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EFFECT OF INTERCROPPING ON SOIL HYDRO-THERMAL REGIME, CROP PERFORMANCE AND WEED SITUATION IN A CASSAVA/OKRA INTERCROP

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ABSTRACT

Experiments were conducted in Abeokuta, south-western Nigeria to evaluate the effect of intercropping okra with cassava (Cv. *Odongbo Idileru and TMS 30572*) on soil hydrothermal regime, weed control, crop growth and yields. Treatments were randomized within three blocks in a split-plot design. Main plot was cropping system and subplot was cassava variety. Intercropping of cassava with okra significantly reduced the soil temperature by 2-7 % and weeds biomass by 60-76 %, and increased soil moisture content by 8-21 % and light interception by 16 % compared with sole cassava. Number of surface earthworm casts was 176 % higher than in sole okra. Intercropping with cassava did not significantly affect the vegetative characters, number of days to flowering and harvesting and harvest duration of okra, irrespective of the cassava cultivars. Vegetative characters and tuber yield of cassava were also not significantly affected by intercropping with okra. Tuber yield of Cv. Odongbo' was significantly reduced by 15-21% than Idileru, and 31-35% than TMS 30572. Yield advantage of intercropping increased by 78-114% compared to sole cropping. It is concluded that okra can be grown in mixture with cassava to provide a suitable environment for growth, but this depends on the cassava cultivar. Using a short early maturing cassava cultivar, with a moderate leaf area index in a mixture with okra is therefore recommended.

Key words Intercropping, Okra, *Abelmoschus esculentus*, Cassava, *Manihot esculenta, Odongbo, Idileru*, TMS 30572, Soil Hydro-thermal regime.

INTRODUCTION

In tropical agriculture, indigenous tropical vegetables are often grown as a component of crop mixtures. They are included for many reasons beside the food they provide (Bunting, 1980; Olasantan, 2007). Sometimes, vegetables are included for their bio-cultural attributes, ecological stability and sustainable production (Bunting, 1980; Okigbo, 1980; Hulugalle *et al*., 1994). Okra (*Abelmoschus esculentus* L. Moench) is an important indigenous tropical vegetable which grows best in warm climates. It is usually found in mixtures with starchy staple food crops such as cassava, yam and maize in most agricultural zones of sub-Saharan Africa (Ikeorgu *et al*., 1989; Olasantan, 1999, 2001; Olasantan and Bello, 2003). The pods grow rapidly being ready for harvest in about 50 – 60 days after planting (Olasantan and

Bello, 2003). The tender unripe pods have a unique texture and sweet flavour. The pods, when cut exude a mucilaginous juice that is used to thicken stews (Norman, 1992). Immature pods of okra are a good source of protein, energy, vitamins and minerals, particularly Ca, P and Mg. A secondary use of okra is for oil (oil content is about 200mg/g) and amino-acids from the mature seeds (Purseglove, 1977). In the humid tropics, cassava is an important root crop often grown in mixtures with other subsistence staples. It is a staple food for 160 million people (40%) out of the population, mostly in the west or central Africa (Anon, 1988). The annual output of cassava in Nigeria; the world's largest producer, is estimated as 33 million tonnes/annum (FAO, 2000). Cassava–based intercropping is a common practice in the sub-humid and humid tropics (Mustaers *et al*., 1993). Besides its use as food, it is an important raw material for production of starch, alcohol, pharmaceutics, gums confectionaries and livestock feed (Nnodu *et al*., 1995). Cassava is a long duration crop that is usually grown in wide-spaced rows and planted early when the rains begin. It occupies the land for about 12-18 months and its initial growth and canopy development is slow. It takes about 3-4 months before its canopy closes (Dahniya and Jalloh, 1995), and more than 50% of the light transmitted is wasted during this period (Tsay *et al*., 1987; Olasantan, 1994). It is therefore uneconomic to grow cassava as a sole crop for such a long period, but the wide inter-row spaces, coupled with the growth habit provide the opportunity of growing vegetables between cassava rows to diversify production (Olasantan, 2001). Attempts to diversify early vegetable production in the tropics must therefore be based on the exploitation of the inter-row spaces provided by cassava. Information is however lacking on the response of different varieties of cassava to intercropping with okra. This study was therefore carried out to evaluate the effect of intercropping okra on soil hydro thermal regime crop growth and yields in a cassava/okra intercrops.

MATERIALS AND METHOD

Description of experimental site

Field experiments were conducted in 2001 and 2002, to evaluate effect of intercropping of okra with cassava on their growth, yield and microenvironment at the University of Agriculture, Abeokuta (7^o 15'N, 3^o 25'E) in south-western Nigeria. The annual rainfall for 2001 and 2002 were 950 and 1721mm, respectively, out of which 62 and 54 % of the total rainfall were received during June to November of the two years. The mean, minimum and maximum air temperatures ranged from 11-18 ^{o}C and 30-36 ^{o}C, respectively (Table 1).

The soil had previously been planted to maize, but left under natural fallow before the experiment began. The soil was a sandy loam with an average of 88 % sand, 5 % silt and 7% clay. The soil had 3.08 % Organic matter, 0.15 % total Nitrogen, 2.56 mgkg^{-1} available P with 22.8, 4.55 and 0.62 Cmolkg^{-1} of Ca, Mg and K respectively. Soil pH was 6.95 at 20 cm depth. The crops were planted on a flat after disc ploughing and harrowing.

Treatments and field Management

Three cassava cultivars, TMS30572, an improved variety, early branching with dense canopy, "*Idileru*", a local variety, late branching with dense canopy, and "*Odongbo*", a local variety, late branching with sparse canopy were used for the experiment. The okra variety (*NHAe* 47-4) is a day neutral plant, with a deep green, broad leaves and moderate canopy height.

Table 1: Monthly rainfall, minimum and maximum temperature in 2001, 2002, at Abeokuta

	Total Rainfall (mm)		Min Air Temp (°C)		Max Air Temp (°C)	
	2001	2002	2001	2002	2001	2002
Jan	2.60	0.0	16.0	14.0	35.1	33.7
Feb	8.60	2.7	15.7	11.8	36.7	36.8
Mar	80.0	380.6	18.5	10	35.0	36.7
Apr	105.0	136.9	16.8	8.9	34.4	32.5
May	154.3	131.9	17.1	9.9	32.8	32.3
Jun	135.9	133.7	17.4	10.2	31.0	31.6
Jul	135.5	325.5	18.0	11.4	29.6	30.5
Aug	57.4	110.1	17.2	8.4	35.7	29.6
Sep	199.3	148.7	11.1	8.4	30.2	30.6
Oct	54.5	297.0	10.7	8.3	32.0	31.5
Nov	17.4	54.5	11.8	10.9	32.2	34.7
Dec	0.0	0.0	12.9	9.9	34.4	35.4
Ann.	950.5	1721.6				
Mean	79.2	143.5	15.3	10.2	33.3	33

Source: Ogun-Oshun River Basin Development Authority, Abeokuta Nigeria

It is popular for its early maturity (60 days) high leaf area index (LAI) and high pod yield. Its pods are prized for their unique flavour, high mucilaginous content, low fibre and moderate size. These attributes are highly acceptable to most farmers and they are valued by consumers in south western, Nigeria. According to Alegbejo, 2003, the variety is also moderately resistant to okra mosaic virus.

Okra was sown on 13 June, 2001 and 20 July, 2002, while cassava was planted on 20 June 2001 and 27 July in 2002. Cassava was planted at 1m x 1m spacing giving 10,000 plants ha^{-1} and okra at 1x 0.3m spacing to give 33,333 plants ha^{-1} in both mono cropping and mixed stands. A constant arrangement of one row of okra bordering one row of cassava with 0.50m apart was used in the mixed stands.

Treatments were randomized within three blocks in a split-plot design, with cropping system (cassava mono cropping and cassava/ okra intercrop) as the main plots and cassava cultivars (*Odongbo, Idileru* and TMS 30572) as subplots. One sole-crop plot of okra was randomized within each block to act as check for okra intercrop. Each subplot measured 12x5m.

A basal treatment of 80kg Nha^{-1} of a compound NPK 20:10:10 fertilizer was applied 3 weeks after planting in all plots containing okra using band method. The fertilizer was drilled into furrows 25cm from the okra and cassava.

Foliar pest were controlled at 4 WAP, by application of 400 ml ha^{-1} of Cymbush 10 EC (containing 100gl^{-1} Cypermethrin in 500L of water).

Data Collection and analysis

Soil temperature at a depth of 10cm was measured with thermometer installed at the centre rows of each plot at 10 and 12 WAP at 16hr local time when the differences between pure and mixed stands were highest (Olasantan, 1988; Olasantan *et al*., 1996). Soil samples were collected at 0-15 cm depth adjacent to the thermometers and oven dried at 105^{o}C for 24hr to determine the gravimetric soil moisture content. Average soil temperature and moisture regimes were determined on clear days of 22 August and 4 September in 2001 and 24 September and 6 October in 2002.

Light interception was measured using a digital micro-ammeter (Type 199.9 μa) at 10 WAP. The light meter in the mixed plots was positioned between cassava and okra at the ground level, one at the top of okra and one at the top of cassava canopy.

Surface earthworm casts were collected three 1m^2 quadrants in each treatment plot at 20 WAP and counted. Parameters on light interception and surface earthworm casts were obtained only in 2002.

All the plots were weeded manually at 4, 8 and 12 WAP. Weed dry weights were measured at 8 WAP in each year, on samples taken from the three 1-m^2 quadrants in each plot after oven drying at 60^{o}C for 72hr.

Ten okra plants were sampled at 8 and 12 WAP in 2001 and in 2002 to determine the plant height, number of leaves and branches per plant and leaf area index (LAI). Okra leaf area was determined non-destructively from its relationship with the length of the mid-rib using linear equation (Asif, 1977). Area of 120 leaves of varying sizes was determined by graph paper tracing. The estimated regression equation between leaf area (Y) and leaf length (X) is:

$$Y = -386.93 + 40.56X \quad (r^2 = 0.91)$$

(Olasantan and Salau, 2008)

Leaf area index (LAI) was determined as

$$LAI = \text{leaf area of plants (cm}^2\text{) plot}^{-1}/\text{plot area (cm}^2\text{)}$$

Number of days to 50% flowering, and to first pod harvest, frequency of harvest and harvest duration were determined. Green immature pods were harvested every 3 days, starting from 66 and 58 days after planting in 2001 and 2002 respectively. The pods of 120 plants from the six innermost rows were picked, counted and weighed. The number, weight and pod sizes were recorded. The percentage weekly pod weight of okra was determined as:

$$\text{Pod yield (\%)} = \frac{\text{weekly pod weight (tha}^{-1}\text{)} \times 100}{\text{Total pod weight (tha}^{-1}\text{)}}$$

Ten cassava plants from each plot were randomly selected at 12 WAP to determine plant height, number of leaves and branches per plant, leaf area and LAI. Leaf area of cassava was determined from its relationship with mid-rib length using linear equation described by Ramanujam and Indira (1978). The estimated regression equation between leaf area (Y) and mid-rib length (X) is

$$Y = 156.64 + 23.07X \quad (r^2 = 0.88)$$

At 15 months after planting, 10 cassava plants were harvested from the centre rows to determine the number of tubers, tuber weight and the fresh tuber yield per hectare.

Land use efficiency of cassava/okra intercrop was determined using land equivalent ratio (LER) concept (Mead and Willey, 1980). LER was defined as the ratio of intercrop yield to sole crop. It was calculated as follows:

$$LER = \sum_{i=1}^{n} (Y_i^I / Y^M)$$

where Y_i^I is the yield of crop i in intercropping, Y_i^M is the yield of crop in mono cropping and n is the total number of crops in association.

Data collected were subjected to analyses of variance (ANOVA) using the procedures of Statistical Analysis System (SAS, 2000). Treatment means were separated by using Standard Error Difference of Mean (S.E.D) at 5% probability level. Simple linear correlation analysis was carried out to estimate the degree of association between crop growth and microenvironment factors.

RESULTS

Modification of growth environment

In 2001 and 2002, soil moisture content and soil temperatures were significantly affected by cropping system (Table 2). Intercropping cassava with okra significantly increased soil moisture content by 8-21 % compared with sole cassava and by 4-13 % compared with sole okra in both years. Soil moisture content in the sole okra was not significantly different from that of sole cassava in both years.

Furthermore, intercropping cassava with okra significantly reduced soil temperature by 2-7 % compared with sole cassava only in 2001. Soil temperature in the sole okra was not significantly different from that of sole cassava in both years.

Cultivar effect was significant on soil moisture content and soil temperature. Soil moisture in Cv TMS 30572 increased significantly by 3-5 % and soil temperature reduced significantly by 2 % compared with that of Cv Odongbo.

Table 2: Soil moisture content and soil temperatures in sole crop okra and in mixture with cassava at Abeokuta, in 2001 and 2002

Cropping system	Soil moisture content (g/kg)				Soil temperature (°C)			
	2001		2002		2001		2002	
	10*	12	10	12	10	12	10	12
Sole crop Okra	124	115	96	102	28.0	30.0	28.3	28.5
Odongbo/ Okra	128	117	97	113	27.8	29.5	28.2	28.2
Idileru/ Okra	132	119	100	115	27.7	29.2	27.8	28.2
TMS30572/ Okra	135	120	102	117	27.6	29.2	28.1	28.2
Intercrop (mean)	132	119	100	115	27.7	29.3	28.0	28.2
Sole crop Odongbo	118	108	83	114	28.8	31.3	28.5	28.6
Sole crop Idileru	122	111	82	115	28.4	30.8	28.5	28.3
Sole crop TMS30572	123	111	84	118	28.0	30.5	28.3	28.3
Sole Cassava mean	121	110	83	116	28.4	30.9	28.4	28.4
S.E.D 0.05	3.14	4.41	4.75	3.42	0.14	0.19	0.15	0.13

* Weeks after planting

Similarly, intercropping significantly increased light interception by 16 % than in sole cassava plots and by 22 % higher than sole okra (Table 3). Number of surface earthworm casts in the cassava/okra mixture was significantly higher by 176% when compared with that of sole okra but not when compared with that of sole cassava. Cassava cultivar effect was not significant on light interception and surface earthworm casts.

Weed dry weight

In both years, effect of intercropping okra with cassava was significant on weed dry weight (Table 3). Cassava/okra mixture decreased weed dry weight by 60-76 % compared with sole crop cassava and by 14 -33% compared with sole crop okra. Cultivar effect was also significant. TMS 30572 decreased weed growth by 17-40 and 21-23 %, more than "*Odongbo*" and "*Idileru*" cultivars respectively.

Table 3: Weed biomass, light interception and number of earthworm Casts of vegetable in monoculture and in mixtures with cassava at Abeokuta in 2001 and 2002

Cropping system	Weed biomass (g/m^2)		Light interception (%)	No. of earthworm casts $/m^2$
	2001	2002	2002	2002
Sole crop Okra	209	163	35.6	17.2
Odongbo/ Okra	134	145	43.6	44.7
Idileru/ Okra	175	138	45.1	48.2
TMS30572/ Okra	147	147	42.2	48.7
Intercrop (mean)	157	143	43.6	47.2
Sole crop Odongbo	311	207	34.7	42.8
Sole crop Idileru	267	214	42.1	43.6
Sole crop TMS30572	235	176	35.9	48.2
Sole Cassava mean	271	199	37.5	45.3
S.E.D 0.05	6.9	7.7	2.0	3.7

*20 weeks after planting

Growth and yield characters of okra

Intercropping okra with cassava did not significantly affect the plant height, number of leaves and leaf area index (LAI) of okra in 2001 and 2002 cropping seasons (Table 4). Similarly, Intercropping with cassava did not significantly affect the number of days to fifty percent flowering and to first pod harvest and duration of harvest (Table 5), number of pods per plant, and fresh pod yield per hectare of okra in both years (Table 6). Patterns of weekly pod yields were significantly different in both years (Fig. 1). In 2001, intercropped okra produced appreciably higher early pod yield at 10-13 and later at 17-20 WAP than sole okra. In 2002, sole okra produced appreciably higher pod yield than intercropped okra only at 9 WAP, whereas intercropped okra produced higher pod yield at 12-14 WAP than sole okra. Peak of pod yields occurred at 12 – 14 weeks in both years, while pod production declined at 23 WAP in 2001 and 15 – 16 WAP in 2002.

Table 4: Plant height, number of leaves and leaf area index of okra as influenced by intercropping with cassava in 2001 and 2002

	2001						2002					
	Plant height (cm)		Number of leaves/plant		Leaf area index		Plant height (cm)		Number of leaves		Leaf area index	
Cropping system	8	12	8	12	8	12	8	12	8	12	8	12
Sole crop okra	58.8	77.8	10.2	18	1.73	4.45	45.9	71.9	14.3	36.4	3.27	5.59
Odongbo /okra	57.8	77.8	10.1	20.4	1.54	4.63	41.4	64.2	12.9	36.5	2.87	5.01
Idileru/ okra	57.9	70.9	8.8	14.3	1.20	3.72	42	71.8	14.3	36.3	2.92	5.28
TMS3057 2/okra	56.4	71.8	9.0 .	17.3	1.42	3.78	42.4	75.1	15	37.3	3.5	5.99
Intercrop (mean)	57.4	73.5	9.3	17.3	1.39	4.04	41.9	70.4	14.1	36.7	3.09	5.43
S.E 0.05	1.7	2.8	0.7	1.7	0.16	0.2	1.6	2.7	0.74	0.94	0.78	1.7

Table 5: Days to 50% flowering and days to first harvest, duration of Harvest of okra in monoculture and in mixture with cassava at Abeokuta in 2001 and 2002

Cropping system	Days to 50% flowering		Days to 1st pod harvest		Harvest duration	
	2001	2002	2001	2002	2001	2002
Sole crop okra	64.0	56.3	67	58	83	56
Odongbo/okra	64.0	56.0	65	58	85	56
Idileru/okra	63.0	56.3	67	58	82	56
TMS30572/okra	64.0	55.7	65	58	83	56
Intercrop (mean)	64.0	56.1	66	58	83	56
S.E.D 0.05	0.65	0.32	0.61	0.57	0.53	0.64

Table 6: Fresh pod yield and yield characters of okra in monoculture and in mixture with cassava at Abeokuta in 2001 and 2002

Cropping system	No. of pods/plant		Weight/pod (g)		Fresh pod weight/plant (g)		Fresh pod yield (t/ha)	
	2001	2002	2001	2002	2001	2002	2001	2002
Sole crop okra	8.5	9.0	13.5	15.8	114.3	142.2	3.82	4.73
Odongbo/okra	10.6	8.3	12.9	16.1	136.7	133.6	4.56	4.45
Idileru/okra	10.3	7.7	12.1	16.6	124.6	127.8	4.15	4.26
TMS 30572/okra	8.5	9.2	13.2	17.0	112.2	156.4	3.74	5.21
Intercrop (mean)	9.8	8.4	12.7	16.5	124.5	138.6	4.15	4.62
S.E.D 0.05	1.15	0.17	1.15	0.74	20.4	23.8	0.68	0.80

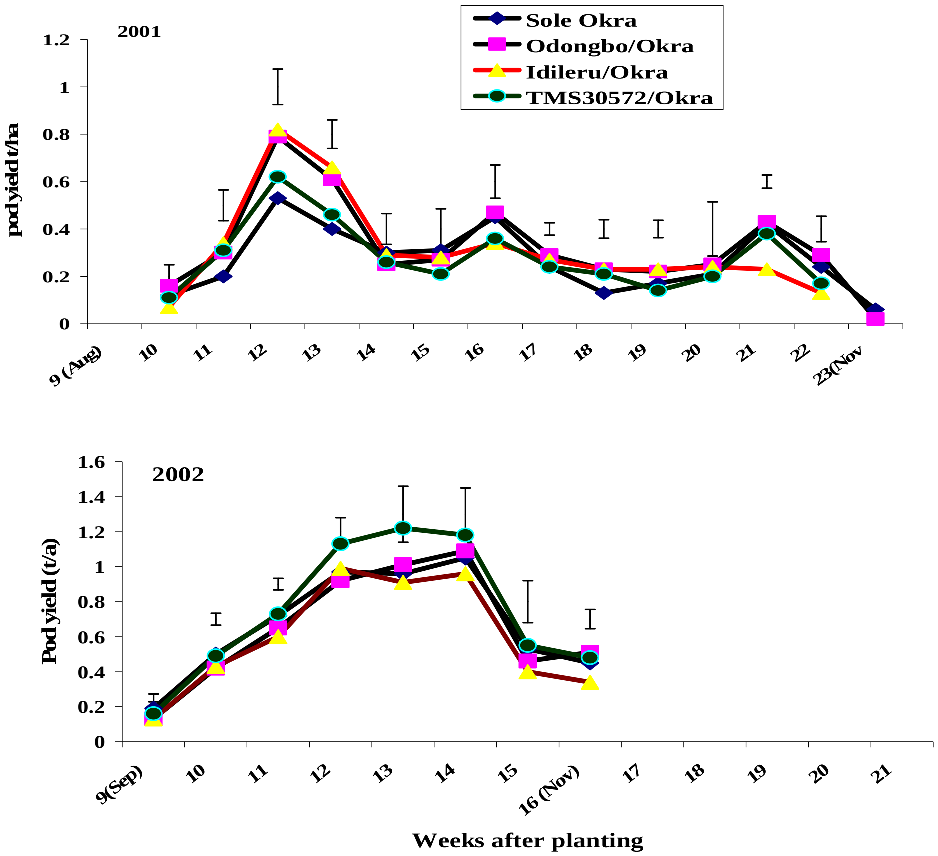

Fig.1: Weekly pod yield of okra as affected by intercropping with cassava in 2001(a) and 2002(b). Vertical bars are S.E.D at p≤0.05

Growth and yield characters of cassava

In both years, plant height, number of leaves per plant, leaf area index (Table 7) and tuber yield and yield characters of cassava (Table 8) were not significantly affected by intercropping with okra. However, cultivar effect was significant. Cv 'Odongbo' produced significantly lower LAI than cvs 'Idileru' and TMS 30572 by 52-68 % and 23-32 %, respectively, in both years. Similarly, tuber yield of cv 'Odongbo' was significantly lower than those produced cv. Idileru and cv. TMS 30572 by 15-21% and 31-35%, also in both years. The corresponding values for cultivars "Idileru" and TMS30572 were similar in both years.

Table 7: Vegetative characters of cassava (3 months after planting) in monoculture and in mixture with Okra at Abeokuta, Nigeria in 2001 and 2002

Cropping system	Plant height cm)		No of leaves/plant		Leaf area Index	
	2001	2002	2001	2002	2001	2002
Sole cassava						
Odongbo	64.5	77.5	29.9	42.1	1.63	1.41
Idileru	69.7	81.9	40.6	61.6	2.48	2.09
TMS30572	64.4	76.5	35.5	52.5	1.91	1.71
Sole cassava (mean)	66.2	78.6	35.5	52.1	2.08	1.73
Odongbo/okra	61.3	69.4	26.6	34.6	1.47	1.07
Idileru/okra	66.6	73.3	37.3	54.2	2.21	1.69
TMS 30572/okra	61.3	68.4	32.3	45.1	1.91	1.35
Intercrop mean	63.1	70.6	32.1	44.6	1.83	1.37
S.E.D 0.05 Cropping (C)	5.96	2.94	4.30	4.64	0.12	0.21
S.E.D 0.05 Variety (V)	7.02	4.47	5.07	2.93	0.10	0.12
S.E.D 0.05 C x V	8.35	6.32	7.17	4.14	0.20	0.17

Table 8: Tuber yield and yield components of sole crop cassava and in mixture with okra at Abeokuta in 2001 and 2002

Cropping system	No. of tubers/plant		Weight/tuber (g)		Tuber yield (t/ha)	
	2001	2002	2001	2002	2001	2002
Sole cassava						
Odongbo	3.3	3.7	657	565	21.7	20.9
Idileru	4.9	4.7	545	519	26.7	24.3
TMS30572	5.6	6.0	509	476	28.5	28.6
Sole cassava mean	4.6	4.8	570	520	25.6	24.6
Odongbo/okra	3.4	3.4	642	603	21.8	20.5
Idileru/okra	5.1	5.0	511	472	26.1	23.6
TMS30572/okra	5.3	5.3	543	519	28.7	27.5
Intercrop mean	4.2	4.6	565	531	25.5	23.8
S.E.D 0.05 Cropping (C)	0.03	0.03	9.12	10.66	0.35	0.35
S.E.D 0.05 Variety (V)	0.02	0.02	7.89	9.23	0.31	0.30
S.E.D 0.05 C x V	0.05	0.04	15.79	18.47	0.61	0.60

Land Equivalent Ratio

Relative yield and land equivalent ratio (LER) of cassava/okra intercropping was presented in Table 9. Intercropping cassava with okra gave LER values of 1.78–2.14 in the two years, giving yield advantage of 78–114% compared with sole crops.

Table 9: A comparison of yield advantages indicated by land equivalent ratio (LER) in a cassava-okra intercropping at Abeokuta in 2001 and 2002

Treatment	Relative yield				LER	
	Vegetable		Cassava			
	2001	2002	2001	2002	2001	2002
Odongbo/okra	1.21	0.96	0.93	0.82	2.14	1.78
Idileru/okra	1.10	0.88	0.82	0.93	1.92	1.81
TMS30572/okra	0.97	1.10	0.87	0.96	1.84	2.06

Correlation Analysis

Variation in aggregate LAI of okra/cassava mixture compared to sole okra accounted for 61 and 69 % of the variation in soil moisture content and soil temperatures, respectively while it accounted for 94 and 84 % of the variation in light interception and dry weed biomass, respectively (Table 10). Variation in soil moisture content and soil temperatures, respectively, accounted for 51 and 54 % of the variation in the mixture earthworm casts, while variation in light interception and weed biomass accounted for 71 and 61 % of the variation in the earthworm casts, respectively.

Table 10: Correlation analysis between hydrothermal variables and Aggregate leaf area index (LAI) earthworm casts and pod yield of okra at Abeokuta

Variables (n-2)	Agg. LAI	Earthworm casts (no/m2)	Pod yield (t/ha)
Soil moisture content(g/kg)	0.606*	0.510*	0.510*
Soil temperature (o C)	-0.692*	-0.536*	-0.389
Weed biomass (g/m2)	0.837**	-0.608*	-0.534*
Light interception	0.937**	0.713**	0.533*

* and ** significant at $p \leq 0.05$ and 0.01, respectively.

DISCUSSION

The study showed that reasonable ecological benefits were obtained in growing okra between cassava rows with regard to changes in the soil micro-environment. The maximum daily air temperatures during the planting and establishment of okra in June-July in both years were between 29-32 ^{o}C and between 31-35 ^{o}C, during reproductive phases of okra in August- September, also in both years (Table 1). This indicates that daily maximum air temperatures during vegetative and reproductive phases of okra were supra-optimal (Lal, 1974, Arnon, 1992). However, soil temperatures under mixed crops were considerably reduced; the soil temperatures were within the range of 26.2-30.1^{o}C. Furthermore, soil moisture contents in the mixed stands of okra, considerably improved. The values were 100-132 gkg,$^{-1}$ in the mixed crops of okra, relative to 83-121gkg,$^{-1}$ in sole cassava and 96-124 gkg,$^{-1}$ in sole okra in both years (Table 2). This implies that the modification of soil environment was greater when okra was planted in the mixtures with cassava than when planted as sole crop (Olasantan *et al*., 1996). The mixture also suppressed weed growth increased earthworm casts and maintained a favourable soil environment. The ground cover provided by the associated okra possibly reduced the amount of radiation flux reaching the soil surface, minimized water loss by evaporation during the daytime and inversion of soil at night. Intercrop okra also utilized solar radiation, water and nutrients which otherwise would have wasted or utilized by weeds in the cassava inter-row space. These findings agreed with the reports of Bunting (1980) and Okigbo (1980) on the usefulness of mixed cropping in the protection of soil surface against solar radiation, evaporation and erosion. Intercropping cassava with vegetables provided remarkable control over weeds. In both years, weed biomass in mixtures with okra was reduced by 14-33 %, respectively, compared to their corresponding sole okra and by 60-76 % compared to sole cassava. Effectiveness of mixed cropping in reducing incidence of weeds had been reported for maize and cowpea (Kyamangwa and Ampofo, 1988) and for sorghum and groundnut (Carson, 1989). The weed suppressing effect of cassava/vegetable mixtures was due to increased aggregate LAI in the mixture. LAI of okra, in mixtures with cassava at 3 months of growth increased by 11-30 % relative to sole okra in both years. At this growth stage, cassava/okra intercepted 19-25 % light more than sole okra and 19 % more than sole cassava. This implies that for effective ground cover and consequently for weed suppression in cassava production, associated intercrops must grow fast. Olasantan *et al*. (1994) reported that associated intercrop with cassava should attain appreciable LAI of at least 1.5 and intercept sufficient light within 8 weeks of growth. Short duration crops like okra is a suitable component crop that could reduce weed growth and still maximize growth resources under cassava, before it effectively covers the ground. The difference in LAI may explain the differences between the growth of cassava and okra. Okra matures between 3-4 months during which cassava is yet to fully establish itself on the field.

Growing okra, between widely spaced rows of cassava did not affect phenological growth stages and yield of okra and the performance of associated cassava plants in both years. This could be attributed to the wide disparity between maturity dates in relation to resource requirement and utilization of both crops. Okra (NHAe 47-4) is a vegetable with high LAI and matures within 60 days while cassava is a slow growing and long duration crop with maturity dates of 250-450 days depending on the variety. Okra had largely reached physiological maturity, before the growth and tuber bulking of cassava was maximal. Consequently, yield performance of intercrop okra was not adversely affected by intercropping with cassava irrespective of the variety.

Cassava variety showed differential response to intercropping with okra in both years. Growth and tuber yields of cassava were not affected significantly by intercropping with okra because of the disparity in their growth habit. After harvesting, cassava intercrops were able to recover and grow properly to adequately benefit from full sunlight and residual soil nutrients and moisture. Similarly, the short period of competition between okra and cassava resulted in an efficient cropping system, judging by their combined LER, being greater than 1.0. Thus, the disparity in the time of reproductive development of both crop species is advantageous for okra because they did not come to the stage of maximum demand for nutrient and moisture, aerial space and light at the same time.

CONCLUSION

The results of the study showed that intercropping okra with cassava is a viable cropping option to diversify production and improve the soil micro environment. Intercropping reduced supra-optimal soil temperature, increased soil moisture, light interception and earthworm activity which subsequently increased total yield. When okra is to be used for both fruit and seed production, intercropping it with an early maturing, high yielding with a moderate high leaf area index cassava is recommended.

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