Short Research Communication

Growth and yield of groundnut (*Arachis hypogaea* L.) as affected by intra-row spacing and irrigation interval in Sudan Savannah Zone of Nigeria

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Field trials were conducted at two locations during the 2019/2020 dry season to investigate the response of groundnut varieties as affected by intra-row spacing and irrigation interval on growth and yield at Teaching and Research Farm of Federal University Dutsin-Ma and Kugado site. Treatments consisted of three varieties of groundnut (SAMNUT 24, SAMNUT 25 and SAMNUT 26), 3 intra-row spacing (15, 20 and 25cm) and three irrigation intervals (3, 6 and 9days). The treatments were factorized and laid out in a randomized complete block design (RCBD) replicated three times. Results from the study revealed that groundnut variety had significant ($P \leq 0.05$) effect on growth and yield parameters at the two locations. SAMNUT 24 significantly ($P \leq 0.05$) outperformed SAMNUT 26 and SAMNUT 25 respectively in terms of number of leaves per plant, number of days to 50% flowering and kernel weight of (14.87 and 10.67 g) per plant at the two locations. Intra-row spacing of 15cm significantly ($P \leq 0.05$) outperformed 20 and 25cm on days to 50% flowering, number of leaves at 3 WAS at Kugado and kernel yield of (11.3 g) per plant at Badole. Irrigation interval of 6days on Kernel weight of (14.69 and 11.10 g) per plant recorded a significant ($P \leq 0.05$) effect at the two locations. However, 3days irrigation interval of (46.93 g) also recorded a significant effect on total dry matter at Badole. The study revealed that SAMNUT 24, intra-row spacing of 15cm, and 3days on yield parameters at Badole and 6days irrigation interval at Kugado proved to be most appropriate.

Keywords: groundnut varieties, growth, intra-row spacing, irrigation interval, yield, parameter

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a leguminous crop belonging to the family *fabaceae* and is cultivated in the semi-arid and subtropical regions of the world. It is a self-pollinated, annual herbaceous plant growing 30 to 50 cm (1.0 to 1.6 ft.) tall, groundnut is known by many other local names such as peanut, earthnut, monkey nut, pygmy nut and pignut. Despite its name and appearance, groundnut is not a nut, but rather specie in the legume or "Bean" family, it is very rich in essential nutrients which are potential to provide health benefits (Janila and Mula, 2015). The crop is

a native to Central America and has never been found uncultivated (Vabi et al., 2019). The World production figure of groundnut in 2019 was 48.8 million tonnes from 29.6 million hectares with average production of 1647 kg ha⁻¹ (FAO, 2021). The production of groundnut is concentrated in Asia and Africa, where the crop is grown mostly by smallholder farmers under rain-fed conditions with limited inputs. Nigeria is the third largest producer of groundnut in 2019 with annual production of 4.4 million tonnes after China 17.1 million tonnes and India 6.7 million

tonnes (FAO, 2021). It is estimated that 3.9 million hectares were planted in 2019 with groundnut in Nigeria (FAO, 2021). The main agro-ecological zones for groundnut production in Nigeria are Sahel, Sudan, northern guinea and most of the southern guinea and derived savannah (Vabi et al., 2019). However, environmental factors for successful groundnut production found during the rainy season also prevail during the dry season in the savanna, while moisture requirements can be adequately met by the supply of water through irrigation (Mukhtar, 2009). Large expanse of arable land exists in the Sudan Savanna Zone of Nigeria with potential for the production of groundnut (Ajeigbe et al., 2015). However, the average yield of grain crops in the zone stood at 1.7 t ha^{-1} compared to the world average of 4.0 t ha^{-1} (FAO, 2012). This represents only 42.5% of the world attainable average yield which might be attributed to small holdings farmed by aging and resource poor farmers, whose yields are determined by the limiting factors of bio-geophysical environment as well as continuous use of low yielding variety. Therefore care has to be taken in selecting the best seed for growing especially under irrigation condition where many resources are used for growing of groundnut. The need to improve groundnut productivity has also necessitated the breeding of varieties that can take the advantage of factors such as high yielding early maturing crop, resistance to pests and diseases, tolerant to drought and escape to end of season drought due to extra early maturity (Vabi et al., 2019).

According to Ahmed et al. (2010), the main problems limiting production of groundnut include inadequate seed (improved varieties) for a particular ecology, inappropriate crop management practices, inadequate weed management, pest and diseases, high labor demand for groundnut production, poor use of mechanization and market constraints. The above listed constraints have contributed immensely to low yield of the crop which discourages farmers from cultivating the crop but rather prefer to grow other food crops like maize, especially in Nigeria. In view of these, it is important to evolve an integrated approach involving combination of improved varieties, intra row spacing and irrigation interval that could prove effective in the production of groundnut under dry season condition. More so, it is necessary to determine the most appropriate and adaptable variety suitable in Sudan savannah zones of Nigeria under dry season condition. This research was made in order to find out the possible solutions to the above stated problems of groundnut production under dry season condition in the study area, therefore variety, intra-row spacing as well as irrigation interval were selected as part of the treatment.

MATERIALS AND METHODS

Experimental Site

Field trials were conducted at two locations during the

2019/2020 dry season to investigate on the effect of intra-row spacing and irrigation interval on growth and yield of groundnut varieties at teaching and Research Farm of the Federal University Dutsin-Ma, and Kugado Fadama site at Mani Local Government Area of Katsina State both in Sudan savannah zone of Nigeria. The soil samples from the two experimental sites were collected randomly at 0 – 30cm soil depths diagonally across the experimental sites before establishing the trial. The composite sample was analyzed for some physical and chemical properties using standard procedures as described by Black, (1968). The soil textures collected from both two sites were sandy loamy with pH of 6.50 and 6.16 also the organic carbon of 4.60 and 1.8, respectively. Data on temperature, sunshine and relative humidity for 2019/2020 dry seasons were collected from both location. The field was cleared, harrowed and ridged. The ridges were subdivided into plots of four ridges per plot at 2 meters length and 0.75m in between rows ($2\text{m} \times 3\text{m} = 6\text{m}^2$) and irrigation channels were constructed to convey water to the furrows. The net plot consists of two inner rows at spacing of $0.75 \text{ m} \times 2$ while the gross plot was $0.75 \text{ m} \times 4 = 3 \times 2$ (6 m^2) given a total area of $6 \text{ m}^2 \times 27$ plots $\times 3$ replications = 486 m^2 . A pass way of 1m was made between the demarcated experimental site and 1 m between the replications. After the seedbed preparation, water was applied at field capacity twice prior to sowing. The seeds of the three varieties (SAMNUT 24, SAMNUT 25 and SAMNUT 26) were sourced from Katsina State Agricultural and Rural Development Authority (KTARDA) and International Crop Research Institute for Semi-arid Tropics (ICRISAT). The seeds were treated with Apron Star at 10g/4kg of seed and sown manually according to the treatment at the depth of 5cm. The seeds were sown on 22nd and 23rd December, 2019 for Badole and Kugado, respectively at the spacing of 15, 20 and 25cm according to the treatment and sown using two seeds per stand. Irrigation was administered immediately after sowing. Subsequently, the plots were irrigated to field capacity twice a week for the first 3weeks to enable the plant to be fully established. Re-seeding was made two weeks after the first planting in order to fill in the missing gap that did not germinate. Irrigation interval of 3, 6 and 9days as per treatment was imposed three weeks after sowing. First and second weeding were conducted manually with hoe at 4 and 8WAS to control weeds and improve soil aeration. Inorganic fertilizer was applied 3weeks after sowing at the rates of 30N, 30P₂O₅ and 30K₂O kg ha⁻¹ to all plots. Harvesting was done manually by hand pulling the entire plant at full maturity (browning of leaves, drying of pods, full coloration of kernel and darkening of inner part of the pod). Data on growth parameters of plant were collected at 3, 6 and 9WAS from five (5) sampled plants per plot while the yield was computed from the entire net plot area. The harvested groundnut were lifted out and laid on the ridges to sundry for 7days. Shelling was done by carefully removing the pods to obtain the kernels. The dried pods and haulms for each net plot were then weighed using weighing balance and the value recorded per plot basis. All

Table 1. Results of soil analysis of the experimental sites in 2019/ 2020 dry seasons at Kugado and Badole

Soil Parameters	Locations	
	Badole	Kugado
Particle size distribution (g kg ⁻¹)		
Clay	120.00	100.00
Silt	140.00	150.00
Sand	740.00	750.00
Textural class	Sandy loam	Sandy loam
Chemical properties		
pH in water	6.50	6.16
Organic Carbon (g kg ⁻¹)	4.60	1.80
Total N (g kg ⁻¹)	0.56	0.28
Available P (mg kg ⁻¹)	3.20	22.25
Exchangeable Cation		
K (cmol kg ⁻¹)	0.16	0.10
Mg (cmol kg ⁻¹)	0.41	1.80
Ca (cmol kg ⁻¹)	1.95	4.20
Na (cmol kg ⁻¹)	0.11	0.23
CEC (cmol kg ⁻¹)	2.73	2.16

Analysis conducted at soil science Department, Bayero University, Kano.

data collected were subjected to statistical analysis of variance (ANOVA) using SAS package version 9.0 (SAS institute, 2002) as described by Gomez and Gomez, (1984) and the differences among treatment means were separated using Duncan's Multiple Range Test (DMRT) Duncan, (1955) at 5% level of probability ($P \leq 0.05$).

RESULTS

The result of soil samples collected from the two location were all sandy loamy with pH of 6.50 and 6.16 respectively. However Badole recoded the highest organic carbon of 4.60 better than Kugado with 1.8 g kgha⁻¹ Kugado also recorded the highest quantity of phosphorus (22.25 mg/kg), magnesium (1.80 cmol/kg), calcium (4.20 cmol/kg) and sodium (0.23 cmol/kg). The result also indicated that Badole outperformed better than Kugado on total nitrogen content (0.56 g/kg), potassium (0.16 cmol/kg) and cation exchange capacity (2.73 cmol/kg) Table 1.

The result on days to 50% flowering of groundnut as affected by variety, intra-row spacing and irrigation interval is presented in Table 2.

The result indicated that variety had significant effect ($P < 0.05$) on days to 50% flowering at Both location and SAMNUT 26 (45) outperformed better than SAMNUT 24 (43) and SAMNUT 25 (44) at *Badole*. However, at *Kugado* the result indicated that SAMNUT 25 (49) outperformed better than SAMNUT 24 and SAMNUT 26 respectively with 44.7 and 47.6 days. Intra-row spacing of 20cm recorded the highest days at both location. had no significant ($P > 0.05$) difference on days to 50% flowering of three groundnut varieties produced under Dry season condition at the two research locations. Irrigation interval had significant ($P > 0.05$) effect on days to 50% flowering at both locations

and 6days irrigation recorded the highest days with (48.4 and 45.1) respectively. There was no significant ($P > 0.05$) difference on all the interactions from the two locations during the experiment.

Number of leaves per plant of three groundnut varieties at 3, 6 and 9WAS as affected by intra row spacing and irrigation interval at *Badole* and *Kugado* (Table 3).

The result showed that there was significance difference between ($P < 0.05$) the varieties on number of leaves per plant of groundnut at both locations during the experiment where SAMNUT 24 recorded the higher number of leaves compared to SAMNUT 25 but statistically similar with SAMNUT 26 at 3, 6 and 9WAS at *Badole* similarly at *Kugado* also SAMNUT 24 outperformed better than SAMNUT 25 and SAMNUT 26 at 3, 6 and 9WAS (Table 3). Intra-row spacing was not significantly different ($P > 0.05$) at 3, 6 and 9WAS on number of leaves per plant observed at both locations except at *Kugado* at 3WAS intra-row spacing of 15cm of (18) significantly outperformed 20cm (16.7) and 25cm (14.5) respectively. Irrigation interval was not significant ($P > 0.05$) at 3, 6 and 9WAS on number of leaves per plant at *Badole* while at *Kugado* irrigation interval of 6days (17.2) recorded the highest at 3WAS and at 9WAS 9days irrigation interval recorded the highest number of leaves (37.7). The interaction between variety, intra-row spacing and irrigation interval was not significant ($P > 0.05$) at the two location.

Result on yield parameters as presented in (Table 4) indicated that variety, intra-row spacing and irrigation interval had significant ($P < 0.05$) effect on kernel yield per plant. The highest value of (14.87 and 10.67g) of kernel yield per plant were recorded by SAMNUT 24 which was significantly higher by (3.67 and 1.66 g) compared with lowest (11.20 and 9.01 g) obtained from SAMNUT 25 at *Kugado* and *Badole* respectively. Intra-row spacing of 15cm significantly ($P < 0.05$) outperformed 20 and 25cm on kernel

Table 2. Effect of variety, intra-row spacing and irrigation interval on number of days to 50 % flowering of groundnut at Badole and Kugado during the 2019/2020 dry season.

Treatments	Days to 50 % Flowering	
	Badole	Kugado
Varieties (V)		
SAMNUT 24	42.9 ^c	44.7 ^b
SAMNUT 25	44.5 ^b	49 ^a
SAMNUT 26	45.3 ^a	47.6 ^b
S.E(±)	0.38	0.38
Significance	*	*
Spacing (cm)		
15	42.9 ^c	47.2 ^b
20	45.5 ^a	48.7 ^a
25	44.3 ^b	45.4 ^c
S.E(±)	0.38	0.38
Significance	*	*
Irrigation interval (Days)		
3	44.7 ^a	46.6 ^b
6	45.1 ^a	48.4 ^a
9	42.9 ^b	46.4 ^b
S.E(±)	0.38	0.38
Significance	*	*
Interactions		
V x S	NS	NS
V x I	NS	NS
S x I	NS	NS
V x S x I	NS	NS

Note *= Significant, NS= Not Significant at 5% level of probability. Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT

Table 3. Effect of variety, spacing and irrigation interval on Number of leaves per plant of groundnut varieties at 3, 6 and 9WAS at Badole and Kugado during the 2019/2020 dry season.

Treatments	Number of leaves per plant					
	3WAS		6WAS		9WAS	
	Badole	Kugado	Badole	Kugado	Badole	Kugado
Varieties (V)						
SAMNUT 24	20.8 ^a	18.7 ^a	27.5 ^a	29.6 ^a	39.6 ^a	43.2 ^a
SAMNUT 25	16.8 ^b	14.7 ^b	22.7 ^c	24.4 ^b	34.3 ^b	33.2 ^b
SAMNUT 26	19.5 ^a	15.9 ^b	25.1 ^b	24 ^b	37.3 ^a	32.5 ^b
S.E(±)	0.53	0.47	1.11	1.51	1.41	0.47
Significance	*	*	*	*	*	*
Spacing (cm)						
15	18.9	18.0 ^a	24.2	26.6	36.8	36.4
20	19.2	16.7 ^b	25.6	26.2	37.9	36.1
25	18.9	14.5 ^c	25.5	25.1	36.5	36.4
S.E(±)	0.53	0.47	1.11	1.51	1.41	0.47
Significance	NS	*	NS	NS	NS	NS
Irrigation interval (Days)						
3	19	15.9 ^b	24.5	25.6	35.6	36.3 ^b
6	18.7	17.2 ^a	25.1	27.3	37.6	35.0 ^b
9	19.4	16.1 ^a	25.7	25	37.9	37.7 ^a
S.E(±)	0.53	0.47	1.11	1.51	1.41	0.47
Significance	NS	*	NS	NS	NS	*
Interactions						
V x S	NS	NS	NS	NS	NS	NS
V x I	NS	NS	NS	NS	NS	NS
S x I	NS	NS	NS	NS	NS	NS
V x S x I	NS	NS	NS	NS	NS	NS

Table 4. Effect of variety, spacing and irrigation interval on Kernel weight per plant and total dry matter yield of groundnut recorded at Badole and Kugado during the 2019/2020 dry season

Treatments	Kernel weight per plant (g)		Total dry matter yield per plant (g)	
	Badole	Kugado	Badole	Kugado
Varieties (V)				
	10.67 ^a	14.87 ^a	42.52	69.47
SAMNUT 25	9.01 ^b	11.20 ^b	41.91	66.36
SAMNUT 26	9.20 ^b	11.94 ^b	42.92	67.27
S.E(±)	0.49	0.92	2.12	5.60
Significance	*	*	NS	NS
Spacing (cm)				
15	11.31 ^a	13.98	40.88	68.26
20	9.52 ^b	11.78	43.23	62.86
25	8.05 ^c	12.24	43.24	71.99
S.E(±)	0.49	0.92	2.12	5.60
Significance	*	NS	NS	NS
Irrigation interval (Days)				
3	9.52 ^b	11.37 ^b	46.93 ^a	62.77
6	11.10 ^a	14.69 ^a	40.60 ^b	67.88
9	8.26 ^c	11.95 ^b	39.82 ^b	72.45
S.E(±)	0.49	0.92	2.12	5.60
Significance	*	*	*	NS
Interactions				
V x S	NS	NS	NS	NS
V x I	NS	NS	NS	NS
S x I	NS	NS	NS	NS
V x S x I	NS	NS	NS	NS

Note *= Significant, NS= Not Significant at 5% level of probability. Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.

yield per plant at *Badole*. Irrigation interval had significant ($P<0.05$) effect on kernel yield per plant and 6day irrigation interval recorded the highest value of (14.69 and 11.10 g) at the two locations however, the least value was recorded from 9days irrigation interval of (8.26 g) at *Badole* while at *Kugado* 3days irrigation interval recorded the least with (11.37 g). The interaction effect was not significant at the two locations.

The results of total dry matter yield of three varieties of groundnut as affected by intra-row spacing and irrigation interval at *Badole* and *Kugado* is presented in Table 4.

The result indicated that there was no significance effect ($P>0.05$) among the three varieties of groundnut on total dry matter yield at both locations. Intra-row spacing was not significant ($P>0.05$) on total dry matter per plant during the 2019/2020 dry season from the two locations. Irrigation interval was also not significant ($P<0.05$) on total dry matter per plant at *Kugado* while at *Badole* was significant ($P<0.05$) at 3days irrigation interval record with total dry matter per plant (46.93 g) followed by 6days irrigation interval (40.60 g) and 9days irrigation interval (39.82 g). The interaction was not significant.

DISCUSSION

SAMNUT 24 significantly outperformed SAMNUT 25 and SAMNUT 26 respectively on number of leaves per plant and

number of days to 50% flowering kernel weight per plant across all sampling periods in the two locations. This could be due to the genetic compositional makeup of the varieties. However, a significant difference recorded at the two locations on growth parameters of groundnut could be attributed to climatic nature of the area as well as gene interaction with environment of the two locations. This result is in line with another finding by Stephen, (2009) who reported that SAMNUT 24 had robust growth in both locations than the other varieties. SAMNUT 24 and 26 had erect bunch growth habit and flowered earlier than SAMNUT 25. The poor performance of SAMNUT 25 could be attributed to its genetic makeup and climatic factor responsible for groundnut production. However the significant effect recorded on days to 50% flowering could be attributed to variation in chemical composition of the soil of the two locations as well as genetic makeup of the variety. This result is in conformity with finding of Gilbert et al. (2020), that varieties of a particular crop differ greatly in the number of days they require to produce a reasonable yield for a particular variety, the growth duration may differ depending upon the soil chemical composition and time the crop is planted.

However, the significant effect recorded on kernel weight per plant could be attributed to genotypic differences and their response to adverse environmental effects. SAMNUT 24 was found to be higher yielding variety than SAMNUT 26 and 25 respectively. This is line with finding of Konlan et al.

(2013) that significant difference in yield could be attributed to varietal composition. The higher number of kernel weight per plant produced by intra-row spacing of 15cm could be attributed to the number of stand count at harvest recorded on intra-row spacing of 15cm which was greater than 20cm and 25cm respectively. This is also in conformity with finding of Mukhtar, (2011) who reported that increase in plant population leads to increase in yield for any given variety and increase pod yield with increase in plant population density of groundnut up to the maximum. Irrigation interval of 6days recorded highest value on kernel weight per plant and total dry matter could be attributed to variation on chemical composition of the soil observed at the two locations and their interaction with moisture, probably soil moisture content significantly affect vegetative growth at the expense of pod yield and other yield parameters. Similar finding was reported by ICRISAT, (2015) that irrigation interval of 7-10day can sustain groundnut growth and later provide good yield. This shows that 6days irrigation interval resulted in significant increase of kernel weight per plant compared to the 3 and 9days irrigation interval as reflected. However, Das, (2004) also reported that providing water at 7 days irrigation interval is suitable for growing groundnut. Therefore status of water in plants represents an integration of atmospheric demand, soil water potential, rooting density and distribution.

CONCLUSION AND RECOMMENDATIONS

The varietal differences recorded in this research indicated that SAMNUT 24 had a better performance on growth and yield parameters measured than SAMNUT 26 and SAMNUT 25 respectively. Intra-row spacing of 15cm produced the highest values on number of leaves per plant and kernel weight per plant than 20 and 25cm respectively while 20cm recorded the highest number of days to 50% flowering at the two locations. 6days irrigation interval on yield parameters proved to be most appropriate at the two locations. The following recommendations are made after a careful consideration of the research findings: -

(i) SAMNUT 24 was the highest yielding among the tested varieties and recommended for cultivation under Dry season condition

(ii) Intra-row spacing of 15cm was recommended at the two locations. Because the research indicated that intra-row spacing of 15cm significantly outperformed better on growth and yield than 20 and 25cm respectively.

(iii) 3days irrigation interval was recommended for groundnut production at *Badole* and 6days irrigation interval at *Kugado* for maximum productivity of Groundnut under Dry season condition.

Conflict of interests

The authors declare that they have no conflicting interests.

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