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Original Research Article

Effect of intercropping some crop species with orange flesh sweet potato on the performance of orange flesh sweet potato varieties in Makurdi

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[1]*Idoko, J.A, [1]Iorlamen, T. and [1]Offordile, A.E.

Department of Crop Production, University of Agriculture, P.M.B.2373, Makurdi, Nigeria

*Corresponding Author E-mail: idokokole2010@yahoo.com

Tel.: +23407034920707

A field experiment was conducted during the growing of season of 2013/2014 and 2014/2015 at the Teaching and Research Farm of the Federal University of Agriculture, Makurdi, Benue State, located in the Southern Guinea Savanna of Nigeria. The objective of the experiment was to identify the effect of intercropping some crop species with orange fleshed sweet potato varieties and to know which crop will be most suitable under intercropping with the orange fleshed sweet potato varieties in Makurdi. The experiment was a 2×2 ×3 split-split plot laid out in randomized complete block design with three replications. The main plot treatments were two cropping systems [sole cropping (sweet potato, cassava, maize, soybean) and intercropping (sweet potato + cassava, sweet potato + maize and sweet potato + soybean)]. The sub plot treatments were made up of two sweet potato varieties (NARSP/05/022 and CIP 440 293). The sub-sub plot treatments comprised of three (3) crop species (cassava, maize and soybean). Each sub-sub plot consisted of 5 ridges spaced 1m apart and 3m long. Sole CIP gave higher vine length of sweet potato than sole NARSP while sole NARSP gave higher number of leaves, number of salable roots, and weight and fresh fodder weight of sweet potato than sole CIP. Intercropping with NARSP also gave higher number of leaves, number of salable roots, and weight and fresh fodder weight of sweet potato than intercropping with CIP. Sole cropping gave higher plant height and stem girth of cassava while intercropping gave higher root length and weight of salable roots of cassava. Intercropping cassava with CIP generally gave higher growth parameters of cassava while intercropping cassava with NARSP gave higher yield and yield parameters of cassava. Parameters evaluated for maize component showed that sole cropping gave higher number of rows/cob, number of kernels per row and grain yield than intercropping. Intercropping maize with CIP proved to be more productive than intercropping with NARSP. Higher growth and yield parameters of soybean were obtained under sole environments than intercropped. Intercropping with NARSP gave generally higher plant height of soybean while intercropping with CIP gave higher yield and yield parameters. Combinations with cassava gave higher values of LER and LEC than the other combinations. CR values of cassava were consistently higher than those of all intercrop combinations while sweet potato produced the lowest CR values.

Key words: Intercropping, sweet potato, maize, soybean, cassava

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is a versatile crop grown for its tubers (Rethinam, 2001). It is an excellent source of vitamin A, if the flesh colour is orange. The strategy of increasing orange flesh sweet potato consumption helps to alleviate vitamin A deficiency (Anderson et al*.,* 2007). It is also rich in vitamin C, vitamin B6, riboflavin, copper, pantothenic acid and folic acid (Woolfe, 1992). The roots and leaves are sources of carbohydrates, proteins and minerals. They are eaten as a vegetable after boiling, baking, or frying and sometimes sliced and sun-dried to produce chips, which are ground into sweet potato flour (Chukwu, 1999). In the semi-arid zone, sweet potato flour is popularly used for sweetening local foods while in the urban markets of the humid south, sweet potato fried chips are produced and marketed (Tewe et al*.,* 2003).

Cassava (*Manihot esculenta* Crantz) is a dicotyledonous plant, belonging to the family *Euphorbiaceae* (Alves, 2002). The crop is a major part of the diet for nearly a billion people in approximately 105 countries mostly in sub-Saharan Africa, Asia, the pacific and South America (FAO, 2008).Cassava roots and leaves are prepared as food by different methods in different parts of Africa. The roots are eaten raw, roasted or boiled. The leaves have a similar nutritive value as other dark green leaves and are valuable sources of vitamins A, C, iron, calcium and protein (Nweke et al., 2002). Cassava flour can practically and technically replace wheat flour in processing meat, sweets, cookies, meat pies, iced creams, bread, etc. In Brazil, every wheat flour product contains at least five percent (5%) cassava flour (Bokanga, 1995). It is also reported that a 15 percent substitution of cassava flour for wheat flour saved Nigeria close to US$ 15 million a year in foreign exchange (FAO, 2005).

Maize (*Zea mays* L) is one of the major cereal crops grown in the humid tropics and Sub-Saharan Africa. It is a versatile crop and ranks third following wheat and rice in world production as reported by Food and Agriculture Organization (FAO, 2002). It is produced extensively in Nigeria, where it is consumed roasted, baked, fried, pounded or fermented (Agbato, 2003). In advanced countries, it is an important source of many industrial products such as corn sugar, corn oil, corn flour, starch, syrup, brewer's grit and alcohol (Dutt, 2005). Maize is a major component of livestock feed and it is palatable to poultry, cattle and pigs as it supplies them energy (Iken et al., 2001).

Soybean (*Glycine max* L.) is an important raw material for food and oil processing industries and it is important in improving soil fertility due to its nitrogen fixing ability (Tesfaye et al., 2010). It is also considered as a strategic crop in fighting the worlds' food shortage and malnutrition problems, and most food aids to displaced and malnourished people are fortified with soybean (Thoenes, 2004). It contains 40-42% protein, 18-22% oil comprising of 85% unsaturated fatty acids and 15% saturated fatty acids, 28% carbohydrate and good amount of other nutrients like phosphorus, calcium, vitamins and iron etc. (Antalina, 1999).

Cassava, maize and soybeans are important crops in the cropping systems of Nigeria and the Southern Guinea Savanna in particular. The option to combine any of those crops with Orange flesh sweet potato in intercropping must be guided by the relative competitiveness or complementarity of species especially when Orange flesh sweet potato is the principal crop. When the famer wants as much as possible the potential pure stand yield of sweet potato in addition to a reasonable output from the other component crop species.

The relative competitiveness or complementarity of the associated crop species plays the determinant role in realizing the goal of the farmer. The least competitive in this case becomes the most compatible species to combine with Orange flesh sweet potato in intercropping system.

This assures maximum relative yield contribution from the Orange flesh sweet potato components. The success of any intercropping system depend on the proper selection of the crop species where competition between them for light, space, moisture and nutrients is minimized (Fukai and Trenbath, 1993). Normally, complimentary use of resources occurs when the component species of an intercrop use quantitatively different times (Tofinga et al., 1993).

In ecological terms, resource complementarity minimizes the niche overlap and the competition between crop species and permit crops to capture a greater range and quantity of resources than the sole crops. This differ in competitive ability in time and species essential for n efficient intercropping system.

The purpose of this investigation was to analyze the interspecies compatibility and the production potentials of some crop species in intercropping with Orange flesh sweet potato in Southern Guinea Savanna of Nigeria.

MATERIALS AND METHODS

Experimental Location

A field experiment was conducted during the growing season of 2015 and 2016 at the Teaching and Research farm of the Federal University of Agriculture, Makurdi (Latitude 07°45′ - 07° 50′ N, Longtitude 08° 45′- 08° 50′ E, elevation 98 meters above sea level) in Benue State, located in Southern Guinea Savannah of Nigeria (Kowal and Knabe, 1972).

Soil Sampling and Analysis

Eight core samples collected from 0-30cm depth before land preparation were bulked into a composite sample, air-dried and ground. The samples were sieved through 2mm and 0.05mm screens for the determination of the physical and chemical properties of the soil (Table 1) before planting.

Experimental Design and Treatment

The experiment was a 2 x 2 x 3 split-split plot laid out in randomized complete block design with three replications. The main plot treatments were two cropping systems [sole cropping (sweet potato, cassava, maize, soybean) and

Table 1. Physical and Chemical Properties of the Surface Soil (0 to 30cm) at the Experimental Site in Makurdi in 2015 and 2016

Parameter	2015	2016
Sand (%)	71	74
Silt (%)	20	18
Clay (%)	9	8
Textual class	Sandy Loam	Sandy Loam
PH (H_2O)	6.45	6.30
Organic Carbon (g kg^{-1})	9.02	8.60
Total N (g kg^{-1})	0.76	8.95
Available P (Cmol kg^{-1} soil)	6.88	14.50
Ca^{2+} (Cmol kg^{-1} soil)	5.42	4.80
Mg^{2+} (Cmol kg^{-1} soil)	2.66	2.05
K^{+} (Cmol kg^{-1} soil)	0.20	0.16
Na^{2+} (Cmol kg^{-1} soil)	0.75	0.82
ECEC (Cmol kg^{-1} soil)	7.65	6.50

intercropping (sweet potato + cassava, sweet potato + maize and sweet potato + soybean)].The sub plot treatments were made up of two sweet potato varieties (NARSP/05/022 and CIP 440 293). The sub-sub plot treatments comprised of three (3) crop species (cassava, maize and soybean). Each sub-sub plot consisted of 5 ridges spaced 1m apart and 3m long (5 x 3= 15m^2).

Source of Planting Material

The orange flesh sweet potato varieties were obtained from National Root Crops Research Institute (NRCRI) Umudike. Cassava and soybean were obtained from Teaching and Research Farm of the University of Agriculture, Makurdi while maize was obtained from Institute of Agricultural research (IAR), Ahmadu Bello University, Zaria, Kaduna State.

Agronomic Practices

Sweet potato vines and cassava stem cuttings measuring 30cm in length were planted by the crest of each ridge. Sweet potato was spaced at an intra-row spacing of 30cm (33,000 plants/ha) while cassava was spaced at 50cm intra-row (20,000 plants/ha). Three maize seeds were planted on the side of the ridge at an intra-row spacing of 50cm and thinned to two (2) plants per stand (40,000 plants/ha). Soybean was planted using drilling method and thinned to an intra-row spacing of 5cm to obtain a population density of approximately 200,000 plants/ha. All crops were planted on the same day (21st July, 2013 and 27th July, 2014). Thinning for maize and soybean was done at 10 days after planting. Intercropping had a 1:1(sweet potato:cassava, sweet potato:maize, sweet potato: soybean) row proportion. 200kg NPK 15:15:15 was applied at land preparation (BNARDA, 2003) by broadcasting before the splitting of the ridges to supply 30kg N + 30kg P_2O_5 + 30kg K_2O. Also, 200 kg NPK 15:15:15 was applied at 3 WAP by spot application. The maize plants were top dressed with urea at 100kg/ha at 6 WAP. Two manual weeding were done at 3 and 6 WAP using traditional hoes. Earthening up was done at 8 WAP. All crops were harvested from the net plot (3m x 3m) and this represented the yield per plot. This was done as each component crop reached physiological maturity.

Data Collection

Parameters measured for sweet potato component included vine length at 4, 8 and 12 weeks after planting (WAP), number of leaves at 4, 8 and 12 WAP, number of salable roots weight of salable roots and fresh fodder weight. The characters measured for the cassava component were plant height at 4, 8 and 12 WAP, stem girth, root length and weight of salable roots. Those measured for maize were plant height at 4, 8 and 12 WAP, number of rows per cob, number of kernels per row and grain yield while those measured for soybean were plant height at 4, 8 and 12 WAP, number of pods per plant, number of seeds per pod and grain yield.

Assessment of Intercrop Productivity

Productivity of the various sweet potato varieties intercropped with various crop species in this work was evaluated using the following tools:

a. Land equivalent ratio (LER) as described by Ofori and Stern (1987).

b. Land equivalent coefficient (LEC) as illustrated by Adetiloye et al. (1983).

c. Competitive ratio (CR) indicates the degree with which one crop competes with the intercrop. This was calculated using the formula proposed by Willey et al. (1980).

Data Analysis

Year effect was not significant ($P \leq 0.05$), so data for both

Table 2. Effect of Intercropping Sweet Potato Varieties with some Crop Species on the Growth and Yield of Sweet Potato in Makurdi

Treatment	Vine Length (cm)			Number of Leaves			Number of Salable Roots	Weight of Salable Roots (t/ha)	Fresh Fodder Weight (t/ha)
	4 WAP	8 WAP	12 WAP	4 WAP	8 WAP	12 WAP			
Sole CIP	29.96	183.06	274.00	16.65	189.83	270.00	32.70	5.60	3.10
Sole NARSP	18.59	125.76	219.90	18.51	244.25	380.70	37.00	6.66	14.70
Mean for Sole Cropping	**24.28**	**154.41**	**246.95**	**17.58**	**217.04**	**325.35**	**34.85**	**6.13**	**8.90**
CIP + Cassava	20.38	171.20	251.00	15.33	155.75	238.70	14.30	2.18	1.60
CIP + Maize	20.90	190.93	259.40	15.98	144.93	242.50	7.30	0.70	0.90
CIP + Soybean	19.21	134.08	253.10	15.03	162.17	234.80	5.00	0.30	0.30
Mean for Intercropping with CIP	**20.16**	**165.40**	**254.50**	**15.45**	**154.28**	**238.67**	**8.57**	**1.06**	**0.93**
NARSP + Cassava	36.90	129.92	220.00	16.33	234.20	368.30	22.30	3.98	20.10
NARSP + Maize	34.80	145.13	180.90	16.48	234.75	346.30	17.00	2.48	21.70
NARSP + Soybean	32.13	139.90	222.20	16.77	226.46	336.30	14.70	1.98	17.50
Mean for Intercropping with NARSP	**34.61**	**138.32**	**207.70**	**16.53**	**231.80**	**350.30**	**18.00**	**2.81**	**19.77**
Mean for Intercropping	**27.39**	**151.86**	**231.10**	**15.99**	**193.04**	**294.49**	**13.29**	**1.94**	**10.35**
Grand Mean	26.61	152.50	235.10	16.39	199.04	302.20	18.80	2.98	9.99
FLSD (0.05)	3.03	1.98	22.79	0.67	5.15	20.93	16.22	2.86	10.61
CV (%)	6.60	0.70	5.60	2.40	1.50	4.00	49.90	55.30	61.30
Unpaired t-test (Sole vs Intercrop)	-29.82*	15.62*	101.59*	6.84*	67.71*	230.95*	167.00*	18.81*	-12.18*
Unpaired t-test (CIP vs NARSP)	-74.52*	130.09*	286.50*	-11.77*	-949.42*	-836.73*	-16.25*	-30.16*	-286.20*

Key: WAP: Weeks after planting

years were pooled together and analyzed. Standard procedures were followed in collecting all data and analysis was done using GENSTAT statistical software. Whenever differences between treatment means were significant, means were separated by Fishers Least Significant Difference at 5% level of probability.

RESULTS

Sweet Potato Component

Vine Length

The vine length of sweet potato varieties as influenced by intercropping with cassava, maize and cowpea was significant (P< 0.05). Data presented in Table 2 showed that at 4WAP, NARSP intercropped with cassava produced the highest vine length but this was not significantly higher than that produced by NRSP + maize intercropping. Generally, intercrops with NARSP gave higher vine lengths than sole cropping which in turn gave significantly higher vine length than intercrops with CIP. At 8 and 12 WAP, a dissimilar trend was observed were intercropping with CIP produced significantly higher vine lengths than sole cropping and intercropping with NARSP respectively. Regardless of the week evaluated, sole CIP gave higher vine length than sole NARSP. The mean values obtained from comparison between sole cropping and intercropping were erratic (Table 2).

Number of Leaves

Significant difference (P< 0.05) was observed on the number of leaves of sweet potato varieties as influenced by intercropping with cassava, maize and cowpea. At 4 WAP, NARSP + soybean intercropping increased the number of leaves of sweet potatoes more than any other treatment and the difference was significant. Sole cropping gave significantly higher number of leaves than intercropping. Intercropping with NARSP gave higher number of leaves than intercropping with CIP (Table 2). At 8 and 12 WAP, sole NARSP produced the highest number of leaves of sweet potatoes and the difference was significant. On a general note, sole cropping gave significantly higher number of leaves than intercropping. However, intercropping with NARSP gave significantly higher number of leaves than sole cropping and intercropping with CIP

Table 3. Growth and Yield of Cassava as Influenced by Intercropping with Sweet Potato Varieties in Makurdi

Treatment	Plant Height (cm)			Stem Girth (mm)	Root Length (cm)	Weight of Salable Roots (t/ha)
	8 WAP	12 WAP	14 WAP			
Sole Cassava	64.20	115.70	219.13	47.20	39.53	44.10
Cassava + CIP	57.17	119.30	210.83	48.63	40.50	38.40
Cassava + NARSP	61.17	89.20	195.00	43.37	45.20	55.10
Grand Mean	60.84	108.10	208.32	46.40	41.74	45.90
FLSD (0.05)	0.96	11.83	1.19	0.98	3.82	11.35
CV (%)	0.80	5.50	0.30	0.90	4.00	12.40

Key: WAP: Weeks after planting

respectively (Table 2).

Number of Salable Roots

The effect of intercropping sweet potato varieties with cassava, maize and soybean on the number of salable roots of sweet potato was significant ($P < 0.05$). NARSP planted as sole produced the highest number of salable roots at harvest but this was not significantly higher than that produced by sole CIP and NARSP + cassava intercropping (Table 2). Sole cropping gave higher number of salable roots than intercropping. The sweet potato variety 'NARSP' produced higher number of salable roots than CIP regardless of the cropping system use (Table 2).

Weight of Salable Roots

The weight of salable roots of sweet potato varieties as influenced by intercropping with cassava, maize and soybean was significant ($P < 0.05$). Sole cropping significantly increased the root weight of sweet potato varieties over intercropping. Irrespective of the cropping system and the crop specie intercropped with, NARSP gave higher root weight than CIP (Table 2).

Fresh Fodder Weight

The fresh fodder weight of sweet potato varieties as influenced by intercropping with cassava, maize and soybean was significant ($P < 0.05$). Data presented in Table 2 show that intercropping gave significantly higher fresh fodder weight than sole cropping. NARSP gave higher fresh fodder weight of sweet potato than CIP regardless of the cropping system and the crop specie intercropped with.

Cassava Component

Plant Height

The plant height of cassava at 8, 12 and 14 WAP as influenced by intercropping with some sweet potato varieties was significant ($P < 0.05$). At 8 WAP, sole cassava gave significantly higher plant height than all the other treatments but this was not so at 12 WAP where intercropping cassava with CIP produced the highest plant height. Sole cassava also produced the highest plant height at 14 WAP and this was significantly higher than that produced by cassava + CIP and cassava + NARSP respectively (Table 3).

Stem Girth

The effect of intercropping cassava with sweet potato varieties was significant on the stem girth of cassava ($P < 0.05$). Cassava intercropped with CIP produced the highest stem girth at harvest and this was significantly higher than that produced by sole cropping and cassava + NARSP intercropping respectively (Table 3).

Root Length

The root length of cassava as influenced by intercropping with sweet potato varieties was significant ($p < 0.05$). Data presented in Table 3 revealed that cassava + NARSP intercropping produced the highest root length and the difference was significant. The root length produced by cassava + CIP intercropping and sole cassava was statistically at par.

Weight of Salable Roots

The effect of intercropping cassava with some sweet potato varieties on the weight of salable roots of cassava was significant ($P \geq 0.05$). Cassava intercropped with CIP produced the highest weight of salable roots per plant but this was only significantly higher than that produced by cassava + NARSP intercropping (Table 3).

Maize Component

Plant Height (cm)

The plant height of maize as influenced by intercropping with sweet potato varieties at 4, 8 and 12 WAP was significant ($P < 0.05$). At 4 WAP, Maize + NARSP gave the highest plant height of maize than sole cropping and maize

Table 4. Growth and Yield of Maize As Influenced by Inter cropping with Sweet potato

Treatment	Plant Height (cm)			Number of Rows/Cob	Number of Kernels/Row	Grain Yield (t/ha)
	4 WAP	8 WAP	12 WAP			
Sole Maize	16.42	85.53	139.23	15.81	35.64	1.78
Maize + CIP	15.74	76.03	154.73	15.38	33.92	1.61
Maize + NARSP	18.78	76.90	153.8	14.44	33.64	1.09
Grand Mean	16.98	79.49	149.26	15.21	34.40	1.51
FLSD (0.05)	0.65	1.22	1.28	0.47	0.66	0.16
CV (%)	1.90	0.80	0.40	1.60	1.00	5.40

Key: WAP: Weeks after planting

Table 5. Growth and Yield of Soybean As Influenced by Inter cropping with Sweet potato

Treatment	Plant Height (cm)			Number of Pods/Plant	Number of Seeds/Pod	Grain Yield (t/ha)
	4 WAP	8 WAP	12 WAP			
Sole Soybean	18.39	62.33	68.07	73.80	2.33	1.07
Soybean + CIP	18.88	57.63	64.63	76.67	2.33	0.99
Soybean + NARSP	19.91	64.90	66.93	69.77	2.13	0.69
Grand Mean	19.06	61.62	66.54	73.41	2.27	0.92
F-LSD (0.05)	0.08	0.81	0.68	0.68	NS	0.09
CV (%)	0.20	0.70	0.50	0.50	6.20	5.10

Key: WAP: Weeks after planting

+ CIP intercropping but this was not so at 8 WAP where sole cropping gave significantly higher plant height than maize + CIP and maize + NARSP intercropping. At 12 WAP, the plant height produced by maize + CIP and maize + NARSP intercropping was statistically at par and significantly higher than that produced by maize planted as sole (Table 4).

Number of Rows per Plant

The effect of intercropping maize with some sweet potato varieties on the number of rows per cob of maize was significant ($P \geq 0.05$). Sole maize produced the highest number of rows per cob of maize but this was only significantly higher than that produced by maize + NARSP intercropping (Table 4).

Number of Kernels per Row

The number of kernels per row of maize as influenced by intercropping with sweet potato was significant ($P < 0.05$). Maize planted as sole produced the highest number of kernels per row and this was significantly higher than that produced by maize + CIP and maize + NARSP intercropping which were statistically at par (Table 4).

Grain Yield

Significant ($P < 0.05$) difference was observed on the grain yield of maize as influenced by intercropping with sweet potato varieties. Data presented in Table 4 show that sole maize produced significantly higher grain yield than maize + CIP intercropping which in turn produced significantly higher grain yield than maize + NARSP intercropping.

Soybean Component

Plant Height (cm)

The plant height of soybean at 4, 8 and 12 WAP as influenced by intercropping with some sweet potato varieties was significant ($P < 0.05$). At 4 and 8 WAP, soybean + NARSP intercropping produced significantly higher plant height of soybean than all the treatments. However, sole soybean gave the highest plant height at 12 WAP and the difference was significant (Table 5).

Number of Pods per Plant

The effect of intercropping soybean with some sweet potato varieties on the number of pods per plant of soybean was significant ($P < 0.05$). Soybean intercropped with CIP produced significantly higher number of pods per plant than sole soybean and soybean + NARSP intercropping respectively (Table 5).

Number of Seeds per Pod

The number of seeds per plant of soybean as influenced by intercropping with some sweet potato varieties was not

Table 6. Land Equivalent Ratio (LER), Land equivalent Coefficient (LEC) and Competitive Ratio (CR) of Intercropped Sweet with Cassava, Maize and Soybean in Makurdi

Treatment	LER	LEC	CR (Sweet Potato)	CR (Cassava)	CR (Maize)	CR (Soybean)
CIP + Cassava	1.66	0.51	0.33	3.20	2.30	2.40
CIP + Maize	1.03	0.12	0.14	10.40	7.30	7.60
CIP + Soybean	0.99	0.40	0.07	29.40	22.30	22.70
NARSP + Cassava	1.46	0.51	0.67	1.50	1.10	1.10
NARSP + Maize	1.00	0.24	0.62	2.30	1.60	1.70
NARSP + Soybean	0.93	0.19	0.44	3.80	2.80	2.80
Grand Mean	1.18	0.33	0.38	8.50	6.20	6.40
FLSD (0.05)	0.31	0.51	0.25	13.38	92.40	10.43

Key: LER: Land Equivalent Ratio; LEC: Land Equivalent Coefficient; CV: Competitive Ratio

significant ($P \geq 0.05$).

Grain Yield

The effect of intercropping soybean with some sweet potato varieties on the grain yield of soybean was significant ($P < 0.05$). Sole soybean produced the highest grain yield of soybean and this was significantly higher than that produced by soybean + CIP intercropping which in turn gave significantly higher grain yield than soybean + NARSP intercropping (Table 5).

Land Equivalent Ratio (LER), Land equivalent Coefficient (LEC) and Competitive Ratio (CR) of Intercropped Sweet with Cassava, Maize and Soybean in Makurdi

All intercrop combinations had LER figures above 1.0 except CIP + soybean, NARSP + maize and NARSP + soybean. Apart from CIP + maize, NARSP + maize and NARSP + soybean, LEC values for all other intercrop combinations were above 0.25 (Table 6). CR values of cassava were consistently higher than those of all intercrop combinations while sweet potato produced the lowest CR values. Combinations with cassava gave higher values of LER and LEC than the other combinations (Table 6).

DISCUSSION

Sweet Potato Component

The increase in plant growth parameters measured (vine length and number of leaves) over time as observed in this study were expected. Somda and Kays (1990) reported that during growth of sweet potato plant, substantial morphological changes occur and these influence the accumulation or distribution of the total dry matter among the major plant organs.

The higher fodder weight, number of salable roots and weight of salable roots of NARSP in sole environments over CIP was also expected as the genetic composition of these materials were probably different. Choudhary et al. (1999) and Muktar et al. (2010) had observed wide variation among sweet potato varieties in their study and attributed such differences to genetic composition. Sole sweet potato produced higher yields than intercropping (number of salable roots and weight of salable roots). This might be due to interplant competition for natural growth resources such as soil nutrients, water, etc. by both intercrop components. It is known that competitive reactions reduce yields in intercropped crop species as compared to mono cropping (Egbe, 2007).

Mean values produced by fodder weight, number of salable roots and weight of salable roots showed that intercropping cassava, maize and soybean with NARSP produced better results than with CIP. This could imply that this variety (NARSP) was more suitable for intercropping in Makurdi environment. Furthermore, better results produced by NARSP regardless of the cropping system suggest that NARSP was genetically modified for higher yield than CIP. Intercropping either of the sweet potato varieties with cassava produced better yield. The suitability of the crops and reduced underground competition for resources could be responsible for this result.

Cassava Component

Sole cropping gave higher plant height and stem girth than intercropping. Sharing of growth resources among components crops under intercropping can limit growth and accumulation of dry matter compared to sole cropping where competition exists (Dasbak and Asiegbu, 2009). Adeniyan et al. (2011) made a similar observation when most of the cassava cultivars evaluated showed degree of yield decrease under cassava-maize intercropping system compared to sole cowpea. However, yield parameters (root length and salable root weight) indicated that intercropping performed better.

The presence of sweet potato did not depress cassava yield probably because the sweet potato conserved soil moisture and reduced weed growth. IITA (1975), Fagbamiye (1977) and Ikeorgu (1984) had reported that melon improved the yield of companion crops by conserving soil moisture and reducing high noon temperature, thereby making the environment more conducive for plant growth and development. This further explains why NARSP (which produced higher number of leaves than CIP gave higher yield of cassava.

Maize Component

The plant height of maize as affected by cropping system was erratic. However, significant yield parameters of maize showed that sole cropping was superior to intercropping. The possible reason for higher yield under intercropping might be due to inter-specific competition between maize and sweet potato for below and above ground growth factors i.e. soil moisture, nutrient, space and solar radiation. Muhammad et al. (2012) made a similar observation when they intercropped maize with mung-beans. The better yield produced by maize when intercropped with CIP can be attributed to suitability of the variety for intercropping with maize in Makurdi.

Soybean Component

Generally, sole cropping performed better than intercropping. The growth and yield reduction in soybean under intercropping with soybean is in agreement with the report of other workers (Singh et al*.,* 1973; Dallal, 1977; Mohta and De, 1980).This can be attributed to inter-specific competition and the depressive effect sweet potato. The higher grain yield of soybean under intercropping with NARSP can be attributed to better suitability of the variety for intercropping in Makurdi environment.

Intercrop Productivity

The LER of CIP + cassava, CIP + maize and NARSP + cassava were all above 1.0 indicating that greater productivity per unit land area was achieved by these combinations than by growing them separately. Ali (1996) had stated that identification of suitable genotypes of the component crops was necessary for complementarity. NARSP + maize gave an LER value of exactly 1.0. This implies the same productivity per unit land area may be achieved regardless of the cropping system used. The LER values below 1.0 produced by CIP + soybean and NARSP + soybean implies that there was no intercrop advantage. Only CIP + cassava, CIP + soybean, and NARSP + cassava produced LEC values above 0.25 indicating that all other combinations will give higher productivity under sole environments.

Competitive ratio (CR) could be useful in comparing the competitive ability of the different crops and it may help clarify the nature of competition between component crops (Egbe, 2005). Cassava proved more competitive than the other crops in this study, fast growing, multiple branching and aggressive cassava cultivars have the tendency of imposing high competition on the associated intercrop component.

Conclusion

Sole CIP gave higher vine length of sweet potato than sole NARSP while sole NARSP gave higher number of leaves, number of salable roots, and weight and fresh fodder weight of sweet potato than sole CIP. Intercropping with NARSP also gave higher number of leaves, number of salable roots, and weight and fresh fodder weight of sweet potato than intercropping with CIP. Sole cropping gave higher plant height and stem girth of cassava while intercropping gave higher root length and weight of salable roots of cassava. Intercropping cassava with CIP generally gave higher growth parameters of cassava while intercropping cassava with NARSP gave higher yield and yield parameters of cassava. Parameters evaluated for maize component showed that sole cropping gave higher number of rows/cob, number of kernels per row and grain yield than intercropping. Intercropping maize with CIP proved to be more productive than intercropping with NARSP. Higher growth and yield parameters of soybean were obtained under sole environments than intercropped. Intercropping with NARSP gave generally higher plant height of soybean while intercropping with CIP gave higher yield and yield parameters. Combinations with cassava gave higher values of LER and LEC than the other combinations. CR values of cassava were consistently higher than those of all intercrop combinations while sweet potato produced the lowest CR values. From the foregoing results, NARSP can be grown under sole cropping or intercropping with cassava for higher yields. Maize and soybean should be grown under sole environments or under intercropping with CIP to maximize yield. Intercropping cassava with NARSP may give higher yields of cassava.

Conflict of interests

The authors declare that they have no conflicting interests.

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