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Growth and Yield Performance of Bambara nuts (*Vigna subterranean* (L). Verdc*)* as Influenced by Cropping System and Plant Spacing in Yola, Nigeria

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Abstract

The experiment was conducted to evaluate the growth and yield performance of Bambara nuts (*Vigna subterramean* (L) Verdc) under a cropping system (bambara nuts/maize intercrop) and different plant spacing. The experiment was conducted during the 2017 and 2018 cropping seasons at the Teaching and Research Farm of the Department of Crop Production and Horticulture, Modibbo Adama University of Technology Yola, Nigeria. The field experiments were factorial design laid out in a split plot design. The treatments consisted of three (3) plant spacings of 20, 25 and 30 cm which were assigned to main plot treatment while maize variety samaz 17 and bambara nut were assigned to the sub- plots treatment was replicated three (3) times. Performance parameters measured included establishment count expressed in percentage, plant height, harvest index, days to 50% flowering, shelling percentage, weight of dry pod, weight of seed and total yields. Results showed that plant spacing and maize-bambara nut intercrop has no significant effect on establishment, plant height, harvest index, days to 50 % podding and shelling percentage of bambara nuts. Results also showed that plant spacing and maize-bambara nut intercrop had significant effect on weight of dry pod, 100 seed weight and total grain yield of bambara nut. It is recommended that a wider plant spacing of 30 cm in a maize – bambara nut intercrop should be observed for meaningful yield in Yola.

Key words: cropping system, plant spacing, maize, bambara nuts, yield.

Introduction

Intercropping is the growing of two or more crops together in proximity on the same land. As a result, two or more crops are managed at the same time (Sullivan, 2003). Jakusko (2016) defined mixed cropping as a type of multiple cropping systems which involves growing two or more crops simultaneously in the same field at the same time, but not in row

arrangement. Seren and Brintha (2010) defined cropping system as the combination of crops grown on a given area within a year. One of these systems is intercropping (Addo-Quaye *et al*., 2011).The growing of two or more crop species simultaneously in the same field during a growing system is important for the development of sustainable food production (Eskandari *et al*., 2009).

Maize is a versatile crop growing across wide range of agro-Ecological zones with United States of America producing almost half of the world's total production (42.5%). Nutritionally, maize contains about 72% starchy, 10% protein, 4.8% oil, 85% fiber, 3% sugar, and 17% ash (Chaudary, 1983). IITA(2009) reported that throughout the tropic and sub-tropics, small scale farmers grow maize mostly for subsistence as part of agricultural system that feature several crops sometimes livestock production unlike developing countries where hybrid are commonly grown with high inputs using mechanical operation system.

Bambara nut,(*Vigna subterramean* (L.) Verdc.) originated from Africa and has been cultivated in tropical Africa for centuries. It is the third most important grain legume crops of the African lowland tropics after the popular groundnuts and cowpea. In recent years there has been renewed interest for the cultivation of bambara nuts in the arid savannah zones. It is cultivated as an intercrop with maize or cowpeas. Reliable production figures for bambara nut are difficult to obtain, because the crop is mainly grown for human consumption and local markets. The estimated production in Africa is about 330000 tons. Nigeria leads in production with 100000 tons followed by Burkina Faso and Mali, Cameroon, and Ivory Coast. It is grown at subsistence level in almost all the sub-Saharan countries in Africa (Seran and Brintha, 2010).

Planting spacing is an important agronomic attribute since it is believed to have effects on light interception during photosynthesis. When plant spacing is inadequate and the plants suffer clustering together the overall yield is drastically reduced. Good plant spacing gives the right plant density, which is the number of plant allowed on given unit of land for optimum yield (Obi, 1991).

Materials and Methods

Experimental Site

Field experiments were carried out at Teaching and Research Farm of the Department of Crop Production and Horticulture, Modibbo Adama University of Technology, Yola, Nigeria during 2017 and 2018 cropping seasons. Yola is located at latitude 9^0 14' North and Longitude 12^0 38' East at an altitude of 185.5m (Adebayo and Tukur, 1999). In this environment the annual rainfall ranges from 700 – 1,000 mm, commencing in late April with

moisture regime peaking in August/September and terminating in late October.

Planting Materials

A Bambara nut was used as an intercrop with early maturing variety of maize, Samaz 17. The seeds were obtained from certified local seed vendor in Yola market and used for the experiment.

Treatments and Experimental Design

The field experiments were factorial arrangements laid out in a split plot design. The treatments consisted of three (3) spacing; 20, 25 and 30 cm which was assigned to main plot treatment while bambara nuts variety was assigned to the sub- plot treatment and was replicated three (3) times.

Cultural Practices

The Land was ploughed with a hoe in other to get a fine tilt before taking the layout measurement of the plot using pegs, rope and meter tape. The seeds were treated with apron plus at the rate of 1 sachet per kg of bambara nut. The seeds were sown to two (2) seeds per hole at the depth of 2-3 cm and pressed lightly.

Data Collected

Measurement of crop performance parameters were taken at 3, 6, 9 and 12 weeks after planting (WAS) and at 95 % maturity. Five random plants were sampled from each plot. The parameters measured were:

Establishment count

Which was obtained by physically counting the established stands per plot at 3 WAS and at harvest.

Plant height

Was measured with a meter rule at 3, 6, 9 and 12 WAS and at harvest.

Harvest index

Was determined as a ratio of pod weight to the weight of total dry matter, thus

$$K(\%) = \frac{weight\ of\ pod\ (kg)}{total\ dry\ matter} \times 100$$

Where K = harvest index expressed in percentage

Days to 50% flowering

Was determined by careful observation of the number of days when half of the plants within each plot had produced flowers.

Weight of dry pod

Was determined when all the plant in a plot has turned yellow leaves and are harvested. The harvested pods are then sun dried and the weight of pods in each plot is taken using an electric weighing machine.

Weight of 100 seed

Was obtained by counting and weighing 100 seed randomly selected from each plot using an electric weighing machine and the mean recorded.

Grain yield (Kg/ha)

Was computed thus:

$$\text{Grain yield} = \frac{\text{(Grain yield/plot (kg) x 10,000m}^2\text{)}}{\text{Net plot size (20m}^2\text{)}}$$

Statistical Analysis

Data collected was subjected to analysis of variance (ANOVA) using a statistical package SAS for windows release 9.2 (SAS Institute, 2009) and Least Significant Difference (LSD) (P>0.05) at ranking was used to separate the means.

Results

Effects of cropping system and plant spacing on establishment count (%)

The result of the effects of cropping system and plant spacing on establishment count of bambara nut in 2017 and 2018 cropping season is presented in Table 1. The result recorded no significant difference (P>0.05) in the intercropping of bambara nut with maize as well as the plant spacing in both cropping seasons. Interaction between cropping system and plant spacing had no significant effect on establishment count of bambara nut in the two cropping seasons.

Table 1: Effects of cropping system and plant pacing on establishment Count of bambara nut in Yola in 2017 and 2018 cropping Season

	Establishment Count (%)	
Treatments	2017	2018
Bambaranut/Maize	23.56	23.78
Bambara nut	26.00	24.11
P<F	0.141	0.814
Level of significance	ns	ns
Plant Spacing		
20 cm	24.83	23.17
25 cm	25.67	23.83
30 cm	23.83	24.83
P<F	0.632	0.624
Level of significance	ns	ns
Cropping system X spacing	ns	ns

ns – Not significant

Effects of cropping system and plant spacing on plants height (cm)

The result of the effects of cropping system and pant spacing on plants height of bambara nut in 2017 and 2018 cropping season is presented in Table 2. The results recorded no significant difference (P>0.05) in the intercropping of bambara nut with maize and among the plant spacing in both cropping seasons. The result also showed that there was no significant interaction (P>0.05) observed between the cropping system and plant spacing on the plant height of bambara nut.

Table 2: Effects of cropping system and plant spacing on plants height of bambara nut in Yola in 2017 and 2018 cropping Seasons

	Plants height 2017 WAS				Plants height 2018 WAS			
Treatments	3	6	9	12	3	6	9	12
Bambara nut/ Maize	13.02	21.98	21.95	23.62	10.14	19.38	20.74	21.96
Bambara nut	13.21	22.29	23.20	23.40	9.82	18.58	20.56	22.82
P<F	0.917	0.560	0.256	0.756	0.459	0.595	0.488	0.242
Level of significance	ns	ns	ns	ns	ns	ns	ns	ns
Plant spacing								
20 cm	12.517	22.77	23.43	22.93	9.43	16.57	20.43	21.73
25 cm	14.133	21.77	22.03	22.93	9.88	20.17	20.80	22.53
30 cm	12.700	21.87	22.27	24.07	10.63	20.20	20.72	20.90
P<F	0.722	0.323	0.518	0.444	0.108	0.113	0.512	0.410
Level of significance	ns	ns	ns	ns	ns	ns	ns	ns

ns - Not Significant

Effects of cropping system and plant spacing on harvest index of bambara nuts

The result of the effects of cropping system and plant spacing on harvest index of bambara nut in 2017 and 2018 cropping seasons is presented in Table 3. The result recorded no significant difference (P>0.05) in the intercropping of bambara nut with maize as well as plant spacing in both the cropping seasons. The result also reported no significant interaction (P>0.05) between cropping system and plant spacing on harvest index of bambara nut in the two cropping seasons.

Table 3: Effects of cropping system and plant spacing on harvest index of bambara nut in Yola in 2017 and 2018 Rainy Seasons

	Harvest Index (%)	
Treatments	2017	2018
Bambaranut/Maize	89.23	85.23
Bambara nut	94.93	86.58
P<F	0.312	0.671
Level of significance	ns	ns
Plant spacing		
20 cm	92.22	82.43
25 cm	86.52	86.38
30 cm	97.52	88.90
P<F	0.290	0.261
Level of significance	ns	ns
Cropping system X Spacing	ns	ns

ns – not significant

Effects of cropping system and plant spacing on 50% flowering

The result of the effects of cropping system and plant spacing on 50% flowering of bambara nut in 2017 and 2018 cropping season is presented in Table 4. The result showed no significant difference (P>0.05) of cropping system and plant spacing on 50% flowering of bambara nut. There was also no significant interaction (P>0.05) between cropping system and plant spacing on days to 50 % flowering of bambara nut in both the cropping seasons.

Table 4: Effects of cropping system and plant spacing on days 50% Flowering of Bambaranut in Yola in 2017 and 2018 Rainy Season

	Days to 50% Flowering	
Treatments	2017	2018
Bambaranut/Maize	47.89	46.89
Bambara nut	48.44	47.33
P<F	0.634	0.671
Level of significance	ns	ns
Plant spacing		
20 cm	49.67	48.16
25 cm	47.50	46.67
30 cm	47.33	46.50
P<F	0.221	0.374
Level of significance	ns	ns
Cropping system X Spacing	ns	ns

ns – not significant

Effects of cropping system and plant spacing on shelling percentage of bambara nut

The result of the effects of cropping system and plant spacing on shelling percentage of bambara nut in 2017 and 2018 cropping seasons is presented in Table 5. The result recorded no significant difference (P>0.05) in the intercropping between bambara nut and maize and plant spacing on shelling percentage of bambara nut in both cropping seasons. No significant interaction (P>0.05) was recorded between cropping system and plant spacing with regards to shelling percentage of bambara nut in both cropping seasons.

Table 5: Effects of cropping system and plant spacing on Shelling percentage of Bambara nut in Yola in 2017 and 2018 cropping seasons.

	Shelling (%)	
Treatments	2017	2018
Bambara nut/Maize	86.24	86.66
Bambara nut	78.96	84.67
P<F	0.082	0.274
Level of significance	ns	ns
Plant spacing		
20 cm	85.32	90.80
25 cm	83.42	85.19
30 cm	79.07	84.02
P<F	0.415	0.275
Level of significance	ns	ns
Cropping system X spacing	ns	ns

ns – not significant

Effects of cropping system and plant spacing on the weight dry pod of bambara nut (kg/plot)

The result of the effects of cropping system and plant spacing on weight of dry pod of bambara nut in 2017 and 2018 cropping seasons is presented in Table 6. The result recorded significant difference (P≤0.01) between the intercropping of bambara nut and maize in both cropping seasons. In 2017, bambara nut recorded the highest dry pod weight of 1.478 kg/plot while bambara nut/maize intercrop had the least weight value of 1.189 kg/plot. The trend continued the same way in 2018 where bambara nut had the highest weight of 1.613 kg/plot while the least weight value of 1.216kg/plot was obtained from bambara nut/maize intercrop. The result also recorded Significant difference (P≤0.01) between the plant spacing in both 2017 and 2018. In 2017, 30 cm spacing had the highest dry pod weight of 1.500 kg/plot followed by 25 cm with a weight value of 1.367 kg/ha while the least dry pod weight of 1.133 kg/plot was obtained from plant spacing of 20 cm. The trend continued the same way in 2018 where 30 cm plant spacing had the highest dry pod weight of 1.415 kg/plot followed by 20 cm with 1.381 kg/plot while the least value of 1.112 kg/plot was obtained from 20 cm. There was no significant interaction (P>0.05) between cropping system and plant spacing on the weight of dry pod in both cropping seasons.

Table 6: Effects of cropping system and plant spacing on weight of dry pod of bambara nut in Yola in 2017 and 2018 cropping Seasons

	Weight of dry pod (kg/plot)	
Treatments	2017	2018
Bambara nut/Maize	1.189	1.216
Bambara nut	1.478	1.613
P<F	0.002	0.003
Level of significance	0.159	0.213
Plant spacing		
20 cm	1.133	1.112
25 cm	1.367	1.381
30 cm	1.500	1.415
P<F	0.006	0.008
Level of significance	0.262	0.202
Cropping system X Spacing	ns	ns

ns – not significant

Effects of cropping system and plant spacing on 100 seed weight of bambara nut in Yola in 2017 and 2018 cropping Seasons

The result of the effects of cropping system and plant spacing on seed weight of bambara nut in 2017 and 2018 cropping seasons is presented in Table 7. The result recorded significant difference ($P \leq 0.05$) between the intercropping of bambara nut and maize in 2017 and 2018. In 2017, bambara nut had the highest seed weight of 1.20 g while the least value of 1.01 g was obtained from bambara nut/maize intercrop. Similar trend also continued the same way in 2018, bambara nut had the highest value of 1.17 g while bambara nut/maize had the least value of 1.03 g. There was also significant difference observed ($P \leq 0.05$) between the plant spacing in both cropping seasons. In 2017, 30 cm plant spacing recorded the highest seed weight of 1.23 g followed by 25 cm with 1.13 g while the least value of 0.95 g was obtained from 20 cm. The same trend was recorded in 2018, the higher value of 1.27g was recorded from plant spacing of 30 cm followed by 25 cm with 1.14 g while the least value of 0.91g was recorded from 20 cm. There was no significant ($P > 0.05$) interaction between cropping system and plant spacing with regards to 100 seed weight of bambara nut in both cropping seasons.

Table 7: Effects of cropping system and plant spacing on 100 seed weight of bambara nut in Yola in 2017 and 2018 cropping Seasons

	100 Seed Weight (g)	
Treatments	2017	2018
Bambara nut/maize	1.01	1.03
Bambara nut	1.20	1.17
P<F	0.013	0.029
Level of significance	0.146	0.117
Plant spacing		
20 cm	0.95	0.91
25 cm	1.13	1.14
30 cm	1.23	1.27
P<F	0.016	0.014
Level of significance	0.178	0.143
Cropping system X Spacing	ns	ns

ns – not significant

Effects of cropping system and plant spacing on grain yield (kg/ha) of bambara nut in Yola in 2017 and 2018 cropping Seasons

The result of the effects of cropping system and plant spacing on grain yield of bambara nut in 2017 and 2018 cropping seasons is presented in Table 8. The result showed significant difference (P>0.05) between bambara nut and maize intercrop in 2017, but there was no significant difference (P>0.05) recorded in 2018. In 2017, bambara nut/maize was found to be statistically better with 29501 kg/ha than bambara nut with 18905 kg/ha. There was no significant difference (P>0.05) observed between the plant spacing in both 2017 and 2018. No significant interaction (P>0.05) between cropping system and plant spacing with regards to garain yield of bambara nuts in 2017 and 2018 cropping seasons.

Table 8: Effects of cropping system and plant spacing on grain yield (kg/ha) of bambara nut in Yola in 2017 and 2018 cropping seasons

	Grain Yield (kg/ha)	
Treatments	2017	2018
Bambara nut/maize	29501	15076
Bambara nut	18905	18752
P<F	0.001	0.124
Level of significance	5350.2	ns
Plant spacing		
20 cm	20711	14059
25 cm	26275	18462
30 cm	25622	18222
P<F	0.169	0.230
Level of significance	ns	ns
Cropping system X Spacing	ns	ns

ns – not significant

Discussion

Effects of cropping system and plant spacing on growth parameters of bambara nuts

The growth parameters measured included crop establishment, plant height, harvest index, days to 50% flowering. Bambara nut intercrop with maize showed good germination and establishment qualities. This might be as a result of certified seed that was obtained and used for the experiment. This submission agrees with Maria *et al.* (2014) who observed that a successful emergence and establishment of crops is a combination of three key factors including environment (temperature, residue, compactness of soil and water), genetic (stress tolerance and vigour), seed quality (harvest moisture, drying, conditioning and planting). Similarly, Orzolek (1991) stated that crop stand establishment is controlled by biotic (soil and planting requirements) and environmental factors (temperature, nutrients, water stress). Successful germination and emergence are the primary requirements for good crop establishment. Similarly, Saxena (1987) reported that temperature and photoperiods are the major factors controlling the time taken by a crop to emerge. In the case of spacing, it was revealed that with the increases of spacing plants receive enough light and nutrient after emergence which leads to attain maximum establishment percentage (Sharma *et al.,* 2001). The wider the spacing, the higher the establishment percentage and this result is in conformity with the findings of (Sharma *et al.*, 2001).

Plant heights of bambara nut under intercrop with maize was not

significant during both 2017 and 2018 growing seasons. An observed reduction of bambara nut plant height under intercrop with maize during the sampling period was observed and this could be as a result of leguminous crop variation and this is similar to the observations by (Undie *et al.,* 2012).

Intercropping of bambara nuts with maize did not significantly affect the days to 50 % flowering. This could be as a result of genetic variation of the bambara nut plant. This is in line with the submission of Maria et al. (2014) who stressed the genetic component of the plant to control stress tolerance and vigour in terms of growth of the plant. However, in 2018, a significant effect was observed which could be due to seasonal variation. This result is similar to that obtained by Muoneke et al. (2007) who did not find any significant difference in terms of days to 50% flowering of soybean intercropped with maize. Similarly, Mpangane *et al.* (2004) reported that there was no significant difference observed in maize – cowpea intercropping. Hardley *et al.* (1983) stated that flowering is dependent on both genotype and environment Kamaga *et al.* (2002) also reported that rainfall and temperature appeared to be the two most important climatic factors that influence vegetative growth and flowering of bambara nut.

The harvest index of bambara nut was not affected by intercropping or spacing. This result is similar to that of Zahoor (1991) who reported that seed weight and harvest index were not significantly influenced by intercropping and different seeding densities. However, Kamithi et al. (2009) reported that harvest index of chick pea increased with an increase in plant population.

Effects of cropping system and plant spacing on Yield Parameters of bambara nuts

Intercropping bambara nut with maize showed a significant effect on the weight of dry pod in both growing season, sole bambara nut was found to be statistically better than the intercropped bambara nut with maize in both 2017 and 2018. The significant differences in both 2017 and 2018 could be attributed to intercropping of bambara nut with maize. Cumberland (1978) reported higher pod yield and dry pod of bambara nut at 14 than at 7 plants/m^2. Similarly, Mkadawire and Sibuga (2002) reported higher dry pod and pod yields at population densities of 22 than at 9 plants/m^2. Furthermore, they reported lower dry pod weight and pod yield of bambara nut with increase in plant density up to 66 plants/m^2. Plant spacing was also affected the weight of dry pod. It was revealed that with the increases in spacing, dry matter production reaches its optimum. Generally, 30 and 25 cm plant spacing gave higher dry pod weight as compared to with 20 cm. Thus, the wider the spacing, the higher the weight of dry pod of bambara nut

because of less competition for nutrients among the plants during growth stages. Similar result was also obtained by (Sharma *et al.,* 2001).

Sole bambara nut performed better than the intercropped with maize in both season. This result is in line with Kamaga et al., (2002) who found that sole bambara nut produced greater number of leaves during physiological growth hence had higher number of seeds and seeds quality. In intercropping system, the yield reduction comparing to its sole crop might be attributed to higher competition for light, space nutrients and water. The result is in full conformity with (Mucheru et al., 2003). Studies by Karikari et al., (1999) showed that intercropping maize with bambara nut did not affect the number of cobs per head and seed weight of maize. Similarly, it was also reported that yield did not reduce nor increase in intercropped sorghum and bambara nuts (Gabatshele *et al.,* 2012). The plant spacing of 30 cm and 25 cm performed better than 20 cm in terms of the seed weight and this could be attributed to good vegetative growth and better physiological performance of the crop. This result is in line with Sharma et al., (2001).

The yield (kg/ha) of the bambara nuts was significantly affected by intercropping bambara nut with maize where reduction in the yield of intercropped bambara nut was recorded. The reduction in yield components of the bambara nuts is in conformity with the work done by Acheampong (2006) who observed a decrease in yield component of the legume with late sowing. The reduction in the yield of the associated cereal can be attributed to competition of intercrop component for growth resources. Yield reduction under intercropping could be associated with the competition effect by the component crop for nutrients, moisture and plant spacing (Adeniyi *et al.,* 2007). Similarly, Nzabi *et al.* (2000), reported that maize grain yield differs with different legume species and intercropping produces higher maize grain yield than sole cropping. On the other hand, wider spacing (25 and 30 cm) performed better than 20cm in terms of yield component and this could be associated with wider plant spacing which ensures less competition during physiological growth which thereby leads to higher yield at the end. This is similar to the findings of (Sharma *et al.,* 2001).

Conclusion

This study revealed that intercropping bambara nuts with maize crops allow farmers to grow more than one crop on the field at the same time. The study also showed that the yield of bambara nut under the intercrop was good which

will provide the resource-poor farmers an additional source of income and improved access to protein. The study further revealed that enough spacing during physiological stage reduce plant competition for sunlight, moisture and other vital nutrients thereby increases vegetative growth and subsequent yield components.

Recommendation

Based on the result of the study, bambara nut intercrop with maize at allows the farmers to make the best use of the available land for production. Wider plant spacing of 30 cm allow farmers to get good yield and is recommended for farmers in Yola.

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