PAT December, 2019; 15 (2):139-147 ISSN: 0794-5213
Online copy available at www.patnsukjournal.net/currentissue
Publication of Nasarawa State University, Keffi

Effect of variety and planting pattern on the productivity of sweet Potato/Sorghum intercrop in Southern Guinea Savanna, Nigeria

Bar-Anyam, M.N., Idoko, J.A., and Ogbaji, M.I.
Department of Crop Production, University of Agriculture,
P.M.B. 2373, Makurdi. Benue State, Nigeria

Abstract
A cropping systems trial involving three sweet potato varieties (King J, Mother's Delight, and Angooji) and planting patterns was conducted in 2016 cropping season at the Teaching and Research Farm of the University of Agriculture, Makurdi and at Gboko, located in Southern Guinea Savanna of Nigeria. The experiment was carried out to identify the suitable variety and planting arrangement for sweet potato-sorghum intercropping system. The system involved different planting patterns (25 cm, 50 cm and Sole) combination of sweet Potato and sorghum. The result showed that both variety and planting pattern influenced the crops' yields. The highest root weight per plant and root yield per hectare was produced by Mother's Delight in both sole and intercrop environments against King J and Angooji. Sole yields of both crops were higher compared to yields obtained in intercropping in both locations. However, intercropping mother's Delight with sorghum at a distance of 50 cm apart gave the highest yields than intercropping with other varieties. LER figures were above one under all intercrop combinations in this study and the highest LER was obtained in intercropping Mother's Delight at 50 cm apart indicating more efficiency in land resource utilization with this variety at this planting pattern.
Keywords: Intercropping, Varieties, Planting pattern, Sweet Potato-Sorghum Productivity.

Introduction

Sweet Potato (*Ipomoea batatas* (L) Lam), a member of convolulaceae family, is a perennial crop usually grown as an annual (Onwueme and Sinha, 1991). It has a long history to stave off famine –especially as a cheap source of calaries (Adam, 2005). It ranks fifth as the most important food crop after rice, wheat, maize and cassava in developing countries (Som, 2007). It is one of the most important staple carbohydrate foods in the Sub-Saharan Africa. It is adaptable to relatively marginal soils and erratic rainfall. It has high productivity per unit land area and guarantee reasonable yields even under the most adverse conditions (NRCRI, 2008). Presently, Nigeria is the largest producer of sweet potato in Africa and the second largest in the world after China with annual output of 2.83 million tonnes in 2010 and 3.45 million tonnes in 2013. 2007). It is nutritionally important as it contains high levels of vitamin A and C (Nwokocha, 1998). Sweet potatoes are rich in B- Carotene (Precursor of vitamin A) and are being used to combat vitamin A deficiency in children, particularly the orange flesh sweet potato. The strategy of increasing orange flesh sweet potato consumption helps to alleviate vitamin A deficiency (Anderson *et al.,* 2007).

Sorghum (*Sorghum bicolor*) is the most widely cultivated cereal crop and important food crop in the Savanna ecological areas (Amon, 1997). The crop is environmentally friendly as it is adaptable to a wide range of environmental conditions. Sorghum flour sole or mixed with other cereals is used in making porridge and leavened bread (Webster and Wilson, 1996). In Nigeria, sorghum flour and paste is used for making meal (Tuwo) beverage (kunu) and pap (kamu) respectively. It is a raw material for bear brewing, a local brew known as 'burukutu' and other beverages. The stalks are used for fencing, as source of fuel for cooking, as fodder for farm animals and for treatment of diabetes because of the slow digestibility of its starch and protein content (Ogbonna *et al.,* 2004a).

Intercropping is the simultaneous growing of two or more crops on the same piece of land (Takim, 2012) in a manner that permits interactions of crops in space and time dimension (Futuless, 2010).

Intercropping has been found to have many advantages, mainly related to the complementary use of environment resources by the component crops. Sustained yield, better nutrient recycling in the soil, better control of weeds, pests and diseases and increased biodiversity are the advantages most commonly described.

Several improved sweet potato varieties have recently been introduced into the cropping systems of farmers in Benue State, especially from NRCRI, Umudike. Farmers in Benue State who interplant sweet potato and sorghum do so in variable planting patterns with the component crop with resultant low productivity that ranges from 3-9 t/ha (Egbe and Idoko, 2009). Intercropping sweet potato and sorghum will not only ensure better environmental resource utilization, but could also provide yield stability and improve the income of the poor resource farmers. Some yield advantages have been obtained from sweet potato intercropping with soybean (Egbe and Osang, 2015), Sweet potato and Okra (Njoku *et al.,* 2007) and sweet potato and soybean (Idoko *et al.;* 2018). Other authors like Egbe *et al.*, 2012, Njoku *et al.;* 2007 have findings with the potential of improving the productivity of sweet potato based intercrop system, however, there is paucity of documented information on the response of sweet potato varieties to various planting patterns in intercropping. The experiment therefore aimed at evaluating the performance of intercropped sweet potato- sorghum as influenced by varieties and planting patterns with the objective of identifying the sweet potato variety and suitablel planting pattern of both crops that will maximize the yields of both crops in mixture.

Materials and Methods

A field experiment was conducted in 2016 cropping season at the Teaching and Research Farm of the Federal University of Agriculture, Makurdi (Latitude 07° 45' -07° 50' N, Longitude 08° 45' - 08° 50' E, elevation 98m) and at Gboko (Latitude 7.35° N and Longitude 8.30° E, 122m) above sea level in Benue State, all locations in Southern Guinea Savanna of Nigeria. The experiment was undertaken to evaluate the productivity of sweet potato/sorghum intercrop as influenced by cultivar and planting pattern in Southern Guinea Savannah of Nigeria. The sweet potato varieties used were King J, Mother's Delight (both orange fleshed cultivars obtained from National Root Crop Research Institute (NRCRI), Umudike, Nigeria) and Angooji (a local cultivar) and Sorghum (local red coloured gem). The experimental areas received a total rainfall of 1026.3mm and 1315.8 mm in Makurdi and Gboko respectively. The soils in both locations, classified as sandy loam was cleared, ridged and divided into 30 plots using local implements. Each plot had an area of $12m^2$. The plot consisted of four ridges of 3m long spaced 1m apart. The trial was a factorial arrangement laid out in a Randomized completed Block Design with three replications. The main plot constituted the planting patterns while the sweet potato varieties were allotted the sub-plots. In the intercrop, sweet potato was planted at the crest of the ridges, at an intra-row spacing of 30cm; while sorghum was planted by the sides at a distance of 25cm and 50cm down the ridge crest. Each ridge had ten sweet potato stands, given a total of 40 plants per plot (33, 333 plants per hectare equivalent). Sorghum had twelve stands per ridge, given a total of 48 plants per plot (40, 000 plants per hectare equivalent). In both sole and intercrop, the recommended plant densities of both crops were maintained.

The recommended rate of mixed fertilizer (NPK) for sweet potato, 60kgN, 15kgP_2O_5 and 75kg k_2O and sorghum, 64kgN, 32kgP_2O_5 and 30kgk_2O (Chude *et al.;* 2007) was applied. Spot application beside the plant method was employed at immediately after planting sweet potato and a second dose at six weeks after planting (Onwueme and Sinha, 1991). Weeding was done at three and six weeks after planting. Harvesting of sweet potato and sorghum were done at physiological maturity. Data taken for sweet potato included vine length per plant (cm), number of leaves per plant, number of branches per plant, all at 4,8 and 12 weeks after planting. Others were number of tubers per plant, tuber weight per plant (kg) and tuber yield per hectare (t/ha). Data taken for sorghum included plant height at harvest (m), panicle weight, 1000 seed weight (g)and grain yield (t/ha). All data taken were subjected to statistical analysis of variance to test for significance of treatment differences using Genstat (2014) seventeenth Edition. The treatment means were compared using Fishers Least Significant Difference (LSD) test at 5% probability level. Intercrop advantage was calculated using Land Equivalent Ratio (LER) (Willey, 1979). LER= (Yab/Yaa) + (Yba/Ybb). Where Yaa and Ybb are yield of sole crops of sweet potato and sorghum and Yab and Yba are yields of intercrops of sweet potato and sorghum respectively. Values of LER greater than 1 are considered advantageous. Land Equivalent Coefficient (LEC), a measure of interaction concerned with the strength of relationship was also calculated. LEC = la x lb (Adetiloye, *et al,*. 1983). Where La= LER of main crop (sweet potato), Lb= LER of intercrop (sorghum). For a two crop mixture the minimum expected productivity coefficient is 25%. ie a yield advantage is obtained if (LEC) value exceeds 0.25. The Percentage (%) Land Saved, an indicator of the percentage of Land a farmer saves from intercrop if the same yield were to be obtained in sole plot was calculated as described by Willey (1985) using the formula: % land saved = 100 – (1/LER x 100).

Results

Productivity of Sweet Potato

The rainfall received in both sites was considered adequate for crop growth and development in 2016. The main effects of sweet potato varieties and the planting patterns were significant on the vine length per plant and number of leaves per plant across the weeks measured in both locations except in Gboko at 8WAP and at 12 WAP for vine length and number of leaves respectively. The interaction of variety and pattern was not significant for both parameters and in both locations of the study. Significant differences ($P \geq 0.05$) existed in the number of tubers per plant for Variety and Planting pattern in Makurdi and Gboko (Table 3).

Table 1: Main Effects of Variety and Pattern on Vine Length per Plant of Sweet Potato in Makurdi and Gboko in 2016

	Vine Length (cm)			Vine Length (cm)		
	Makurdi			Gboko		
Variety	4 WAP	8 WAP	12 WAP	4 WAP	8 WAP	12 WAP
King J	44.84	136.90	215.39	53.74	130.70	232.27
Mother's Delight	81.19	351.60	520.20	75.98	243.10	433.63
Angooji	45.87	126.70	211.77	49.17	114.00	200.34
F-LSD (0.05)	2.14	39.46	34.04	2.87		6.93
F-pr	<0.001	<0.001	<0.001	<0.001	Ns	<0.001
Pattern						
25 cm away	56.08	199.00	308.92	58.10	150.00	283.14
50 cm away	58.51	201.60	311.60	61.15	159.80	285.22
Sole	61.70	214.50	326.83	63.11	178.00	297.89
F-LSD (0.05)	1.75	6.44	3.88	1.79	20.17	1.07
F-pr	0.011	<0.001	<0.001	0.003	0.031	<0.001

F-LSD (0.05) = Fisher's Least Significant Difference at 5% level of probability; F-pr = Probability value; Ns = Not significant, WAP=Weeks After Planting

King J recorded the highest number of roots per plant while the least number of roots was observed in Mother's Delight. Planting pattern did not affect number of roots significantly in Gboko, however, sole planting of sweet potato produced the lowest number of roots per plant followed by that planted at 50 cm apart. This trend was observed in Makurdi and Gboko. Variety and Pattern (V X P) interaction effect was not significant for number of roots per plant Gboko in 2016 (Table 4). Results of analysis of variance indicated that the main effects of Variety and planting Pattern significantly ($P \geq 0.05$) influenced the root weight per plant in both locations of the study in 2016 (Table 3). The highest root weight per plant was obtained in Mother's Delight (1.69 kg) and (2.60 kg) in Makurdi and Gboko respectively while the least was obtained in King J. This trend was observed in both Makurdi and Gboko locations of the study in 2016. Planting Patterns significantly influenced the root weight per plant as the highest root weight per plant was obtained in sole cropping; sole cropping recorded the highest value of 1.75.kg root weight per plant in Makurdi, while the highest value 2.32kg weight per plant was recorded in Gboko (Table 3).

Table 2: Main Effects of Variety and Pattern on Number of Leaves per Plant of Sweet Potato in Makurdi and Gboko in 2016

	Number of Leaves per Plant			Number of Leaves per Plant		
	Makurdi			Gboko		
Variety	4 WAP	8 WAP	12 WAP	4 WAP	8 WAP	12 WAP
King J	29.53	113.83	440.70	44.90	249.60	429.80
Mother's Delight	34.84	122.30	466.40	35.80	342.50	517.80
Angooji	30.65	119.05	432.10	38.20	274.70	469.40
F-LSD (0.05)	3.21	5.62	23.64	6.51	41.28	
F-pr	0.010	0.034	0.034	0.027	0.008	Ns
Pattern						
25 cm away	30.20	113.25	394.00	38.20	265.60	454.70
50 cm away	32.22	116.26	470.90	41.10	278.50	464.90
Sole	35.29	125.67	474.30	44.63	322.70	497.40
F-LSD (0.05)	2.62	1.66	28.55		10.52	8.42
F-pr	0.025	<0.001	<0.001	Ns	<0.001	<0.001

F-LSD (0.05) = Fisher's Least Significant Difference at 5% level of probability; F-pr = Probability value; Ns = Not significant, WAP=Weeks After Planting

Table 3: Main Effects of Variety and Pattern on Number of Roots per Plant, Root Weight per Plant and Root Yield per Hectare of Sweet Potato in Makurdi and Gboko in 2016

	Number of roots per plant		Root weight per plant (kg)		Root yield (t/ha)	
Variety	Mkd	Gbk	Mkd	Gbk	Mkd	Gbk
King J	4.17	3.96	1.11	1.28	13.65	14.36
Mother's Delight	2.86	3.05	1.69	2.60	29.86	18.70
Angooji	3.07	3.41	1.49	2.01	16.41	19.50
F-LSD (0.05)	0.50	0.45	0.224	0.309	2.67	2.63
F-pr	0.004	0.013	<0.001	<0.001	0.004	<0.001
Pattern						
25 cm away	3.69	3.62	1.12	1.74	14.96	17.22
50 cm away	3.31	3.36	1.43	1.83	16.52	18.70
Sole	3.11	3.44	1.75	2.32	19.44	22.44
F-LSD (0.05)	0.37		0.224	0.100	0.701	0.86
F-pr	0.015	Ns	<0.001	<0.001	<0.001	<0.001

Key: Mkd= Makurdi, Gbk= Gboko, Ns= Not significant, F-pr=Probability value, F-LSD (0.05) = Fisher's Least Significant Difference at 5% level of probability

Result indicated that Variety and Planting Pattern interaction effect was not significant on the root weight per plant in 2016 in Makurdi and Gboko (Table 4). Root yield per hectare differed significantly (P≥ 0.05) among the sweet potato cultivars and planting patterns tested in this study in Makurdi and Gboko in 2016) (Table 3). Mother's Delight produced the highest root yield per hectare followed by Angooji. The least root yield was obtained in King J. Root yield varied across the planting patterns with sole cropping giving the highest root yield. This was followed by intercropping sweet potato at 50cm apart while planting at 25 cm apart recorded the least yield per hectare. These were observed in Makurdi and Gboko locations of the study (Table 3). Root yield was not significantly affected by the interaction effects of Variety and Pattern in Makurdi (Tables 4). Table 5 indicated that grain yield of sorghum was significantly affected by intercropping with sweet potato varieties and in the planting patterns employed in Makurdi and Gboko in 2016. In both locations of the study, sorghum intercropped at 50 cm apart with Mother's Delight produced the highest grain yield of sorghum per hectare as compared to the other varieties and planting pattern tested, this however, was not statistically (P≤ 0.05) different from the other varieties in Makurdi. Sole sorghum recorded the highest grain yield per hectare in both locations.

Table 4: Interaction Effects of Variety and Pattern on Number of Roots per Plant, Root Weight per Plant and Root Yield per Hectare of Sweet Potato in Makurdi and Gboko in 2016

		Number of roots per plant		Root weight per plant (kg)		Root yield (t/ha)	
Variety	Pattern	Mkd	Gbk	Mkd	Gbk	Mkd	Gbk
King J	25 cm	4.52	4.15	0.92	1.03	11.30	13.04
‘’	50 cm	4.33	3.85	1.19	1.17	13.35	13.61
‘’	Sole	3.67	3.89	1.25	1.64	16.30	16.42
Mother's Delight	25 cm	3.04	3.19	1.36	2.43	18.77	21.21
‘’	50 cm	2.44	3.07	1.65	2.46	20.52	23.85
‘’	Sole	3.11	2.89	2.06	2.92	23.30	25.45
Angooji	25 cm	3.52	3.52	1.08	1.74	14.80	17.42
’’	50 cm	3.15	3.15	1.44	1.89	15.69	18.64
Sole	Sole	2.56	3.56	1.94	2.40	18.72	22.45
F-LSD (0.05)		0.64					2.60
F-pr		0.037	Ns	Ns	Ns	Ns	0.027

F-LSD (0.05) = Fisher's Least Significant Difference at 5% level of probability; F-pr = Probability value; Ns = Not significant, WAP=Weeks After Planting

Table 5: Interaction Effect of Variety and Pattern on the Grain Yield of Sorghum in Makurdi and Gboko in 2016

		Grain Yield (t/ha) 2016	
Variety X	Pattern	Makurdi	Gboko
King J	25 cm	1.16	0.90
	P_{50} cm	1.19	0.93
Mother's Delight	25 cm	1.53	1.31
	50cm	1.66	1.43
Angooji	25 cm	1.24	0.98
	50 cm	1.27	1.03
	Sole	1.68	1.46
F- LSD (0.05)			0.46
F-pr		Ns	0.029

F-LSD (0.05) = Fisher's Least Significant Difference at 5% level of probability; F-pr = Probability value; Ns = Not significant.

Productivity Assessment of Sweet Potato – Sorghum Intercropping System

The intercrop treatment combinations all had LER figures above 1 and LEC figures above 25% both in Makurdi and Gboko. The highest Land Equivalent Ratio (LER) (1.87 and 1.92) and Land Equivalent Coefficient (LEC) (0.87 and 0.92) for Makurdi and Gboko respectively were obtained by intercropping with Mother's delight at the distance of 50cm apart. Intercropping sorghum with Mother's delight at the distance of 50cm apart recorded the highest percentage of and saved (Table 6).

Table 6: Land Equivalent Ratio (LER), Land Equivalent Coefficient (LEC), and Percentage Land Saved of Intercropping Sweet Potato with Sorghum in Makurdi and Gboko in 2016

Treatments	LER		LEC		% Land saved	
	Makurdi	Gboko	Makurdi	Gboko	Makurdi	Gboko
King J 25 cm	1.38	1.41	0.48	0.49	27.54	29.08
King J 50cm	1.53	1.47	0.58	0.53	34.64	31.97
Mother's Delight 25 cm	1.72	1.73	0.74	0.75	42.20	39.40
Mother's Delight 50 cm	1.87	1.92	0.87	0.92	47.92	45.06
Angooji 25 cm	1.53	1.45	0.58	0.52	34.64	31.03
Angooji 50 cm	1.60	1.54	0.64	0.59	37.50	35.06

Key: LER = Land Equivalent Ratio; LEC= Land Equivalent Coefficient;

Discussion

The significant differences observed in the vine length, number of leaves as well as number of roots per planr, tuber weight and tuber yield among the sweet potato cultivars could be ascribed to the genetic constitution of the varieties as opposed to planting environment. This agrees with Anshebo *et al.,* (2004) who reported high heritability estimates for vine traits such as length of vine and weight of foliage of sweet potato in Madras, India. Similarly, Hossain *et al.,* (1994) on effect of vine parts on growth of sweet potato discovered that vine length was cultivar dependent. Idoko *er al*, (2018) also reported branching of the sweet potato to be cultivar dependent varying not only in the number but also in the distance of the branches growing outward from the crown of the plant. Mother's delight consistently gave the highest yields of the growth and tuber yield components than the other varieties. This might be ascribed to its genetic characteristics; this agrees with the finding of Belehu (2003) who observed that the rate of partitioning of assimilates to the sink vary from one cultivar to another. The superior performance in sole as compared to intercropping could be as a result of greater availability of growth resources (light, water, soil nutrients, etc) to sole crop plants than those intercropped with sorghum, sharing of growth resources among component crops under intercropping can limit growth and accumulation of dry matter compared to sole cropping where competition exist (Dasbak and Asiegbu (2009). Egbe and Idoko (2009) had observed depressive effects of pigeon pea on yields of sweet potato varieties at Otobi and associated such responses to decline in photosynthesization due to decreased solar radiation by shading of the sweet potato by the taller pigeon pea component. Similarly, Silwana and Lucas (2002) reported that intercropping reduced vegetative growth of component crops.

The superior performance of Mother's delight over the other varieties in Makurdi and Gboko could imply that this variety was more suitable than the other varieties tested for cultivation with or without sorghum in Makurdi and Gboko. This is in line with Sauti *et al.;* (1991) when they worked on the performance of sweet potato varieties with maize and sorghum intercrops in Malawi; it was

reported that some varieties of maize as well as sorghum performed well in intercropping with sweet potato but sweet potato did not tolerate intercropping with maize. It was concluded that some varieties are better suited than others for intercropping. Intercropping sorghum at a distance of 50cm apart produced significant higher values for the growth and yield attributes than intercropping at a distance of 25cm apart. This could be ascribed to the near absence of competition of growth factors between the component crops in the mixture due to the distance between them as this increased the nutrient absorption by the plants. Similarly, the reduction in the yield components and grain yield of intercropped sorghum as compared with its sole planting might be as a result of underground competition for soil growth resources such as water and soil nutrients between the intercrop components. It is known that competitive reactions reduce yields in intercropped crop species as compared to sole cropping (Egbe *et al.* 2012). Grain yield of sorghum was influenced by intercropping with sweet potato cultivars and planting patterns. Intercropping sorghum with Mother's Delight gave higher grain yield of sorghum however sole sorghum recorded the highest grain yield of sorghum. The superior performance of sole sorghum compared to its intercropping might be associated with the complete absence of interspecies competition in the sole system and the presence of both inter and intra- specific competition in intercropping.
The LER and LEC Values in Makurdi and Gboko signified intercrop advantages in combining both crops. These intercrop advantages may have arisen from the high yields of the sweet potato component. The highest LER, LEC and Percentage Land Saved was produced when sorghum was intercropped at the distance of 50cm apart with Mother's Delight (1.87 and 1.92), LEC (0.87 and 0.92) and percentage land saved values (47.92 and 45.06) for Makurdi and Gboko respectively. LEC values showed that compatibility exist between sweet potato varieties and the local red gem sorghum variety. Egbe and Idoko (2009) and Njoku *et al.;* (2007) had also observed genotypic compatibility on sweet potato and pigeon pea and on sweet potato and okra respectively. The highest percentage of land saved by planting sorghum with Mother's Delight at the distance of 50cm apart indicates that it is advantageous to have the crops in mixture since the farmer would need as much as 87% and 92% hectare of land in Makurdi and Gboko respectively when crops are grown sole in order to achieve the same yield level from one hectare of land when crops are grown in mixture, thereby saving 47.92% and 45.06% of land for Makurdi and Gboko respectively. The implication of the study is that to maximize intercrop yields of sweet potato and sorghum (local red germ) in Makurdi and Gboko locations in Southern Guinea Savanna of Nigeria, the suitable Sweet Potato Variety is Mother's Delight and optimal planting pattern in planting at 50cm apart. This should therefore be recommended for these locations.

Conclusion

Planting sorghum (Local Red gem) 50 cm away from sweet potato (Mothers Delight) was the best practise for superior productivity of the mixture to maximize yield.

References

Adam, K.L., 2005. *Sweet potato: Organic production.* http://www.ncat.org/attra-pub/sweetpotato.html.

Anderson, P., Kapenga, R., Zhang, D. and Hermann, M., 2007. Vitamin A for Africa (VITAA): An entry point for promoting orange-fleshed sweet potato to combat vitamin A deficiency in sub-saharan Africa. *In:proceedings of the 13th ISTRC Symposium.* Tanzania: Arusha, Tanzania, pp 711-720

Amon, (1997). Crop production in dry regions. Vol. 2. Leonard Hill. London, U.K. pp 172.

Anshebo, T., Veeraragavatha Tham, D. and Kannan, M. (2004). Genetic variability and correlation studies in sweet potato (*Ipomoea batatas* L. Lam) Madras Agric. J, 91(7-12):420-424.

Belehu,T. (2003). Agronomical and physiological factors affecting growth, development and yield of sweet potato in Ethiopia. Ph.D. thesis, dept. of Plant Production and Soil Science. University of Pretoria, Pretoria, South Africa.

BNARDA (2007). Benue State Agricultural and Rural Development Authority. Annual Report, BNARDA, Makurdi, Nigeria, 25Pp.

Chude V.O., S.O Olayinka, C. Daudu, A. Ekeoma. (2007). FERTILIZER USE AND MANAGEMENT PRACTICES FOR CROPS IN NIGERIA. 4th EDITION

Dasbak, M.A.D. and Asiegbu, J.E., 2009. Performance of pigeonpea genotypes intercropped with maize under humid tropical Ultisols conditions

Egbe, O.M. and Idoko, J.A. (2009). Agronomic assessment of some sweet potato varieties for intercropping with pigeon pea in Southern Guinea Savanna of Nigeria. J. Prodtn. Agric. Tech. 7(1) 1-14.

Egbe, O.M., and P.O. Osang (2015) Farming Systems Study: “Intercrop Advantage of some improved Sweet Potato + Soybean in Makurdi, Benue State Nigeria” international letters of Natural Sciences, Vol.39.pp28-39, 2015

Egbe, O.M. Afuape, S.O. and Idoko, J.A. (2012) Performance of improved sweet potato (*Ipomoea batatas* (L) Varieties in Makurdi, Southern Guinea Savanna of Nigeria. *American Experimental Agriculture* 2:573-586.

Futuless, K.N. (2010). Evaluation of maize-soyabean intercrop as influenced by sowing date of soyabean in Northern Guinea Savanna of Nigeria. New York Science Journal, 3 (10): 12-16.

GENSTAT (2014). GENSTAT release 10.3 DE, Lowes Agric. Trust Rolbamsted experimental station.

Hossian, M.M. and Mondol. M.A.A (1994). Effects of vine parts on the growth and yield of three sweet potato varieties. *Bangladesh Journal of Science and Industrial Research.* 29(3) 181-184

Idoko, J.J., Oorlamen, T. and Offordile, A.E. (2018). Effect of intercropping some crop species with orange-flesh sweet potato varieties in Makurdi. *International Journal of Agricultural Policy and Research.* 6(3): pp 28 37

Nwokocha, H.N. (1993). Technological packages for increased sweet potato production in Nigeria

Njoku, S.E. Muoneke, C.O; Okpara, D.A. and Agbo, F.M.O (2007). Effect of intercropping varieties of sweet potato and okra on ultisol of South Eastern Nigeria. Africa J. Biotech. 6(14) 1560-1654.

NRCRI, (2008). National Root Crop Research Institute: Sweet Potato programme. Online Available From: http://www.nrcri.gov.ng/pages/spotato.html.

Ogbonna, A.C, Obi, S.K.C, Okolo, B.N. &Odibo, F.J.C. (2004a). SORGHUM: AN ENVIRONMENTALLY-FRIENDLY FOOD AND INDUSTRIAL GRAIN IN NIGERIA. *Journal Science of Food and Agriculture* 84: 113-120

Onwueme, I.C. and Sinha, T.D. (1991). Field Crop Production in Tropical Africa CTA, Ede, The Netherlands. 480p.

Putnam, D.H., Herbert, S.J. and Vargas, A. (1984). Intercropped corn-soybean density studies.1. Yield complementarity. Expl. Agric. 21:41-51. Russell, J.T. and Caldwell, R.M. (1989). Effect of component densities and nitrogen fertilization on efficiency and yield of maize/soybean intercrop. *Experimental Agriculture*. 25: 529-540

Saddique, M.A. (1985). Studies on the morphology, growth and yield of some sweet potato genotypes. MSc. (Agric.). Thesis, Dept of Horticulture, Bangladash Agricultural University, Mymensingh.

Sauti R.F.N., E.S. Matabwa, D.F. Bakali, W.S. Braunnworth Jr. (1991). The performance of sweet potato varieties with maize and sorghum intercrops in Malawi *http:www.actahort.org/books/380/380_113.htm*

Silwana, T.T.,and Lucas, E.O. (2002). The effect of planting combination, weeding and yield component crops of maize- bean and maize- pumpkin intercrops. *Journal of Agricultural Science* 138:193-200

Som, D. (2007) *Handbook of horticuluture (*pp. 416-512). New Delhi: India Council of Agricultural Research.

Takim, F.O. (2012) Advantages of maize-cowpea intercropping over sole cropping through competition indices. J. Agric. Biod. Res, 1 (4) 53-59

Willey, R.W. (1979). Intercropping – Its importance and research needs – 1. Completion and yield advantages. *Field Crops Aster.* 32 (1):1-10

Willey, R.W. (1985). Evaluation and presentation of intercropping advantages. Exptl. Agric. 21:119-133.

Willey, R.W. and Rao, M.R. (1980). A competitive ratio for qualifying competition between intercrops. Exptl. Agric.16:117-125.