Journal of Applied Horticulture, 11(2): 153-159, July-December, 2009

Growth, yield and productivity responses of okra-papaya mixture to intercropping in South West Nigeria

O.O. Olubode*, I.O.O. Aiyelaagbe and J.G. Bodunde

*Department of Horticulture, University of Agriculture, P.M.B. 2240, Abeokuta, Ogun State, Nigeria. *E-mail: oluomobode@gmail.com*

Abstract

Field experiments were conducted between 2006 and 2007 at the University of Agriculture, Abeokuta, South Western Nigeria, to determine the growth and yield responses of okra (*Abelmoschus esculentus*) grown in orchards of two papaya (*Carica papaya* L.) varieties, 'Homestead Selection' and 'Sunrise Solo', at three different stages of papaya growth. Different sequences of okra sowing were; at three weeks before papaya (early), same time with papaya (simultaneous) and three weeks after papaya (late). Results showed that early and simultaneous introduction of okra performed significantly better than the late, with respect to plant height, number of leaves, leaf area, number of pods, pod weight plant^{-1} and total pod yield. All the okra intercrops experienced competitive effects that reflected in reduced yield more pronounced in Homestead Selection than in Sunrise Solo. The productivity efficiency index recorded intercropping advantages for the okra in mixture compared to the sole okra with a land equivalent ratio (LER) >1.0 while the area harvest equivalent ratio (AHER) was more descriptive of the trends observed among the sequences. In cv Homestead Selection, the highest profit margin (47.64 %) was recorded in the simultaneous papaya-okra intercrop, followed by early (44.57 %). A similar trend was observed in cv Sunrise Solo, where simultaneous and early okra introduction had a profit margin of 40.06 and 39.72%, respectively. Late sequence had the least profit margin in both papaya cultivars. .

Key words: *Abelmoschus esculentus* (L.) Moench., papaya, growth and yield, intercropping sequence, productivity efficiency indices, profit margin.

Introduction

Okra (*Abelmoschus esculentus*) plays important role in diets as it is regarded as an important draw soup in the tropical diet. Okra is rich in vitamins and mineral salts such as calcium, phosphorus, magnesium and iron and it is very valuable with regards to anti-carcinogenicity, human immunity promotion and ageing prevention (AVRDC, 1991). Vegetables occupy a valuable ecological niche in tropical agriculture and play a significant role in the eco-physiology of mixed systems (Olasantan, 2001). The planting of two or three crops concurrently or sequentially could have implications on the availability of limited natural resources. The resulting ecological relationships could be competitive or complementary in nature. However, the planting of several crops, which differ in height, root development and light requirement, allows for a more efficient use of solar energy, soil nutrient and water. Intercropping has been associated with such advantages as better utilization of growth resources, greater yield stability, soil protection, variability of food supply, increased return per unit area and insurance against crop failure (Beet, 1982). Szumigalski and Acker (2005) and Ofosu-Anim and Limbani (2007) reported that annual intercrops can enhance weed suppression and crop production compared with sole crops.

Fukai and Trenbath (1993) reported that intercrops are most productive when their component crops differ greatly in growth duration so that their maximum requirements for growth resources occur at different times. In 'additive' intercrops, where growth durations of component crops are similar, the crops compete more intensely for available resources but may nevertheless, be productive, particularly where growth resources are more completely captured than in corresponding sole crops. However, in 'replacement' intercrops where the non-replenished growth resources are utilized too rapidly, the less-competitive component may suffer greatly. Intercropping okra with papaya, which is more of replacement competition, specifically has to do with its compatibility in terms of favourable competition for soil nutrients, soil moisture and light. John and Mini (2005) observed favourable land equivalent ratio (LER), land equivalent co-efficiency (LEC), area time equivalency ratio (ATER), aggressivity values and total biomass production for the intercropping of okra with cucumber, implying their intrinsic advantages over sole crops. Okra intercrop in papaya has been observed to show effect of competition among the component crops (Aiyelaagbe and Jolaoso, 1992; Olubode *et al.,* 2005), but they also reported improved LER of the okra papaya mixtures. Calculated LER proved that plant growth resources were used 27 to 31% more efficiently by intercrop than the sole crop (Hauggaard-Nielsen *et al.,* 2003).

Intercropping is practiced with the sole aim of maximizing plant cooperation for maximum crop yield (Sullivan, 2001). Olasantan and Lucas (1992) had noted that canopy height is one of the important features that determine competition ability of plants for light. Palaniappan (1985) observed that when one component is taller than the other in an intercropping, the taller component intercepts major share of the light such that growth rates of the two components will be proportional to the quality of the photo-synthetically active radiation they intercepted. Muoneke *et al.* (1997) also reported that the taller okra plants obtained in intercrop with maize was a bid to display their leaves for solar radiation. Njoku *et al.* (2007) observed that intercropping generally increased okra plant height while intercropping with TIS 2532P.1.13 sweet potato significantly increased the number of pods per plant of okra than intercropping with other sweet potato cultivars.

Previous works done on okra mixture with papaya varieties (Aiyelaagbe and Jolaoso, 1992; Olubode *et al.,* 2008) mostly considered the competitive effect when both components are grown concurrently but the time based sequential introduction of okra crop components to obtain the best time for highest profit was not considered. This experiment seeks to determine the best cropping sequence most suitable for okra papaya mixture and the crop responses of crops to alternate cropping sequence of components.

Materials and methods

The experiment was conducted at the University of Agriculture, Abeokuta, South Western Nigeria, (latitude 7°15´N, longitude 30° 25´E, altitude of 100m above sea level). Meteorological data for the experimental location and period are shown in Fig. 1. Composite analysis results of soil sampled are shown in Table 1. Two soil types dominate the location, *viz.*, the Iwo series and Apomu series (Smyth and Montgomery, 1962; FDALR, 1990). The Iwo series-Kandic Paleustalf (USDA, 1999), Ferric Luvisols (FAO/UNESCO, 1990), are generally well drained, fine sandy loam to sandy clay loam soils and Apomu series-Typic Transporthants (USDA, 1999), Eutric Regosols (FAO/UNESCO, 1990), are excessively drained sand to sandy loam. Analysis of the pacesetter organo-mineral fertilizer applied as 10 ton ha^{-1} basal application in the experiment is shown in Table 2.

The experimental design included two varieties of papaya and three times of introduction of crop components at the early, simultaneous and late sequence. The experiment was a randomized complete block design (RCBD) fitted into a split plot arrangement and replicated three times. The main plot was the papaya varieties while the sub-plot was the three times of introducing the components. The okra (*A. esculentus*) cv. V35, an erect and early variety was introduced into plots of papaya (*C. papaya* L.) varieties Homestead Selection, (a dioecious variety) and Sunrise Solo, an hermaphrodite, in three sequences of okra 3 weeks before papaya (early intercropping), okra same time with papaya (simultaneous intercropping) and okra 3 weeks after the planting of papaya (late intercropping).

Table 1. Characteristics of the soil used in okra papaya mixture in 2006

Depth (cm)	Particle size analysis			Chemical analysis					Exchangeable bases			
	Sand (%)	Clay (%)	Silt (%)	Soil pH (H_2O)	Organic carbon (%)	Organic matter	N (%)	P (ppm)	K (cmol kg^{-1})	Na (cmol kg^{-1})	Ca (cmol kg^{-1})	Mg (cmol kg^{-1})
0 - 15	61.20	22.00	16.80	7.78	1.08	1.86	0.081	6.74	0.31	0.35	3.48	0.52
16-30	73.40	14.30	7.30	6.90	0.44	0.76	0.055	10.05	0.15	0.43	1.66	0.18

Table 2. Analysis of Pacesetter Organo-mineral fertilizer used

OMF sample	N (%)	P (%)	K (%)	(%) Ca	Fe (mg kg^{-1})	Mg (mg kg^{-1})
	4.89	0.53	0.33	0.87	4.8	0.9

Source. Pacesetter purchased samples analytical results.

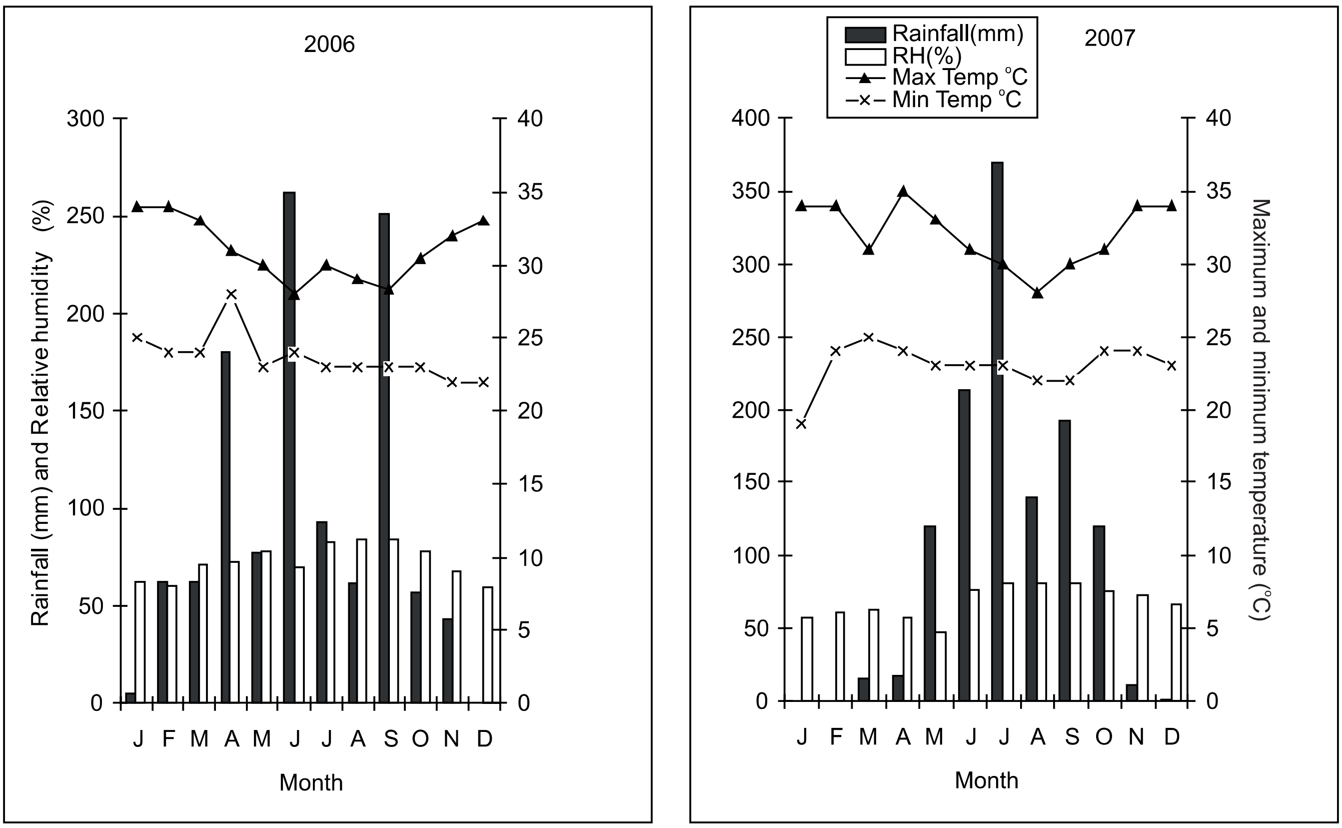

Fig. 1. Meteorological data for the experimental location for 2006 and 2007.

Three month old papaya seedlings were transplanted in August 2006 at a spacing of 2 x 2 m into holes of 60 cm^3 size while okra was spaced 0.5 x 0.3 m at the three sequences. The experiment was repeated in 2007 when the okra was sown into the alleys of one year old papaya orchards at the onset of rains. All plots were weeded manually while insect pests and diseases were controlled biologically using approaches reported by Lowell (1998).

Growth parameters estimation for the okra involved weekly measurement of plant height (cm), number of leaves and leaf area (cm^2) estimated by using leaf area formula described by Asif (1977), *i.e.* Y = 115X -1050 where, Y = leaf area (cm^2) and 'X' is the length of the midrib (cm $plant^{-1}$). Other parameters measured on okra include number and weight of pods, pod yield (ton ha^{-1}).

Growth parameters of papaya, measured fortnightly, were plant height, stem girth and leaf area using the formula described by Aiyelaagbe and Fawusi (1998) *viz.*, Y = 316.06- 47.09X, where Y = leaf area (cm^2) and X is the sum of the media midrib (cm $plant^{-1}$). Yield parameters of number of flowers, number of fruits and fruit weight (g $plant^{-1}$) were measured weekly. Net returns were calculated to determine the economic yield of the system. Intercropping efficiency was evaluated by comparing the productivity of a given area of intercropped land with sole crop using the competitive index of land equivalent ratio (LER) (Wiley, 1979). Other productivity indices like land equivalent co-efficiency (LEC) (Adetiloye *et al.,* 1983), area x time equivalency ratio (ATER) (Hiesbsch and McCollum, 1987), area harvest equivalency ratio (AHER) (Balasubramanian and Sekayange, 1990), relative crowding coefficient (RCC) (de Wit, 1960), aggressivity values (McGilchrist, 1965) and monetary equivalency ratio (MER) (Adetiloye and Adekunle, 1989) were compared with the LER.

Data collected were subjected to the analysis of variance procedures (SAS, 1990). Treatment means of each of the parameters measured were compared using the least significant difference technique (Steel and Torrie, 1980).

Results

Response of crop components to crop mixture: Okra and papaya growth and yield were significantly influenced by intercropping. Okra mixture with papaya significantly affected okra growth and yield parameters when compared with the sole crop (Tables 3 and 4). The okra performed significantly better under the Sunrise Solo than under the Homestead Selection papaya with regards to the leaf area (Table 5). Sole papaya was significantly better than papaya in mixture in plant height, leaf area and in the reproductive parameters like number of flowers, number of fruits and fruit yield (Table 6). Observed morphological differences in the papaya varieties are shown in Table 6. Plant height, stem girth and leaf area were higher in Homestead in the

Table 3. Growth responses observed for okra grown in mixture with papaya in 2006 and 2007

Cropping system/ sequence	2006				2007			
	Plant height (cm)	Number of leaves	TDW at 6 WAP (g)	Leaf area (x '000 cm^2)	Plant height(cm)	Number of leaves	TDW at 6 WAP (g)	Leaf area (x '000 cm^2)
Okra in Homestead								
Early	42.23	14.27	9.70	2.45	26.14	4.91	8.07	2.04
Simultaneous	39.75	13.43	9.13	2.30	24.60	4.62	7.60	1.92
Late	38.34	12.95	8.81	1.93	23.73	4.16	7.33	1.61
Mean	40.11	13.55	9.21	2.23	24.82	4.56	7.67	1.86
Okra in Sunrise								
Early	44.51	14.07	10.74	2.71	31.27	4.16	8.37	2.11
Simultaneous	41.35	13.07	9.97	2.51	29.05	3.87	7.78	1.96
Late	39.91	12.62	9.63	2.23	28.04	3.74	7.51	1.74
Mean	41.92	13.25	10.11	2.48	29.45	3.92	7.89	1.94
LSD(*P*=0.05)Var	1.17*	NS	NS	0.12*	2.13*	NS	NS	NS
Seq	2.48*	0.18*	0.57*	0.38*	3.75*	0.31*	NS	NS
Var X Seq	NS	NS	NS	NS	NS	NS	NS	NS

*- *P*= 0.05, NS-not significant, Var-Variety, Seq-Sequence, TDW-total dry weight, WAP-weeks after planting.

Table 4. Yield responses observed for okra grown in papaya cropping mixture in 2006 and 2007

Cropping system/ sequence	2006				2007			
	Number of pods	Weight per pod (g)	Pod weight $plant^{-1}$ (g)	Pod yield (ton ha^{-1})	Number of pods	Weight per pod (g)	Pod weight $plant^{-1}$ (g)	Pod yield (ton ha^{-1})
Okra in Homestead								
Early	5.30	14.30	75.87	3.79	3.10	3.42	10.6	0.53
Simultaneous	8.26	8.50	70.20	3.51	2.78	3.53	9.8	0.49
Late	7.92	7.65	60.60	3.03	2.35	3.83	9.0	0.45
Mean	7.16	10.15	68.89	3.44	2.74	3.59	9.8	0.49
Okra in Sunrise								
Early	5.32	14.62	77.80	3.89	4.12	2.67	11.00	0.55
Simultaneous	7.85	9.22	72.49	3.62	3.45	2.96	10.2	0.51
Late	8.22	8.52	70.00	3.50	3.98	2.51	10.0	0.50
Mean	7.13	10.79	73.43	3.67	3.85	2.71	10.4	0.52
LSD(*P*=0.05)Var	NS	0.56*	1.32*	0.21*	0.12*	0.47*	NS	NS
Seq	1.21*	2.13*	5.27*	0.40*	1.13*	0.74*	1.56*	0.046*
Var x Seq	*	NS	NS	NS	NS	*	NS	NS

**P*= 0.05, NS-not significant, Var-Variety, Seq-Sequence.

first year but in the second year, the stem girth and leaf area was more in Sunrise. Okra performed better under the Sunrise Solo due to less shading by the papaya canopy than the Homestead. Mixture with okra significantly influenced papaya growth as reflected in plant height, number of leaves and leaf area leading to growth and yield reductions.

Responses of crop components to cropping sequence: Cropping sequence significantly affected okra and papaya growth, yield determinants and yield. The early-introduced okra was best, followed by simultaneous okra and papaya. Both were though not significantly different but were significantly better than late introduction of okra into papaya. The okra in early sequence was highest in growth and yield performances under Sunrise Solo variety followed by early sequence under Homestead, simultaneous under Sunrise Solo and under Homestead, in that order. The late introduction of okra had the lowest growth and yield performances. Early introduction of okra into papaya orchard was superior in both years, with a significant difference for all the parameters in 2006 and all but yield in 2007 (Table 4). Both the component crops, papaya and okra experienced yield reduction at the reproductive phase of papaya (Fig. 2).

Productivity of the mixtures: The productivity efficiency index >1.0 was obtained for the mixture using LER. The LER values ranged between 1.06 for Homestead late sequence to 1.33 for Homestead simultaneous. Other indices like LEC, ATER and RCC gave similar responses. AHER gave a descriptive trend where Sunrise early sequence was highest with a value of 1.81 and Homestead late a value of 1.44. ATER was practically insensitive (Table 7) where a common value of 1.25 was obtained across board. Aggressivity was negative for okra and papaya was dominant over okra in the mixture. The crop productivity observed in the sequences showed a higher economic returns for the mixtures as shown in Table 8, where okra simultaneous with Homestead was highest with a profit margin of 47.64%, followed by early okra sequence in Homestead (44.57%) and okra simultaneous sequence in Sunrise (40.06%), while okra late sequence in Sunrise and Homestead in that order were least recording 34.99 and 33.62%, respectively.

Discussion

The observed growth and yield responses of okra in cropping mixture confirmed earlier findings by Palaniappan (1985), Olasantan and Lucas (1992), who reported that plant height is one of the important features that determine competitive ability of plants for light, while Muoneke *et al.* (1997) and Njoku *et al.* (2007) also confirmed that the taller okra plants obtained in intercrop with maize and sweet potato, respectively was a bid to display their leaves for solar radiation, hence intercropping generally increased okra plant height. The observed papaya

Table 5. Growth and yield responses observed for okra grown sole and in mixture with papaya in 2006 and 2007

Cropping mixture	2006					2007				
	Plant height (cm)	Number of leaves	TDW at 6WAP (g)	Leaf area (x'000cm^2)	Pod yield (ton ha^{-1})	Plant height (cm)	Number of leaves	TDW at 6WAP (g)	Leaf area (x'000cm^2)	Pod yield (ton ha^{-1})
Sole	38.65	14.74	18.33	2.56	4.30	41.74	13.93	13.75	2.44	4.04
Hs +okra	40.11	13.55	9.21	2.23	3.44	24.82	4.56	7.67	1.86	0.49
Ss +okra	41.92	13.25	10.11	2.48	3.67	30.0	4.0	8.03	1.80	0.52
Mean	40.23	13.85	12.55	2.42	3.80	32.19	7.50	9.82	2.03	1.68
LSD(*P*=0.05)	1.06*	NS	1.52*	0.31*	0.21*	3.17*	2.59*	1.13*	0.35*	0.33**

* *P*= 0.05, ** P= 0.01, NS-not significant, Hs-Homestead Selection, Ss-Sunrise Solo.

Table 6. The mean treatment effects of papaya vegetative and reproductive responses for the crop sequence with okra in 2006 and 2007

Cropping system/ sequence	Plant height (cm)		Stem girth (cm)		Leaf area (cm^2)		Number of flowers	Number of fruits	Fruit yield (ton ha^{-1})
	28 MAT	72 MAT	28 MAT	72 MAT	28 MAT	72 MAT	18 MAT	18 MAT	18 MAT
Py sole	80.72	246.17	3.26	15.60	12987	91838	78.07	58.54	33.63
Py + okra	67.28	199.80	2.16	13.26	9947	56104	70.74	48.49	26.97
Hs sole	83.77	252.17	3.97	16.22	15729	97217	67.28	48.44	41.17
Ss sole	77.67	240.17	2.55	14.98	10244	86459	88.85	68.63	26.08
Hs + ok Early	81.33	240.40	3.03	14.37	16590	59948	51.26	36.46	30.99
Hs + ok simult	72.67	193.37	2.44	12.51	13999	54120	63.22	41.29	35.10
Hs + ok Late	61.33	168.51	1.75	11.38	4550	41563	67.66	31.27	26.58
Ss + ok Early	72.33	238.10	2.34	15.48	6905	71763	81.59	60.81	23.11
Ss + ok simult	62.67	191.52	1.80	13.54	10436	61781	89.59	63.79	24.24
Ss + ok Late	53.33	166.90	1.60	12.30	7200	47445	71.10	57.32	21.78
Mean	67.28	199.80	2.16	13.26	9947	56103	70.74	48.49	26.97
LSD(*P*=0.05)									
Var	NS	NS	NS	NS	3674**	NS	4.37**	5.23**	5.03**
Intc	NS	28.77*	0.52**	NS	NS	19118*	3.24**	NS	1.08*
Seq	13.25*	56.29**	0.90**	NS	6073*	NS	3.86**	2.44*	2.11**
Var x Intc	NS	NS	*	NS	NS	NS	**	**	**
Var x Seq	NS	NS	NS	NS	*	NS	**	**	**
Intc x Seq	NS	NS	NS	NS	NS	NS	**	*	NS
Var x Intc x Seq	NS	NS	NS	NS	NS	NS	**	**	*

* *P*= 0.05, ** P= 0.001, NS-not significant, Py-Papaya mean, Hs-Homestead Selection, Ss-Sunrise Solo, ok-okra, Var-Variety, Intc-Intercrop, Seq-Sequence, MAT-months after transplanting.

Table 7. Productivity efficiency indices observed for okra-papaya cropping system.

Cropping sequence	Fruit yield (ton/ha)	Efficiency index						
		LER	LEC	ATER	AHER	RCC	Aggre-ssivity	MER
Homestead								
Early	31.23	1.28	0.39	1.25	1.75	3.38	-0.24	0.37
Simultaneous	35.10	1.33	0.41	1.25	1.77	5.33	-0.37	0.34
Late	26.53	1.06	0.27	1.25	1.44	1.30	-0.23	0.30
	30.95	1.22	0.36	1.25	1.65	3.34	-0.28	0.34
Sunrise Solo								
Early	20.54	1.32	0.42	1.25	1.81	4.22	-0.26	0.46
Simultaneous	21.56	1.32	0.41	1.25	1.78	4.68	-0.33	0.43
Late	19.36	1.22	0.36	1.25	1.66	2.66	-0.26	0.41
	20.49	1.29	0.396	1.25	1.75	3.85	-0.28	0.43
LSD(*P*=0.05)Var	8.79*	NS	NS	NS	NS	NS	0.035**	0.039**
Seq	12.94*	0.062**	0.037**	NS	0.074**	NS	NS	0.020**
Var x Seq	NS	**	**	NS	**	NS	**	**

LER-land equivalent ratio, LEC-land equivalent coefficient, ATER.-area x time equivalent ratio, AHER.-area harvest equivalent ratio, RCC-relative crowding coefficient, MER.-monetary equivalent ratio, *P= 0.05, **P= 0.001, ns-not significant.

Table 8. Profit margin calculated showing the profitability of each cropping system in the okra papaya sequence

Cropping sequence	Two year yield (ton ha^{-1})		Selling price kg^{-1} (₦)[a]		Yield values (₦)[a]	Production cost (₦)[a]	Profit (Naira ha^{-1}) (₦)[a]	Profit margin (%)
	Papaya	Okra	Papaya	Okra				
Sole								
	41.17	-	35.29	-	1,452,889	910,289	542600	37.35
	26.08	-	46.50	-	1,212,720	910,289	302,431	24.94
	-	8.34	-	125.00	1,010,000	639,250	370,750	36.71
Homestead + okra								
Early	31.23	4.32	35.29	125.00	1,642,107	910,289	731818	44.57
Simultaneous	35.10	4.00	35.29	125.00	1,738,679	910,289	828390	47.64
Late	26.53	3.48	35.29	125.00	1,371,244	910,289	460,955	33.62
Sunrise + okra								
Early	20.54	4.44	46.50	125.00	1,510,110	910,289	599,821	39.72
Simultaneous	21.56	4.13	46.50	125.00	1,518,790	910,289	608,501	40.06
Late	19.36	4.00	46.50	125.00	1,400,240	910,289	489,951	34.99

'a' denotes Naira (₦ 190.00 equivalent $1 US dollar).

growth and yield reduction in mixture with okra in this study corroborates earlier reports by Aiyelaagbe and Jolaoso (1992) and Olubode *et al.* (2008). This may have been due to competition by the components for limited growth resources. The taller height of okra in intercrop compared to sole and the shorter height of papaya component compared to the sole indicated signs of competition.

In the first year of okra sowing competition for soil nutrient was the likely to be critical factor as papaya was yet to have a wide canopy cover that could make competition for light critical, while at the second year cropping, it was clearly the problem of light interception which was advantageous to papaya but deleterious to okra growth and yield as a result of the relative heights of both crops. The near linear trend observed for the response of okra intercrops to time of introduction indicates the level of available nutrient and/or minimal light interference derived from the competition with papaya, which obviously affected the okra growth and yield. The okra introduced earlier had greater advantage and access to soil nutrient coupled with unhindered access to solar radiation for a greater part of the time which produced the significantly higher pod yield observed but caused more nutrient depletion to papaya compared to simultaneous and late introduction. The interaction observed under number of pods and pod weight showed the contributive effects of shading and nutrient availability to these parameters. Sunrise Solo had lower interference with okra growth and yield as the leaf area at the vegetative phase was lower compared to Homestead.

The intercrop competition effect was observed in the second year of papaya growth. Okra's improved growth and yield under Sunrise Solo and at the early sequence compared to other treatments could be as a result of higher light interception. The more than unity LER recorded under intercropping demonstrated higher yield advantage for the intercropped plots. In particular, papaya and okra in simultaneous planting gave higher LER of 1.33, implying that 33% more land would be required as sole crop to produce the equivalence of yield obtained under intercropped situation. LEC and ATER and RCC values followed trends that though not quite similar to that of LER but proved the higher productivity of the mixtures. AHER was more useful in apportioning productivity to the mixtures as recommended by Fukai and Trenbath (1993). The negative aggressivity value for okra shows that papaya was dominant while okra was dominated. The net returns also showed that Homestead mixtures with higher harvest index were more profitable than the Sunrise mixtures and the simultaneous planting followed by early okra introduction were more profitable than late sequence which was lowest.

In conclusion, papaya varieties would vary in their tolerance to intercropping as Sunrise Solo variety was found more suitable for good growth and yield of okra. For economic land utilization and crop productivity, okra papaya mixture with early introduction of okra is recommended. Okra introduced before the papaya component comes into full establishment and fruit bearing was satisfactory in growth and yield relative to sole okra. Intercropping advantage derived from the various indices used indicated that

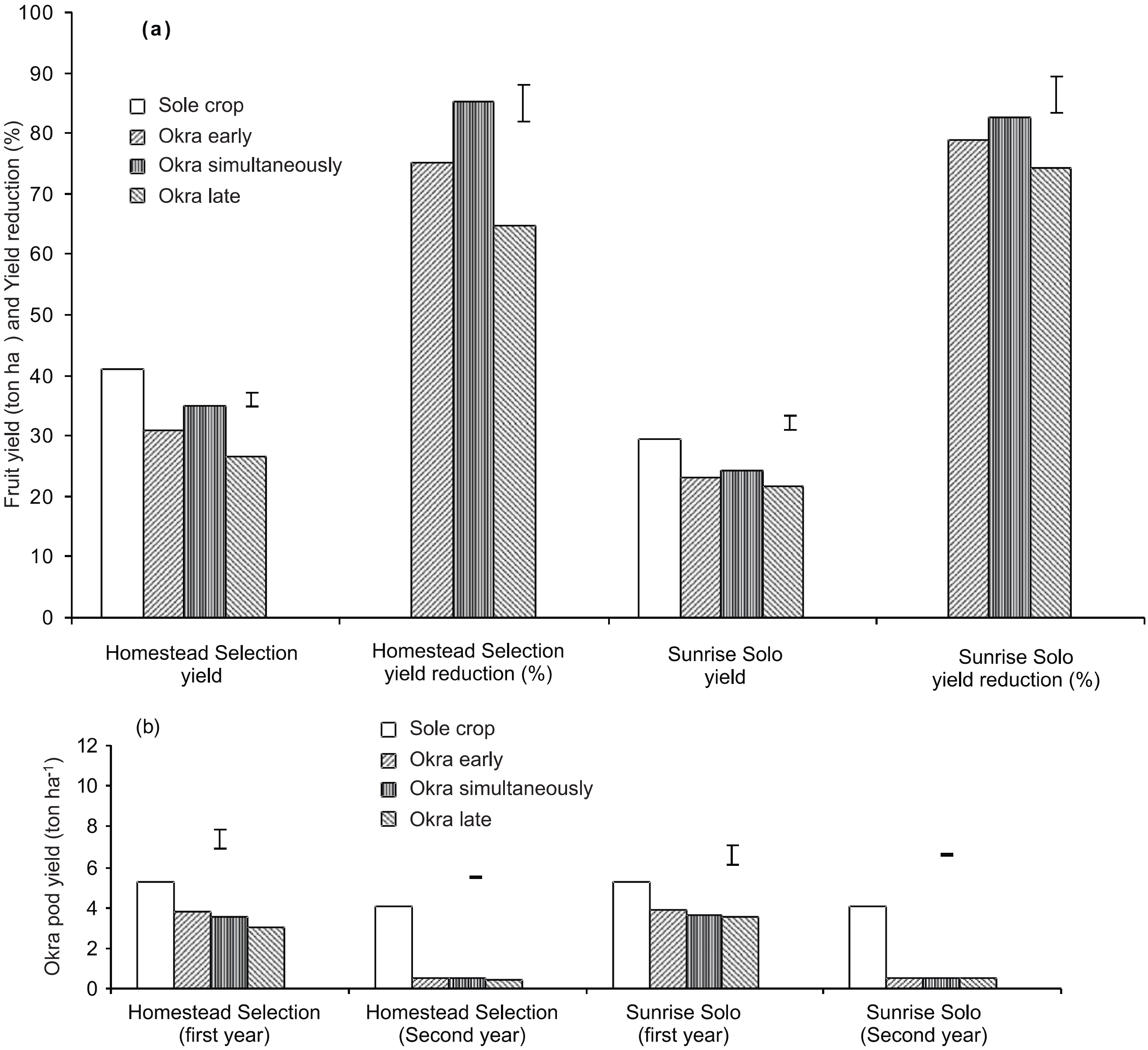

Fig 2. Fruit yield and percent reduction of component crops in papaya-okra mixtures showing (a) sole papaya varieties cv. Homestead (Hs) and Sunrise (Ss) and sole okra responses compared with papaya mixtures in early, simultaneous and late sequences, (b) okra in sequence with papaya varieties in 2006 and 2007. Vertical bars denote LSD (*P*=0.05).

okra-papaya mixture could be profitably grown.

Acknowledgements

We thank Mr. Adelaja, Assist. Director, NIHORT, Ibadan, Nigeria, Mr. Rafiu Ogunwale, NIHORT and Mr. Adetumbi, I.A.R. & T., Moor plantation, Ibadan, Nigeria for their significant contributions.

References

Adetiloye, P.O. and A.A. Adekunle, 1989. Concept of monetary equivalent ratio and its usefulness in the evaluation of intercropping advantages. *Tropical Agriculture* (Trinidad), 66(4): 337-341.

Adetiloye, P.O., F.O.C. Ezedinma and B.N. Okigho, 1983. A land equivalent coefficient concept for the evaluation of competitive and productive interaction on sample complex crop mixtures. *Ecol. Modelling*, 17: 27-39.

Aiyelaagbe, I.O.O. and M.A.O. Fawusi, 1988. Estimation of the area of detached or intact leaves of papaya. *Indian Journal of Agricultural Sciences,* 58(4): 322.

Aiyelaagbe I.O.O. and M.A. Jolaoso, 1992. Growth and yield response of papaya to intercropping with vegetable crops in South Western Nigeria. *Agroforestry Systems,* 19: 1-14.

Asif, M.I. 1977. Estimation of leaf area in okra *Abelmoschus esculentus* (L.) Moench. *Tropical Agriculture* (Trinidad), 54: 192.

AVRDC, 1991. *Vegetable Research in 1990*. Asian Vegetable Research Development Center, Shanhua, Tainan, Taiwan.

Balasubramanian, V. and L. Sekayange, 1990. Area harvests equivalency ratio for measuring efficiency in multi season intercropping. *Agron. J.*, 82: 519-522.

Beet, W.C. 1982. *Multiple Cropping and Tropical Farming Systems.* Weslview Press Inc., Boulder Colorado, 8030, USA.

de Wit, C.T. 1960. On competition. *Verslag Lanbouw Kundige Onderzock*, 66: 1-82.

FAO/UNESCO, 1990. *Soil Map of the World*. Revised Legend. Food and Agricultural Organisation of the United Nations, Rome.

FDALR, 1990. The Reconnaissance Soil Survey of Nigeria (1:650000). *Soils Report. Vol.3.* Federal Department of Agricultural Land Resources, Abuja.

Fukai, S. and B.R. Trenbath, 1993. Processes determining intercrop productivity and yields of component crops. *Field Crops Research*, 34(3-4): 247-271.

Hauggaard-Nielsen, H., P. Ambus and E.S. Jensen, 2003. The comparison of nitrogen use and leaching in sole cropped versus intercropped pea and barley. *Nutrient Cycling in Agro-ecosystems,* 65(3): 289-300.

Hiesbsch, C.K. and R.E. McCollum, 1987. Area x Time Equivalent Ratio: A method of evaluating the productivity of intercrops. *Agron. J.,* 79: 15-22.

John Susan Anna and C. Mini, 2005. Biological efficiency of intercropping in okra (*Abelmoschus esculentus* Moench) (L.). *J. Trop. Agric.*, 43 (1-2): 33-36.

Lowell, J. F. 1998. Producing Foods without pesticides. Local solutions to crop pest control in West Africa. Technical center for Agricultural and Rural Cooperation. (ACP-EC). CTA, Postbus 380, 6700 AJ, Wagenigen, The Netherlands.

Muoneke, O.O., J.E. Asiegbu and A.C.C. Udeogalanya, 1997. Effect of relative sowing time on the growth and yield of the component crops in okra/ maize and okra/cowpea intercropping systems. *J. Agric. Sci. Technol*., 1 & 2(1): 13-15.

McGilchrist, C.A. 1965. Analysis of competitive experiments. *Biometrics*, 21: 975-985.

Njoku, S.C., C.O. Muoneke, D.A. Okpara and F.M.O. Agbo, 2007. Effect of intercropping varieties of sweet potato and okra in an ultisol of S. Eastern Nigeria. *African J. Biotech.*, 6(14): 1650-1654.

Ofosu-Anim, J. and N.V. Limbani, 2007. Effect of Intercropping on the growth and yield of cucumber (*Cucumis sativus* L.) and okra (*Abelmoschus esculentus* (L.) Moench.) *Intl. J. Agri. Biol.*, 9(4): 594-597.

Olasantan, F.O. and E.S.C. Lucas, 1992. Intercropping maize with crops of different canopy heights and similar or different maturities using different spatial arrangements. *J. Agric. Sci. Technol.,* 1 & 2 (1): 13-15.

Olasantan, F. O. 2001. Optimum plant populations for okra (*Abelmoschus esculentus* Moench) in a mixture with cassava (*Manihot esculentus*) and its relevance to rainy season-based cropping systems in South Western Nigeria. *J. Agric. Sci. Camb.,* 136: 207-214.

Olubode, O.O., I.O.O. Aiyelaagbe, J.G Bodunde and F.O. Olasantan, 2008. Growth and yield of Papaya varieties (*Carica papaya* L.) intercropped with okra and cucumber. *Nig. J. Hort. Sci.,* 13: 25-34.

Palaniappan, S.P.C. 1985. *Cropping Systems in the Tropics. Principles and Management.* Wiley Estern ltd, India. pp. 215.

Smyth, A.J. and R.F. Montgomery, 1962. *Soils and Land Use in Central Western Nigeria*. The Government of Western Nigeria, Ibadan.

Statistical Analysis System, 1990. *SAS/STAT Users' Guide.* Version 6 Fourth Edn. Cary, NC: SAS Institute.

Steel, R.G.D. and J.A. Torrie, 1980. *Principles and Procedures of Stastistics.* McGraw Hill Book Co., New York.

Sullivan, P. 2001. *Intercropping Principles and Production Practices*: *Appropriate Technology Transfer for Rural Areas (ATTRA)*, USDA Rural Business. ATTRA Publication No. IP135.

Szumigalski, A. and R. Van Acker, 2005. Weed suppression and crop production in annual intercrops. *Weed Science*, 53(6): 813-825.

U.S.D.A. 1999. *Soil Taxonomy*, 2nd Ed. A basic system of soil classification for making and interpreting soil surveys. USDA - Soil Conservation Service, Agricultural Handbook #436, U.S. Government Printing Office, Washington, DC, 869p

Wiley, R.W. 1979. Intercropping– It's importance and research needs. Part 1. Competition and yield advantages. *Field Crop Abstracts,* 32(1): 1-10.