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Evaluation of Five Improved Maize Varieties for Intercropping with Sweet Potato in Makurdi, Southern Guinea Savanna Ecology of Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author JAI designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors BWA and JIO managed the analyses of the study. Author JIO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out during the cropping seasons of 2014 and 2015 at the Teaching and Research Farm of the University of Agriculture, Makurdi, Benue State, Nigeria. The experiment sought to determine the influence of intercropping maize and sweet potato on the yield and yield components of five newly introduced maize varieties to improving the productivity of maize/sweet potato intercropping in Makurdi. The experiment was a 2 x 5 factorial laid out in Randomized Complete Block Design with three replications. The treatments consisted of two cropping systems (sole cropping (maize, sweet potato) and intercropping (maize + sweet potato)] and 5 improved maize varieties (Pool-18R/AK94DMRESR-Y, Pool 18SR/AK933/ DMRESR, OBATANPA, and POP.66SR/ACR.91 SUWAH 1-SR, OBATANPA/T2LCOMP.1SYN-W-1). A result obtained from the experiment showed that intercropping led to growth and yield decline, the extent of which depended on the maize variety used in combination with sweet potato. Maize variety pool 18R/AK94 DMR ESR- Y was least depressed while Obantakpa was most. There was higher total output per unit area in intercropping compared to sole LER of all maize varieties intercropped with sweet potato were higher than unity, a development which showed intercrop

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advantage over the sole. Intercropping maize variety 18R/AK94 DMR ESR- Y with sweet potato was most productive and therefore recommended for Makurdi location of Southern Guinea Savannah of Nigeria.

Keywords: Intercropping; maize; sweet potato; variety.

1. INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal crop globally after wheat and rice [1]. In advanced countries, it is an essential source of many industrial products such as corn sugar, corn oil, corn flour, starch, syrup, brewer's grit and alcohol [2]. In Africa, maize is the most dominant food crop of rural diets. The husk is used to wrap food while the cobs and stovers are used as bio-fuels [3]. The grain contains calories and protein and is used to formulate food for babies [4]. Its grain has great nutritional value and can be used as raw material for manufacturing many industrial products [5]. The grain, leaves, stalk, tassel and cob can be used to produce a large variety of food, non-food products [6] and industrial products.

Among the root and tuber crops in Nigeria, sweet potato ranked third in a production area, following cassava and yam. The crop is used as food for humans and domestic animals. It is also used to brew alcoholic beverages [7]. Sweet potato is a nutritious, high energy crop that is rich in carotene, vitamins and dietary fibers [8]. It equally contains high levels of minerals and proteins [9].

Lack of farmers' awareness of maize varieties suitable for intercropping with sweet potato hampers production. Since intercropping of cereals with sweet potato is a common feature in the cropping system of the Southern Guinea Savannah of Nigeria, the choice of genotypes is imperative, especially when dealing with the crops such as maize whose varieties inherently vary in morphology, maturing periods and physiology. This study was carried out to evaluate the suitability of five maize varieties for intercropping with some sweet potato varieties in Makurdi, Southern Guinea Savannah of Nigeria, with a view to improving the productivity of the intercropping system.

2. MATERIALS AND METHODS

2.1 Experimental Location

A field experiment was carried out during the cropping seasons of 2014 and 2015 at the Teaching and Research Farm of the University of Agriculture, Makurdi [Latitude 07º45' - 07º 50' N, Longtitude 08º 45'- 08º 50' E, elevation 98 m above sea level] in Benue State, located in Southern Guinea Savanna of Nigeria. The objective of the experiment was to determine the performance of some maize varieties when intercropped with sweet potato.

2.2 Soil Sampling and Analysis

Eight core samples of soil were collected from different parts of the field from 0-30 cm and bulked into a composite sample and used for the determination of physical and chemical properties of the soil (see Table 1) before planting.

2.3 Treatment and Experimental Design

The treatments consisted of two cropping systems [sole cropping (maize, sweet potato) and intercropping (maize + sweet potato)] and 5 improved maize varieties (Pool 18R/AK94DMRESR-Y, Pool 18SR/AK933/ DMRESR, OBATANPA/T2LCOMP.1SYN-W-1, POP.66SR/ACR.91 SUWAH 1-SR and OBATANPA) factorially laid out in Randomized Complete Block Design with three replications. The sweet potato variety used was NARSP/05/022. Each experimental plot consisted of five (5) ridges spaced 1 m apart and 3 m long (5 m x 3 m=15 m^2). The net plot measured 9 m^2.

2.4 Agronomic Practices

Land was prepared manually using hoes and cutlasses. Planting was done on the 2nd of July, 2014 and 4th July, 2015. Three maize seeds were sown at a spacing of 50 cm intra-row by the side of each ridge and thinned to two plant per stand ten (10) days after plant (40,000 plants ha^{-1}). Sweet potato vines of 30 cm in length were planted at the crest of each ridge at an intra-row spacing of 30 cm giving an approximate plant population density of 33,333 plants ha^{-1}. Both maize and sweet potato were planted on the same day. Intercropping had a 1:1 (maize:sweet potato) row proportion. 200 kg of NPK 20:10:10

Table 1. Physical and chemical properties of the surface soil (0-15 cm) at the experimental site in 2014 and 2015

Parameters	Value	
	2012	2013
Sand (%)	73.10	75.10
Silt (%)	12.30	11.20
Clay (%)	14.60	14.20
Textural class	Sandy loam	Sandy loam
pH (H_2O)	6.13	6.50
Organic Carbon (%)	0.82	0.90
Organic Matter (%)	1.35	1.58
Total Nitrogen (%)	0.85	0.94
Available Phosphorus (ppm)	3.30	3.90
Cal^{2+} Cmol kg^{-1} soil)	3.53	3.85
Mg^{2+} (Cmol kg^{-1} soil)	1.73	1.94
K^{+}Cmol kg^{-1} soil)	0.30	0.36
Na^{+}Cmol kg^{-1} soil)	0.72	0.86
CEC Cmol kg^{-1} soil)	6.65	7.18
Base Saturation (%)	95.20	98.00

per ha was applied to maize in split doses by spot application while 400 kg per ha of NKP 15:15:15 was applied to sweet potato. All plots were hand weeded at 3 and 6 weeks after planting (WAP).

2.5 Data Collection

All data at harvest were collected from the net plot. For the maize component, data was collected on plant height at 4, 6 and 12 WAP, cob length, number of kernels per cob, grain yield and hundred seed weight. Data on sweet potato component was collected on vine length, fresh fodder weight, root diameter, root length, number of saleable roots per hectare and weight of saleable roots. Saleable roots were fresh roots ≥ 150g.

2.6 Assessment of Measures of Intercrop Productivity

a) Land Equivalent Ratio (LER) as described by [10].
b) Land Equivalent Coefficient (LEC) [11].
c) Competitive ratio (CR) indicates the degree with which one crop competes with the intercrop. This was calculated using the formula proposed by [12].

2.7 Data Analysis

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. T-test at 5% probability was also used to separate treatment means where appropriate.

3. RESULTS

3.1 Maize Component

3.1.1 Plant height (cm)

The main effect of cropping system and variety as well as the interaction effects of cropping system x variety on the plant height of maize at 4, 8 and 12 WAP was significant ($P \leq 0.05$) in 2014 and 2015. Paired t-test value obtained by comparison between the two years showed that the plant height produced in 2015 was significantly higher than that produced in 2014 (Table 3). At 4 WAP, Pool 18R/AK94DMRESR-Y planted as sole gave the highest plant height of maize in both years but the difference was not significantly higher than that produced by sole OBATANPA and POP.66SR/ACR.91 SUWAH 1-SR. Intercropped OBATANPA/T2LCOMP.1SYN-W-1 gave the lowest plant height at 4 WAP in both years. A similar trend was observed at 8 and 12 WAP where sole Pool 18R/AK94DMRESR-Y gave significantly higher plant height than any other treatment in both years. Intercropped OBATANPA/T2LCOMP.1SYN-W-1 produced the lowest plant height at 8 WAP in both years while sole Pool 18SR/AK933/DMRESR produced the lowest plant height at 12 WAP in 2014 and 2015 (Table 3). On a general note, sole cropping gave significantly higher plant height than intercropping in both years regardless of the week evaluated. Among the maize varieties examined, Pool 18R/AK94DMRESR-Y gave the highest plant height across the weeks evaluated in both years (Table 2).

3.1.2 Cob length (cm)

The cob length of maize as influenced by the main effect of cropping system x variety as well as the interaction effects of cropping system x variety was significant ($P \leq 0.05$) in 2014 and 2015. The result obtained from t-test analysis showed that higher cob lengths where obtained in 2015 than 2014 (Table 5).

Regardless of the cropping system used, OBATANPA/T2LCOMP.1SYN-W-1 produced the highest cob length in both years. The lowest cob length was obtained in 2014 and 2015 when Pool 18R/AK94DMRESR-Y was intercropped with sweet potatoes (Table 5). Sole cropping generally gave significantly higher cob length than intercropping in each year. OBATANPA/T2LCOMP.1SYN-W-1 and Pool 18R/AK94DMRESR-Y gave the highest and lowest cob length among the varieties evaluated in both years (Table 4).

Table 2. Effect of cropping system and variety on the plant height of Maize in Makurdi in 2014 and 2015

Cropping system	Plant height (cm)					
	4 WAP		8 WAP		12 WAP	
	2014	2015	2014	2015	2014	2015
Intercrop	20.19	21.51	153.86	156.42	167.72	172.84
Sole	22.46	25.02	158.89	162.85	176.41	181.17
F - LSD (0.05)	0.75	1.49	4.20	3.78	6.44	2.55
Variety						
A	22.68	24.84	174.50	176.64	194.27	195.31
B	21.64	23.56	153.77	160.92	149.16	156.02
C	17.58	19.27	137.07	139.43	177.36	182.17
D	22.57	24.43	154.79	156.98	160.69	163.53
E	22.18	24.74	161.78	164.22	178.83	188.00
F - LSD (0.05)	1.19	2.35	6.64	5.98	10.18	4.04

Key:A: Pool 18R/AK94DMRESR-Y; B:Pool 18SR/AK933/DMRESR; C: OBATANPA/T2LCOMP.1SYN-W-1; D: POP.66SR/ACR.91 SUWAH 1-SR; E: OBATANPA; WAP: Weeks after planting

Table 3. Interaction of cropping system x variety on the plant height of maize in Makurdi in 2014 and 2015

Cropping system	Variety	Plant height (cm)					
		4 WAP		8 WAP		12 WAP	
		2014	2015	2014	2015	2014	2015
Intercropping	A	22.46	23.80	172.21	174.95	188.03	189.17
	B	21.51	22.43	146.87	150.60	150.31	157.78
	C	16.16	17.70	135.96	138.72	164.89	170.62
	D	20.68	21.97	153.55	155.62	156.05	158.78
	E	20.13	22.65	160.72	162.21	179.32	187.83
Sole cropping	A	22.90	25.87	176.78	178.32	200.51	201.45
	B	21.76	24.68	160.66	171.24	148.00	154.25
	C	18.99	20.83	138.17	140.13	189.82	193.72
	D	24.45	26.88	156.03	158.33	165.33	168.28
	E	24.22	26.82	162.83	166.22	178.33	188.17
LSD (0.05)		1.69	3.32	4.02	8.47	6.40	5.71
Paired t-test (0.05)							
2014 vs 2015		-8.99**		-3.85**		-4.81**	

*Key: A: Pool 18R/AK94DMRESR-Y; B: Pool 18SR/AK933/DMRESR; C: OBATANPA/T2LCOMP.1SYN-W-1; D:POP.66SR/ACR.91 SUWAH 1-SR; E: OBATANPA; WAP: Weeks after planting;**: Significant at 1 and 5% level of probability*

3.1.3 Kernels per cob

The number of kernels per cob as influenced by the main effect of cropping system and variety as well as the interaction effects of cropping system by variety was significant (P≤ 0.05) in 2014 and 2015. The number of kernels produced in 2015 were significantly higher than that produced in 2014 according to data obtained from paired t-test (Table 5).In both years, Pool 18R/AK94DMRESR-Y produced the highest number of kernels per cob irrespective of the cropping system used. The lowest number of kernels per cob among the treatments evaluated was produced when OBATANPA/T2LCOMP.1SYN-W-1 was intercropped with sweet potatoes (Table 5). Sole cropping gave higher number of kernels per cob than intercropping in each year. Pool 18R/AK94DMRESR-Y showed superiority concerning number of kernels per cob than all the other varieties in both years (Table 4).

3.1.4 Grain yield (t ha^{-1})

The main effect of cropping system and variety as well as the interaction effects of cropping system x variety on the grain yield of maize was significant (P≤ 0.05) in 2014 and 2015. Paired t-test between 2014 and 2015 showed that the grain yield obtained in 2015 was significantly higher than that obtained in 2014 (Table 5). Data presented in Table 5 showed that in 2014, Pool 18R/AK94DMRESR-Y gave the highest grain yield when it was planted as sole and the difference was significant. A similar trend was observed in 2015 where sole Pool 18R/AK94DMRESR-Y produced the highest grain yield, but this was not significantly different from that produced by sole Pool 18SR/AK933/DMRESR. Intercropped OBATANPA/T2LCOMP.1SYN-W-1 gave the lowest grain yield in both years (Table 5). Sole cropping gave significantly higher grain yield in both years than intercropping. In 2014, Pool 18R/AK94DMRESR-Y gave the highest grain yield among the varieties examined but the difference was only significantly higher than that produced by OBATANPA/T2LCOMP.1SYN-W-1 and POP.66SR/ACR.91 SUWAH 1-SR. Similarly, Pool 18R/AK94DMRESR-Y gave the highest grain yield in 2015 among the varieties under study and the difference was significant(Table 4).

3.1.5 100-seed weight (g)

100- seed weight was significantly (P≤ 0.05) affected by the main effect of cropping system and variety as well as the interaction effects of cropping system x variety in 2014 and 2015. Paired t-test showed that the 100-seed weight produced in 2015 was significantly higher than that produced in 2014 (Table 5). In both years, OBATANPA gave the highest 100-seed weight of maize irrespective of the cropping system used. In 2014, OBATANPA/T2LCOMP.1SYN-W-1 gave the lowest 100-seed weight when it was planted as sole. A dissimilar trend was observed in 2015 where intercropped OBATANPA/T2LCOMP.1SYN-W-1 produced the lowest 100-seed weight (Table 5). Sole cropping gave higher 100-seed weight than intercropping in both years. OBATANPA gave significantly higher grain yield than all the other varieties evaluated in both years (Table 4).

3.2 Sweet Potato Components

3.2.1 Vine length

Sweet potato intercropping with maize varieties had significant effect on the vine length of sweet potato in 2014 and 2015. Values obtained from paired t-test showed that higher sweet potato vines were produced in 2015 than 2014 at 4 and 8 WAP while there was no significant difference at 12 WAP (Table 6). Sweet potato vines increased steadily across the weeks. Regardless of the week evaluated, sole sweet potato gave the highest vine length and the difference was significant. At 4 WAP, sweet potato intercropped with Pool 18R/AK94DMRESR-Y produced the lowest vine length in both years but this was not so at 8 and 12 WAP where sweet potato intercropped with Pool 18SR/AK933/DMRESR gave the lowest vine length (Table 6).

3.2.2 Fresh fodder weight (t ha^{-1})

Sweet potato/maize intercropping had significant (P≤ 0.05) effect on the fresh fodder weight of sweet potato in 2014 and 2015. Paired t-test showed significantly higher fresh fodder weight values in 2015 than 2014. In both years, sole sweet potato gave higher fresh fodder weight than intercropped sweet potato. The lowest fresh fodder weight was produced when sweet potato was intercropped with Pool 18SR/AK933/DMRESR in both years (Table 7).

3.2.3 Root length (cm)

The root length of sweet potato as influenced by intercropping with maize varieties was significant (P≤ 0.05). In 2014, sole sweet potato gave the highest root length but this was not significantly different from that produced when sweet potato was intercropped with OBATANPA/T2LCOMP.1SYN-W-1 and OBATANPA. Similarly, sole sweet potato produced the highest root length in 2015 but this was only significantly higher than that produced by sweet potato intercropped with Pool 18R/AK94DMRESR-Y and POP.66SR/ACR.91 SUWAH1-SR Significantly higher root length was obtained in 2015 than 2014 (Table 6).

3.2.4 Root diameter

The effect of intercropping on the root diameter of sweet potato was significant (P≤ 0.05) in 2014, however, no significant (P≥ 0.05) difference was observed in 2015. Data presented in Table 7 revealed that sole sweet potato gave higher root diameter of sweet potato but this was only significantly higher than that produced by intercropping with Pool 18R/AK94DMRESR-Y and POP.66SR/ACR.91SUWAH1-SR and POP.66SR/ACR.91SUWAH1-SR. Root diameter values in 2015 where significantly higher than those in 2014 (Table 7).

3.2.5 Number of saleable roots per hectare

The number of saleable roots per hectare as influenced by intercropping with maize varieties was significant (P≤ 0.05).

Table 4. Yield and yield parameters of maize as influenced by cropping system and variety in Makurdi in 2014 and 2015

Treatment	Cob length (cm)		Kernels per Cob		Grain yield (t ha^{-1})		100-Seed weight (g)	
	2014	2015	2014	2015	2014	2015	2014	2015
Cropping system								
Intercrop	13.76	14.33	453.10	457.70	1.78	1.95	23.10	23.42
Sole	14.33	15.22	489.67	496.36	2.24	2.48	24.02	24.84
F - LSD (0.05)	0.76	0.15	11.56	5.95	0.25	0.15	0.66	0.45
Variety								
A	13.21	14.71	510.19	515.09	2.35	2.57	23.43	24.08
B	14.22	14.80	462.34	469.12	2.10	2.31	24.31	24.99
C	14.44	15.08	446.19	450.52	1.67	1.78	21.34	22.13
D	14.21	14.75	456.60	461.76	1.84	2.12	22.76	23.37
E	14.16	14.55	481.62	488.67	2.11	2.32	25.97	26.08
F-LSD (0.05)	0.43	0.24	18.27	9.41	0.41	0.24	1.05	0.70

Key:A: Pool 18R/AK94DMRESR-Y; B:Pool 18SR/AK933/DMRESR; C: OBATANPA/T2LCOMP.1SYN-W-1; D: POP.66SR/ACR.91 SUWAH 1-SR; E: OBATANPA; WAP: Weeks after planting

Table 5. Interaction effects of cropping system x variety on the yield and yield components of maize in Makurdi in 2014 and 2015

Cropping system	Variety	Cob length (cm)		Kernels per Cob		Grain Yield (t ha^{-1})		100-seed weight (g)	
		2014	2015	2014	2015	2014	2015	2014	2015
Intercropping	A	12.83	13.51	494.19	499.33	2.01	2.40	22.38	23.05
	B	14.03	14.53	451.52	456.18	1.85	2.08	23.53	23.95
	C	14.06	14.77	394.11	398.44	1.29	1.38	21.59	21.31
	D	14.02	14.59	448.53	452.42	1.75	1.89	22.45	23.39
	E	13.87	14.25	477.16	482.11	1.99	2.02	25.57	25.38
Sole Cropping	A	13.58	15.90	526.18	530.84	2.68	2.74	24.47	25.10
	B	14.40	15.07	473.15	482.06	2.34	2.53	25.09	26.02
	C	14.82	15.38	498.26	502.59	2.04	2.17	21.09	22.95
	D	14.39	14.91	464.67	471.10	1.92	2.35	23.07	23.35
	E	14.44	14.85	486.08	495.23	2.23	2.62	26.36	26.77
F - LSD (0.05)		1.70	0.34	25.84	13.30	0.12	0.34	1.48	0.99
Paired -test (0.05)									
2014 vs 2015		-4.59**		-7.57**		-3.36**		-3.38**	

*Key:A: Pool 18R/AK94DMRESR-Y; B:Pool 18SR/AK933/DMRESR; C: OBATANPA/T2LCOMP.1SYN-W-1; D: POP.66SR/ACR.91 SUWAH 1-SR; E: OBATANPA; WAP: Weeks after planting; **: Significant at1 and 5% level of probability*

Table 6. Vine length of sweet potato as influenced by intercropping with some Maize varieties in Makurdi in 2014 and 2015

Treatment	Vine Length (cm)					
	4 WAP		8 WAP		12 WAP	
	2014	2015	2014	2015	2014	2015
A + SP	44.12	45.75	112.10	113.34	153.60	156.74
B + SP	45.49	46.33	100.10	100.45	143.60	131.50
C + SP	43.38	48.25	104.60	109.72	149.20	159.65
D + SP	43.56	48.38	101.10	108.54	147.20	147.79
E + SP	49.19	51.38	114.00	120.56	155.60	168.25
Intercrop Mean	45.15	48.02	106.38	110.52	149.84	152.79
Sole SP	53.88	58.00	121.90	126.98	160.40	171.50
Grand Mean	46.60	49.68	108.97	113.27	151.60	155.91
F - LSD (0.05)	3.42	3.26	5.34	3.05	4.86	5.43
Paired t-test (0.05)						
2014 vs 2015	-4.14**		-3.49*		-1.17^{ns}	

*Key:A: Pool 18R/AK94DMRESR-Y; B:Pool 18SR/AK933/DMRESR; C: OBATANPA/T2LCOMP.1SYN-W-1; D: POP.66SR/ACR.91 SUWAH 1-SR; E: OBATANPA; SP: Sweet Potato; WAP: Weeks after planting; **: Significant at1 and 5% level of probability; *: Significant at 5% level of probability; ns: Not significant at 1 and 5% level of probability*

Table 7. Fresh fodder weight, root length, root diameter, number of saleable roots per hectare and weight of saleable roots of sweet potato as affected by intercropping with maize in Makurdi in 2014 and 2015

Treatment	Fresh fodder weight ($t\ ha^{-1}$)		Root length (cm)		Root diameter (cm)		Number of saleable roots per hectare		Weight of saleable roots ($t\ ha^{-1}$)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A + SP	31.14	34.24	19.71	20.38	5.45	7.74	43453.51	44832.41	10.27	10.95
B + SP	24.40	32.38	19.64	21.73	6.08	7.95	47665.64	48655.75	11.02	11.15
C + SP	31.17	37.25	21.12	25.00	6.05	8.00	68834.65	73896.53	14.89	16.08
D + SP	29.54	33.75	17.43	20.95	5.72	8.25	53056.87	56753.13	12.50	12.70
E + SP	32.67	35.73	20.45	22.62	6.20	7.58	57646.67	65854.57	12.98	14.01
Intercrop Mean	29.78	34.67	19.67	22.14	5.90	7.90	54131.47	57998.48	12.33	12.98
Sole SP	34.23	38.56	23.25	25.15	7.09	8.45	84878.65	88765.54	16.46	16.77
Grand z	30.53	35.32	20.27	22.64	6.10	8.00	59256.00	63126.32	13.02	13.61
F - LSD (0.05)	4.06	3.56	3.68	3.56	1.21	ns	135.22	143.56	4.40	3.56
Paired t-test (0.05)										
2014 vs 2015	-4.98**		-4.85**		-8.53**		-3.12*		-3.92**	

Key:A: Pool 18R/AK94DMRESR-Y; B:Pool 18SR/AK933/DMRESR; C: OBATANPA/T2LCOMP.1SYN-W-1; D: POP.66SR/ACR.91 SUWAH 1-SR; E: OBATANPA; SP: Sweet Potato; WAP: Weeks after planting; ns: Not significant at 5% level of probability

In both years, sole sweet potato gave the highest number of saleable roots per hectare and the difference was significant. Intercropping with Pool 18R/AK94DMRESR-Y gave the lowest number of saleable roots in both years. The number of saleable roots obtained in 2015 was significantly higher than that obtained in 2014 (Table 7).

3.2.6 Weight of saleable roots ($t\ ha^{-1}$)

Intercropping had significant (P≤ 0.05) effect on the weight of saleable roots of sweet potato. Data presented in Table 7 showed that in sole sweet potato gave the highest weight of saleable roots but this was not significantly different from that produced when sweet potato was intercropped with OBATANPA/T2LCOMP.1SYN-W-1. Higher weight of saleable roots was obtained in 2015 than 2014 (Table 7).

3.2.7 Assessment of measures of intercrop productivity

Table 8 presents the results of measures of intercrop productivity [Land Equivalent Ratio (LER), Land Equivalent Coefficient (LEC)] and measures of competitive interactions [Competitive Ratio (CR)] between the intercrop components of maize and sweet potato in Makurdi in 2014 and 2015.

All intercrop combinations had LER figures above 1.0 and LEC values above 0.25 in both years. CR values of maize were consistently higher than those of sweet potato in all intercrop combinations except when OBATANPA/T2LCOMP.1SYN-W-1 was intercrop with sweet potato. The combinations of OBATANPA with sweet potato had higher values of LER and LEC than the other combinations (Table 8).

4. DISCUSSION

4.1 Maize Component

Cropping system, variety and their interaction had significant effect on plant height of maize in both years. In 2014 and 2015, sole cropping produced higher plant height than intercropping regardless of the week evaluated. The reduction in height of intercropped maize might be associated with inter-specific competition between the intercrop components for growth resources (light, water, nutrients, air, etc.) and the depressive effects of sweet potato. [13] had observed similar height reductions in soybean intercropped with maize and associated the height depression to competition for light. Plant height varied with maize variety and Pool 18R/AK94DMRESR-Y gave the highest plant height in both years and at all the weeks irrespective of the cropping system used. Such differential responses might be due to inherent genotypic capabilities of this variety. Similar observations were reported in pigeon pea by [14] when different pigeon pea varieties were evaluated under intercropping with sorghum.

In both years, sole cropping produced higher cob length, number of kernels per cob, grain yield and 100-seed weight than intercropping. The reduction in yield and yield parameters of maize under intercropping may be ascribed to both above-and below-ground competition for growth resources. In agreement with this study, [15] also reported higher cob length and 100-seed weight under sole cropping than intercropping and attributed it to less competition under sole cropping for below and above ground growth factors i.e. soil moisture, nutrient, space and solar radiation. [16] also made a similar observation when most of the maize varieties evaluated showed degree of yield decrease under cassava-maize intercropping system compared to sole maize. [17] explained that sharing of growth resources among components crops under intercropping can limit growth and accumulation of dry matter compared to sole cropping where competition exists.

Table 8. Land Equivalent Ratio (LER), Land Equivalent Coefficient (LEC) and Competitive Ratio (CR) of intercropped maize with sweet potato in Makurdi in 2014 and 2015

Treatment	LER		LEC		CR maize		CR sweet potato	
	2014	2015	2014	2015	2014	2015	2014	2015
A + SP	1.37	1.53	0.47	0.57	1.20	1.34	0.83	0.62
B + SP	1.46	1.49	0.53	0.55	1.18	1.24	0.85	0.68
C + SP	1.54	1.59	0.57	0.61	0.70	0.66	1.43	2.16
D + SP	1.67	1.56	0.69	0.61	1.20	1.06	0.83	0.78
E + SP	1.68	1.61	0.70	0.64	1.13	0.92	0.88	0.96
Grand mean	1.54	1.56	0.59	0.60	1.08	1.05	0.97	1.04
F - LSD (0.05)	1.43	1.26	0.19	0.21	1.02	1.12	0.21	0.17
Paired t-test (0.05)								
2014 vs 2015	-1.04^{ns}		-1.01^{ns}		-0.75^{ns}		-1.11^{ns}	

Key:A: Pool 18R/AK94DMRESR-Y; B:Pool 18SR/AK933/DMRESR; C: OBATANPA/T2LCOMP.1SYN-W-1; D: POP.66SR/ACR.91 SUWAH 1-SR; E: OBATANPA; SP: Sweet Potato

Genotypes that give high yields in sole systems are not necessarily the most yielding under intercropping [18] however, Pool 18R/AK94DMRESR-Y produced higher grain yield in both years regardless of the cropping system used. This may be attributed to the higher number of kernels per cob produced by this variety and its suitability for intercropping with sweet potato. [19] had indicated that identification of suitable genotypes of component crops was essential for complementarity.

4.2 Sweet Potato Component

Sole sweet potato produced the higher vine length at 4, 8 and 12 WAP in both years than all intercropped treatments. The reduction in vine length under intercropping was probably due to effect of shade exerted on the intercropped sweet potato by the taller maize thereby reducing light interception by sweet potato hence the reduced photosynthetic activities of the crop. Apart from light, crops grown in association compete for water and nutrients in the soil [20] Similarly, sole cropping produced higher fodder weight, root length, root diameter, number of saleable roots and weight of saleable roots than intercropping in both years. This result is consistent with several previous reports [21, [22,23]. The tall maize might have depressed photosynthetic capacity of the sweet potato through shading.Interplant competition for natural growth resources such as soil nutrients, water, etc. by both intercrop components might have also brought about this reduction. It is known that competitive reactions reduce yields in intercropped crop species as compared to mono cropping [24]. Intercropping sweet potato with OBATANPA/T2LCOMP.1SYN-W-1 gave higher fodder weight, root length, root diameter, number of saleable roots and weight of saleable roots than intercropping with any other maize variety. This implies that this variety (OBATANPA/T2LCOMP.1SYN-W-1) was more suitable for intercropping with sweet potato in Makurdi environment.

4.3 Measures of Intercrop Productivity

Land equivalent ratio (LER) values were above 1.0 in all intercrop combinations signifying intercropping advantages for all treatments. Similarly, LEC figures were above 0.25 indicating there was yield advantage of intercropping maize with sweet potato. Complementarity in the maize/sweet potato intercropping may have been derived from the differences in the rooting systems of the component crops. These differences may have resulted in a fuller exploration of the whole soil profile by component crops than can be achieved by separate sole crops. [25] had indicated that complementarity in intercropping could be achieved when shallow-rooted crops (e.g cereals) and deep-rooting (e.g legumes) are combined. [26] reported that LER values above unity indicated complementarity in resource utilization by the component crops. [27] had indicated that if the competitive ratio (CR) was less than 1, there is a positive benefit and the crop can be grown in an association, but if greater than 1, there was a negative benefit. CR values indicated that maize was more competitive than sweet potato except when OBATANPA/T2LCOMP.1SYN-W-1 was intercropped with sweet potato. According to [12], CR gives a better measure of the competitive ability of crops and can prove a better index as compared to aggressivity. The better performance of maize over sweet potato might probably be due to the height advantage of maize over the sweet potato component. The taller growing maize component intercepted more solar radiation and shaded the lower growing sweet potato component. [28] had stated that such competition usually decreased survival, growth or reproduction of at least one species, usually the shaded species.

5. CONCLUSION

Intercropping with sweet potato caused depression in growth and yield of maize, the extent of which was dependent on the variety of maize combined with sweet potato. Maize variety pool 18R/Ak94/DMR ESR-Y significantly out-yielded the other varieties when intercropped with sweet potato. Even though the yield of maize varieties was depressed in intercropping compared to sole cropping, the sweet potato yield compensated for this depression thereby leading to intercrop advantage over either sole maize or sweet potato system. LER and the LEC values for all the intercrop combinations have shown that it is advantageous to intercrop each of the maize varieties with sweet potato. Maize variety pool 18R/Ak94/DMR ESR-Y intercropped with sweet potato has proved to be most productive while Obatankpa with sweet potato was least.

Pool 18R/Ak94/DMR ESR-Y with sweet potato intercrop is therefore recommended for farmers in Makurdi location of Nigerian Southern Guinea Savannah Agro-ecology.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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