SUSTAINABLE CROP PRODUCTION: GROWTH AND YIELD RESPONSE OF THREE VARIETIES OF GROUNDNUT (*ARACHIS HYPOGEAL* L.) SOWN TO THREE WEEDING REGIMES AND TWO PLANT SPACING IN ANYIGBA, KOGI STATE, NIGERIA

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Abstract

Weed control is a serious drain on farmers' human and financial resources, requiring adequately management techniques that is both efficient, cost effective and labour saving. Noting that groundnut cannot compete effectively with weeds, particularly 3 - 6 weeks after sowing, an experiment was therefore conducted at the Kogi State University Students' Research and Demonstration Farm (Latitude 7^0 30^1 and Longitude 7^0 09^1 E), Anyigba in the Southern Guinea Savannah agro ecological zone of Nigeria to investigate the response of three varieties of groundnut to weeding regime and plant spacing. The experiment, a split plot design with three replications had Variety (Samnut 23, Samnut 24 and Angba-Chido) as factor A , Spacing (15 x 75 and 23 x 75 cm) as factor B and Weeding regime (no weeding after flower appearance, no weeding after peg appearance and weeding all through) as factor C. Data collected include: establishment count/ m^2, canopy height, yield parameters such as pod yield, shelling percentage, harvest index, number of seeds per pod, hundred seed weight, grain yield, as well as total dry matter yield (biomass), weed identification, weed population / m^2 and weed dry weight, among others. Analyzed data show that variety and weeding regime were not significant on crop establishment, but expectedly, sowing method significantly influenced plant/m^2. However, since yield is the character for which most varieties are judged, Samnut 24 gave the largest biomass (21.05 t/ha), which was not statistically different from Angba-Chido which recorded 20.76 t/ha, with the least biomass observed in Samnut 23 (17.19 t/ha). In addition, Samnut 24 also recorded significantly, the highest pod yield/ha (8.46 t/ha), followed by Angba-Chido (6.50 t/ha), as well as the highest seed yield/ha (6.16 t/ha), which was also followed by Angba-Chido with 4.32 t/ha. While considering harvest index, Samnut 23 recorded 28.33%, Samnut 24 gave 40.19%, while Angba-Chido recorded harvest index of 31.31%; the highest therefore being from Samnut 24. Considering these yield related performance, Samnut 24 is recommended for farmers in the experimental area, while sowing groundnut at 23 x 75 cm as against narrower spacing such as 15 x 75 cm is also recommended as this gave better yield performance for most yield related parameters.

Key words: *canopy height, dry weight, establishment count, groundnut, weed identification, weed population and yield parameters*

INTRODUCTION

Unchecked weeds have been observed to cause yield reduction by 34 - 55% in maize, 28 - 100% in rice, 40 – 67% in grain legumes, 52% in sun flower and 65 - 91% in root and tuber crops (Akobundu, 1987), while estimated annual crop losses due to *Striga spp.* alone in Africa was put at 7 billion US dollars (Adu, 2005). Observing that crop losses due weed incidences is a function of length of weed-crop association, weed competitiveness in comparison with the associating crop, weed population/unit area of land, weed morphology, among other factors, crop losses may reach 100% in heavily infested fields, causing farmers to abandon their agricultural lands (Lagoke *et al.*, 1999). For adequate weed management, time of weeding, frequency of weeding, method employed are critical for good weed control. However, achieving successful weed control requires labour and capital inputs, usually not within the reach of the average African farmer. Weed control alone, can account for over 60% cost of food production, as well as being responsible for most of the time farming family's children missed school, particularly where herbicidal weed controls have not been imbibed.

Groundnut (*Arachus hypogeal* L.) as one of the world's principal oil seed crops is rated fourth for its oil production (FAO, 2011). The crop is grown in over 20 million hectares in tropical and subtropical

countries, and plays important role in both micro and macro economy of rural areas. The total annual world production amounts to about 25 million tons of unshelled nuts, 70% of which is contributed by India, China and USA (El Naim *et al.*, 2010a).

Groundnut was an important cash crop in Nigeria prior to the discovery and diversion of attention to crude oil. Although groundnut pyramids that were visible symbols of the northern Nigerian economy have long disappeared, groundnut is still an important component of the micro-level family economy in northern Nigeria; used in the production of various family food needs as well as industrial raw materials.

Considering government's planned re-focusing on agriculture with the noticeably dwindling fortunes in crude oil, groundnut may still play its previous role in the Nigerian economy as well as ensuring food security. This will be particularly so in the economy of the northern parts of the country, where agriculture remains the main stay of the family life in rural areas.

The crop is usually established either on ridges or on the flats, with the predominant cropping system being a mixture of cereals and groundnut, with maize, sorghum or millet being major cereals often intercropped with groundnut. The choice of cereal depends on the agro-ecological zone, and as influenced by rainfall pattern, length of cropping season, customs and practices of the farmers. In most instances, no forms of chemicals (fertilizer, herbicides, fungicides, insecticides) are used in groundnut production. Spacing and seed rates adopted by farmers are related to growth habits of the variety sown. However, the closer the spacing the higher the yield (Norman *et al*., 1995). This was also found to help prevent too much damage from groundnut rosette virus, suppressed weed growth, or at least renders it ineffective, thus producing more compact and more even maturity (Evans, 1960; Norman *et al*., 1995).

Groundnut pod yields from farmer's field are low averaging about 800 kg ha^{-1}, less than $^1/_3$ the potential yield (Dalley *et al.*, 2004; Norman *et al*., 1995; Konlan, 2013a & b). This large gap between actual and potential yields is due to several factors, including non-availability of seeds of improved varieties for a particular ecology, poor soil fertility, inappropriate crop management practices, pests and diseases (Dalley *et al.*, 2004; Norman *et al*., 1995; Konlan, 2013a & b). Generally, factors promoting vegetative growth after anthesis in groundnut, such as low plant population greatly reduce pod yield at maturity (Steiner, 1982; Norman *et al*., 1995). However, the main problems holding back groundnut yield are poor cultural / management practices (Mubarak, 2004), particularly those involving weed management practices.

Groundnut cannot compete effectively with weeds, particularly 3 - 6 weeks after sowing; therefore, early removal of weeds is important before flowering and during pegging (Bedry, 2007). High cropping densities in groundnut is known to reduce weed competition for space and growth resources (Dalley *et al.*, 2004). While the establishment of sole groundnut on wide rows result in sub-optimum plant production densities and often led to lowered yields ha^{-1} due to inefficient utilization of crop growth resources (Konlan, 2013a & b).

Groundnut is an important component of Nigerian diet and about 5% of the estimated 58.9% of crude protein available per head per day, is contributed by groundnut (ICRISAT, 2005). As population continues to grow the demand for edible oil in many developing countries such as Nigeria will also continue to grow (El Naim *et al.*, 2010b). Groundnut will therefore continue to be important in satisfying this growing demand because it is adaptable to a wide range of environments from sandy soils of the Sahel to favourable irrigated areas; this thus justifies this research. High cost of weeding, scarcity of labour to weed, late weeding due to social functions like funerals, marriage ceremonies justifies a study into understanding the most appropriate time to weed groundnut fields, without missing out on these social functions. Again, farmers plant on mounds, ridges or randomly without any defined rows, thus not obtaining the required optimum plant population and hence lower yields. Plant spacing plays an important role in canopy development and weed control. Therefore, there is the need to research into agronomic practices such as weeding and spacing to improve upon the growth and yield of groundnuts.

Hence the general objective of the study is to evaluate effect of spacing and weeding regime on the growth, development, yield components and yield of three varieties of groundnut. The specific objectives are:

(i) To determine effect of three weeding regimes on three groundnut varieties.

(ii) To determine effect of crop spacing on three groundnut varieties.

(iii) To determine the interaction effects of spacing, weeding regime and varieties on groundnut crop in the study area.

MATERIALS AND METHODS

Field experiments conducted during the rainy season at the Kogi State University Students' Research and Demonstration Farm (Latitude 7^0 30^1 and Longitude 7^0 09^1 E), Anyigba in the Southern Guinea Savannah agro ecological zone of Nigeria. The experiment a 3 x 2 x 3 Split plot Design with three replications, had eighteen treatments in total. Factor A consisted of three varieties: Samnut 23, Samnut 24, Angba - Chido (a local variety); while Factor B consisted of two plant spacing: spacing at 15 cm x 75 cm and spacing at 23 cm x 75 cm. Factor C was made up of three weeding regimes: No weeding after flowering, No weeding after pegging (peg production) and weeding all through.

The field was prepared into sub-plots each measuring 2 m x 2 m with 50 cm in between sub-plots and 1 meter between blocks and consisting of four rows of crop. In all, there were 54 sub-plots in the trial.

Prior to the commencement of the trial, soil samples were randomly collected from ten points at two depths: 0 - 15 cm and 15 - 30 cm, on the experimental plot thoroughly mixed together to form two composite samples. The samples collected was air dried, crushed with the aid of wooden roller and sieved through 2 mm sieve. The samples were then subjected to physical and chemical analysis in line with Bray and Kurtz (1945). Plough, harrow and ridging operations were carried out before seeds were sown. Seeds of three varieties: Samnut 23, Samnut 24 and Angba-Chido were sown two seeds per hole later thinned to one plant per stand at two weeks after sowing (2 WAS). Two spacing: 15 cm x 75 cm and 23 cm x 75 cm were considered in line with the treatment. Data were collected appropriately, which include the following parameters:

Establishment Count (m^2)

Data on establishment counts were taken three weeks after seed sowing (3WAS). Plants within the net-plot (1 m^2) were counted and extrapolated to plant population/ha.

Growth Parameters

Canopy height

Three plant stands each from the net plot (1 m^2) was randomly selected and identified with a tag. Canopy heights (determined using meter rule) of these selected plants were monitored at four weeks interval until harvest.

Yield Parameters

Biomass yield

At harvest, crop population in the net plot (1 m^2) were harvested, air dried for five days before weighing using a top-loading scale. The data obtained were expressed in t/ha.

Pod yield

The crops harvested from each net plot were stripped of their pods sun-dried for seven days in a glass-house with a midday temperature usually exceeding 55 ^{0}C before it was weighed using a top loading scale. The data obtained were expressed in t/ha.

Harvest index

The harvest index was calculated as ratio of total grain yield (Economic yield) to biomass yield (total dry matter) expressed in percentage.

Shelling percentage

Shelling percentage expressed as ratios of seed weight relative to pod weight in percentage. To obtain this parameter, two batches of fifty seeds were weighed per plot, hand shelled and the seeds obtained were weighed while the results were expressed as means of the total seeds in grams.

Number of seeds per pod

To obtain this parameter fifty pods were randomly sampled hand-shelled and the seeds counted and expressed relative to total pods shelled in percentage.

Hundred seed weight

Three-hundred seed lots were randomly sampled from each of the treatment and each batch weighed on a metler balance and the results expressed as means of the three batches in grams.

Grain yield

Grain yield per treatment were obtained by hand shelling all pods harvested from each net plot and the results expressed as grain/ha after weighing on a top loading scale as t/ha.

Weed Records

Identification: weed identification using three quadrat throws per sub plot were carried out every three weeks until crop harvest (Appendix I).

Population / m^2: weed population / m^2 using three quadrat throws was determined every three weeks until crop harvest.

Dry weight: this was determined every three weeks until crop harvest. Sampled weed population using three quadrat throws were harvested close to the ground surface oven dried at 70 ^oC for 24 hours, cool to constant weight then weighed on a Metler scale.

All data obtained on weed were transformed using square root transformation method before subjecting them to statistical analysis.

Data Analysis

Data collected were subjected to statistical analysis using SAS statistical package: GLM Procedure, and significant means separated using Turkey's Studentized Range (HSD) Test (SAS, 2002).

RESULTS AND DISCUSSION

Effect of Variety, Plant Spacing, Weeding Regime and their Interactions on Groundnut Establishment and Canopy Development in Anyigba, Kogi State, Nigeria

Generally, establishment of adequate crop stand is a basic prerequisite for a successful crop (Rowland and Whiteman, 1993; Guedira *et. al*., 1997), this is more so in crops (such as groundnuts) that do not tiller, thus lack the compensating ability of tillers to make up for population reduction resulting from low establishment counts. This underscores the importance of determining the effect of imposed treatment on groundnut establishment. Also, noting that population per unit area of land should be expected to differ between the investigated spacing adopted with closer spacing expected to give more crop stands per unit area than the wider spacing. In line with this expectation, establishment count taken at 3WAS indicates that groundnut establishment was significantly influenced ($p \leq 0.05$) by spacing, but not by variety, or weeding regime nor by their interactions (variety*spacing, variety*weeding regime, spacing*weeding regime and variety*spacing*weeding regime) (Table 1).

Observing that seedling germination and subsequent emergence is a prerequisite for seedling establishment, these, therefore take precedence, without which there cannot be seedling establishment. However, germination and subsequent seedling emergence is dependent on both internal and external conditions (Hay and Walker, 1989) including water imbibition, conducive temperature, enzymatic reactions, food stored, presence of oxygen (Hay and Walker, 1989) among others. Where imposed treatments positively or negatively impacted on these factors, they may influence germination, and likely to influence establishment, noting that percentage germination may influence to some extent percentage establishment, all things being equal. The results obtained for variety and weeding regime thus imply that these were not able to positively influence seed germination and emergence significantly to induce statistical variations. Contrary to this outcome, Rowland and Whiteman (1993) had observed that, among other things, crop emergence and establishment are affected by crop variety, while Mayer and PolJakoff-Mayber (1989), reported that germination decreased with increasing age of seeds and observed varietal and genetic differences in the length of time seeds remained viable.

Where higher seed rates are used, either by narrowing crop spacing (as in this experiment), or increasing seeds per hole, there is the tendency to have higher seed establishment, all things being equal (assuming high percentage of seed viability), which may have accounted for the result obtained for spacing. Whether such higher establishment count will translate to higher canopy heights or crop yields is another issue; as this will depend on other height or yield determining factors, besides stands per unit areas (Hay and Walker, 1989). Generally, Hay and Walker (1989) reported that the primary effect of increasing plant population is to increase competition between adjacent crop for solar radiation, leading to leaf sheath and blade elongation. However, where such competition is not intense enough, significant height variations may not occur. Thus spacing effect did not translate into statistically significant ($p \geq 0.05$) canopy height variations, though crops in the narrower spacing were consistently taller. The implication of this is that reducing crop spacing from 23 x 75 cm to 15 x 75 cm may not have imposed intense competition for solar radiation in the 15 x 75 cm spacing to induce statistically significant stem elongation, which often results from such competition for solar radiation (Hay and Walker, 1989).

Since high cropping densities in groundnut is known to reduce weed competition for space and growth resources (Dalley *et al.*, 2004), sowing at 15 x 75 cm may be advantageous on the long run.

Variety was statistically significant ($p \leq 0.05$) on canopy heights at 4, 8 and 12 WAS. Samnut 24 (V_2) gave consistently the tallest plants (18.33, 23.25 and 38.13 cm, respectively at 3, 6 and 9 WAS), while Samnut 23 (V_1) was consistently the shortest crop at 4, 8 and 12 WAS with 14.72, 17.90 and 25.51 cm, respectively. The local variety (Angba-Chido) compared favorably with Samnut 24 (V_2), which gave the tallest crop canopy height. The observation was in line with Kochhar (1981) who had reported that varieties vary differently in their habit, form and structure.

Taller canopy could have positive implications for dry matter as well as pod yields, observing that the latter (pod) is borne by plant pegs, which arise from the stem internodes. Where longer stems translate to more nodes and invariably more pegs, with possibility for additional pods, higher pod yields/ha should be expected.

Table 1: Effect of variety, plant spacing, weeding regime and their interactions on groundnut establishment and canopy development in Anyigba, Kogi State, Nigeria

Treatment	Average Est. count /m^2	Average Canopy Height (cm)		
	3WAS	4WAS	8WAS	12WAS
Variety (V)				
Samnut 23, (V_1)	9.06	14.72 ^{c}	17.90 ^{c}	25.51 ^{c}
Samnut 24 (V_2)	9.50	18.33 ^{a}	23.25 ^{a}	38.13 ^{a}
AngbaChido (V_3)	8.83	16.19 ^{b}	20.19 ^{b}	30.44 ^{b}
MSD (0.05)	0.947 ^{ns}	1.343*	1.419*	2.142*
Spacing (cm) (S)				
15 x 75 (S_1)	13.19 ^{a}	16.60	20.89	31.86
23 x 75 (S_2)	9.07 ^{b}	16.23	20.00	30.86
MSD (0.05)	0.642*	0.914^{ns}	0.962 ^{ns}	1.452 ^{ns}
Weeding Regime (W)				
W_1	9.39	16.53	20.42	32.21
W_2	8.83	16.22	20.42	30.75
W_3	9.17	16.49	20.49	31.11
MSD (0.05)	0.947 ^{ns}	1.343 ^{ns}	1.419 ^{ns}	2.142 ^{ns}
Interactions				
V*S	Ns	Ns	Ns	Ns
V*W	Ns	Ns	Ns	Ns
S*W	Ns	Ns	Ns	Ns
V*S *W	Ns	Ns	Ns	Ns

*W_1: Weeding until flowering; W_2: Weeding until pegging; W_3: Weeding all through; MSD: Minimum significant difference; Ns: not statistically significant at $p \geq 0.05$, and *: statistically significant at $p \leq 0.05$*

Weeding regime did not translate into statistically significant ($p \geq 0.05$) canopy height variation among the groundnut crop. Considering that weed population on the experimental plot did not indicate statistical differences for variety, spacing, weeding regime and their interactions (Table 2), the non-significant influence of weeding regime on plant canopy height is therefore not surprising.

Effect of Variety, Plant Spacing, Weeding Regime and their Interactions on Weed Population and Weed Dry Weight in Groundnut in Anyigba, Kogi State, Nigeria

Results of statistical analysis show a non-significant effect of variety on weed population/m^2 as well as weed dry weight/m^2 throughout the period of data collection. Though weed populations were higher in the wider spacing with corresponding effect on weed dry weight, significant ($p \leq 0.05$) effect was only recorded at 6WAS, while returning non-significant ($p \geq 0.05$) effect at other periods of data collection (Table 2). Weeding regime significantly ($p \leq 0.01$) influenced weed population/m^2 at 9 and 12WAS with corresponding effects on weed dry weight/m^2 at 9 and 12WAS. There were observed interactions between V*S at 12 WAS ($p \leq 0.05$) as well as between S*W at 6WAS ($p \leq 0.01$). While the interaction

between V*S at 12WAS could be the effect of the highly significant ($p \leq 0.01$) influence of weeding regime within the same period on weed population, the same cannot be said of the interaction between S*W where all the individual effects produced non-significant results. However, synergistic interactions between all the individual treatments may have enhanced their individual effects thus producing a significant two-way interaction between S*W. The significant effect of weeding regime on weed population at 6WAS as well as on weed dry weight must have resulted from a zero weed population recorded in W_3 treatment compounded by the higher weed population recorded in the W_1 treatment. The great differences between W_1 and other weeding regimes (W_2 and W_3) at 6 and 9WAS must have been responsible for the high significant differences within these periods.

Effect of Variety, Plant Spacing, Weeding Regime and their Interactions on Yield Parameters in Groundnut in Anyigba, Kogi State, Nigeria

Yield is the character for which most varieties are judged; especially that a variety is able to give good yields under varying conditions. Effect of variety on yield parameters show high statistical significance ($p \leq 0.01$) for biomass yields, pod yield/ha, effective pods, 100-seed weight and seed yield/ha (Table 3). Samnut 24 gave the largest biomass yield (21.05 t/ha), which was, however not statistically different from Angba-Chido which recorded 20.76 t/ha. The least biomass yield was observed in Samnut 23 (17.19 t/ha). The variety (Samnut 24) also recorded significantly the highest pod yield/ha (8.46 t/ha), followed by Angba-Chido (6.50 t/ha), as well as the highest seed yield/ha (6.16 t/ha), which was also followed by Angba-Chido with 4.32 t/ha. The highest number of effective (filled) pods was however, recorded in Samnut 23, (57.22%), and while the least filled pods was observed in Angba-Chido (50.88%). The high percentage of empty pods as observed in all the varieties could be an indication of early harvest, or failure in translocation of adequate photosynthate to storage organs, such as the pods, or inefficient solar harvest (Hay and Walker, 1989) by the canopy.

Generally all the varieties gave good yields in comparison with the national average (Norman *et al.,* 1995). Computing the harvest index (HI), Samnut 23 recorded 28.33%, Samnut 24 gave 40.19%, while Angba-Chido recorded harvest index of 31.31%; the highest thus being from Samnut 24. The low HI recorded in all the varieties implies that vegetative growth did not fully translate into economic yields.

Furthermore, though not statistically different ($p \geq 0.05$), for all yield parameters computed the wider spacing, 23 x 75 cm performed better than the narrower spacing (15 x 75 cm) except for effective pods and 100-seed weight. This outcome is in conflict with earlier literature (Dalley *et al.*, 2004) which observed that high cropping densities in groundnut is known to reduce weed competition for space and growth resources, therefore positively impacting on yield. While the establishment of sole groundnut on wide rows was reported to result in sub-optimum plant production densities and often led to lowered yields ha^{-1} due to inefficient utilization of crop growth resources (Konlan, 2013).

In conclusion, weeding regime investigated did not exert any significant influence on all yield parameters studied, neither were there interactions between the treatments to exert any significant effect on these yield parameters. The non-significant influence of weeding regime on these parameters could have resulted from level of weed infestation, or length of association between the crop and the weeds, or weed competitiveness (Dalley *et al.*, 2004). As the ability of weeds to compete with cultivated crops depends on their root system, height, leaf area, density and frequency of occurrence. Some weeds even utilize cultivated crops for support and strangle them to death (Dalley *et al.*, 2004). This competition adversely affects growth and development of crops.

As for the groundnut crop, it has been observed that the most critical time to cause much damage to groundnut crop is during the first 45 days of its growth, or presumably 3-6weeks after sowing (Dalley *et al.*, 2004; Norman *et al*., 1995; Konlan, 2013a & b). Noting that if early weeding is done well, as in this experiment where weeding restrictions were not imposed until at flowering (6WAS) or pegging (8WAS), as well as crop spacing recommendations followed, effect of weed infestation may not be pronounced; as weeds that may come up later are smothered with the vigorous growth of the crop (Dalley *et al.*, 2004; Norman *et al*., 1995; Konlan, 2013a & b). Observing that adequate weed control measures were in place pass the critical period of groundnut vulnerability may have accounted for the non-

significant effect of this treatment on yield parameters. Notwithstanding that weeds have the ability to reduce yields by competing directly for the resources of the environment and inputs in terms of water, nutrients, space and light and where the weeds are abundant and grow faster than the crop plants, they may choke up the crop (Dalley *et al.*, 2004; Norman *et al*., 1995; Konlan, 2013a & b). In addition, an attempt to keep pace with the fast growing weeds, the crop may grow tall, lean and weak or etiolated and finally give poor yields (Dalley *et al.*, 2004; Norman *et al*., 1995; Konlan, 2013a & b).

Notwithstanding, weeds are among the most serious crop pests farmers have to contend with and farms are often abandoned when the weed pressure becomes unmanageable (Dalley *et al.*, 2004; Norman *et al*., 1995; Konlan, 2013a & b). A variety of weeds were associated with the groundnut cultivation (Table 4) in the study area, which comprise diverse plant species of annual grasses and seasonal broad leaves either erect or prostate in nature: *Cleome rutidosperma*, *Tridax procumbens*, *Perotis indica*, *Spilanthes filicaulis*, *Blepharis*, *Combretum hispidum sp, Cleome viscosa,* among other, which could pose a threat to yields. It was previously observed that groundnut cannot compete effectively with weeds, particularly 3 - 6 weeks after sowing; therefore, early removal of weeds is important before flowering and during pegging.

Table 2: Effect of variety, plant spacing, weeding regime and their interactions on weed population and weed dry weight in groundnut in Anyigba, Kogi State, Nigeria

Treatment	Average Weed Population /m^2				Average Weed Dry Weight (g)/ m^2			
	3WAS	6WAS	9WAS	12WAS	3WAS	6WAS	9WAS	12WAS
Variety (V)								
Samnut 23, (V_1)	300	148	26	74	134.38	144.88	14.50	29.59
Samnut 24 (V_2)	273	122	21	48	143.58	115.36	4.51	36.20
AngbaChido (V_3)	252	139	26	52	164.58	128.39	14.32	27.00
MSD (0.05)	65.5 ^{ns}	43.6 ^{ns}	38.2 ^{ns}	45.6 ^{ns}	57.094^{ns}	72.412 ^{ns}	25.594 ^{ns}	40.922 ^{ns}
Spacing (cm) (S)								
15 x 75 (S_1)	271	119b	14	52	143.34	119.84	4.05	24.48
23 x 75 (S_2)	278	153a	35	64	15.67	139.23	18.17	37.38
MSD (0.05)	44.4^{ns}	29.5*	25^{ns}	30.9 ^{ns}	38.703 ^{ns}	49.094 ^{ns}	17.344^{ns}	27.734 ^{ns}
Weeding Regime (W)								
W_1	278	130	69^{a}	109^{a}	139.4	136.7	31.5^{a}	66.0^{a}
W_2	269	161	4^{b}	22^{b}	159.8	130.2	1.8^{b}	3.4^{b}
W_3	279	117	0^{b}	43^{b}	143.3	121.7	0.0^{b}	23.4^{b}
MSD (0.05)	65.5 ^{ns}	43.56^{ns}	34.5**	45.6**	57.09^{ns}	72.41^{ns}	25.59**	40.92**
Interactions								
V*S	Ns	Ns	Ns	*	Ns	Ns	Ns	Ns
V*W	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
S*W	Ns	Ns	Ns	Ns	Ns	**	Ns	Ns
V*S *W	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

W_1: Weeding until flowering; W_2: Weeding until pegging; W_3: Weeding all through; MSD: Minimum significant difference, Ns: not statistically significant at p≥0.05: statistically significant at p≤0.05, **: statistically significant at p≤0.01*

Table 3: Effect of variety, plant spacing, weeding regime and their interactions on yield parameters in groundnut in Anyigba, Kogi State, Nigeria

Treatment	Yield Parameters (Mean)						
	Biomass yield (t/ha)	Pod yield (t/ha)	100 pod weight (g)	Effective pods/100	Empty Pods/ 100	100 Seed weight (g)	Seed yield t/ha
Variety (V)							
Samnut 23, (V_1)	17.19^{b}	4.87^{c}	49.13	57.22^{a}	42.78	26.22^{c}	2.60^{c}
Samnut 24 (V_2)	21.05^{a}	8.46^{a}	49.20	52.67^{b}	47.33	35.85^{a}	6.16^{a}
AngbaChido (V_3)	20.76^{a}	6.50^{b}	49.98	50.88^{b}	49.12	33.20^{b}	4.32^{b}
MSD (0.05)	0.172**	0.086**	2.355^{ns}	3.839**	-	2.016**	1.028*
Spacing (cm) (S)							
15 x 75 (S_1)	19.57	6.41	49.89	54.15	45.85	31.99	4.11
23 x 75 (S_2)	19.76	6.81	48.99	53.04	46.96	31.52	4.38
MSD (0.05)	1.703^{ns}	0.850^{ns}	1.596^{ns}	1.299^{ns}	-	1.367^{ns}	0.784^{ns}
Weeding Regime (W)							
W_1	19.52	6.34	49.80	54.10	45.90	31.94	4.07
W_2	19.88	6.90	48.58	53.39	46.61	30.82	4.38
W_3	19.59	6.55	49.95	52.78	47.22	32.51	4.26
MSD (0.05)	2.513^{ns}	1.256^{ns}	2.355^{ns}	3,830^{ns}	-	2.016^{ns}	1.028^{ns}
Interactions							
V*S	Ns	Ns	Ns	Ns	-	Ns	Ns
V*W	Ns	Ns	Ns	Ns	-	Ns	Ns
S*W	Ns	Ns	Ns	Ns	-	Ns	Ns
V*S *W	Ns	Ns	Ns	Ns	-	Ns	Ns

*W_1: Weeding until flowering; W_2: Weeding until pegging; W_3: Weeding all through; MSD: Minimum significant difference, Ns: not statistically significant at p≥0.05, *: statistically significant at p≤0.05, **: statistically significant at p≤0.01*

Table 4: Weed identification on the experimental plot

	Scientific Name	Family Name	Common Name	Leaf Category
1	*Cleome rutidosperma*	Cleomaceae	Fringed Spider Flower	Dicotyledon
2	*Tridax procumbens*	Asteraceae	Coat Buttons	Dicotyledon
3	*Perotis indica*	Poaceae	Indian Comet Grass	Monocotyledon
4	*Spilanthes filicaulis*	Asteraceae	English Brazil Cress	Dicotyledon
5	*Blepharis sp*	Acanthaceae	Creeping blepharis	Dicotyledon
6	*Combretum hispidum*	Combretaceae		Dicotyledon
7	*Commelina Sp*	Commelinaceae	Dayflowers	Dicotyledon
8	*Cleome viscosa*	Capparaceae	Asian spider flower	Dicotyledon
9	*Pennisetum violaceum*	Poaceae	Fountain grasses	Monocotyledon
10	*Chloris pilosa*	Poaceae	Finger grass	Monocotyledon
11	*Synedrella nodiflora*	Asteraceae	Cinderella weed	Dicotyledon
12	*Laportea ovalifolia*	Urticaceae	Rawaya	Dicotyledon
13	*Sclerocarpus africanus*	Asteraceae	African bone bract	Dicotyledon
14	*Kyllinga Squamulata*	Cyperaceae	Spikes edges	Monocotyledon
15	*Panicum repens*	Poaceae	Torpedo grass	Monocotyledon
16	*Heteropogon contortus*	Poaceae	Black spear grass	Monocotyledon
17	*Melanthera Scandens*	Asteraceae	Black anther	Dicotyledon
18	*Emilia Coccinea*	Asteraceae	Tassel flower	Dicotyledon
19	*Conyza sumatrensis*	Asteraceae	Guernsey fleabane	Dicotyledon
20	*Chrysanthellum indicum*	Asteraceae		Dicotyledon
21	*Celosis leptostachya*	Amaranthaceae	Wool flowers	Dicotyledon
22	*Sida linifolia*	Malvaceae	Wire weed	Dicotyledon
23	*Calopogonium mucanoides*	Fabaceae	Wild groundnut	Dicotyledon
24	*Euphorbia heterophylla*	Euphorbiaceae	Wild poinsettia	Dicotyledon
25	*Vernonia perrottetii*	Asteraceae	Iron weed	Dicotyledon
26	*Tephrosia pedicellata*	Fabaceae		Dicotyledon
27	*Cenchrus biflorus*	Poaceae	Indian Sandbur	Monoctyledon
28	*Cyathula prostrata*	Amaranthaceae	Prostrate pasture weed	Dicotyledon

CONCLUSION

An experiment was therefore conducted at the Kogi State University Student Research and Demonstration Farm (Latitude $7^0 30^1$ and Longitude $7^0 09^1$ E), Anyigba in the Southern Guinea Savannah agro ecological zone of Nigeria to investigate the response of three varieties of groundnut (Samnut 23, Samnut 24 and Angba-Chido) to weed interference (no weeding after flower appearance, no weeding after pegging and weeding all through) and plant spacing (15 x 75 and 23 x 75 cm). The experiment, a split plot design with three replications had Variety as factor A, Spacing as factor B and Weeding regime as factor C. Data collected include: establishment count m^2, canopy height, shoot dry matter, yield

parameters (pod yield, shelling percentage, harvest index, number of seeds per pod, hundred seed weight, grain yield), weed identification, weed population / m^2, and weed dry weight, among others.

Though a variety of weeds were associated with the groundnut cultivation in the study area, which include: *Cleome rutidosperma*, *Tridax procumbens*, *Perotis indica*, *Spilanthes filicaulis*, *Blepharis*, *Combretum hispidum sp, Cleome viscosa, Heteropogon contortus*, *Melanthera Scandens*, *Emilia Coccinea*, *Cyathula prostrata,* which could pose a threat to yields, weeding regime investigated did not exert any significant influence on all yield parameters studied. It was argued that the non-significant influence of weeding regime on these parameters could have resulted from level of weed infestation, or length of association between the crop and the weeds, or weed competitiveness. Also, observing that where early weeding is done well, as was in this experiment where weeding restrictions were not imposed until at flowering (6WAS) or pegging (8WAS), effect of weed infestation may not be pronounced. To probably address some of the treatment limitations in future studies, additional weeding restrictions may be imposed, such as: no weeding before flowering then weeding subsequently until harvest; secondly, no weeding before peg initiation then weeding subsequently until harvest and thirdly, no weeding throughout the crop life.

Effect of variety on yield parameters show high statistical significance for biomass yields, pod yield/ha, effective pods, 100-seed weight and seed yield/ha. Samnut 24 gave the largest biomass yield (21.05 t/ha), which was, however not statistically different from Angba-Chido which recorded 20.76 t/ha. The least biomass yield was observed in Samnut 23 (17.19 t/ha). The variety (Samnut 24) also recorded significantly the highest pod yield/ha (8.46 t/ha), followed by Angba-Chido (6.50 t/ha), as well as the highest seed yield/ha (6.16 t/ha), which was also followed by Angba-Chido with 4.32 t/ha. The highest number of effective (filled) pods was however, recorded in Samnut 23, (57.22%), and while the least filled pods was observed in Angba-Chido (50.88%). Considering these yield related performance, Samnut 24 is recommended for farmers in the experimental area (since it gave the best pod and seed yields, as well as biomass yield). Thus whatever the focus of the farmer, being pods, seeds or biomass, Samnut 24 should meet the farmer's yield expectations. For this trial, the wider spacing, 23 x 75 cm performed better than the narrower spacing (15 x 75 cm) except for effective pods and 100-seed weight thus sowing groundnut at 23 x 75 cm as against narrower spacing such as 15 x 75 cm is also recommended as this gave better yield performance for most yield related parameters.

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Appendix I: Result of soil analysis

Characteristics	Values	Units
Clay	8.32	
Silt	5.72	
Sand	82.96	
Textural class	Sandy Loam	
pH	7.3	
Organic carbon	0.72	
Organic matter	1.24	g kg/ha
Available phosphorus	8.60	ppm
Total nitrogen	0.0014	%
Calcium	4.42	C/mol kg/ha
Magnesium	1.51	C/mol kg/ha
Potassium	2.61	C/mol kg/ha
Sodium	1.17	C/mol kg/ha
(CEC)	10.49	