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Effect of Planting Systems on the Growth and Yield of Bambara Nut (*Vigna Subterranean l. Verdic*) Intercropped with Maize (*Zea Mays l.*)

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Effect of Planting Systems on the Growth and Yield of Bambara Nut (*Vigna Subterranean l. Verdic*) Intercropped with Maize (*Zea Mays l.*)

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Abstract

Two experiments were set up to evaluate the effect of planting systems on the growth and yield of Bambara nuts (*Vigna subterranea L. Verdec*) intercropped with maize. Three intercropping planting systems were used: monocropped Bambara nuts, intercropped Bambara nuts with maize and monocropped maize. The objective of the study was to determine grain and pod yield for intercrop. Bambara nuts were planted in 1:1 alternate rows of maize and at various population densities/spacing. The spacings for Bambara nuts were varied at 45, 35, 30, 25 and 15 cm giving population densities of 76190, 95235, 114285, 133333 and 222222 plant ha-^{1}, respectively, while spacing for maize was constant at 30 x75 cm at the population density of 45714 plants/ha for all plots. Bambara nut landrace KK204 developed at Kenya Agricultural and Livestock Research Organisation (KALRO), Kakamega was used for the study. A medium maturing maize variety Hybrid H513 was sown at the constant intra- and inter-row spacing of 30 x 75 cm. The experiment was replicated three (3) times and planted for three (3) seasons. Data was collected at 25, 40, 86 and 95 days after sowing (DAS). Number of pods per plant, weight of pods per plant and grain yield were determined. Data analysis was done by SAS. The number of pods per plant, weight of pods per plant and grain yield of Bambara nuts intercropped with maize was depressed throughout the study because of an attack by leaf blight.

Keywords: Bambara nuts, Growth, Intercropping, Maize, Planting System, Maize, Yield.

Introduction

Bambara nut (*Vigna subterranea* L. Verdec.) is a legume indigenous to tropical Africa where it ranks third in importance after groundnuts (*Arachis hypogea*) and cowpeas (*Vigna unguiculata L. Walp*) in terms of production and consumption (Dadson and Brooks 1989. Bambaranut's potential of contributing to food security has fuelled increasing research interest (Hornetz et al, 2000). Bambaranuts are an important source of protein and carbohydrates for the rural poor. They contain 7.3 - 8.5% oil, 17.5 – 21.1% protein and 53.0 - 60% carbohydrate (Amarteifio et al, 2006).

According to Ngugi (1995), Bambara nuts are used in a number of ways, immature pods are boiled and eaten fresh, mature seeds are mixed with maize and cooked as "*nyoyo, githeri* or *nkhowe"*, fresh or dry seeds are also roasted or mixed with sesame (*Sesamum indicum*) or groundnuts and sometimes mixed with beef or chicken stew. In Bambara nut growing areas, leaves are used as medicine or pesticide against ticks in conjunction with lantana (*Lantana camara)* while leaves mixed with common salt are used to cure cattle infected with mouth sores (Ngugi 1995). Bambara nut is a crop grown by resource challenged farmers mostly women who generally have no right to land (Coudert 1982). The crop is grown with minimal to no inputs such as fertilizers and pesticides. Consequently, the major inputs for bambaranut production are land, unimproved seed, and labour (Sibuga, 2000). Studies by Smyths (1968) and Sibuga et al, (1997) showed that seed yields as high as 1.8 tonnes per hectare are achievable. Farmer's yields are low due to limited supply of improved seeds, late planting, unfavourable climatic conditions, soil fertility, pests and diseases and intercropping with high population densities of maize (Mabika, 1991; Ngugi 1995; Mbewe et al, 1995). The average farmers seed yield ranges between 300-800 kg/ha depending on landrace, climatic conditions and cropping system used (Duke et al, 1977). In Tanzania, farmers yield per plant are higher than per unit area due to a wider spatial arrangement (Ntundu 1995). In Kenya, Bambara nuts are currently grown in Western and at the Coastal regions.

Although an evaluation of yield in intercropped Bambara nut has been done elsewhere, very little has been done to evaluate Bambara nut-intercropping systems under Kenyan conditions (Refay et al., 2013). Although there is evidence that the combined yields of intercrops exceeds the sole crop yield, experiences on Bambara nut intercrop production in Kenya is not well documented. Hence the need to study: (1) the influence of environmental factors such as soil nutrition, soil and ambient temperature on the performance of Bambara nut intercrops; (2) allometric relationships such as land equivalent ratio (LER), area time equivalent ratio (ATER), relative yield (RY), shelling percentage (SP), leaf area index (LAI), systems productivity index (SPI), and canopy spread (CS) in Bambara nut and maize intercropping systems. Allometric relationships provide a reliable means of estimating dimensions of plant growth (http://aob.oxfordjournals.org 2000). These relationships change from time to time during the period of plant growth. It is against this background information that this study is proposed to determine yield and growth response of bambaranut to intercropping with maize in humid environments of Western Kenya with reference to population density and spatial arrangement by looking at resource use efficiency and allometric relationships in intercropping systems.

The aim of the study was to determine grain yield and yield components from the intercropped Bambara nut and Maize.

Materials and Methods

The study was conducted at the Kenya Agricultural and Livestock Research Organization (KALRO) at Kakamega in western Kenya. KALRO - Kakamega is located in Agro-ecological Zone (AEZ) UM_1 at latitude $0^0$16' North and longitude 34^0 45' East at an altitude of 1585 m.a.s.l. This area receives about 1800 mm of bimodal rainfall because of its proximity to Lake Victoria thus receiving convection rain and to the equator and the Kakamega tropical rainforest. KALRO -Kakamega experiences an average temperature of 21 ± 1^0 C per year. The soils are mollic Nitisols which are well drained, extremely deep, dark red, friable clay, while some places have humic top soil Dystric Nitisols (Jaetzold and Schmidt 1982).

The experiment was laid out in a randomized complete block design (RCBD) and replicated three times (Figure 1).

Figure 1. *Healthy Bambaranut Pods on the Left and Those Attacked by Moth Beetle (Piezolrachelus Ugandum) on the Right*

Bambara nuts were planted in alternate rows at varying spacings in between maize rows as outlined in Appendix IV. The experiment was carried out for two years. The sizes of the experimental plots were 3.5 m x 4.5 m each. Distance between individual plots was 0.5 m and 1 m between replicates. Intra- and inter-row spacing for maize was constant (30 x 75 cm) with a population density of 45, 714 plants/ha) for all plots. There were 15 treatment combinations with each spacing (45, 35, 30, 25 and 15 cm) divided into three categories (mono-cropped bambaranut, bambaranut intercropped with maize and mono-cropped maize). Inter-row spacing for Bambara nuts was constant at 37.5 cm with one row of Bambara nuts in between maize rows. Intra-row spacing was varied according to the spacing of the treatment combinations (45, 35, 30, 25 and 15 cm). Weeding and earthing up were done three times by hand during the growing season. Both bambaranut and maize were fertilized with a basal application of SSP at the rate of 100 kg/hectare.

During growth and at the harvesting stage, number of pods per plant, weight of pod per plant and grain yield were taken and recorded. Data for all variables were analysed individually by SAS (2002) computer package to generate ANOVA tables.

Results

Number of Pods per Plants and Weight of Pods per Plant

Significant ($P \geq 0.05$) differences were apparent for the number of pods per plant and weight of pods in grams per plant for both mono- and intercropped bambaranuts (Table 1). The number of pods per plant was highest (22.10) at the population density of 133,333 plants ha^{-1} at the spacing of 25 cm for monocropped bambaranuts. The rest of the means for monocropped bambaranuts were not significant ($P \leq 0.05$). However, in the intercrop the highest (10.90) number of pods was recorded at the population density of 114,285 plants ha^{-1} at the spacing of 30 cm. In general, intercropping depressed the number of pods per plant.

Table 1. *Number of Pods/Plant and Weight of Pods/Plant for Bambaranuts Grown at KALRO Kakamega 2008/09 Growing Season as Affected by Planting System*

	Number of Pods/Plant		**Weight of Pods in g/Plant**	
Pop/ Spacing	*Mono-crop*	*Inter-crop*	*Mono-crop*	*Inter-crop*
76,190 (45 cm)	14.67 b	5.33 e	162.51 bc	21.75 d
95,235 (35 cm)	13.77 b	8.10 de	159.58 bc	32.90 d
114,285 (30 cm)	14.53 b	10.90 cd	143.29 c	21.42 d
133,333 (25 cm)	22.10 a	7.00 e	173.57 b	33.31 d
222,222 (15 cm)	12.47 bc	6.13 e	203.10 a	34.48 d
Mean	15.51	7.49	168.41	28.77
CV	14.21	14.21	15.21	15.21
MSE	1.63	1.63	14.87	14.87
LSD	2.80	2.80	25.69	25.69

Means within a column followed by the same letter (s) are not significantly ($P \leq 0.05$) different by Tukey's multiple range test.

Yield of Bambara

Bambaranut grain yields in kg/ha are summarised in Table 2. Results showed significant ($P \leq 0.05$) differences during 2006/07, 2008/09 and 2008/09 growing seasons. Monocropped bambaranuts (2006/07) had the highest (310.84) grain yield at the population density of 133,333 plants ha^{-1} at the spacing of 25 cm. This was followed by population density of 95,235 plants/ha at the spacing of 35 cm. The lowest grain yield of 187.65 kg/ha was recorded at the plant population density of 222,222 at the spacing of 15 cm which initially produced the highest unshelled yield in kg/ha. This is attributed to a low shelling percentage as indicated in Table 12 because there was a higher percentage of pods affected by moth beetle. Bambaranuts intercropped with maize had the highest (74.85 kg/ha) shelled yield at the population density of 133,333 plants ha^{-1}at the spacing of 25 cm. Grain yield was lowest (38.80 kg/ha) at the population density of 76,190 plants ha^{-1} at the spacing of 45 cm.

During 2007/08 growing season population density at 222,222/ha at the spacing of 15 cm in the monocrop resulted into the highest (476.66 kg/ha) bambaranut grain yield. The lowest grain yield was produced at the population density of 76,190 at the spacing of 45 cm. In the same growing season Bambara nuts planted under maize produced highest grain yield at the population densities of 95,235 and 133,333 plants ha^{-1} at the spacing of 25 and 35 cm. The lowest grain yield was recorded at the plant population density of 114,285 at the spacing of 30 cm.

During 2008/09 growing season monocropped bambaranuts gave the highest grain yield (742.80 kg/ha) at the population density of 222,222 plants per hectare at the spacing of 15 cm. The lowest grain yields of (305.22 kg/ha) was recorded at the population density of 76,190 plants per hectare at the spacing of 45 cm. Bambaranuts intercropped with maize were not significantly affected by planting system.

Table 2. *Grain Yield of Bambara in kg/ha as Influenced by Planting System for KALRO Kakamega during 2006/07, 2007/08 and 2008/09 Cropping Seasons*

Pop (Spacing)	**2006/07**		**2007/08**		**2008/09**	
	Mono-crop	Inter-crop	Mono-crop	Inter-crop	Mono-crop	Inter-crop
76,190 (45 cm)	273.72 ab	38.80 f	160.15 e	340.37 b	305.22 c	19.31 d
95,235 (35 cm)	263.30 b	68.09 d	250.98 d	358.97 a	527.13 b	34.77 d
114,285 (30 cm)	271.40 ab	44.21 ef	380.64 b	317.17 c	530.08 b	35.85 d
133,333 (25 cm)	310.84 a	74.85 d	321.30 c	365.44 a	636.19 ab	37.09 d
222,222 (15 cm)	187.65 c	72.79 d	476.66 a	345.50 b	742.80 a	88.03 d
Mean	261.38	59.75	317.95	345.43	548.28	43.01
CV	10.02	10.02	4.76	4.76	24.17	24.17
MSE	15.99	15.99	15.14	15.14	71.47	71.47
LSD	28.23	28.23	28.50	28.50	122.60	122.60

Means within a column followed by the same letter (s) are not significantly ($P \leq 0.05$) different by Tukey's multiple range test.

Grain Yield of Bambara Nut

Grain yield of mono- and intercropped maize showed significant (P≤ 0.05) differences during the growing season in 2006/07 (Table 3). Results for 2008/09 were not significant (P≤ 0.05). In 2006/07 growing season 133,333 at the maize spacing of M4, 222,222 at the maize spacing of M5 and 76,190 at the maize spacing of M1 produced the highest (3576.70, 3047.60 and 3195.80 kg/ha) for monocropped maize, respectively. The lowest (2031.80 kg/ha) yield was recorded at the bambaranut population density of 114,285 at the maize spacing of M3 for pure stand of maize. Shelled maize intercropped with bambaranut recorded the highest (3936.70 kg/ha) at the population density of 95,235 at the maize spacing of M2 and the lowest (2497.40 kg/ha) at the bambaranut population density of 114,285 at the maize spacing of M3.

During 2007/08 highest (652.47 kg/ha) at the bambaranut population density of 95,235 at the maize spacing of M2 for the monocrop with the lowest (422.15, 427.61 and 431.99 kg/ha) recorded at the maize spacing of M5, M3 and M4, respectively. Intercropped maize recorded the highest (502.34 kg/ha) at the bambaranut population density of 95,235 at the maize spacing of M2) with the lowest (450.40kg/ha) reported at the bambaranut population density of 114,285 at the maize spacing of M3. As noted earlier grain yield for maize was low because the crop was affected by leaf blight during the season. Leaf blight reduced the surface area of photosynthesis. These yields were the lowest recorded during the entire three seasons the crop was grown.

Table 3. *Grain Yield of Maize in kg/ha as Influenced by Planting System for KALRO Kakamega during 2006/07, 2007/08 and 2008/09 Cropping Season*

Pop (Spacing)	**2006/2007**		**2007/2008**		**2008/2009**	
	Mono-maize	Maize+bam'ra	Mono-maize	Maize+bam'ra	Mono-maize	Maize+bam'ra
76,190 (M1)	3195.80 a	2772.50 bc	517.35 b	498.37 bc	3220.00 a	3128.90 a
95,235 (M2)	2687.80 ab	3936.50 a	652.47 a	502.34 bc	3936.50 a	3022.20 a
114,285 (M3)	2031.80 b	2497.40 d	427.61 f	450.40 def	2951.10 a	2808.90 a
133,333 (M4)	3576.70 a	3386.20 abc	431.99 f	474.54 cd	2808.90 a	2737.80 a
222,222 (M5)	3047.60 a	2984.10 bdc	425.15 cde	467.15 cde	3697.80 a	3260.00 a
Mean	2907.94	3115.34	490.91	478.56	3322.86	2991.56
CV	17.86	17.86	4.32	4.32	20.90	20.90
MSE	519.30	519.30	21.17	21.17	649.38	649.38
LSD	977.76	977.76	36.46	36.46	1113.90	1113.90

Means within a column followed by the same letter (s) are not significantly (P≤0.05) different by Tukey's multiple range test.

Discussion

Optimization of plant spatial arrangement and intercropping is essential for maximizing yield of any crop. Research on manipulation of plant density and intercropping to fit production factors and objectives are, therefore, of practical interest for agronomists (Amedie et al., 2010). Variation in yield and yield components in relation to factorial change in spatial arrangement and intercropping in a bunch type bambaranut (Ofori and Stern 1987).

These results of the study are in agreement with similar studies by Kouassi and Zorobi (2011) and Alhassan *et al*. (2012) who reported higher pod and grain yields in pure culture if compared to intercropped bambaranuts. Both pod and grain yields realized in this study were lower than those reported in Potchefstroom by Swaneverder (1998) in South Africa and Begemann (1988) who reported that the yield potential of bambaranuts ranged between 500-2,600 kg ha^{-1} depending on variety, cropping system and management. A number of factors could have accounted for low bambaranut yields in this study such as soil pH which was much lower (4.00) while the recommended soil pH value is in the range 5.0-6.0 (Swaneverder 1998; Yao et al, 2005). Studies by Gueye (1986) on the effect soil pH on the growth of bambaranuts showed that plants grew better at pH 7.20 and 7.50. At this range plants maintained their green colour and none withered. However, higher pH levels stop the growth of bambaranuts which was attributed to unavailability of some nutrients. The soils in the experimental area were also calcareous and it is reported that bambaranuts do not do well in such soils (Swanvelder 1998). The other factor could have been infestation of moth beetle (*Piezolrachelus ugandum*) which attacked the bambaranut flowers as well as developing pods (Swanvelder 1998). Damage by hailstorm may also have contributed to lower yield of bambaranuts. Hailstorm damage has been linked to reduced yields of a number of crops such as maize (Olivier et al 1992; (Mwakha 1987; Magambo and Kilavuka 1978). The results of hailstorm damage in bambaranuts is the loss of leaves, petioles and stems resulting into reduced photosynthetic activity leading to low dry matter accumulation and low pod production (Al shareef 2010).

In intercropping system, the yield reduction comparing to its sole crop might be attributed to higher competition for light, space, nutrients and water. The results of combined yield are in full conformity with Mucheru-Muna 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 the intercrop of sorghum and Bambara nuts (Gabatshele et al, 2012). On the contrary, Ogah and Ogbodo (2012) reported a significant increase in total grain yield of maize when intercropped with Bambara nut than in the sole crop maize. The total percentage yield loss due to stem borer infestation in maize was also reported to be significantly lower in intercrop with Bambara nut. He further maintain that the 2:2 maize/Bambara nut intercrop produced meaningfully higher number of cobs, quantity of seeds, and seed weight with less infestation than 1:1 maize/Bambara intercrop (Ogah and Ogbodo, 2012). Maize plants that were grown in intercrop with Bambara nut were also found to have a significant reduction in the density of larvae, number of borers and percentage dead heart (Ogah and Ogbodo, 2012).

Conclusions

This study revealed that intercropping bambaranut with maize enabled farmers obtain additional bambaranut yield. The study further showed that Maize and with the additional production of yet another crop meant optimal use of resources especially in areas where land is a limiting factor of production.

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