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GROWTH AND YIELD OF GROUNDNUT (*Arachis hypogaea*) AND SORGHUM (*Sorghum bicolor*) AS INFLUENCED BY CROPPING PATTERN

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ABSTRACT

Experiments on the effects of cropping pattern on the growth and yield of groundnut/sorghum inter-crop were carried out during 1998 rainy season at the Dry Land Teaching and Research Farm, Usmanu Danfodiyo University Sokoto, in Sudan savannah zone of Nigeria. The experiment consisted of improved groundnut (RRB) and sorghum (ICSV400) crops in four different combinations viz: 1:1, 2:1, 3:1 and 4:1. The treatments were laid out in a randomized complete block design (RCBD) with three replications. Results from the experiment revealed the effects of combinations on growth of the groundnut to be inconsistent. Highest dry pod and kernel yields of 713Kg ha^{-1} and 483Kg ha^{-1} were obtained when groundnut was intercropped with sorghum in 4:1 and 1:1 cropping patterns, respectively. Highest land equivalent ratios (LER) of 3.77 and 2.29 were obtained from groundnut/sorghum mixture in 3:1 and 2:1 ratios, respectively. Generally, mixtures produced higher yields than sole cropping.

Keywords: Growth; Yield; Groundnut; Sorghum; Cropping pattern

INTRODUCTION

Intercropping is a common practice among peasant farmers in many parts of the world. The practice is common in sub-Saharan Africa, and it evolved naturally as answer to very challenging environmental constraints toward food production (Powel, 1984; Baker and Yusuf, 1976).

There are numerous reports where growing two crops has resulted in up to 60% more yield. Most intercrops contain a legume but this has not always been found necessary for increased yields (Andrews, 1970). Intercropping is practiced to a great extent by peasant farmers to safeguard against total crop failure when conditions are not favourable. Higher yield is obtained with the use of intercropping as a result of which the farmer gets higher return compared to sole cropping. When different corps are planted population of pests is highly reduced, since they have less hosts to attack.

Intercropping is an old practice in Nigeria. Baker and Norman (1975) summarised surveys which showed that 93%, 83% and 53% of cropped land are found in Sokoto, Zaria and Omu-Aran, respectively, in the northern Nigeria were planted to crop mixtures. However, there is high labour requirement in intercropping when compared to sole cropping. This is because different crops have different agronomic requirements.

For years, research work towards increased food production in Nigeria has been predominantly carried out using sole cropping instead of traditional mixed cropping systems (Baker and Norman, 1975). There is therefore the need to carry out research of this nature in the Sudan savanna zone such as Sokoto, since the few researches undertaken on intercropping were conducted in the Guinea savanna zone. The objective of this research was therefore to determine the best planting pattern for increased output of intercrop of groundnut and sorghum in the study area.

MATERIALS AND METHODS

Study Site

The study was conducted at the Dry land Teaching and Research Farm of Usmanu Danfodiyo University, Sokoto, during 1998 rainy season. The site lies on latitude 13^0 01^1N, longitude 5^0 15^1E, and 350 m above sea level in the Sudan Savanna agro-ecological zone (Sokoto State Government, 2003).The annual rainfall ranges from 550 to 600mm per annum distributed over three to four months. The soil type of the area is predominantly sandy in nature and classified as entisols which is characterized by low fertility and poor water holding capacity (Noma and Yakubu, 2002).

Experimental Design and Treatments

The treatments consisted of grain sorghum and groundnut varieties namely ICSV 400 and RRB respectively, intercropped in four different patterns (ratios) (groundnut/sorghum 1:1, groundnut/sorghum 2:1, groundnut/sorghum 3:1 and groundnut/sorghum 4:1) and sole groundnut and sorghum. The treatments were laid out in a randomized complete block design (RCBD) replicated three times. The land was harrowed and prepared in gross plots of $45m^2$ that comprises 10 rows for sole cropping, 1:1 and 4:1 ratios. Seventeen (17) kilograms of 15:15:15 NPK fertilizer was applied before planting and sorghum crop was top-dressed with Urea six weeks after planting and the plots were weeded regularly.

Data Collection and Analysis

Five plants in each plot of groundnut and sorghum were earmarked and measurements of agronomic data was made on the plant spread, plant height, days to 50% flowering, days to maturity, dry pod yield, haulm yield, kernel yield and shelling percentage.

Land equivalent ratio (LER) is the ratio of the amount of land needed to grow both crops together compared to the amount of land needed to grow pure stands of each. It was calculated using the formula by Francis (1986) and Kantor (1999) as follows:

$$\text{Land Equivalent Ratio (LER)} = \frac{\text{Intercrop sorghum yield}}{\text{Sole crop sorghum yield}} + \frac{\text{Intercrop groundnut yield}}{\text{Sole crop groundnut yield}}$$

When LER is greater than 1.0 it shows that intercropping is advantageous and less than 1.0 shows a disadvantage. For example LER of 1.15 means that an area planted as a sole would require 15% more land to produce the same yield as the same area planted in an

intercrop combination. An LER of 2.0 means the intercropped area would produce twice as much as the sole. On the other hand, an LER of 0.80 indicates that the intercrop yield was only 80% of the yield of sole stand (Francis, 1986; Kantor, 1999).

Data collected were subjected to analysis of variance and differences among treatment means were compared using Duncan Multiple Range Test (DMRT) (SAS, 2003).

RESULTS AND DISCUSSION

Groundnut

Plant establishment

Establishment count of groundnut at two weeks after sowing was significantly ($P<0.05$) influenced by cropping pattern (Table 1). Maximum number of stands (36,296 stands ha^{-1}) was found in the mixture of groundnut/sorghum in the ratio of 3:1 which was significantly higher than the one obtained from ratio of 4:1 which had 35,277 stands ha^{-1}. The least number of stands (19,259) was found when groundnut was intercropped with sorghum in ratio of 2:1 (Table 1). This finding agrees with the report of Robert and Andrew (1992) that, competition for resources could affect plant population.

Table 1**:** Effect of cropping pattern on growth attributes of groundnut in groundnut/sorghum intercrop during 1998 rainy season at Sokoto.

Cropping pattern	Establishment count (ha^{-1})	Canopy spread (cm)	Plant height at 9 WAS (cm)
Groundnut/sorghum 1:1	34222^{c}	16.45^{c}	31.18^{ab}
Groundnut/sorghum 2:1	19259^{e}	16.83^{c}	25.00^{c}
Groundnut/sorghum 3:1	36296^{a}	17.05^{b}	31.78^{ab}
Groundnut/sorghum 4:1	35277b	21.21^{a}	28.30^{b}
Sole groundnut	31110^{d}	16.34^{c}	34.91^{a}
SE ±	12.485	0.657	2.683

Means in a column followed by same letter(s) are not significantly different ($P>0.05$)

Canopy spread

Canopy spread at 3 weeks after sowing (Table 1) showed that there was significant difference ($P<0.05$) among the different planting ratios. The canopy spread was highest when groundnut was intercropped with sorghum in 4:1 ratio (21.21cm) which was significantly higher than 17.05cm obtained from 3:1 ratio. The smallest canopy spreads were observed in the remaining planting ratios which were found to be at par ($P>0.05$). The larger value for the canopy spread observed in groundnut/sorghum ratio of 4:1 was due to availability of light to the groundnuts as a result of fewer rows of sorghum, hence less shading effect. This is corroborated by the findings of Steiner (1982) that taller plants are usually the dominant plants intercepting the greater share of light, while the smaller dominated plants grow less than the dominant plants, and slight differences in height even at early growth stage could cause serious competition thereby increasing the differences between dominated and dominant plants. Similarly, Ofori and Stern (1987) stated that the

taller component suppresses the companion legume through shading, and this was accentuated by the application of nitrogen.

Days to 50% flowering

Cropping pattern had significant effect (P<0.05) on the days to 50% flowering (Table2). Groundnut intercropped with sorghum in ratios of 1:1 and 2:1 significantly took more number of days (36) to attain 50% flowering than the other ratios including the control. Groundnut intercropped with sorghum in 3:1 and 4:1 ratios took fewer (33 days) to flower. It was observed that intercropping with sorghum prolonged flowering in such a way that the higher the number of sorghum rows in the groundnut plots, the longer it took to flower. This could be due to the shading made by the former during the vegetative growth. This observation agrees with the findings of Owonubi and Yusuf (1986) who reported that shading during vegetative phase significantly reduced the rate of flowering of groundnut while shading after the vegetative phase did not affect flowering but reduced pod yield. Owonubi *et al*. (1991) also found that planting sorghum simultaneously with groundnut prolonged flowering during peak production phase of groundnut as observed in the present study.

Table 2: Effect of cropping pattern on yield and yield attributes of groundnut in groundnut/sorghum intercropping during 1998 rainy season at Sokoto.

Cropping pattern	Days to 50% flowering	Haulm yield (kg ha^{-1})	Pod yield (kg ha^{-1})	Kernel yield (kg ha^{-1})	100 seed weight (g)
Groundnut/sorghum 1:1	36^{a}	919.99	215.55^{e}	251.85^{e}	56.41^{a}
Groundnut/sorghum 2:1	36^{a}	788.89	366.67^{d}	366.67^{d}	46.64^{c}
Groundnut/sorghum 3:1	33^{b}	734.04	591.11^{c}	453.33^{c}	46.61^{c}
Groundnut/sorghum 4:1	33^{b}	752.77	713.87^{b}	483.32^{b}	50.23^{b}
Sole groundnut	33^{b}	908.55	706.55^{a}	472.33^{a}	40.62^{d}
SE ±	0.474	ns	0.374	0.219	0.591

Means in a column followed by same letter(s) are not significantly different (P> 0.05)

Pod, kernel and haulm yields

Dry pod yield (Table 2) was significantly affected by cropping pattern (P<0.05). Highest dry pod yield (713.87kg/ha) was recorded when groundnut and sorghum were intercropped in the ratio of 4:1, followed by 591.11kg/ha at 3:1 ratio. The lowest yield (215.53kg/ha) was obtained in the mixture ratio of three rows of groundnut to one row of sorghum. Kulkerni and Sojitra (1986) reported that pod yield was significantly reduced under cereal intercropping as compared with the yield of groundnut under sole cropping and attributed this to the reduced photosynthetic activity due to shading.

There were significant differences in kernel yield between the treatments (P<0.05). The highest kernel yield (483.32kg/ha) was obtained when groundnut was intercropped with sorghum in ratio of 4:1. This was followed by 453.33kg/ha obtained when groundnut was combined with sorghum in ratio of 3:1. The higher yields obtained with ratio 4:1 could

be attributed to reduced competition between sorghum and groundnut and also to less shading effect of sorghum on groundnut. This finding concurs with that of Anon. (1994) that yields of groundnut were depressed more when intercropped with tall and late maturing sorghum varieties.

Differences in haulm yield were not significant (P>0.05) among the treatments. However, intercropped mixture of 4:1 produced higher haulm yield compared to sole cropping which recorded the lowest haulm yield.

Shelling percentage and 100-seed weights

There was no significant difference in the shelling percentage among the treatments (Table 2), but mixtures in the ratios of 3:1 and 4:1 had almost the same shelling percentages of 70.28 and 70.86, respectively. The lowest (53.61%) was obtained in the groundnut/sorghum mixture of 2:1. Olorunju *et al*. (1994) obtained similar results and stressed that plant density has been found to have the greatest influence on yield and shelling percentage.

There was significant difference on the 100 seed weight (Table 2). The groundnut mixture with sorghum in the ratio of 4:1 recorded significantly higher seed weight (55.78g) which was statistically at par with 55.76g obtained from 3:1 cropping ratio. While cropping ratio of 1:1 recorded the least 100 seed weight of 43.25g. The higher kernel weight obtained from 4:1 and 3:1 cropping ratios could be attributed to less competition for space enjoyed by the groundnut stands, hence more kernel weight.

Sorghum

Establishment count

There was significant effect of intercropping on the plant establishment (Table 3). The highest (43,333 plants/ha) was obtained when groundnut was intercropped with sorghum in the ratio of 4:1.while the least establishment (31,999 plants/ha) was recorded from sorghum planted as a sole crop. This might be as a result of poor seed germination due to soil crust across the experimental area. Anon (1985) reported that hard pan inhibits seedling emergence in sorghum.

Table 3: Effect of cropping pattern on growth components of sorghum in groundnut/sorghum intercropping during 1998 rainy season at Sokoto

Cropping pattern	Establishment count (plants ha^{-1})	Plant height (cm)	Days to 50% flowering
Groundnut/sorghum 1:1	32444^{c}	1.62^{a}	56^{e}
Groundnut/sorghum 2:1	35556^{b}	1.16^{c}	58^{c}
Groundnut/sorghum 3:1	35555^{b}	1.52^{a}	57^{d}
Groundnut/sorghum 4:1	43333^{a}	1.45^{b}	59^{b}
Sole sorghum	31999^{d}	1.24^{b}	83^{a}
SE ±	5.485	0.116	0.627

Means in a column followed by same letter(s) are not significantly different (P> 0.05)

Plant height

There was significant difference in the sorghum plant height, where groundnut/sorghum ratio of 1:1 gave the tallest plants (1.62m), while the mixture of groundnut/sorghum in the ratio 2:1 gave the shortest sorghum plants of 1.16m (Table 3).

Days to 50% flowering and maturity

Number of days to 50% flowering showed significant differences among the treatments (Table 3). Intercropping groundnut with sorghum in the ratio of 1:1 and sole cropping of sorghum gave the same number of days (56) to attain 50% flowering. Intercropping ratio of 3:1, 2:1 and 4:1 brought about additional 1, 2, and 3 days respectively.

As regards days to maturity (Table 4), sorghum to groundnut ratio of 1:1 and sole sorghum took sorghum fewer days (96) to maturity, while planting ratio of 4:1 took the highest number of days (99) to attain maturity in sorghum.

Sorghum yields and 100 seed weight:

Sorghum grain yield (Table 4) showed significant differences among treatments ($P<0.05$). Sorghum/groundnut mixture in ratio of 1:1 recorded the highest yield (791.10kg/ha). This was followed by 4:1 ratio (711.11kg/ha). The least grain yield (318.52kg/ha) was obtained from 2:1 planting ratio. It was observed that there was low yield of sorghum which could be attributed to non availability of water during grain filling period. This was buttressed by the report of Andrew (1974) who reported that in Nigeria sorghum flowers as the rains stop and ripens on residual moisture.

Across the treatments, there was a significant effect of intercropping on the 100 grain weight (Table 4). The highest value (1.82g) was recorded in intercropping ratio of 3:1, while the lowest (1.70g) was in 2:1 ratio.

Table 4: Effect of cropping pattern on yield and yield components of sorghum in groundnut/sorghum intercropping during 1998 rainy season at Sokoto

Cropping pattern	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	100-seed weight (g)	Days to maturity
Groundnut/sorghum 1:1	791.10[a]	1648.8	1.76	96[d]
Groundnut/sorghum 2:1	318.00[e]	1318.52	1.70	98[b]
Groundnut/sorghum 3:1	666.67[c]	1766.66	1.82	97[c]
Groundnut/sorghum 4:1	711.11[b]	1422.22	1.80	99[a]
Sole sorghum	646.66[d]	1593.52	175	96[d]
SE ±	2.410	ns	0.026	0.789

Means in a column followed by same letter(s) are not significantly different ($P>0.05$)

Stover yield

There was no statistical difference in yield among the sorghum/groundnut intercropping ratios (Table 4). Planting ratio of 3:1 produced the highest Stover yield (1766.66kg/ha), followed by 1:1 (1648.87kg/ha). The least Stover yield (1318.52kg/ha) was obtained from groundnut/sorghum ratio of 2:1.

Land Equivalent Ratio (LER)

Intercropping resulted in yield advantage among the treatments (Table 5). Highest value of LER (2.60) was obtained in groundnut/sorghum ratio of 1:1, followed by 2.30 obtained from ratio 4:1. The least was obtained from growing groundnut or sorghum as a sole crop.

Table 5: Land equivalent ratio of the cropping patterrn

Cropping pattern	Land Equivalent ratio (LER)
Groundnut/sorghum 1:1	2.60[a]
Groundnut/sorghum 2:1	1.28[c]
Groundnut/sorghum 3:1	2.04[b]
Groundnut/sorghum 4:1	2.30[b]
SE ±	0.031

Means in a column followed by same letter(s) are not significantly different (P > 0.05)

CONCLUSION

From the results obtained in this research, it could be concluded that intercropping had advantage over sole cropping. Mixture of groundnut and sorghum in the ratio of 4:1 appeared to be advantageous in both pod and kernel yield of groundnut, while planting ratio of groundnut to sorghum in the ratio of 1:1 appeared to be the best combination for sorghum.

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