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EFFECT OF TIME OF EGGPLANT INTRODUCTION ON THE PRODUCTIVITY OF WHITE AND ORANGE-FLESHED SWEETPOTATO/EGGPLANT INTERCROP IN SOUTH-EAST, NIGERIA

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ABSTRACT
A field experiment was conducted to evaluate the effect of time of introduction of eggplant on the productivity of white and orange-fleshed sweetpotato/eggplant intercropping in the rainforest agro ecological zone of south east, Nigeria in 2014 and 2015 cropping seasons. The experiment was laid out as factorial in randomized complete block design (RCBD) with three replications. The treatments consist of combinations of five different times of introduction of eggplant [(simultaneous planting of eggplant and sweetpotato varieties, eggplant 2 weeks before planting (WBP) and 2 weeks after planting (WAP) sweetpotato varieties; eggplant 4 WBP and 4 WAP sweetpotato varieties) and two sweetpotato varieties (white fleshed TIS 87/0087 and orange-fleshed Umuspo 1)]. Results indicate that intercropping reduced growth and yield of eggplant and sweetpotato. Eggplant introduced 4 WBP sweetpotato resulted significantly ($P<0.05$) to a higher fruit yield of eggplant while eggplant introduced 4 WAP sweetpotato gave higher sweetpotato root yield compared to other times of introducing eggplant. Total LERs for both years were above unity for all times of eggplant introduction but the best productivity was obtained from simultaneous planting of eggplant and orange-fleshed Umuspo 1 sweetpotato variety. The highest gross monetary returns and net returns were also obtained from simultaneous planting of eggplant and orange-fleshed Umuspo 1 sweetpotato variety.

Keywords: Intercropping, Introduction, Sweetpotato, Eggplant, and Productivity

Introduction

Generally, resource poor farmers practice inter-cropping due to enormous advantages. It provides additional crop yield per unit area of land use, efficient utilization of crop growth resources and increased productivity, weed and soil erosion control, insurance against crop failure, even distribution of farm labour, reduction in insects and disease infestation compared to mono cropping (Okpara, 2000; Muoneke and Mbah, 2007; Hector, 2010; Eskandari, 2012a). Appropriate time of introduction plays a vital role in crop production, in order to obtain optimum and sustainable yield. In intercropping system, small-scale farmers who adopt this system may decide to plant at the same time or introduce them over time. Muoneke *et al*., (1997) reported that farmers may choose to plant component crops at the same time or stagger them over time. In Nigeria, between 60% and 70% of cropped land is devoted to growing crop mixtures of two or three crops but also up to eight crops simultaneously (Elemo *et al.*, 1990). It is a means of improving the productivity of the traditional farming systems which constitute over 70% of farming population of sub- Saharan Africa (Elemo *et al*., 1988).

Eggplant (*Solanum gilo* L.) is a fruit vegetable that belongs to the Solanaceae family of flowering plants. In Nigeria it has cultural, social and economic importance. It is almost as important as tomatoes in many West African Countries. As a popular salad item, it is cherished as snack. The fruits are eaten fresh, boiled or fried for culinary use. It contains a lot of vitamins and minerals e.g. vitamin B, C, and Fe (Udo *et al*., 2005). It also contains phyto-nutrients such as nasunin and chlorogenic acid (Sabo and Dia, 2009).

Sweetpotato, *Ipomoea batatas* (L.) Lam) is one of the world's most widely grown crops, and farmers in more than 100 countries rely on its ability to produce high yield in marginal soil with little investment (Horton *et al.*, 1989). It is an important root crop widely grown in sub Saharan Africa. It is used for poverty alleviation and food security due to its productivity per unit land area and time which makes

it a crop for the survival of resource poor farmers in Nigeria (NRCRI, 2005). It is a high calorie food and is grown for its roots as a source of carbohydrate, vitamins, minerals, feed and agro industrial raw material (Wolfe. 1992). It is a source of food for man (30%), livestock feed (63%) and other purposes, (7%) (Onunka and Onwunali, 2008). In traditional farming systems, farmers produce several species of crop plants and numerous varieties of each species in mixtures. In South Eastern Nigeria, a typical compound farm contains an array of both annual, biennial and perennial crops like banana/plantain, yam, oil palm tree, maize, cassava, cocoyam, a number of herbaceous spice plants (scent leaf) and vegetables like waterleaf, green, okra, bitter leaf etc (Okafor, 1991). The best time of introduction of crops which will give the optimum yield is important to a farmer. These crop species and varieties can be planted by the farmer at any time and they differ in maturity periods, height, establishment rate, growth, rooting pattern and demand for growth resources. The objective of this study was to determine the effect of time of introduction of eggplant in white and orange-fleshed sweetpotato varieties/eggplant intercrops and the productivity of the system.

Materials and Methods

The field experiment was carried out at the National Root Crops Research Institute, (NRCRI), Umudike experimental fields during the 2014 and 2015 cropping seasons. Umudike is located on longitude 07˚ 33' E and latitude 05˚ 29' N and at an elevation of 122 m above sea level in the rainforest agro-ecological zone of Nigeria. The soils were sandy loam and pH slightly acidic with total annual rainfall of about 2076 mm (Okwuowulu, 2000). The experiment was laid out in factorial arrangement using randomized complete block design (RCBD) and replicated three times following the procedure of Gomez and Gomez (1980) and Steel and Torrie (1980). Each plot size was 6m x 4m ($24m^2$). The experimental field was cleared, disc ploughed, harrowed and ridged in 2014 and 2015 cropping seasons. Two varieties of sweetpotato – Orange fleshed Umuspo 1 and white fleshed TIS 87/0087 and one variety of eggplant (Ngwa - large) were used. Both sweetpotato varieties and eggplant were raised in the nursery before transplanting. There were five different times of introduction including simultaneous planting of eggplant and sweetpotato; eggplant 2 weeks before planting (WBP) and 2 weeks after planting (WAP) sweetpotato varieties; eggplant 4 WBP and 4 WAP sweetpotato varieties. The treatments were 13 and consist of all possible combinations of two sweetpotato varieties and the eggplant time of introduction. The sole crops were established in order to measure productivity and profitability of the systems. Data collected were on eggplant height, number of branches, leaf area index (LAI) and fruit yield (t/ha), sweetpotato vine length, number of branches, LAI and root yield (t/ha). Land equivalent ratio and gross monetary returns (GMR) were used to determine the productivity and profitability of the systems. All the data generated were subjected to analysis of variance using Genstat Discovery edition 1 (Lawes Agricultural Trust, 2003) and means compared using Fisher's least significance difference (LSD) at 5% level of probability.

Results and Discussion

Introduction of eggplant in sweetpotato affected significantly ($P<0.05$) plant height, number of branches, leaf area index (LAI) and fruit yield of the eggplant in 2014 and 2015 (Table 1). Sole eggplants were taller than in the inter-crop while eggplants introduced 2 or 4 weeks before planting sweetpotato were taller, had higher number of branches/plant and higher LAI than when introduced 2 or 4 weeks after planting sweetpotato. Eggplant intercropped with Umuspo 1 had taller plants and higher number of branches than those intercropped with TIS 87/0087 in both years while for LAI of eggplant at 8 and 10 weeks had statistically similar values in the sweetpotato varieties in both years. Yield and yield components of eggplant varied significantly ($P<0.05$) with time of introduction of eggplant in the intercropping system. Simultaneous planting of eggplant and sweetpotato and planting of eggplant 4 and 2 weeks before sweetpotato gave higher fruit yield than planting eggplant 4 weeks after sweetpotato in both years. Introduction of eggplants into sweetpotato variety Umuspo 1 gave higher fruit yield of eggplant compared with introduction of sweetpotato variety TIS 87/0087. Different times of introduction of eggplant in sweetpotato cropping system did not affect the vine length, number of branches and LAI of sweetpotato in 2014 and 2015. Umuspo 1 had higher number of branches and LAI than TIS 87/0087 while the reverse was the case with vine length. This trend was maintained in both years. Interaction effects of cropping system x sweetpotato, and sweetpotato varieties x time of introduction on growth attributes of sweetpotato were not significant in both years. There were reduced root yield (t/ha) of the intercrop compared to sole crop in 2014. The trend was almost similar in 2015 (Table 2).

Productivity of the inter-cropping systems

The total LERs in 2014 and 2015 were all above unity (1) except when eggplant was introduced 4 weeks before planting of sweetpotato (Tables 3 and 4). Introduction of eggplant at 2 and 4 weeks after planting TIS 87/0087 variety of sweetpotato contributed the highest partial LERs (0.82) and (0.90) in 2014 and 2015 respectively while the least LERs (0.29 and 0.44) were from the introduction of eggplant 4 weeks before planting Umuspo 1 variety of sweetpotato for both years. For eggplant, the highest partial LERs (0.63 and 0.71) were from introduction of eggplant 4 weeks before planting Umuspo 1 in both

2014 and 2015 while the least LER (0.31) was from introduction of eggplant 4 WAP TIS 87/0087. Simultaneous planting of eggplant + Umuspo 1 contributed the highest total LER of (1.29) while introduction of eggplant 4 WBP Umuspo 1 had the lowest total LER of 0.92. The highest GMR ₦1,593,600 and net returns (NR) ₦1,251,000 in 2014 and in 2015, (₦2, 038,500) and (₦1,696,500) were obtained from simultaneous planting of eggplant + Umuspo 1 while the lowest GMR (₦810,510.00) and NR (₦468,150) in 2014 were from simultaneous planting of eggplant and TIS 87/0087 and in 2015, the lowest GMR (₦1,385,700) and NR ₦1,043,700 were obtained from introduction of eggplant 2 WBP TIS 87/0087.

Introduction of eggplant into Sweetpotato at the times assessed in this study reduced in most cases the growth and yield of the component crops. This reduction could be as a result of interspecific competition for light, space, water and nutrient. Arubalueze, (2016) who worked on cassava, maize and cowpea intercrop reported similar reduction. Planting of eggplant 2 and 4 weeks before planting sweetpotato increased eggplant growth and fruit yield compared to introduction of eggplant 2 and 4 weeks after planting sweetpotato. Planting eggplant before sweetpotato allowed them to germinate and become established before sweetpotato and thus they were able to compete with the main crop for nutrients leading to better fruit yield. This finding was consistent with the report of Muoneke and Mbah, (2007), and Adipala (2002). Conversely when eggplants were planted simultaneously or at 2 and 4 weeks after sweetpotato, growth and fruit yield of eggplants were reduced as evidenced in this study. Similar results have been reported for maize/cowpea (Ofori and Stern, 1987a), okra/maize (Ijoyah and Dzer, 2012), and soybean/cassava intercropping systems (Tamiru, 2013). However planting eggplant simultaneously and after sweetpotato increased root yield in the latter. It is probable that rapid establishment, early growth and spread growth habit of sweetpotato gave it an advantage over eggplant in interspecific competition with eggplants.

The total LERs were all above unity (1) for most treatments in both years. This indicates yield advantages depicting a higher productivity per unit area due to intercropping compared to sole crop. The highest yield advantage was from the simultaneous planting of eggplant and Umuspo 1 sweetpotato in 2014 and 2015 cropping seasons. The results of this study were in line with the study of Okoli *et al.*, (1996) on cassava/cowpea intercrop. The partial LERs of the crops indicate yield advantages contributed by each crop and showed that sweetpotato contributed more than eggplant in both years of study. GMR and net returns in the intercrop had higher values than sole crops. The highest GMR of ₦1,593,600 and ₦2,038,500 and net returns of ₦1,251,000 and ₦1,696,500 were obtained from simultaneous planting of eggplant and Umuspo 1 variety of sweetpotato in 2014 and 2015 cropping seasons. Arubalueze, (2016) also obtained higher GMR from intercrop of cassava, maize and cowpea. This shows that farmers will gain more GMR and net returns by planting eggplant and sweetpotato simultaneously.

Conclusion

Time of introduction of eggplant in sweetpotato/ eggplant inter-cropping system showed that simultaneous planting of sweetpotato and eggplant gave the best yield, higher LER, GMR and NR. The study recommends that farmers should plant sweetpotato and eggplant same time in order to optimize yield and make more profit.

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Table 1: Effect of cropping system and time of introduction eggplant on growth and yield sweetpotato/eggplant in 2014 and 2015 cropping seasons

	Plant height/plant (WAP)				Leaf area index/plant (WAP)				No. of branches/plant (WAP)				Fruit yield (t/ha)	
	2014		2015		2014		2015		2014		2015		2014	2015
	8	10	8	10	8	10	8	10	8	10	8	10	At harvest	
Cropping system														
Sole	68.40	134.10	73.70	140.40	0.21	0.49	0.26	0.51	9.67	12.50	9.58	14.25	5.85	9.35
Intercrop	46.60	89.50	51.70	96.50	0.12	0.25	0.15	0.26	4.97	7.75	4.70	8.22	2.53	4.77
LSD (0.05)	12.38	16.51	13.35	16.81	0.04	0.09	0.06	0.10	2.59	2.42	2.69	2.83	0.85	1.63
Time of introduction														
Eggplant 2 WAP Sweetpotato	40.20	85.00	44.40	86.60	0.11	0.18	0.12	0.19	3.58	5.96	3.54	6.38	2.11	4.56
Eggplant 2 WBP Sweetpotato	49.70	94.60	60.00	108.60	0.14	0.30	0.18	0.32	5.58	8.46	5.21	8.88	2.62	5.23
Eggplant 4 WAP Sweetpotato	36.40	77.70	38.80	86.20	0.07	0.19	0.08	0.19	3.08	6.04	2.92	6.50	2.02	3.18
Eggplant 4 WBP Sweetpotato	56.40	100.00	62.00	107.30	0.15	0.32	0.21	0.32	7.29	10.00	6.71	10.25	3.17	6.19
Simultaneous planting	50.20	89.50	53.40	93.90	0.14	0.26	0.15	0.27	5.33	8.29	5.12	9.08	2.74	4.69
LSD (0.05)	1.57	6.77	2.89	0.53	0.03	0.08	0.03	0.06	0.23	0.04	0.62	0.07	0.05	1.10
Sweetpotato varieties														
Umuspo 1	51.60	97.50	55.70	105.20	0.14	0.25	0.16	0.24	5.97	8.78	5.88	9.28	2.85	5.36
TIS 87/0087	41.50	81.40	47.80	87.80	0.11	0.26	0.14	0.28	3.98	6.72	3.52	7.15	2.21	4.18
LSD (0.05)	6.78	8.24	5.85	81.15	NS	NS	NS	NS	1.38	1.31	1.35	1.58	0.48	0.92
Cropping system x sweetpotato varieties														
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sweetpotato varieties x eggplant population														
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of cropping system and time of introduction eggplant on growth and yield sweetpotato/eggplant in 2014 and 2015 cropping seasons

	Vine length/plant cm (WAP)				Leaf area index/plant (WAP)				No. of branches/plant (WAP)				Root yield (t/ha)	
	2014		2015		2014		2015		2014		2015		2014	2015
	8	10	8	10	8	10	8	10	8	10	8	10	At harvest	
Cropping system														
Sole	167.00	230.00	170.00	223.00	0.65	0.95	0.63	0.85	4.88	6.08	5.12	5.79	18.86	24.18
Intercrop	122.00	156.00	128.00	156.00	0.44	0.55	0.43	0.58	3.83	4.66	3.75	4.41	15.05	15.52
LSD (0.05)	NS	NS	NS	NS	NS	0.37	NS	NS	1.01	1.13	1.02	1.12	0.62	4.05
Time of introduction														
Eggplant 2 WAP Sweetpotato	121.00	144.00	122.00	149.00	0.47	0.57	0.44	0.58	3.92	4.42	4.20	4.38	12.91	17.83
Eggplant 2 WBP Sweetpotato	98.00	130.00	116.00	150.00	0.41	0.54	0.43	0.61	3.50	4.71	3.78	4.29	10.81	12.11
Eggplant 4 WAP Sweetpotato	151.00	197.00	155.00	186.00	0.48	0.58	0.47	0.62	4.42	4.96	4.40	4.75	14.08	19.55
Eggplant 4 WBP Sweetpotato	96.00	127.00	96.00	119.00	0.31	0.40	0.30	0.40	3.38	4.42	3.60	3.92	7.04	10.82
Simultaneous planting	145.00	180.00	150.00	179.00	0.52	0.07	0.51	0.68	3.92	4.79	3.82	4.71	13.18	17.70
LSD (0.05)	NS	NS	NS	NS	NS	0NS	NS	NS	NS	NS	NS	NS	0.60	0.70
Sweetpotato varieties														
Umuspo 1	66.60	91.80	69.10	93.80	0.69	0.96	0.69	0.97	4.88	5.97	4.83	5.65	16.94	19.16
TIS 87/0087	192.00	244.70	200.50	241.40	0.26	0.28	0.24	0.28	3.12	3.82	3.12	3.63	9.39	14.71
LSD (0.05)	24.47	32.04	24.89	29.98	0.10	0.17	0.10	0.14	0.50	0.50	0.52	0.55	3.11	NS
Cropping system x sweetpotato varieties														
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sweetpotato varieties x eggplant population														
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Effect of time of induction of eggplant in sweetpotato/eggplant intercropping system on land equivalent ratio (LER) and gross monetary returns (GMR) and net returns (NR) in 2014

Cropping systems	LER			Gross monetary returns (GMR)			N et returns (NR)
	Partial		Total	Partial		Total (₦)	(₦)
	Sweetpotato	Egg plant		Sweetpotato	Egg plant		Sweetpotato and eggplant
Sole Umuspo 1				1,519,800		1,519,800	₦1,198,800
Sole TIS 87/0087				750,600		750,600	₦429,000
Sole Eggplant					877,500	877,500	₦535,500
Simultaneous Eggplant + Umuspo 1	0.71	0.58	1.29	1,083,600	510,000	1,593,600	₦1,251,000
Simultaneous Eggplant +TIS87/0087	0.67	0.35	1.02	499,200	310,950	810,150	₦468,150
Eggplant 2 WAP Umuspo 1	0.69	0.37	1.06	902,400	324,000	1,226,400	₦884,400
Eggplant 2 WBP Umuspo 1	0.54	0.48	1.02	752,400	420,000	1,172,400	₦830,400
Eggplant 4 WAP Umuspo 1	0.76	0.38	1.14	1,158,000	132,000	1,290,000	₦948,000
Eggplant 4 WBP Umuspo 1	0.29	0.63	0.92	438,600	554,550	993,150	₦651,150
Eggplant 2 WAP TIS 87/ 0087	0.82	0.35	1.17	616,200	308,550	924,750	₦582,750
Eggplant 2 WBP TIS 87/0087	0.74	0.42	1.15	552,600	367,050	919,650	₦577,650
Eggplant 4 WAP TIS 87/ 0087	0.77	0.31	1.08	575,400	276,000	851,400	₦507,400
Eggplant 4WBP TIS 87/ 0087	0.55	0.63	1.18	412,800	554,550	967,350	₦625,350

NRCRI Market price in 2014 sweetpotato 1kg @ ₦60 and egg plant 1kg @ ₦15

Table 4: Effect of time of induction of eggplant in sweetpotato/eggplant intercropping system on land equivalent ratio (LER) and gross monetary returns (GMR) and net returns (NR) in 2015

Cropping systems	LER			GMR			Net returns (NR)
	Partial		Total	Partial		Total (₦)	(₦)
	Sweet potato	Egg plant		Sweet potato	Egg plant		Sweetpotato and eggplant
Sole Umuspo 1				1,680,000		1,680,000	₦1,338,00
Sole TIS 87/0087				1,159,800		1,159,800	₦817,800
Sole Eggplant					1,402,500	1,402,500	₦1,060,500
Simultaneous Eggplant + Umuspo 1	0.69	0.62	1.32	1,173,000	865,500	2,038,500	₦1,696,500
Simultaneous Eggplant +TIS87/0087	0.82	0.39	1.20	946,000	541,500	1,487,500	₦1,145,500
Eggplant 2 WAP Umuspo 1	0.73	0.54	1.27	1,233,000	754,500	1,987,500	₦1,645,500
Eggplant 2 WBP Umuspo 1	0.46	0.61	1.17	780,000	855,000	1,635,000	₦1,293,000
Eggplant 4 WAP Umuspo 1	0.77	0.39	1.16	1,299,600	544,500	1,844,100	₦1,502,800
Eggplant 4 WBP Umuspo 1	0.44	0.71	1.15	733,200	999,000	1,723,200	₦1,381,200
Eggplant 2 WAP TIS 87/ 0087	0.78	0.44	1.22	906,000	613,500	1,519,500	₦1,177,500
Eggplant 2 WBP TIS 87/0087	0.59	0.51	1.10	673,200	712,500	1,385,700	₦1,043,700
Eggplant 4 WAP TIS 87/ 0087	0.90	0.30	1.20	1,046,400	411,000	1,457,400	₦1,115,400
Eggplant 4WBP TIS 87/ 0087	0.49	0.61	1.10	566,000	856,500	1,422,500	₦1,080,500

NRCRI Market price in 2014 sweetpotato 1kg @ ₦60 and garden egg 1kg @ ₦150