Performance of Groundnut Genotypes under Millet Based Intercropping Systems in Sudan Savanna of Nigeria

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Abstract: **Spatial arrangement of crops is critical in determining the growth and yield of lower crops in intercropping. The productivity of two spatial arrangements of pearl millet-groundnut intercrops was studied in the Sudan savanna of Nigeria during 2014 rainy season at Wasai (5ˈN, 08°62ˈE) in Minjibir of Kano state, and Rahama (11°40ˈN, 09°20ˈE) in Dutse of Jigawa state. The treatments were two millet varieties (Dankaranjo and SuperSosat), two intercropping systems (2:2 and 2:4; reflecting millet to groundnut row) and four groundnut genotypes (SAMNUT 21, SAMNUT 22, SAMNUT 23 and SAMNUT 24). The experiment was laid out in split-split plot design with four replications. Among the groundnut genotypes, pod yield was greater at 2:4 system at Minjibir, while SAMNUT 23 and SAMNUT 24 were significantly ($P<0.05$) better than SAMNUT 21 and SAMNUT 22, SAMNUT 21 was best in terms of pod yield (480 Kg ha^{-1}) at Dutse followed by SAMNUT 22 and SAMNUT 23 and least was SAMNUT 24 (293 Kg ha^{-1}). Higher haulm yields were produced by SAMNUT 21 and SAMNUT 22 at both locations followed by SAMNUT 23 and SAMNUT 24 which had similar haulm yields at Minjibir.**

Keywords: **Spatial arrangement, intercropping, pearl millet, groundnut.**

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important food and cash crop across West Africa owing to its diverse forms of processing. Groundnut is the 4th most important oil crop in the world and 13th most important food crop, especially in developing countries of Africa and Asia (FAO, 2013). The major groundnut production states in Nigeria are Kano, Jigawa, Borno, Nassarawa, Bauchi, Gombe, Taraba and Plateau (Taru *et al*., 2008). It was reported by Okigbo and Greenland (1976), that 95% of the groundnuts in Nigeria are grown in mixtures with other crops.

Resources (light, moisture and nutrients) utilization in intercropping was found to be sub optimal due to faulty intercropping pattern, and intercrop works best only when the positive effects are stronger than negative ones (i.e facilitation and competition respectively) (Vandermeer, 1992). Also the continuous development and release of new groundnut varieties by Research Institutes to the farming communities present a threat as these varieties are mostly evaluated under systems of monocropping, thus, there is need to identify suitable genotype for intercropping (Smith, 2002). Henceforth, the resultant of faulty intercropping system; such as defective intercropping system, use of low yielding varieties, inappropriate sowing dates and other undesirable operations, together with various crop stress factors (biotic and abiotic), greatly reduces the efficacy of the system and causes considerable reduction in output (Singh and Ajeigbe, 2002).

In view of these, this experiment was aimed at evaluating the performances of the groundnut genotypes in different patterns of intercropping with millet in the Sudan savanna of Nigeria.

MATERIALS AND METHODS

Experimental Sites

The experiment was conducted at two locations; one in IAR Research Farm at Wasai (12°15ˈN, 08°62ˈE), Minjibir Local Government Area, Kano State, and the second at Rahama (11°40ˈN, 09°20ˈE), Dutse Local Government Area, Jigawa State, Nigeria. The sites fall under the Sudan Savanna ecology characterized with mean annual rainfall range of 560-1000mm (Craufurd and Wheeler, 1999), minimum mean temperature of 21°C and maximum mean temperature of 35°C and reddish brown loamy sands with loamy and clayey surface soil (Agboola, 1986).

Experimental Lay-out

The experiment consisted of four groundnut varieties (SAMNUT 21, SAMNUT 22, SAMNUT 23 and SAMNUT 24) intercropped with two millet varieties (SuperSosat and Dankaranjo as the local variety) at two different row arrangements. Two rows of millet were intercropped with two rows of groundnut (2M:2G), and two rows of millet intersecting four rows of groundnut (2M:4G).

The experiment was laid out in a split-split plot design and replicated four times. Millet is the main factor and was allocated to the main plot, while the cropping systems were allocated to the sub plot as sub treatments, and groundnut was assigned to sub-sub plot. Each plot comprised 5m long ridges. Gross plots varied according to the intercropping pattern. Six ridges constituted the plots for 2:2 system, thus the gross plot was 5 x 0.75 x 6 = 22.5m^2, while net plot was 5 x 0.75 x 4 = 15m^2. The gross plot for 2:4 system was 5 x 0.75 x 8 = 30m^2, six ridges were harvested.

Land Preparation and Sowing

The land was cleared, harrowed and ridged. Appropriate plots were marked out and pegged. The distance of 1m was left as alley between plots and 1.5m to separate each replicate. The seeds were dressed with Apron plus at the rate of 10g per 5kg of seed for protection against soil borne insect pests and fungal infection. Sowing was done manually, millet was sown on ridges at 50cm x 75cm, and thinned to 2 plants per hill at 2WAS. Groundnut was sown at spacing of 20cm x 75cm. All the plots received 30 kg N, 13 kg P and 24.3 kg K_2O ha^{-1} as basal dressing and millet was top dressed with 30kg N ha^{-1} at 6 WAS. Manual weed control was carried out at 3, 6 and at 9 WAS.

Data Collected and Statistical Analysis

Data collected included plant height, stand count, days to 50% flowering, days to 80% maturity, grain yield ha^{-1} (for millet) and pod yield ha^{-1} for groundnut. The data collected were analysed using Genstat (17th Edition) for Analysis of Variance (ANOVA) and where significant, means of the treatments were separated using Tukey HSD test.

RESULTS AND DISCUSSIONS

The results of soil analysis for the two locations are presented in Table 1. Physical properties of the soils were characterized as sandy-loam textural class with sand having higher proportion of more than 80%. Chemically, the two soils varied with respect to location, soil in Minjibir have higher values for available soil nutrients like Na, K, Mg, Organic Carbon and Ca. However, pH of the soil at Minjibir was found to be more acidic than that of Dutse. Cation Exchange Capacity (CEC) was also higher at Minjibir.

The meteorological data in Table 2 indicated that total rainfall received during the experimental period differed in terms of quantity; amount of rainfall (715.8mm) was higher at Minjibir, likewise average maximum temperature (33^{0}C). Minimum temperature reading was higher at Dutse, in contrast, relative humidity of 61.7% was higher at Minjibir than 59.0% at Dutse during the experimental period.

Groundnut stand count was significantly influenced by companion millet variety and system only at Dutse where intercropping with SuperSosat gave statistically higher stand count than with Dankaranjo. The 2:2 system recorded higher number of groundnut stands than 2:4 system. The groundnut genotypes showed a similar trend for stand count at both locations; SAMNUT 21 had statistically ($P \leq 0.05$) higher stands than the other varieties at both locations. Significant ($P \leq 0.01$) millet x groundnut interaction at Dutse indicated that combination Dankaranjo- SAMNUT 23 produced the highest stands, while SAMNUT 24 proved to be the worst in terms of stand count irrespective of the millet companion.

However, higher number of stands obtained in 2:4 system for groundnut could be due to higher efficiency in complimentarity in soil moisture utilization. Millet was sown earlier than groundnut, as rightly suggested by Shiyam (2010) and Kassam(1976), crops mostly uses relatively little water at early stages of development could be inter planted with smaller crop that could take advantage of the unused moisture. Groundnut stand count was significantly higher when intercropped with SuperSosat, this finding is supported by principles of competition; in this case Dankaranjo is being more efficient competitor because it produced higher number of tillers, dense rooting system, superior height and higher leaf area hence required more resources; consequently, higher competition was faced by groundnuts intercropped with Dankaranjo; and this led to lower available soil moisture that promotes seed germination (ICRISAT, 1994).

Groundnut height was not significantly affected by millet variety at both locations, whereas intercropping system affected groundnut height at Minjibir; where plants under 2:2 system produced significantly taller plants. The groundnut genotypes varied significantly in terms of maximum height attained. At both locations SAMNUT 24 was the tallest followed by SAMNUT 23 while SAMNUT 22 and SAMNUT 21 were statistically similar. These differences among the genotypes in respective heights attained revealed that maximum height is strongly controlled by genetic constitution of the crop; as established by Castiglioni *et al.* (2008) that difference in plant height is attributed to genetic background of a genotype. Nevertheless, this assertion narrowed height control only to genetic impression; however, the findings of this work showed that proximity of intercrops has an influence on growth and development. The groundnut intercropped at 2:2 system were taller compared to 2:4 system is an indication that height is promoted when plants are closer. Findings by Muhammad *et al.* (2000) on millet-cowpea intercropping confirms that where millet density is high or component crops proximity was close, competition tends to be intense which promotes vertical growth. Similarly, it can be argued that height is not controlled singly by genetic background, but combination of both genetic and environmental factors during development; this is what was also recorded by Cooper (2001). Overcrowding encourages strong competition for growth factors especially sunlight which usually promotes vertical growth in plants. Comparable result was also obtained by Shiyam (2010).

The result shows that attainment of 50% flowering and maturity do not usually differ whether the crop is grown in sole or in mixture, therefore attainment of reproductive and maturity phases are strongly varietal characteristics as a result of genetic constitution of the varieties as stated by Muoneke *et al.* (2007). However, early maturity genotypes require fewer days to attain 50% flower and vice-versa.

Pod yield was not significantly controlled by companion millet variety at both locations, however, system 2:4 significantly out yielded 2:2 at both locations; this is obviously true as observed by many researchers (Ajeigbe *et al.,* 2005, Reddy *et al.,*1992*)* on cereal-legume intercropping systems. In cowpea-millet trial, Clark and Myers (1994) noted that cowpea in narrow strips (2:2) yielded average of 46% less than in wider strips (2:4) or in monocrop. Singh and Ajeigbe (2002) also recommended that this system might also be more suitable and help maintain soil fertility because two-thirds of the area is legume and only one-third is cereal. The genotypes were found to be of two yield classes at Minjibir; with SAMNUT 23 and SAMNUT 24 having similar yields which were statistically higher when compared to SAMNUT 21 and SAMNUT 22 that produced statistically similar pod yield. In contrast, SAMNUT 21 excelled in pod yield per hectare at Dutse, it was followed by SAMNUT 22 and SAMNUT 23 which were statistically similar, and least pod yield was produced by SAMNUT 24.

Haulm yields were shown to be affected by all the three factors. Haulm yield for groundnut was significantly affected by the component millet variety at both locations; where it was significantly higher when intercropped with SuperSosat at both locations. Also, the cropping system had a significant effect on the groundnut biomass. Similar studies by Ajeigbe *et al.,* (2005) concluded that where cereal proportion to cowpea is high fodder yield is seriously decreased because of shading and other competition effect, while higher cowpea proportion reduced stalk yield. There was a significant genotypic difference among the groundnuts in haulm yield where SAMNUT 21 and SAMNUT 22 proved to be the best at both locations. SAMNUT 23 and SAMNUT 24 were statistically similar at Minjibir but were at par with SAMNUT 21 and SAMNUT 22 at Dutse. The haulm yield was influenced significantly ($P \leq 0.05$) by millet at Minjibir because of taller millet plants than those at Dutse. This situation caused serious shading to the under-growing groundnut which consequently affected the haulm yield. Shading is probably more pronounced when local millet was inter planted because of taller plant produced compared to SuperSosat, this might be the reason for haulm being higher in SuperSosat-groundnut combinations as a result of less shading.

CONCLUSION

It can be concluded that all the three factors (millet varieties, system and groundnuts genotypes) have a significant influence in determining performance of the groundnut in intercropping systems in the Sudan savanna zone of Nigeria. Among the intercropping systems, 2:4 was more productive than 2:2 and this can be suggested for farmers planning to intercrop groundnut in the study area.

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Table 1. Physico-chemical Properties for Soils (0-30 cm) at Minjibir and Dutse.

Location	Minjibir	Dutse
Physical Properties		
Sand (%)	89.8	86
Silt (%)	4.2	6
Clay (%)	6	8
Texture	Sandy-loam	Sandy-loam
Chemical Properties		
pH (H_20)	6.1	6.7
Organic carbon (%)	0.49	0.19
Available P (ppm)	15.55	17.65
Ca	0.30	1.85
Mg	4.12	1.17
K	0.61	0.23
N	0.32	0.17
CEC mol/kg	4.33	2.33

Table 2. Meteorological data for Minjibir and Dutse during 2014 period of the experiment.

Location	Minjibir					Dutse				
Variable	Rainfall(mm)	Temp (^oC)		R/H (%)		Rainfall (mm)	Temp(^oC)		R/H (%)	
Month		Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.
June	87.2	25	37	44	63	53.5	31	33	43	51
July	194.2	24	33	60	70	96.1	29	30	61	73
August	283.1	23	31	68	77	276.5	30	35	69	74
September	112.7	23	32	60	71	117.7	27	28	63	67
October	25.3	22	35	39	54	18.4	26	29	45	55
November	11.3	23	30	27	35	2.2	26	31	29	34
Total/ave	715.8	23	33	49.7	61.7	537.4	28	31	51.7	59

Sources: IITA Kano and Department of Environmental Sciences, Federal University, Dutse.

Table 3. Intercropping effect on stand count and plant height of groundnut.

	Stand count (ha^{-1})		Plant height (cm)	
Treatment	Minjibir	Dutse	Minjibir	Dutse
Millet varieties(M)				
Dankaranjo	48,601	28,451b	42.0	35.0
SuperSosat	44,593	31,136a	40.3	35.0
SE ±	1,911	686	1.39	0.90
Intercropping System (S)				
2:2	46,726	40,806a	44.0a	34.2
2:4	46,468	18,780b	39.0b	36.0
SE ±	1,911	686	1.39	0.90
Groundnut genotypes (G)				
SAMNUT 21	51,000a	33,346a	31.0c	29.0c
SAMNUT 22	43,045b	28,197b	35.0c	31.0c
SAMNUT 23	46,282b	31,667a	41.0b	38.0b
SAMNUT 24	46,061b	25,964b	57.90a	43.0a
SE ±	2058.5	1493	1.79	1.27
Interactions				
M*S	NS	NS	NS	NS
M*G	NS	**	NS	NS
S*G	*	NS	NS	NS
M*S*G	NS	NS	NS	NS

Means followed by the same letter within treatment are not significantly different at 5% using Tukey HSD Test.

Table 4. Interaction between System and Groundnut on Groundnut Stand at Minjibir.

	Groundnut genotypes			
Intercropping System	SAMNUT 21	SAMNUT 22	SAMNUT 23	SAMNUT 24
M2:G2	50,083a	42,049c	50,649a	44,124bc
M2:G4	51,916a	44,041bc	41,916c	47,998b
S.E ±	2,709			

Table 5. Interaction Effect of Millet and Groundnut on Groundnut Stand at Dutse.

	Groundnut genotypes			
Millet varieties	SAMNUT 21	SAMNUT 22	SAMNUT 23	SAMNUT 24
Dankaranjo	33,485b	29,602b	37,291a	24,165c
SuperSosat	33,206b	26,792c	26,042c	27,763c
S.E ±	2,353			

Means along the same column and row having different letter are significantly different at P≤ 0.05 using Tukey HSD test.

Table 6. Intercropping effect on days to 50% flowering and 80% maturity of groundnut.

	Days to 50% flowering		Days to 80% maturity	
Treatment	Minjibir	Minjibir	Dutse	Minjibir
Millet variety (M)				
Dankaranjo	28.4	28.4	102.0	103.7
SuperSosat	28.6	28.1	102.7	103.1
SE ±	0.10	0.10	0.50	2.20
Intercropping systems(S)				
2:2	28.3	28.5	104.1a	101.6

2:4	28.2	28.4	102.7b	103.2
SE ±	0.10	0.10	0.50	2.20
Groundnut genotypes (G)				
SAMNUT 21	30.7a	31.3a	117.0a	117.9a
SAMNUT 22	29.2b	29.9b	116.9a	110.0a
SAMNUT 23	28.2c	28.4c	95.8b	96.8b
SAMNUT 24	24.9d	24.3d	83.9c	84.0c
SE ±	0.18	0.18	0.70	3.10
Interactions				
M*S	NS	NS	NS	NS
M*G	NS	NS	NS	NS
S*G	NS	NS	NS	NS
M*S*G	NS	NS	NS	NS

Means followed by the same letter within treatment are not significantly different at 5% using Tukey HSD Test.

Table 7. Intercropping effect on pod and haulm yields.

Treatment	Pod yield (kgha^{-1})		Haulm yield (kgha^{-1})	
	Minjibir	Dutse	Minjibir	Dutse
Millet varieties (M)				
Dankaranjo	541	400	956b	506b
SuperSosat	543	383	1,134a	558a
SE ±	112.3	21.4	53.6	96.2
Intercropping system(S)				
2:2	433b	316b	956b	570
2:4	651a	467a	1176a	494
SE ±	82.1	93.1	69.3	84.8
Groundnut genotypes (G)				
SAMNUT 21	480b	480a	1,335a	660a
SAMNUT 22	489b	410b	1,088a	593a
SAMNUT 23	646a	384b	879b	399b
SAMNUT 24	553a	293c	879b	475ab
SE ±	79.3	31.2	88.6	65.5
Interactions				
M*S	NS	NS	NS	NS
M*G	NS	NS	NS	NS
S*G	NS	NS	NS	NS
M*S*G	NS	NS	NS	NS

Means followed by the same letter(s) within treatment are not significantly different at 5% using Tukey HSD Test.

