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Productivity of sweet Potato/Sorghum Intercrop as influenced by Sweet Potato cultivars and time of introducing sorghum in Southern Guinea Savanna, Nigeria

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Abstract:

The productivity of integrating sorghum into various sweet potato varieties at different times and were evaluated in 2017 in Makurdi and Gboko, located in Southern Guinea Savanna of Nigeria. The aim of the experiment was to identify the suitable sweet potato variety for intercropping with sorghum and the optimal time of introducing sorghum that will maximize yields of the component crops in mixture. Sorghum was introduced into Sweet Potato (King J, Mother's Delight, and Angooji) at different times (0, 14 days and 28 days after planting). Results showed that variety and time of introducing sorghum significantly (P≥ 0.05) affected the root yield and relative yield of sorghum. Root yield obtained from Mother's Delight was 23.10% and 22.41% more than King J and Angooji respectively in Makurdi and 29.54% and 24.38% more than King J and Angooji respectively in Gboko. The highest intercrop yields of sweet potato and sorghum were obtained when sorghum was inter-planted with Mother's Delight at 14 DAP sweet potato as indicated by LER value of 1.72 and 1.81 at Makurdi and Gboko respectively. With the LER values, 41.86% and 44.75% of land was saved at Makurdi and Gboko respectively.

***Keywords: Intercropping, Time of Introduction, Sweet Potato- Sorghum Productivity*.**

Introduction:

Sweet Potato (*Ipomoea batatas* (L) Lam) is a member of convolulaceae family, is a perennial crop usually grown as an annual (Onwueme and Sinha, 1991). It ranks fifth as the most important food crop after rice, wheat, maize and cassava in developing countries (Som, 2007). 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*(L.) Moench) is the most widely cultivated cereal crop and important food crop in the Savanna ecological areas (Amon, 1997). In Africa and Asia, it serves as a staple food for people and the total cultivated area is surpassed only by rice, wheat and maize (Dogget, 1988). The crop is environmentally friendly as it is adaptable to a wide range of environmental conditions. It has a number of morphological characteristics that contribute to its adaptation to dry conditions. These include on extensive root system, waxy surface of the leaves that reduces water loss, ability to stop growth in periods of drought and resume when conditions are favourable as well as tolerance to water logging (FAO, 1995).

Intercropping is the simultaneous growing of two or more crops on the same piece of land 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.

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), and sweet potato and soybean (Idoko *et al.;* 2018). Several improved sweet potato varieties have been introduced into the cropping systems of farmers in Benue State, especially from NRCRI, Umudike. Farmers in Makurdi and Gboko interplant sweet potato and sorghum in variable times of introducing the component crop with resultant low productivity (Egbe and Idoko, 2009). Other authors like Egbe *et al.*, 2012, Njoku *et al.,* 2007 have reported findings with the potential of improving the productivity of sweet potato based intercropping system, however, there is dearth of information on the response of sweet potato varieties to time of introducing sorghum in intercropping. The experiment therefore aimed at identifying the sweet potato variety and optimal time of introducing sorghum that will maximize the yields of both crops in mixture.

Materials and Methods:

A field experiment was conducted in 2017 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. The experiment was undertaken to evaluate the productivity of sweet potato-sorghum intercrop as influenced by cultivars and time of introducing sorghum in Southern Guinea Savanna of Nigeria. The trial was a factorial arrangement laid out in a Randomized completed Block Design. The treatment combinations consisted of three sweet potato varieties (King J, Mother's Delight and Angooji) and Three times of introducing sorghum (Same time, 14DAP and 28DAP) as well as sole crops. The experimental area sites, classified as sandy loam soil was ploughed, harrowed, ridged and divided into 36 plots. Each plot had an area of $12m^2$. The plot consisted of four ridges of 3m Long Spaced 1m apart. 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 down the ridge crest at an intra-row spacing of 50cm. 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 16^{th} and 24^{th} week after planting respectively when leaves were observed to dry, turn yellowish and falling off, which were signs of tuber maturity and senescence.

Data taken for sweet potato included vine length per plant (cm), number of leaves per plant, 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) and panicle weight (t/ha). Others were 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. Land Equivalent Coefficient (LEC) as described by Adetiloye *et al.,* (1983), Land Equivalent Ratio (LER) and percentage land saved as described by Willey, 1985 were used to assess the advantage of the intercropping system.

Results:

Productivity of Sweet Potato

The rainfall received during the experimental period in 2017 was considered adequate for crop growth and development. There was highly significant ($P \leq 0.001$) influence of Variety and Time of introducing sorghum on the vine length per plant across the weeks measured in Makurdi and Gboko except at 8 WAP in Gboko where it was not significant (Table 1).

Table 1: Main Effects of Variety and Time of Introduction of Sorghum on the Vine Length of Sweet Potato in Makurdi and Gboko in 2017

Vine Length per Plant (cm)				Vine Length per Plant (cm)			
Makurdi				Gboko			
Variety	4 WAP	8WAP	12WAP	Variety	4WAP	8WAP	12WAP
KingJ	78.53	136.05	210.60	KingJ	65.87	129.55	199.7
Mother's Delight	112.74	350.60	518.60	Mother's Delight	109.87	239.9	341.66
Angooji	70.03	125.00	214.00	Angooji	58.55	112.45	231.45
F-LSD (0.05)	3.46	40.70	33.02	F-LSD (0.05)	4.21		7.10
F-pr	<0.001	<0.001	<0.001	F-pr	<0.001	Ns	<0.001
Time				Time			
Same time	83.39	193.85	300.3	Same time	73.14	141.15	274.8
14DAP	87.53	200.75	307.1	14DAP	79.24	154.8	282.835
28DAP	70.37	206.4	323.4	28DAP	82.31	168.6	294.905
Sole	92.17	214.55	326.85	Sole	83.83	178	297.885
F-LSD (0.05)	3.49	11.97	4.015	F-LSD (0.05)	3.10	16.73	1.35
F-pr	0.002	0.013	<0.001	F-pr	0.001	0.001	<0.001

Key: DAP= Days After Planting, WAP= Weeks After Planting; F – LSD (0.05) = Fisher's Least Significant Differences at 5% Level of Probability; F-pr = Probability value; Ns= Not significant.

Mother's delight produced the highest vine length per plant while Angooji gave the least vine length per plant. This trend was observed in both locations of the study in 2017. Delayed introduction of sorghum up to an interval of 28 days after planting (WAP) resulted in significant increase in the vine length (Table 1). While sole sweet potato gave the highest vine length per plant, introducing sorghum at 28 WAP produced the highest vine length than the other times of introduction tested. Significant differences existed ($P \leq 0.05$) on the root weight per plant for Variety and differed highly significantly ($P \leq 0.001$) on the time of introducing sorghum in both locations of the study in 2017 (Table 2). King J recorded the least root weight per plant while Mother's Delight produced the highest root weight per plant (1.53kg and 3.10kg at Makurdi and Gboko respectively). This was 34.64% and 15.03% heavier than King J and Angooji respectively at Makurdi and 54.52% and 31.93% heavier than King J and Angooji respectively at Gboko.

It was observed that root weight per plant increased significantly, when introduction of sorghum was delayed to 28 DAP. This trend was observed in Makurdi and Gboko in 2017 (Tables 2). The effect of interaction of Variety and Time of introduction was not significant for root weight per plant in Gboko in 2017 (Tables 3).

Table 2 : Main Effects of Variety and Time of Introduction of Sorghum on the Root Weight per Plant in Makurdi and Gboko in 2017

	Root Weight per Plant (kg)	
Variety	Makurdi	Gboko
KingJ	1.00	1.41
Mother's Delight	1.53	3.10
Angooji	1.30	2.11
F-LSD (0.05)	0.19	0.89
F-pr	<0.001	0.008
Time		
Same time	0.97	1.73
14DAP	1.08	1.98
28DAP	1.31	2.32
Sole	1.75	2.79
F-LSD (0.05)	0.22	0.50
F-pr	<0.001	<0.001

Key: DAP= Days After Planting, F – LSD (0.05) = Fisher's Least Significant Differences at 5% Level of Probability; F-pr = Probability value.

Table 3: Root Weight per Plant of Sweet Potato as Affected by Interaction of Variety and Time of Introduction in Makurdi and Gboko in 2017

		Root Weight per Plant (kg)	
Variety (V)	Time (T)	Makurdi	Gboko
King J	Same time	0.82	1.00
	14DAP	0.78	1.24
	28DAP	1.16	1.41
	Sole	1.25	1.98
Mother's Delight	Same time	1.15	2.61
	14DAP	1.37	2.90
	28DAP	1.55	3.25
	Sole	2.07	3.62
Angooji	Same time	0.95	1.57
	14DAP	1.07	1.79
	28DAP	1.23	2.29
	Sole	1.94	2.75
F-LSD (0.05)		0.386	
F-pr		<0.001	Ns

Key: DAP= Days After Planting, WAP= Weeks After Planting; F – LSD (0.05) = Fisher's Least Significant Differences at 5% Level of Probability; F-pr = Probability value; Ns= Not significant.

Root yield per hectare produced by the varieties differed significantly, Mother's delight produced 29t/ha and 48.02t/ha at Makurdi and Gboko respectively which was 23.10% and 22.41% higher than King J and Angooji respectively at Makurdi and 29.54% and 24.38% higher than King J and Angooji respectively at Gboko (Table 4). The interaction effect of variety and time was not significant (P≤ 0.05) at Makurdi and Gboko (Table 5). Sorghum grain yield was influenced by intercropping with sweet potato varieties (Table 6). Combining the sweet potato cultivars with sorghum at different times influenced the grain yield of sorghum. Simultaneous planting of both crops produced the highest grain yield compared to when sorghum was introduced at 14 and 28 days after planting sweet potato however, sorghum intercropped with Mother's delight at 14 days after planting produced the highest grain yield than the other varieties and times of introduction tested. Sole cropping of sorghum however gave the highest grain yield (Table 6).

Table 4 : Main Effects of Variety and Time of Introduction of Sorghum on the Root Yield per Hectare in Makurdi and Gboko in 2017

	Root Yield per Hectare (t/ha)	
Variety (V)	Makurdi	Gboko
KingJ	22.30	28.20
Mother's Delight	29.00	48.02
Angooji	21.50	38.26
F-LSD (0.05)	5.17	5.044
F-pr	0.012	0.001
Time		
Same time	19.70	31.77
14DAP	21.30	33.32
28DAP	28.40	36.68
Sole		
F-LSD (0.05)	5.97	1.808
F-pr	0.008	<0.001

Productivity Assessment of Sweet Potato – Sorghum Intercropping System
The Land Equivalent Ratio (LER), Land Equivalent Coefficient (LEC), and Percentage Land Saved of Intercropping Sweet Potato with Sorghum in Makurdi and Gboko.

All intercrop treatments had LER figures above unity in Makurdi and Gboko. LEC values were greater than 0.25 in all intercrop situations in Makurdi and Gboko. Intercropping with Mother's Delight at 14 days after planting produced the highest LER of 1.72 and 1.81 in Makurdi and Gboko respectively. All the intercropped varieties had the highest LER when sorghum was introduced at 14 DAP except Angooji that had the highest LER value at simultaneous planting in Gboko. The lowest LER was obtained in King J when sorghum was introduced at 28 DAP in Makurdi, this might be as a result of the decrease in yield of the sorghum component. Generally, the percentage of land saved was highest when sorghum was introduced into the sweet potato varieties at 14 DAP except in Gboko where Angooji recorded the highest percentage land saved in simultaneous planting of both crops. The lowest percentage of land saved was obtained from introducing

sorghum at 28 DAP into all the sweet potato varieties in Makurdi and Gboko respectively (Table 7).

Table 5: Root Yield per Hectare of Sweet Potato as Affected by Interaction of Variety and Time of Introducing Sorghum in Makurdi and Gboko in 2017

		Root Yield per Hectare (t/ha)	
Variety	Time	Makurdi	Gboko
King J	Same time	17.90	26.16
	14 DAP	19.90	26.40
	28 DAP	23.30	28.68
	Sole	25.50	32.83
Mother's Delight	Same time	20.80	40.42
	14 DAP	26.60	43.97
	28 DAP	29.00	46.20
	Sole	30.60	46.89
Angooji	Same time	18.30	31.72
	14 DAP	19.40	32.89
	28 DAP	22.50	35.55
	Sole	22.59	37.89
F-LSD (0.05)			
F-pr		Ns	Ns

Key: DAP= Days After Planting; F-LSD= Fisher's Least Significant Difference; F-pr = Probability value; Ns = Not significant

Table 6: Interaction Effect of Variety and Time of Introduction of Sorghum on Grain Yield of Sorghum in Makurdi and Gboko in 2017

		Grain Yield (t/ha)	
Variety X	Time	Makurdi	Gboko
King J	Same time	2.93	2.43
	14DAP	2.74	2.29
	28DAP	0.68	0.87
	Sole	4.25	3.47
Mother's Delight	Same time	3.59	3.26
	14DAP	3.48	2.96
	28DAP	1.63	1.48
	Sole	4.08	3.41
Angooji	Same time	3.24	2.56
	14DAP	3.03	2.33
	28DAP	0.77	1.13
	Sole	3.98	3.38
F-LSD (0.05)		1.19	0.84
F-pr		<0.001	<0.001

Key: DAP= Days After Planting; F-LSD= Fisher's Least Significant Difference; F-pr = Probability value; Ns = Not significant

Table 7: Land Equivalent Ratio (LER), Land Equivalent Coefficient (LEC), and Percentage Land Saved of Intercropping Sweet Potato with Sorghum in Makurdi and Gboko in 2017

	LER		LEC		Percentage Land Saved	
	Makurdi	Gboko	Makurdi	Gboko	Makurdi	Gboko
King J Same time	1.39	1.55	0.48	0.60	28.06	35.48
King J 14 DAP	1.45	1.77	0.52	0.54	31.03	43.50
King J 28 DAP	1.08	1.13	0.15	0.23	7.41	11.50
Mother's Delight same time	1.52	1.80	0.57	0.81	34.21	44.45
Mother's Delight 14 DAP	1.72	1.81	0.74	0.82	41.86	44.75
Mother's Delight 28 DAP	1.36	1.42	0.39	0.43	26.47	29.58
Angooji	1.57	1.58	0.62	0.62	36.31	36.71
Angooji 14 DAP	1.60	1.55	0.64	0.59	37.50	35.48
Angooji 28 DAP	1.18	1.27	0.19	0.31	15.25	21.26

Key: LER: Land equivalent ratio, LEC: Land equivalent coefficient, DAP= Days After Planting

Discussion

Mother's Delight gave a superior performance both in sole planting and in intercropping. Mother's Delight produced the highest root yield of 29.00t/ha and 48.02t/ha in Makurdi and Gboko respectively. Mother's Delight was significantly more responsive to the times of introduction of sorghum into the intercrop than King J and Angooji based on the assessed growth and yield attributes. The more delay in introducing sorghum to 28 days after planting (DAP) resulted to increase in growth and yield contributing characters of the sweet potato crop. The superior performance of the variety over King J and Angooji may be due to the genetic factors and the cultivar' ability to initiate preform root primordial and partitioning of much assimilates to the storage root. This agrees with the finding of Belehu (2003) and Jahan and Saddique (2001) who observed that the rate of partitioning of assimilates to the sink vary from one cultivar to another. Similarly, Ali *et al.;* (2009) on evaluation of yield performance of five sweet potato varieties reported that yield of the different varieties tested were as a result of their genetic composition. Time of introduction of sorghum significantly influenced the growth and yield of sweet potato characters. Vine length, number of leaves, number branches, leaf area, as well as root weight and tuber yield increased as a result of delayed introduction of the component crop to 28 DAP. This trend was observed in both Makurdi and Gboko. The highest growth and yield attributes values were obtained from intercropped sweet potato at 28 DAP irrespective of sweet potato cultivar. This was followed by those intercropped at 14 DAP and the least values were obtained from intercropped sweet potato in simultaneous planting. The reductions observed in simultaneous planting in this study could be ascribed to inter-specific competition of the component crops largely due to absence of temporal separation in the early stages of growth and shading of the sweet potato by the taller sorghum resulting in depression of photosynthesis due to decrease in solar radiation. Egbe and Bar-Anyam (2010) reported reductions in the number of branches per plant of pigeon pea intercropped with sorghum and noted that it was influenced by interplant competition. Similarly, Egbe and Idoko (2009) and Bar-Anyam (2019) had reported reductions in the total fresh root yield of sweet potato varieties intercropped with pigeon pea and sorghum respectively and attributed it to depression in photosynthesis due to decrease in solar radiation by shading of the sweet potato; this assertion is also supported Natarajan and Willey, (1985).

The yield attributes as well as grain yield of sorghum was influenced by intercropping with sweet potato cultivars and time of introduction of sorghum. Sorghum intercropped with Mother's Delight

gave higher grain yield of sorghum however, sole sorghum recorded the highest grain yield. 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. Higher yields in sole over intercropped plants had been reported by Olufajo (1995) Muneer *et al.;* (2004) and Ijoyah *et al.* (2015).

The superior performance of sorghum intercropped with Mother's Delight over the other varieties in both locations could imply that Mother's Delight was more suitable than the other varieties for cultivation with 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.

The intercrop combinations gave LER values above unity in all the times of introducing sorghum in Makurdi and Gboko and LEC Values above 25% signifying intercrop advantages. These intercrop advantages may have arisen from the high yields of the sweet potato component which made up for the reduction in the sorghum yields. The highest LER, LEC and Percentage Land Saved was produced when sorghum was introduced into Mother's Delight at 14 DAP; LER (1.72 and 1.81) LEC (0.74 and 0.82) and percentage land saved values (41.86 and 44.75) in 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) had also observed genotypic compatibility on sweet potato and pigeon pea. The highest percentage of land saved by introducing sorghum into Mother's Delight at 14 DAP indicates that it is advantageous to have the crops in mixture since the farmer would need as much as 72% and 81% 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 41.86% and 44.75% of land for Makurdi and Gboko respectively.

Conclusion

Introducing sorghum into sweet potato (Mothers Delight) at 14 days after planting sweet potato exhibited superior performance compared to other varieties and time of introduction. Intercropping Sweet Potato varieties at 28 days after planting sweet potato produced higher tuber yield of sweet potato and influenced superior grain yield of sorghum in simultaneous planting.

Recommendations

1 In order to enhance maximum productivity of sweet potato-sorghum intercropping system, it is recommended that sorghum be introduced into Mother's delight at 14 days after planting.

2. Irrespective of sweet potato cultivar, introducing sorghum into sweet potato at 28 days after planting gave higher yield of sweet potato, however, sorghum introduced into Mothers Delight at 28 days after planting gave the highest yield, this variety is thereby recommended to farmers both in Makurdi and Gboko.

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