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Comparative growth and yield analysis of intercropped African yam bean with maize

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The experiment consists of five local accessions of African Yam Bean viz; Gboko, Makurdi, Otukpo, Ukum and Ushongo accessions; inter-row spacing was 75 cm while intra-row spacing was 30 cm for African Yam Bean and 75 cm x 20 cm, 75 cm x 30 cm and 75 cm x 40 cm for maize. The experiment was laid in a Randomized Complete Block Design (RCBD) with three (3) replicates. A plot size of 4 m x 3.4 m (13.6 m^2) was used; parameters measured include plant height, number of seeds per plant, number of leaves per plant, number of seeds per pod, grain yield, pod length, percentage seed weight, cob length and cob width. The experiment revealed that Otukpo accession of African Yam Bean intercropped with maize at 40 cm x 75 cm gave the highest grain yield (2.15 t/ha) and highest number of pods/plant (18.88). The Gboko accession of the African Yam Bean intercropped with maize at 40 cm x 75 cm gave the highest pod length (16.93 cm) and highest number of seeds/plant (14.45). Sole planting of the Otukpo accession of the African Yam Beam gave the highest percentage seed weight. Sole planting of the Oshongo accession of the African Yam Beam also produced the tallest plants (28.01 cm and 79.37 cm) consistently. Similarly, Oshongo accession when intercropped with maize at 40 cm x 75 cm gave the highest number of leaves (135 and 175) consistently. Percentage seed weight, cob length, cob weight and grain yield of maize was affected by intercropping as Markurdi accession of AYB intercropped with maize at 40 cm x 75 cm produced the highest grain yield (2.09 tha^{-1}) of maize. Grain yield result of AYB shows that Otukpo

accession intercropped with maize at 40 cm x 75 cm presents optimum potential for intercropping and highest performance among other accessions examined and therefore recommended for Makurdi farmers.

Key words: *accession, african yam bean, intercropping, maize population, sole cropping*

INTRODUCTION

The AYB [*Sphenostylis stenocarpa* (Hochst. Ex A. Rich) Harms] belongs to the family *Leguminae,* and has been described as climbing plant accustomed to lowland tropical environment. According to Apata and Ologhobo (1990), AYB is not widely recognized crop but cultivated extensively in the Southern Nigeria. AYB is a rich source of protein in human diet (Saka et al., 2007). Protein of the legume source has been regarded as less expensive than those of the animal products. Globally, the AYB which is regarded as a main supplier of less expensive protein is well balanced and high in ammo acid constituent than the pigeon peas, cowpeas, and the bambaranut especially in the third world countries where animal protein utilization is constrained by economic, social, cultural or religious factors (Olayide, 1982; Uguru & Madukaife, 2001). A primary part of AYB that's of intense economic relevance is the seed and tubers used as food in developing countries with ecological preferences according to Adewale & Dumet (2010). Worldwide food insecurity is however increasing despite the continuous less-dependence on a major staple crop. This has given rise to tremendous drop not only in crop diversity but also in crop variabilities in the ecosystem. The legume, AYB which is mostly grown for rich edible seeds and tubers (Klu et al., 2001) in most Sub-Saharan regions of the African countries is one of the underutilized crops with high nutritional value. The seed contains between 21 and 29 % crude protein while tuber contains 11 – 19 % protein on dry weight basis and this protein constitute lysine and methionine rates that is same or greater than those found in *Glycine max.* (Ene-Obong & Okoye, 1992). Several authors have confirmed the nutritional constituent of AYB. According to Uguru & Madukaife (2001), in their experiment where 44 accession of AYB was examined, reported that AYB is far better in essential amino acid than Pigeon pea, Bambaranut and Cowpea. Culturally and economically, Potter & Doyle (1992) reported that AYB is the most essential of the seven species of the genus (*Sphenostylis)* and however, is well domesticated, cultivated, distributed within the confines of tropical Africa where it has exhibited a high percentage of diversity (Potter, 1992). According to Okpara & Omaliko (1995), AYB is a crop of minor importance utilized for dual purpose (grain and tuber) in third world and/or developing countries. Wide knowledge of the AYB still remained unexploited despite its role as one of the staple food crop in the tropical Africa. As a grain legume, AYB was initially welcomed at a grain legume improvement workshop held at the International Institute for Tropical Africa at Ibadan (Okigbo, 1973). Classification of AYB as minor crop results from it under exploitation according to Saka et al. (2004). As a native crop, AYB is mostly grown in mixture with *Dioscorea spp*, *Manihot esculenta*, *Zea mayz,* and *Sorghum bicolor.* Mostly, *Manihot esculenta*, *Zea mayz,* and *Sorghum bicolor* serve as stake for yam and also support for the crop (Togun & Egunjobi 1997).

MATERIALS AND METHODS

The field trial was conducted at the Research Field of the Federal University of Agriculture, Makurdi. Makurdi falls within the Southern Guinea Savanna zone of Nigeria at Latitude 7^{o} 15'– 7^{o} 40^{1} N and Longitude 8^{o} 15^{1} –8^{o} 40^{1} E with an elevation of 97 m. The experimental field is predominated by Sandy-loam soil (Ogbaji & Okeh, 2014). It experiences a typical climate with dual distinct seasons with the wet season lasting between April and October and the dry season which is characterized by hamarttan dry wind and lasts between

November and March. It is marked by an average yearly precipitation amount of about 1000 – 15000 mm, a mean yearly temperature of about 32^0 – 40^0 C occurring between the second and the fourth month of every year. The vegetation is characterized by open woodland with tall trees as well as short, bold and broad leaves. The trees are basically 12 – 17 m tall and are rarely up to 27 m or over 30 m. The vegetation is usually destroyed annually by fire in the dry season.

Treatment and experimental design

Five accessions of the AYB were collected from five different locations (Makurdi, Otukpo, Oshongo, Ukum, and Gboko) in Benue State. These towns can be found in separate LGAs of the State. The seed characteristics were measured and then classified on the basis of location and size of varieties.

Treatment consisted of 5 accession of African Yam Bean (Makurdi, Otukpo, Oshongo, Ukum, & Gboko), and a local maize cultivar combined in various maize population density (table 1). Total treatment amount to twenty and this was laid in a Randomized Complete Block Design (RCBD) with three replicates. There were a total of sixty (60) plots in all, each plot measuring 36 m^2 with an inter plot spacing of 0.5 m and inter block spacing of 1 m to narrow variations within and between blocks. A total of 131 m x 20 m (2620 m^2 | 0.262ha) was used for the experiment. Treatments were allocated to individual plot using a random number system to prevent biasness as every replication takes equal number of treatments. The plots were prepared and tilled by properly mixing the soil.

Cultural practices/data collection

Land preparation was done manually; the land was cleared with cutlass and ridges were made by using hoe. Ridges were made with an inter-row spacing of 70 cm, intra-row spacing of 30 cm for African yam bean and 20 cm, 30 cm and 40 cm intra-row spacing for maize. Seeds were planted immediately into the field of known soil characteristics. Seeds of both crops were planted in rows of 8 per plot. Planting was done at 3 seeds / stand and was thinned after germination to 2 stands for the duo crops. The plots were weeded three times before harvest as there was much precipitation during the period of the experiment. When plants became tall enough, they used the maize plants as stakes.

The parameters measured included; length of pods, no of seeds/pod, no of leaves/plant, height of plants, grain yield, percentage seed weight and no of pods/plant on AYB. Those measured on maize plant include; plant height, 100-seed weight, cob length, cob weight and grain yield respectively. The no of leaves per plant was taken at 4, 6 and 8 weeks after planting. The no of pods per plant was taken at 19 WAP. After each harvest, pod length was measured based on the number of pods obtained in each accession. Thereafter, all harvested pods in a plot were threshed and seeds measured in a weighing balance.

All data obtained was subjected to Analysis of variance (ANOVA) at 5% level of probability using MSTAT statistical package. Significant differences between treatment means were determined using Fishers Least Significant Difference (LSD) at 5% level of probability according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

African Yam Bean accession significantly affected ($P \leq 0.05$) plant height at 4 and 8WAP but not significant at 6WAP. In each accession examined, sole planting produced the tallest crops consistently throughout the sampling periods (Table 2). Sole planting of Ukum accession produced the tallest plant at 4WAP (29.20cm), while Ushongo accession produces the tallest crops (79.37cm) at 8WAP respectively. However, intercropping system showed that Ukum accession intercropped with maize at 40 cm x 70 cm spacing [Uktmaize (40cm)] produced the tallest plants (28.40cm) at 4WAP, while [Ushmaize (40cm)] produced the tallest plants (76.14cm) at 8WAP among other intercropping systems. Similarly, [Mkdmaize (20cm)] produced the shortest plant (23.76cm, 49.40cm) at 4 and 8WAP respectively.

Table 1. Treatment combination table

	Gboko	**Makurdi**	**Otukpo**	**Oshongo**	**Ukum**
Sole legume	Gbk	Mkd	Otk	Osh	Ukt
Maize (20 cm x 75 cm)	Gbkmaize (20cm)	Mkdmaize (20cm)	Otkmaize (20cm)	Oshmaize (20cm)	Uktmaize (20cm)
Maize (30 cm x 75 cm)	Gbkmaize (30cm)	Mkdmaize (30cm)	Otkmaize (30cm)	Oshmaize (30cm)	Uktmaize (30cm)
Maize (40 cm x 75 cm)	Gbkmaize (40cm)	Mkdmaize (40cm)	Otkmaize (40cm)	Oshmaize (40cm)	Uktmaize (40cm)

Table 2. Effect of Maize population density on the Growth characters of African Yam Bean (AYB) accessions in Makurdi, Benue State

		Plant Height (cm)			**Number of Leaves**		
Accession	**Intercropping**	**4WAP**	**6WAP**	**8WAP**	**4WAP**	**6WAP**	**8WAP**
Gboko	Sole	27.72	39.30	71.01	35	88	143
	Gbkmaize (20cm)	24.40	34.92	59.03	27	63	97
	Gbkmaize (30cm)	25.73	36.52	63.40	32	75	112
	Gbkmaize (40cm)	26.66	37.01	68.40	43	92	138
Makurdi	Sole	28.01	40.03	73.31	43	92	149
	Mkdmaize (20cm)	23.76	35.65	49.40	32	81	102
	Mkdmaize (30cm)	27.09	36.80	58.80	45	92	121
	Mkdmaize (40cm)	27.89	38.45	69.30	40	102	157
Otukpo	Sole	27.92	39.33	74.38	42	85	162
	Otkmaize (20cm)	25.29	35.34	62.65	45	97	151
	Otkmaize (30cm)	25.42	36.70	69.21	58	92	172
	Otkmaize (40cm)	27.32	37.03	71.40	35	113	168
Ukum	Sole	29.20	38.01	69.80	43	73	102
	Uktmaize (20cm)	26.16	25.84	59.30	68	71	135
	Uktmaize (30cm)	27.42	37.32	66.05	74	85	168
	Uktmaize (40cm)	28.40	37.68	66.80	48	112	153
Ushongo	Sole	28.01	40.00	79.37	56	87	151
	Ushmaize (20cm)	25.46	35.93	61.82	82	93	148
	Ushmaize (30cm)	25.85	37.05	74.40	91	109	161
	Ushmaize (40cm)	27.44	38.40	76.14	91	135	175
	F-LSD $_{(0.05)}$	**0.509**	**ns**	**0.42**	**ns**	**0.477**	**1.91**

ns: *not significant*

Gbkmaize (20cm): Gboko accession x maize intercrop @ 66, 666 maize populations. Gbkmaize (30cm): Gboko accession x maize intercrop @ 44, 444 maize populations. Gbkmaize (40cm): Gboko accession x maize intercrop @ 33, 333 maize populations. Mkdmaize (20cm): Makurdi accession x maize intercrop @ 66, 666 maize populations. Mkdmaize (30cm): Makurdi accession x maize intercrop @ 44, 444 maize populations. Mkdmaize (40cm): Makurdi accession x maize intercrop @ 33, 333 maize populations. Otkmaize (20cm): Otukpo accession x maize intercrop @ 66, 666 maize populations. Otkmaize (30cm): Otukpo accession x maize intercrop @ 44,444 maize populations. Otkmaize (40cm): Otukpo accession x maize intercrop @ 33, 333 maize populations. Uktmaize (20cm): Ukum accession x maize intercrop @ 66, 666 maize populations. Uktmaize (30cm): Ukum accession x *maize intercrop @ 44, 444 maize populations. Uktmaize (40cm): Ukum accession x maize intercrop @ 33, 333 maize populations. Ushmaize (20cm): Ushongo accession x maize intercrop @ 66, 666 maize populations. Ushmaize (20cm): Ushongo accession x maize intercrop @ 44, 444 maize populations. Ushmaize (20cm): Ushongo accession x maize intercrop @ 33, 333 maize populations.*

Among the accessions evaluated, Ushongo accession produced the tallest plants in both sole and intercropping systems at 8WAP which was significantly ($P \leq 0.05$) different from accessions in both sole and intercrops. Number of leaves/plant of the AYB accessions was significantly affected ($P \leq 0.05$) maize population at 6 and 8WAP respectively. Intercropping system with maize produced plants with higher number of leaves than the sole cropping of the accessions at 6 and 8WAP (table 2). The Ushongo accession intercropped with maize at 40 cm x 70 cm spacing [Ushmaize (40cm)] produced plants with the highest number of leaves (135) followed by Otkmaize (40cm), Uktmaize (40cm), Ushmaize (30cm), Otkmaize (20cm) in that order at 4WAP. In the same manner, Ushongo accession intercropped with maize at 40 cm x 70 cm spacing [Ushmaize (40cm)] produced plants with the highest number of leaves (175) followed by Otkmaize (30cm), Otkmaize (40cm), Uktmaize (30cm) in that order. These yield were significantly different from other intercropping system. However, the Gboko accession intercropped with maize at 20 cm spacing [Gbkmaize (20cm)] consistently produced plants with the least number of leaves at both 6 and 8WAP respectively. Table 3 shows the result of maize population density on yield characters of AYB in Makurdi. Number of pods/plant was significantly affected ($P \leq 0.05$) by maize population. Otukpo accession intercropped with maize at 40 cm x 70 cm spacing [Otkmaize (40cm)] produced crops with the highest number of pods (18.88), followed by Gbkmaize (30cm), Gbkmaize (40cm), Mkdmaize (40cm) in that order. this was significantly different from those obtained from other intercropping systems. Mkdmaize (30cm) consistently produced crops with the least number of pods. Number of seeds/plants of the AYB was also affected by maize population, the highest number of seeds (14.45) was obtained when Gboko accession was intercropped with maize at 40 cm spacing [Gbkmaize (40cm)] followed by Gbkmaize (30cm). This was significantly different from other the number of seeds/plant obtained from intercropping systems. Uktmaize (20cm) and Mkdmaize (20cm) consistently produced the least number of seeds/plant.

Pod length was highest (16.41 cm) with sole cropping of Gboko accession (table 3). However, intercropping system with varying maize population showed that Gboko accession intrcropped with maize at 40 cm spacing [Gbkmaize (40cm)] performed better with the highest pod length (16.93 cm) followed by [Ushmaize (40 cm)] yielding 16.90 cm pod among other intercropping systems. Ukum accession intercropped with maize at 20 cm [Uktmaize (20cm)] produced pods with the shortest length (12.87 cm) consistently. The % Seed weight was also highest when Otukpo accession was planted sole (table 3). However, the intercropping system shows that Gbkmaize (40cm) had optimum performance followed by Gbkmaize (30cm), Ushmaize (40 cm), Ushmaize (30 cm) respectively and this was significantly different from other intercropping systems. Mkdmaize (20cm) yielded the least % seed weight among other accession examined.

The result of grain yield of AYB showed that Otukpo accession intercropped with maize at 40cm [Otkmaize (40 cm)] appeared promising as it gave the highest grain yield (2.15 t/ha). However, this was followed by the sole cropping of Otukpo accession which gave a yield of 2.05 t/ha. This was significantly higher than other accession in sole cropping system and intercropping under examination. Similarly, Makurdi accession intercropped with maize at 40 cm spacing [Mkdmaize (40cm)] produced yield (2.03 t/ha) which follows Otukpo sole cropping. This is also significantly different from other accessions in the same intercrop of varying maize populations. However, Mkdmaize (20cm) produced the least grain yield (1.37 t/ha) among other intercropping systems of different maize populations (Table 3).

Table 3. Effect of Maize population on the yield characters of African Yam Bean (AYB) accessions in Makurdi, Benue State

Accession	Intercropping	No. of pod/plant	No. of seed/plant	Pod length (cm)	% Seed weight (g)	Grain yield
Gboko	Sole	18.40	13.84	16.41	10.30	1.89
	Gbkmaize (20cm)	17.68	12.85	16.14	8.00	1.68
	Gbkmaize (30cm)	18.67	14.20	16.16	10.44	1.75
	Gbkmaize (40cm)	18.84	14.45	16.93	10.85	1.83
Makurdi	Sole	16.68	12.80	14.40	10.10	1.98
	Mkdmaize (20cm)	16.33	11.23	12.89	6.30	1.37
	Mkdmaize (30cm)	16.03	11.32	14.60	7.99	1.49
	Mkdmaize (40cm)	18.67	13.69	15.71	9.85	2.03
Otukpo	Sole	18.47	13.25	14.79	11.01	2.05
	Otkmaize (20cm)	18.07	12.65	13.82	9.31	1.74
	Otkmaize (30cm)	18.45	12.95	14.17	9.45	1.95
	Otkmaize (40cm)	18.88	14.15	16.37	10.06	2.15
Ukum	Sole	16.40	11.76	13.79	9.41	1.92
	Uktmaize (20cm)	16.15	11.23	12.87	7.95	1.61
	Uktmaize (30cm)	16.46	11.90	13.86	8.14	1.69
	Uktmaize (40cm)	16.58	12.15	14.63	8.55	1.79
Ushongo	Sole	18.14	13.55	15.64	10.12	1.83
	Ushmaize (20cm)	17.83	13.45	14.84	8.61	1.41
	Ushmaize (30cm)	18.33	13.52	15.19	10.25	1.47
	Ushmaize (40cm)	18.45	13.68	16.90	10.29	1.67
	F-LSD $_{(0.05)}$	**0.85**	**0.128**	**0.276**	**0.050**	**0.062**

***ns**: not significant*

Table 4 presents the effect of AYB accessions on the height of maize. Maize height was significantly affected (P ≤ 0.05) by these accessions at 4 and 6WAP. However, at 8WAP, there was no significant effect of these cultivars on maize population. Ukum accession x Maize at 40 cm spacing intercrop produced maize with the tallest plant (65.81 cm). This was followed by Ushongo accession x Maize intercrop at 40cm spacing (59.99 cm), Makurdi accession x Maize at 40 cm spacing (58.50 cm) in that order. Similarly, Makurdi accession x maize intercrop at 40cm spacing produced the tallest maize plants (113.90 cm) at 6WAP which was also significantly different from other intercropping system of varying maize population. This was followed by Ushongo accession x Maize intercrop at 40cm spacing (111.09 cm), Ukum accession x Maize at 40cm spacing (110.53 cm) in that order. The Otukpo accession x maize intercrop at 20 cm spacing produced the shortest maize height consistently. Similarly, % seed weight and grain yield of maize was significantly influenced by AYB accessions (table 5). Highest % seed weight (39.33g) was obtained from Makurdi accession x Maize at 40 cm spacing intercrop followed by Ukum accession x Maize at 40cm spacing (38.67g), Ukum accession x Maize at 30cm spacing (38.43g), Makurdi accession x Maize at 30 cm spacing (33.33g) in that order. Intercropping Gboko accession with Maize at 20 cm spacing gave the least % seed weight (20.98g). grain yield was highest (2098.17 t/ha) with makurdi accession x maize intercrop at 40 cm spacing. This was significantly different from those obtained with other intercropping systems in the same manner. This wqas followed by Ukum x maize intercrop at a spacing of 40 cm (1619.07 t/ha). However, Otukpo accession intercropped with maize at 20 cm gave the least maize yield (547.33) throughout the experiment.

Table 4. Effect of intercropping AYB on the height of maize population in Makurdi, Benue State

Treatments		Plant Height (cm)		
Accession	**Intercropping spacing**	**4WAP**	**6WAP**	**8WAP**
Gboko	Gbkmaize (20cm)	31.75	76.11	113.49
	Gbkmaize (30cm)	37.10	81.28	118.84
	Gbkmaize (40cm)	50.76	95.15	132.52
Makurdi	Mkdmaize (20cm)	35.70	79.69	117.18
	Mkdmaize (30cm)	53.41	101.73	128.60
	Mkdmaize (40cm)	58.50	113.90	147.91
Otukpo	Otkmaize (20cm)	20.86	65.89	102.76
	Otkmaize (30cm)	36.29	80.63	118.04
	Otkmaize (40cm)	47.56	92.03	129.40
Ukum	Uktmaize (20cm)	42.59	86.81	124.14
	Uktmaize (30cm)	54.55	98.92	139.60
	Uktmaize (40cm)	65.81	110.53	147.50
Ushongo	Ushmaize (20cm)	25.42	69.66	107.15
	Ushmaize (30cm)	54.45	78.59	116.26
	Ushmaize (40cm)	59.99	111.09	138.19
	F-LSD $_{(0.05)}$	7.67	6.28	ns

ns*: not significant*

Table 5. Effect of intercropping AYB on the yield characters of maize population in intercropping system in Makurdi

Treatments		% Seed weight (g)	Cob length (cm)	Cob weight (g)	Grain yield (t/ha)
Accession	Intercropping Spacing				
Gboko	Gbkmaize (20cm)	20.98	29.33	1132.50	592.50
	Gbkmaize (30cm)	29.57	33.17	1962.03	757.50
	Gbkmaize (40cm)	32.65	38.00	2711.73	851.67
Makurdi	Mkdmaize (20cm)	27.13	34.33	1394.20	700.90
	Mkdmaize (30cm)	33.33	43.67	2575.10	960.27
	Mkdmaize (40cm)	39.33	46.33	3360.87	2098.17
Otukpo	Otkmaize (20cm)	21.10	20.67	892.30	547.33
	Otkmaize (30cm)	24.47	28.33	1428.88	644.43
	Otkmaize (40cm)	30.83	33.83	2210.47	764.37
Ukum	Uktmaize (20cm)	26.13	35.50	1139.50	597.50
	Uktmaize (30cm)	38.43	40.23	2385.30	856.67
	Uktmaize (40cm)	38.67	42.67	3243.10	1619.07
Ushongo	Ushmaize (20cm)	23.52	31.33	1361.17	697.90
	Ushmaize (30cm)	29.70	37.00	2526.53	864.67
	Ushmaize (40cm)	31.42	40.67	3357.87	957.27
	F-LSD $_{(0.05)}$	0.828	ns	ns	53.98

ns*: not significant*

Effect of maize population on grain yield of AYB

Grain yield of African Yam Bean consistently improved with increasing spacing of maize crops. The highest grain yield of African Yam Bean was obtained at an intercropping spacing of 40 cm with maize while the lowest yield was obtained at a spacing of 20 cm with maize. This means that increasing maize population result in decreases in yield of component crop. This has been reported by Sarlak et al. (2008) who stated that reducing spacing in maize plant (increasing density per unit area) beyond the peak level results in yield drop; while reduced plant population densities usually result in yield increase. Similarly, grain yield was significantly higher in AYB when grown as intercrop with maize than when planted as a sole crop. This is reflected in the report of Adeniyan et al. (2007) who stated highest seed yield of African Yam Bean from the intercropping system of Maize-Kenaf-AYB and AYB-Kenaf. This yield increase might probably be described as advantageous due to the fact that maize serve as life stakes for the African Yam Beans. AYB-Maize mixtures resulted in significant increase in grain yield of African Yam Beans. Apparently, the sole African Yam Beans experienced stiffer challenges of unavailable and/or staking materials through its physiological stages. Weak stakes could result from pest infestation (such as termites) and harsh ecological condition (rainstorm). Consequently, the grain yield of African Yam Beans sufficiently improved with the availability of life stakes provided by maize stalk for its sufficient growth and physiological development. This result is conformity with Ikhajiagbe et al. (2007) who reported that yield parameters strongly influence grain yield of AYB. Similarly, Adeniyan et al. (2007) supported this assertion stating that cropping pattern positively affect the seed yield of AYB adding that seed yield of AYB can significantly be higher when intercropped with Maize and Kenaf than when planted solely.

Effect of maize population on growth and yield characters of AYB

Yield characters of AYB was significantly affected by maize population, intercropping AYB with maize at 40cm (33,333plants) spacing prove to be outstanding among other maize population in the intercropping system. Intercropping system has reportedly affects yield characters of AYB (Okpara & Omaliko, 1995). This can be explained from intercropping point of view as there is increased competition for resources necessary growth and physiological performance. These are competition for light by component crop which is reflected in the number of leaves and higher leaf canopy, taller plants resulting from increasing light interception which is reflected in accumulation of enough photosynthates and translated to higher grain yield, percentage seed weight and increased number of seeds/pod. This is in conformity with the results of Jamshidi et al. (2008), Tumwegamire et al. (2014) and Mwanga et al., (2007; 2009) who investigated how the yield and b-carotene content of orange-fleshed sweet potatoes can be affected by maize populations. In addition, Maize which is a C_4 (taller) crop, when grown in mixtures with C_3 crops, exhibit an exposure to full solar radiation as the latter crop tends to exhibit little efficiency in carbon assimilation because its shaded by the former (Skillman, 2008).

Effect of intercropping AYB on maize population

Intercropping AYB with maize at 40cm spacing (33,333plants) produced significant growth and yield characters in maize crop, this is a reflection of the fact that reduced plant population of maize in intercropping system is beneficial to both crops in examination. However, higher maize population had resulted in higher competition for resource use which translated to reduced growth and yield in both crop components. This result is in agreement with Asiimwe et al., (2016) who reported that raising maize population to 88,888 plants ha^{-1} is irrelevant to maize grain yield as there exist no yield increase. Additionally, Tsubo et al. (2004) also reported no yield drop in maize in maize – bean intercropping experiment.

CONCLUSION

This study depicts that there were yield advantages in growing maize and African Yam Bean (AYB) together. Considering genetic exorbitance of the plant, the environmental factor and complementary potentials of maize (i.e. as stake, C_4 crop) to support growth and development of African Yam Bean (AYB), such intercropping system is worth the while. In addition, reduced maize populations have proven highly effective in the system and hence highly advisable. This will excellently affect the growth and yield of both crops in a positive direction. In this case, Otukpo accession of the AYB intercropped with maize at 40 cm spacing (i.e. 33,333 plants) presents optimum potential for intercropping and highest performance among other accessions examined. Similarly, Percentage seed weight, cob length, cob weight and final yield of maize was positively improved by intercropping as Markurdi accession of AYB intercropped with maize at 40 cm x 70 cm produced the highest grain yield (2.09 tha^{-1}) of maize. Therefore, in the intercropping system of the duo, where the farmers' desires maize as primary crop on the field, Markurdi accession of AYB could be considered for optimum yield and intercropping potential. If otherwise, Otukpo accession should be prioritized.

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AUTHOR CONTRIBUTIONS

This work was carried out in collaboration of all authors. Author Yusuf Momohjimoh designed the study, wrote the protocol and interpreted the data. Author Musa Musa Anu and Atenyi Gabriel Enefo anchored the field study, gathered the initial data and performed preliminary data analysis, Author Alao Adeoye Oyebisi managed the literature searches and produced the initial draft. All authors read and approved the final manuscript.

COMPETING INTERESTS

The authors have declared that no conflict of interest exists.

ETHICS APPROVAL

Not applicable

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