowing (WAS) to give a population of 133 200 plants ha^{-1}. The gross plot was 6.0×4.5 m (6 rows, 6 m long) while net plot was 6.0×3.0 m (4 rows, 6 m long). Before planting, seed was treated with Apron Star at a rate of 10 g per 3 kg of seed. Full dose of fertilizer in each case was applied side-dressed according to treatment at 2 WAP. Nitrogen was applied as Urea (46% N), while phosphorus and potassium were applied as single superphosphate (7.9% P) and muriate of potash (49.8% K), respectively. Butachlor 50 EC at the rate of 4 L ha^{-1} was applied pre-emergence as weed control measure with supplementary hoe-weeding done at 6 WAS.

Measurements: Five plants were randomly tagged per plot from where periodic observations were made at 3, 6, 9 and 12 WAS for measurement of growth parameters. Five plants per plot were sampled at 3-week intervals by cutting at ground level starting at 3 WAS through 12 WAS and dried in an oven at 70°C until constant dry weight. Dry weights were used to determine dry matter accumulation and crop growth rate (CGR). CGR, a measure of increase in dry weight per unit of land area per unit time, was determined at 3-week intervals using the standard formula (Watson, 1952).

Other parameters measured include canopy spread, dry matter accumulation and days to 50% flowering.

Data analysis: Data collected were subjected to one-way analysis of variance using the SAS software (SAS Institute, 2001) to determine the significance of treatment effects on each parameter (Snedecor and Cochran, 1967) and the means were separated using the Duncan's Multiple Range Test (Steel *et al*., 1997).

RESULTS AND DISCUSSION

General: The modest response to NPK fertilizer application observed in the present investigation can be explained in a number of ways. Groundnut is generally known not to demand high levels of nitrogen but it responds to phosphorus in most situations depending on native phosphorus soil status. Naseri *et al*. (2010) opined that P-availability and use by plants vary among plant species. Hence they hypothesized that P-availability and uptake relate to sorption characteristics of soil. This assertion would explain why response to phosphorus by crops is not likely to be consistent. The result of work by Onduru *et al*. (2008) in Kenya showed that the sole application of manure or inorganic fertilizer provides a better picture of actual fertihzer rate required by crops in sub-humid and semi-arid environments in Sub-Saharan Africa.

Canopy spread: Delaying of sowing from mid-June until end of June and even later up to mid-July in 2005 did not significantly influence canopy spread (Table 2) in groundnut at 3, 6 and 12 WAS. However, when sowing was delayed from mid-June to mid-July canopy spread at 9 WAS declined significantly. This occurred probably because the later sown crop was not able to fully harness and utilize available natural resources (radiation, moisture and nutrient) hence the observed decrease in canopy spread. In addition, later sowing caused progressively slower canopy development because of the differences in cumulative interception of incident light caused by different leaf area duration. This is in accordance with the reported results of Bell (1986) who found that differences in aboveground dry matter production among different sowing dates under irrigation were associated with variation in cumulative interception of incident irradiation. The

Table 2: Canopy spread (cm) of groundnut as affected by sowing date, NPK fertilizer rate and variety in the 2005 cropping season at Samaru, Nigeria

	Weeks after sowing			
Treatment	3	6	9	12
Sowing date				
Mid-June	15.00	34.60	56.90[a]	66.80
End-June	15.40	35.70	51.40[b]	66.00
Mid-July	15.60	32.20	49.10[c]	66.60
SE±	0.22	0.53	0.81	0.98
NPK fertilizer rate (kg ha^{-1})				
10N:13P:13K	15.30	36.10[a]	53.40	66.00
20N:26P:26K	15.60	35.60[a]	51.90	64.70
30N:39P:39K	15.10	33.90[b]	52.10	64.60
SE±	0.22	0.53	0.81	0.98
Variety				
SAMNUT-22	16.10[a]	36.30[a]	53.40[a]	65.90
SAMNUT-23	14.60[b]	34.00[b]	51.50[b]	64.30
SE ±	0.27	0.46	0.57	0.69

Means within the same column followed by the same letter(s) are significantly different at 5% probability level according to Duncan's multiple range test (DMRT) medium NPK application rate of 20 kg N+26 kg P+26 kg K ha^{-1} resulted in a wider crop canopy which translated into higher crop growth rates. These increases could have been as a result of increase in leaf area index, leaf area duration and net assimilation rate as reported by Augadi *et al*. (1990). At 3, 6 and 12 WAS, SAMNUT-22 plants produced significantly wider crop canopies than plants of SAMNUT-23. This is simply because the former variety has a spreading growth habit, expression of which was enhanced by early sowing. This observation is in consonance with an earlier report by Patel *et al*. (2005) who indicated that spreading and semi-spreading groundnut varieties differ in their potential productivity.

Significant sowing date× NPK fertilizer rate and sowing date× variety interactions for canopy spread at 9 WAS in the 2005 cropping season were observed (Table 3). Under the lowest NPK fertilizer rate canopy spread was widest at the mid-June sowing. The canopy spread at end-June and mid-July sowing dates decreased, even though both of them were at par. Under the highest NPK fertilizer rate, canopy spread declined significantly as sowing date was delayed from mid-June through mid-July (Table 3). Under the mid-July sowing date, canopy spread remained unchanged until the highest NPK fertilizer rate was applied and canopy spread declined significantly, with values of 50.5 and 50.8 cm for NPK 10:13:13 and 20: 26: 26, respectively and 46.0 cm for NPK 30: 39: 39. Whereas, under the mid-June and end-June sowing dates, canopy spread increased significantly at this highest NPK fertilizer rate.

Under variety SAMNUT-22, canopy spread declined progressively as sowing date was delayed from mid-June through mid-July; whereas, under variety SAMNUT-23, canopy spread responded modestly to sowing date such that the three sowing dates were statistically at par. Under the mid-June sowing var. SAMNUT-22 had a significantly wide canopy spread than SAMNUT-23 while under the other two later sowing dates, both varieties were at par.

Dry matter accumulation: Dry matter (DM) accumulation in groundnut at 9 and 12 WAS in 2004 and 9 WAS in 2005 responded significantly to sowing date as groundnut plants accumulated less DM as sowing was delayed (Table 4). This result corroborates the result of Bell (1986) who conducted research under irrigation in a monsoonal tropical environment in Australia and reported that vegetative development in groundnut was very responsive to sowing date, with progressive reductions in vegetative dry matter as sowing was delayed. DM at 9 WAS in 2004 did not decline until sowing was delayed till mid-July, when decline was up to 21.2% while at 12 WAS, it declined by 25.1%. Relative to DM for mid-June sowing, DM for the mid-July sowing was 23.3% lower in value when determined at 12 WAS in 2005. Babu *et al*. (2004) asserted that potential productivity

Table 3: Sowing date×NPK fertilizer rate and sowing date×variety interactions for canopy spread (cm) at 9 weeks after sowing of groundnut in the 2005 cropping season at Samaru, Nigeria

	NPK fertilizer rates			Varieties	
Sowing date	10N:13P:13K	20N:26P:26K	30N:39P:39K	SAMNUT- 22	SAMNUT-23
Mid-June	57.6[a]	55.5[bc]	57.3[a]	59.0[a]	54.8[b]
End-June	51.7[cd]	49.5[d]	53.1[b]	52.9[b]	49.9[bc]
Mid-July	50.5[cd]	50.8[cd]	46.0[e]	48.4[c]	49.8[bc]
S.E.±	1.22			1.38	

Means within the interaction table followed by the same letter (s) are not significantly different at 5% probability level according to the Duncan's multiple range test

Table 4: Dry matter accumulation (g plant^{-1}) in groundnut as affect by sowing date, NPK fertilizer level and variety in 2004 and 2005 cropping seasons at Samaru, Nigeria

	Weeks after sowing					
	2004			2005		
Treatment	6	9	12	6	9	12
Sowing date						
Mid-June	8.43	29.07^{a}	43.06^{b}	8.43	31.18^{ab}	72.13
End-June	7.93	29.56^{a}	53.96^{a}	7.63	34.05^{a}	70.79
Mid-July	8.50	23.30^{b}	40.41^{b}	7.26	26.10^{b}	63.34
S.E.±	0.286	1.373	2.681	0.48	1.92	3.93
NPK fertilizer rate (kg ha^{-1})						
10N:13P:13K	8.27	27.58	46.93	7.67	30.04	68.71
20N:26P:26K	7.97	25.20	41.26	8.00	32.11	72.95
30N:39P:39K	8.63	29.16	49.28	7.54	29.20	67.60
S.E.±	0.286	1.373	2.681	0.477	1.921	3.93
Variety						
SAMNUT-22	7.95	25.00^{b}	44.55	7.25	30.69	68.49
SAMNUT-23	8.62	29.64^{a}	47.09	8.23	30.22	71.01
S.E.±	0.234	1.121	2.189	0.39	1.569	3.208

Means within the same column followed by the same letter(s) are significantly different at 5% probability level according to Duncan's multiple range test (DMRT)

of groundnut depends on weather relations during the crop growth period, which in turn depends on time of sowing. Similarly, differences in DM production in bambara groundnut (*Vigna subterranea*) landraces in Dodoma, Tanzania were attributed to variation in the amount and distribution of rainfall and to decline in temperatures towards the end of the season (Collinson *et al*., 2000).

DM accumulation in groundnut at the three growth stages did not respond to NPK fertilizer rate significantly in both years. Similarly, the two groundnut varieties did not differ in their DM accumulation with the exception of 9 WAS in 2004 when var. SAMNUT-23 accumulated greater DM than var. SAMNUT-22 (Table 3). DM accumulated by the former variety was 18.6% greater than that by the latter.

Crop growth rate: Groundnut crop growth rate (CGR) responded inconsistently to sowing date, NPK fertilizer rate and variety during the three growth periods in 2004 (Table 5). While CGR values during 3-6 and 6-9 WAS did not respond to sowing date, the CGR values during 9-12 WAS were highest for the end-June sowing relative to the mid-June and mid-July sowing. Similarly, CGR during 6-9 WAS was highest for 20 kg N+26 kg P+26 kg K per ha fertilizer rate relative to either the higher or lower NPK fertilizer rate. The CGR for this same NPK fertilizer rate was 59.4% higher than that for the lowest NPK rate and 50.1% higher than that for the highest NPK fertilizer rate i.e., 30 kg N+39 kg P+39 kg K ha^{-1} fertilizer rate. Such an observation could be as a result of higher levels of leaf area index, leaf area duration and net assimilation rate under the 20 kg N+26 kg P+26 kg K per ha rate as earlier opined by Augadi *et al*. (1990). Fertilizer rate did not influence CGR during 3-6 and 9-12 WAS. CGR in SAMNUT-23 during 3-6 WAS was significantly higher than for var. SAMNUT-22 whereas during other two growth periods, the two varieties did not differ in their CGR values.

Table 5: Crop growth rate (g $m^{-2}.wk^{-1}$) of groundnut as affected by sowing date, NPK fertilizer rate and variety in the 2004 cropping season at Samaru, Nigeria

	Weeks after sowing		
Treatment	3-6	6-9	9-12
Sowing dates			
Mid-June	2.67	7.35	5.40[b]
End-June	1.50	7.71	8.23[a]
Mid-July	2.68	10.09	6.04[ab]
SE±	0.098	1.248	0.88
NPK fertilizer rate (kg ha^{-1})			
10N:13P:13K	2.62	6.88[b]	6.87
6.8720N:26P:26K	2.50	10. 97[a]	5.72
5.7230N:39P:39K	2.73	2.31[b]	7.11
SE±	0.098	1.248	0.886
Variety			
SAMNUT-22	2.49[b]	8.33	6.92
SAMNUT-23	2.74[a]	8.44	6.21
SE±	0.079	0.019	0.723

Means within the same column followed by the same letter(s) are significantly different at 5% probability level according to Duncan's multiple range test (DMRT)

The result is similar to the one reported by Patel *et al.* (2005) who revealed that all the HPS II lines produced slightly higher CGR values relative to that of JL 24 in India. The present result is not totally unexpected given that variety SAMNUT-23 has a semi-erect growth habit, with earlier maturity than SAMNUT-22 and would be able to intercept greater solar radiation and accumulate greater DM per unit land area per unit time as shown here.

Days to 50% flowering: Sowing date, NPK fertilizer rate and variety influenced days to 50% flowering in groundnut significantly in 2004 and 2005 (Table 6). The groundnut crop took more days to attain 50% flowering as sowing date was delayed. This attests to the belief that reproductive growth in groundnut is strongly related to day length during emergence through 50% flowering. In other words, earlier sowing caused earlier flowering. This result corroborates that of Nur and Gasim (1978) who reported that the earlier the sowing of groundnut the later was kernel initiation and maturity at Wad Medani in the Sudan. It however, contradicts the observation by Caĥskan *et al.* (2008) in the Mediterranean-type environment of Turkey, who reported lengthening of growth duration when groundnut was early sown, even though this was favourable to yield. Generally, the two later sowing dates did not differ with respect to when the crop flowered. The first sown crop was exposed to a period of higher temperatures than the crop that was sown at the two later sowing dates hence the earlier flowering. Average daily maximum temperatures would seem to have a major impact on number of days to flowering. Ono (1979) had reported that as daily temperature rises, the number of days for the first flowering to occur reduced in sub-species *hypogaea*. It was only in 2005 that NPK fertilizer influenced days to 50% flowering significantly. Application of NPK 30 kg N+39 kg P+39 kg K ha^{-1} increased days to 50% flowering modestly relative to application of NPK 10 kg N+13 kg P+13 kg K ha^{-1}. This result suggests that nutrient deficiency is likely to hasten flowering in groundnut.

Table 6: Number of days to 50% flowering of groundnut as affected by sowing date, NPK fertilizer rate and variety in the 2004 and 2005 cropping seasons at Samaru, Nigeria

	Years		
Treatment	2004	2005	Combined
Sowing dates			
Mid-June	33.60[b]	33.60[b]	33.60[b]
End-June	38.70[a]	38.00[ab]	38.30[a]
Mid-July	38.30[a]	38.40[a]	38.40[a]
SE±	0.28	0.16	0.24
NPK fertilizer rate (kg ha^{-1})			
10N:13P:13K	36.80	36.40[b]	36.60
20N:26P:26K	36.80	36.60[ab]	36.70
30N:39P:39K	37.00	36.90[a]	36.90
SE±	0.28	0.16	0.24
Variety			
SAMNUT-22	40.80[a]	40.60[a]	40.79
SAMNUT-23	32.90[b]	32.60[b]	632.80[b]
SE±	0.18	0.11	0.17

Means within the same column followed by the same letter(s) are significantly different at 5% probability level according to Duncan's Multiple Range Test (DMRT)

Table 7: Sowing date×variety interaction for number of days to 50% to flowering in groundnut in the 2004 and 2005 cropping seasons at Samaru, Nigeria

	Varieties			
	2004		2005	
Sowing dates	SAMNUT-22	SAMNUT-23	SAMNUT-22	SAMNUT-23
Mid-June	38.25[a]	29.00[b]	37.75[c]	49.25[a]
End-June	42.42[a]	34.92[a]	42.58[b]	33.38[c]
Mid-July	41.83[a]	34.83[a]	41.58[b]	35.25[c]
S.E.±	0.04		0.23	

Means within the same column followed by the same letter(s) are significantly different at 5% probability level according to Duncan's multiple range test (DMRT)

Variety SAMNUT-22 consistently attained 50% flowering later than var. SAMNUT-23 in both years, by as much as 8 days in each year, representing some 24.0% delay. This observation did not come as a surprise considering that var. SAMNUT-23 is an earlier maturing variety than SAMNUT-22.Studies on heat unit requirements of field grown groundnut varieties in parts of Tamil Nadu, India revealed that number of days taken to attain 50% flowering and maturity varied with varieties due to inherent genetic variation (Babu *et al*., 2004).

Sowing date×variety interaction for 50% flowering was statistically significant in both 2004 and 2005 (Table 7). While days to 50% flowering in var. SAMNUT-22 did not respond to sowing date, it was increased significantly in var. SAMNUT-23 as sowing was delayed until end-June or mid-July. In 2005, the result was slightly different, Even though days to 50% flowering in var. SAMNUT-22 increased significantly with delay in sowing, reverse was the case in var. SAMNUT-23, as days to 50% flowering decreased with delay in sowing. In other words, the two varieties responded differently with respect to attainment of 50% flowering.

CONCLUSION

It can be concluded from the result of this investigation that the two varieties differed significantly with respect to most of the growth parameters, with SAMNUT-22 being superior to SAMNUT-23. It could be recommended that SAMNUT-22 if sown early (mid-June) and given a fertilizer rate of 20:26:26 kg ha^{-1} NPK dressing will produce higher, with respect to most of the growth parameters.

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