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

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ABSTRACT

In order to determine the optimum sowing date and NPK fertilizer rate for two groundnut (*Arachis hypogaea* L.) varieties for best yield performance and to improve their production, field trials were conducted during the 2004 and 2005 cropping seasons at Samaru, Nigeria. The treatments were composed of factorial combinations of three sowing dates (mid-June, end-June and mid-July), three NPK 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 rates x sowing dates 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. Delaying of groundnut sowing till mid-July caused a 27.3% decline in number of pods per plant. When sowing was delayed until end of June or mid-July, pod, seed and haulm yields declined 44.9, 45.2 and 23.5%, respectively relative to sowing in mid-June. However, parameters such as number of pods per plant, pod yield and seed yield were not influenced significantly by fertilizer rate. Variety SAMNUT-23 produced significantly more pods per plant and higher pod, seed and haulm yields than SAMNUT-22. Significant interactions were observed between the treatment factors for most yield attributes. In most cases variety was a function in the response of the parameters to treatments. It was found that when SAMNUT-23 was sown in mid-June it significantly out-performed SAMNUT-22. We conclude that early sowing enhanced positive response of pod yield to NPK fertilizer application while the optimum sowing date for good yield performance in both varieties is mid-June.

Key words: Fertilizer rate, groundnut, semi-arid environment, sowing date, yield attributes

INTRODUCTION

Groundnut (*Arachis hypogaea* L.), one of the world's most important pulse crops, is an oilseed crop of economic importance in Nigeria. All the parts of the crop are of importance in the sense that the seed is a primary source of protein and oil for human consumption while the haulm and shells are important animal feed and source of supplementary income during the dry season (Arslan, 2005; Ahmad *et al.*, 2007; Naab *et al.*, 2009). Hence, groundnut is an important component of cropping systems of smallholder farmers in Nigeria. Unfortunately, low average pod yields of the crop continue to pose a serious challenge in production, causing serious shortfalls in supply. However, it is known to have the ability to thrive on newly reclaimed sandy soils, being a legume of high nutritive value (Desire *et al.*, 2010).

Another important component of cropping systems in sub-Saharan Africa is nutrient management. Balanced use of fertilizers has therefore been said to play an important role in sustainable crop production (Afridi *et al.*, 2002). Soil fertility is among important factors that influence crop production in tropical regions (Wandahwa *et al.*, 2006) such that soil productivity is hampered by the deficiencies of major nutrients. It was concluded that phosphorus is essential for improving productivity of smallholder agriculture in sub-Saharan Africa (Snapp, 1998). It is also believed that groundnut requires large quantities of phosphorus, calcium and sulphur for seed development and oil quantity. Because nutrients are removed and consequently lost as result of cropping with crop harvests, there is need to replace lost nutrients through the application of inorganic fertilizers in order to maintain a positive nutrient balance (Buah and Mwinkaara, 2009).

Many investigations on NPK effects on various crop species have been reported. Under different cropping systems in southwest Nigeria crop yields were the same under NPK alone and NPK+poultry manure both higher than poultry alone and control in both locations (Ayoola and Adeniyan, 2006).

In semi-arid Nigeria, Jaliya *et al.* (2008) observed that application of 150:26:50 kg NPK ha^{-1} produced higher maize cob yield and grain weight $plant^{-1}$ than the lower rates in both years while Babaji *et al.* (2010) at the same semi-arid location found that application of 120:60:60 kg NPK ha^{-1} produced 140 and 69% higher maize cob yield than the no-fertilizer control in 2005 and 2006, respectively. Elsewhere in Nigeria, significant fruit yield increase obtained by the application of fertilizer clearly demonstrated the benefit of the application of NPK fertilizer to tomato plant (Law-Ogbono and Egharevba, 2008). In the same vein, fertigation with 100% NPK water-soluble fertilizers increased tomato fruit yield significantly over furrow irrigation control, drip irrigation (Shedeed *et al.*, 2009). Okra (*Abelmoschus esculentus* L. Moench) is another crop that was said to benefit from NPK application. It had been reported that fertilizer NPK significantly increased yield and yield components with maximum pod yield being obtained at 150 kg NPK ha^{-1} (Omotoso and Shittu, 2007).

In order to raise production level, the investigation reported here was initiated to study the effects of fertilizer application and sowing date on the agronomic performance of two varieties of groundnut. The main objective of the investigation was therefore to determine the response of yield and yield attributes of two groundnut varieties to different sowing dates and NPK fertilizer rates.

MATERIALS AND METHODS

Field trials were conducted during the 2004 and 2005 cropping seasons at the Institute for Agricultural Research experimental 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 yield performance of two groundnut varieties under varying sowing dates and NPK fertilizer rates. The experimental site had 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) and the results of these have earlier been presented elsewhere (Bala *et al.*, 2011).

The treatments tested consisted of factorial combinations of three sowing dates (mid-June, end-June and mid-July); three NPK fertilizer rates (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 110-120 days maturity period while SAMNUT-23 is early maturing with 90-100 days maturity period. Both varieties are relatively 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 sub-plot. Other agronomic details have been presented in an earlier paper in the series (Bala *et al*., 2011).

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

Pod yield: In each of the two years, pod yield declined progressively as sowing was delayed from mid-June through mid-July (Table 1). When the data were pooled over years, pod yield declined 385 and 937 kg ha^{-1} when groundnut was sown late June and mid-July, respectively. Among the sowing dates, the lowest and highest pod yields were 1106 and 2043 kg ha^{-1}, respectively. Pod yield was unaffected by NPK fertilizer application in both years but var. SAMNUT-23 out-yielded SAMNUT-22 by margins of 448 and 636 kg ha^{-1} in 2004 and 2005, respectively. Overall, var. SAMNUT-23 produced 542 kg ha^{-1} greater pod yield than SAMNUT-22.

Sowing date×NPK fertilizer rate interaction on groundnut pod yield was statistically significant in 2005 (Table 2). The highest pod yield (1878 or 1894 kg ha^{-1}) was obtained when the mid-June sown crop received either the lowest or highest NPK fertilizer rate. However when the latest sown crop received the highest NPK fertilizer rate, the lowest pod yield was produced.

Sowing date x variety interaction on pod yield was statistically significant in 2005. The two groundnut varieties responded differentially to sowing date with respect to pod yield (Table 3). Even though pod yield declined in both varieties as sowing was delayed, pod yield in var. SAMNUT-23 responded more negatively to delayed sowing than did var. SAMNUT-22. Pod yield declined 596 and 1012 kg ha^{-1} in SAMNUT-22 and SAMNUT-23, respectively as sowing was delayed till mid-July.

Seed yield: Seed yield responded negatively to delay in sowing in a consistent manner just as pod yield in 2004 and 2005 (Table 4). When sowing was delayed till late June and mid-July in 2004 groundnut seed yield declined 283 and 526 kg ha^{-1}, respectively. Corresponding decreases in seed yield in 2005 were 178 and 439 kg ha^{-1}. Pooled over the two years, seed yield declined significantly with delay in sowing by as much as 231 and 483 kg ha^{-1} when the crop was sown in late June and mid-July, respectively. The lowest and highest seed yields recorded were 585 and 1068 kg ha^{-1}, respectively among the different sowing dates in the pooled data. Conversely, seed yield was not influenced by NPK fertilizer application. Variety SAMNUT-23 out-yielded SAMNUT-22 significantly in both years. Seed yield in the former variety was higher than in the latter by 109, 201 and 156 kg ha^{-1} in 2004, 2005 and when data were pooled, respectively.

Delayed sowing of groundnut affected the seed yield in SAMNUT-23 more negatively than it did in the case of SAMNUT-22 in 2005 (Table 5). In var. SAMNUT-23 as sowing was being delayed

Table 1: Pod yield (kg ha^{-1}) 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 date			
Mid-June	2243a	844.0a	2043.0a
End-June	1850b	1465.0b	1658.0b
Mid-July	1172c	1040.0c	1106.0c
SE±	105	58.9	81.6
NPK fertilizer rate (kg ha^{-1})			
10N:13P:13K	1716	1506.0	1609.0
20N:26P:26K	1865	1384.0	1625.0
30N:39P:39K	1684	1461.0	1572.0
SE±	105	58.9	81.6
Variety			
SAMNUT-22	1531b	1131.0b	1331.0b
SAMNUT- 23	1979a	1767.0a	1873.0a
SE±	86.1	44.9	73.2

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

Table 2: Sowing date x NPK fertilizer rate interaction on pod yield (kg ha^{-1}) of groundnut in the 2005 cropping season at Samaru, Nigeria

	NPK fertilizer rates (kg ha^{-1})		
Sowing date	10N:13P:13K	20N:26P:26K	30N:39P:39K
Mid-June	1878a	1760.0ab	1894a
End-June	1644ab	1192.0cd	1559b
Mid-July	988cd	1202.0c	929d
SE±		95.3	

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

Table 3: Sowing date x variety interaction on pod yield (kg ha^{-1}) in groundnut in the 2005 cropping season at Samaru, Nigeria

	Varieties	
Sowing date	SAMNUT-22	SAMNUT-23
Mid-June	1424c	2263a
End-June	1142d	1788b
Mid-July	828e	1251cd
SE±	83.2	

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

from mid-June through mid-July, seed yield decline continued progressively. Whereas, in the case of var. SAMNUT-22, seed yield decline was slight as sowing delay progressed to the extent that seed yields were at par.

Table 4: Seed yield (kg ha^{-1}) 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 date			
Mid-June	1139a	997.0a	1068.0a
End-June	856b	819.0b	837.0b
Mid-July	613c	558.0c	585.0c
SE±	63.4	39.9	42.8
NPK fertilizer rate (kg ha^{-1})			
10N:13P:13K	873	796.0	835.0
20N:26P:26K	910	749.0	830.0
30N:39P:39K	824	828.0	826.0
SE±	63.4	39.9	42.8
Variety			
SAMNUT-22	815b	690.0b	752.0b
SAMNUT-23	924a	891.0a	908.0a
SE±	37	29.1	41.2

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

Table 5: Sowing date x variety interaction on seed yield (kg ha^{-1}) in groundnut in the 2005 cropping season at Samaru, Nigeria

	Varieties	
Sowing date	SAMNUT-22	SAMNUT-23
Mid-June	799b	1194a
End-June	741bc	896b
Mid-July	530cd	585cd
SE±	56.5	

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

Haulm yield: Haulm yield declined significantly in response to delay in sowing in 2004 and 2005 (Table 6). The nature of response to delayed sowing differed between the two years and when the data were pooled over years and the lowest and highest haulm yields were 2166 and 2832 kg ha^{-1}, respectively. While haulm yield declined significantly with delayed sowing only up to late June in 2004, haulm yield decline did not occur in 2005 until sowing was delayed till mid-July. When the data were pooled over the two years, haulm yield declined steadily as sowing was delayed from mid-June through mid-July. Haulm yield declined 390 and 666 kg ha^{-1} as sowing was delayed till late June and mid-July, respectively. Haulm yield did not respond to NPK fertilizer application in the first year but its application increased haulm yield in 2005, the only year that differences in haulm yield were observed between the two groundnut varieties. Variety SAMNUT-23 produced 9.1% greater but statistically significant haulm yield than SAMNUT-22.

Number of pods per plant: Number of pods per plant generally decreased as sowing was delayed from mid- June through mid-July in both years (Table 7). Decline in pod number was sharper in 2004 than in 2005. Between the earliest and the latest sowing dates, decrease in pod number was 27.3%. It was only in 2004 that NPK fertilizer application influenced number of pods per plant

Table 6: Haulm yield (kg ha^{-1}) of groundnut as affected by sowing date, NPK fertilizer rate and variety in the 2004 and 2005 cropping seasons at Samaru, Nigeria

Treatment	Years 2004	2005	Combined
Sowing date			
Mid-June	3129a	2534.0a	2832.0a
End-June	2366b	2518.0a	2442.0b
Mid-July	2557b	1775.0b	2166.0c
SE±	129.2	125.0	123.3
NPK fertilizer rate (kg ha^{-1})			
10N:13P:13K	2672	2222.0	2447.0
20N:26P:26K	2838	2241.0	2540.0
30N:39P:39K	2542	2363.0	2453.0
SE±	129.2	125.0	123.3
Variety			
SAMNUT-22	2751	2177.0b	2464.0
SAMNUT-23	2617	2375.0a	2496.0
SE±	128.9	67.7	113.3

Means within the same column followed by the same letter(s) are not significantly different according to Duncan's multiple range test (DMRT)

Table 7: Number of pods per plant in groundnut as affected by sowing date, NPK fertilizer rate and variety in the 2004 and 2005 cropping seasons at Samaru, Nigeria

Treatment	Years 2004	2005	Combined
Sowing date			
Mid-June	47.9a	25.3a	36.6a
End-June	40.8b	23.8ab	32.3b
Mid-July	32.4c	20.1b	26.6c
SE±	1.98	1.45	1.47
NPK fertilizer rate (kg ha^{-1})			
10N:13P:13K	37.9b	24.20	32.00
20N:26P:26K	45.5a	22.20	33.80
30N:39P:39K	37.7b	22.80	30.20
SE±	1.98	1.45	1.47
Variety			
SAMNUT-22	38.8	20.4b	29.6b
SAMNUT-23	41.9	25.8a	33.8a
SE±	1.99	1.2	1.64

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

significantly. The highest pod number was produced by the application of 20 kg N+26 kg P+26 kg K ha^{-1}. Variety SAMNUT-23 produced significantly more pods per plant than SAMNUT-22 in 2005 and when data were pooled by margins 26.5 and 14.2%, respectively.

Weight of dry pods per plant: Sowing date×NPK fertilizer rate interaction on weight of dry pods per plant was statistically significant in 2005 (Table 8). Under the lowest NPK fertilizer rate weight

Table 8: Sowing date x NPK fertilizer rate interaction on weight of dry pods per plant (g plant^{-1}) in groundnut in the 2005 cropping season at Samaru, Nigeria

	NPK fertilizer rates (kg ha^{-1})		
Sowing date	10N:13P:13K	20N:26P:26K	30N:39P:39K
Mid-June	28.49bc	21.85c	32.43a
End-June	30.21b	26.78bc	22.28c
Mid-July	24.43c	25.39bc	26.10bc
SE±		2.564	

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

Table 9: Sowing date x variety interaction on weight of dry pods per plant (g plant^{-1}) in groundnut in the 2004 cropping season at Samaru, Nigeria

	Varieties	
Sowing date	SAMNUT-22	SAMNUT-23
Mid-June	1424c	2263a
End-June	1142d	1788b
Mid-July	828e	125cd
SE±	83.2	

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

of dry pods per plant decreased only when sowing was delayed till mid-July while under the highest NPK fertilizer rate, the highest and lowest weights of dry pods per plot observed were from mid-June and late June sown crops, respectively. The earliest sowing date produced the lowest weight of dry pods per plant under the 20 kg N+26 kg P+26 kg K ha^{-1} application rate.

Sowing date x variety interaction on weight of dry pods per plant was statistically significant in 2004 (Table 9). Under the earliest sowing date, the values for weight of dry pods per plant for both groundnut varieties were similar. However, under the latest sowing date var. SAMNUT-23 produced a 62.8% higher weight of dry pods per plant than SAMNUT-22.

DISCUSSION

Number of pods per plant: Overall, delaying of groundnut sowing until mid-July caused some 27.2% reduction in number of pods per plant. Similar influence of sowing date on pod number had been reported in India by Morthy and Rao (1986) who attributed this to decrease in vegetative cycle and shortening of maturation. The present findings agree with those of Caliskan *et al.* (2008) who reported that number of pods per plant from all cultivars was significantly decreased in harvest from the June 6-10 planting dates. Both sowing date and cultivar significantly affected number of pods per plant pod yield, shelling percentage and 100-seed weight in groundnut (Caliskan *et al.*, 2008). Lack of response to NPK fertilizer application by pod number corroborates earlier findings by Hossain *et al.* (2007) who observed that application of nitrogen and phosphorus had no effect on this parameter. Considering that var. SAMNUT-23 is inherently higher-yielding than SAMNUT-22, it is therefore not surprising that the former produced more pods than the latter in the present investigation. Bell (1986) concluded from his work on irrigated groundnut in a monsoonal tropical environment that pod number was more sensitive to sowing date than pod yield but that later sowings tended to compensate for lower pod number by having higher average weights.

Pod yield: Pod yield declined consistently with delay in sowing from the earliest sowing to the latest sowing in both years. This result confirms the findings of several workers who reported consistent reduction in pod yield with delay in sowing of groundnut (Sardana and Kandhola, 2007; Canavar and Kaynak, 2010). Some of them attributed the higher pod yield with early sowing to increased number of pods per plant. This was also demonstrated in the present study. Unfavourable weather conditions during the late planting date reduced pod yield and yield components similar to the present findings (Caliskan *et al.*, 2008; Canavar and Kaynak, 2008). Similarly, Canavar and Kaynak (2010) opined that late sown groundnut cultivars were stressed because of shortened growth period and unsuitable growing conditions. In other words, the effect of climatic parameters during growth phases of the crop determined yield and yield components. However, conflicting reports exist. A contradictory report by Collinson *et al.* (2000) indicated that no significant differences in pod yields were found between two sowing dates in bambara groundnut landrace in Tanzania. Another contradictory report was by Caliskan *et al.* (2008) who claimed that very early sowing did not generate any advantage for groundnut yield.

Pod yield was positively influenced by a combination of the highest NPK fertilizer rate and the earliest sowing date because of the benefit of a longer growth period and a longer vegetative phase. This resulted in greater production of assimilate and its preferential partition to the reproductive sink represented by the pods. Positive response of groundnut pod yield to phosphorus application had been reported from Ghana while application of P to fungicide-treated plots further increased pod yield by 32% when compared to fungicide alone in on-farm tests (Naab *et al.*, 2009). It should however be noted that response to P may sometimes vary with years. Under the earliest sowing date var. SAMNUT-23 out-yielded SAMNUT-22 significantly, similar to the findings of Ahmed (1992) who observed significant positive interaction between groundnut cultivars and sowing date. Also, variations among groundnut varieties in their responses to sowing date were recently reported from North Carolina, USA by Carley *et al.* (2008) and Sorensen and Butts (2008) who observed that a particular variety yielded best under early sowing while another variety did not respond to sowing date. It was reported elsewhere that pod yield decrease rates were not consistent among planting dates as pod yields of genotypes were greater when planted in mid-May compared to either April or June (Tillman *et al.*, 2007).

Seed yield: Seed yield decreased significantly and consistently as sowing was delayed from mid-June through mid-July in both years. This result corroborates the findings of Morthy and Rao (1986) who reported decrease in vegetative cycle and shortening of maturation as sowing was delayed. A similar assertion by Canavar and Kaynak (2010) was that groundnut varieties were stressed in late sowing because of the shortened growth cycle and unsuitable growing conditions and hence the observed reduction in pod and seed yields. Yield and yield components of the groundnut were affected by climatic parameters during all the growth stages (Canavar and Kaynak, 2010). In on-farm and on-station studies in Ghana, groundnut haulm, pod and seed yields with P application increased by about 32-35% on average across the villages over a 2-year period (Naab *et al.*, 2009). Elsewhere, application of N and P fertilizer did not influence seed yield in groundnut (Hossain *et al.*, 2007). Better efficiency of var. SAMNUT-23 in the manufacture of assimilate and partition of same to the reproductive sink would explain its superiority over var. SAMNUT-22 in seed yield.

Haulm yield: There was significant decline in haulm yield as groundnut sowing was delayed, an observation that had been attributed to the shortening of vegetative cycle by delayed sowing (Morthy and Rao, 1986). Overall, NPK fertilizer application did not influence haulm yield per hectare because the physico-chemical analysis of soil of the experimental site reflected a high level of total nitrogen. Varietal differences in haulm yield per hectare observed between the two groundnut varieties had earlier been reported in two groundnut varieties in India (Patel *et al.*, 2005). However, a combination of early sowing and highest rate of NPK fertilizer application produced a significantly higher haulm yield.

CONCLUSION

Sowing date has a very strong influence on groundnut performance, particularly with respect to pod number per plant and pod, seed and haulm yields. Response to sowing date by groundnut is also a function of cultivar as shown by the strong interactions between varieties and sowing date. In this particular study, NPK fertilizer application had a modest influence on groundnut performance. Sowing of groundnut in mid-June with application of 20 kg N+26 kg P and 29 kg K per ha will produce decent pod, seed and haulm yields in semi-arid parts of Nigeria.

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