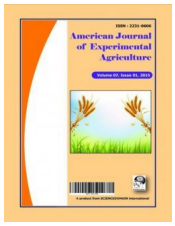

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Response of Kenaf to Early and Late Cropping Seasons in Cassava-Maize Based Intercrops

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Field experiments were conducted in 2013 and 2014 to study the response of kenaf to early and late cropping seasons in relay intercropping system with cassava-maize based intercrop at Ibadan Research Farm of the Institute of Agricultural Research and Training (IAR&T), Obafemi Awolowo University, Moor Plantation Ibadan. The experimental design was a randomized complete block design with 7 treatments and three replications. All data collected from the growth and yield parameters of component crops were subjected to analysis of variance to test the effects of the cropping systems separately using the MSTATC package. Intercropping depressed the weight of 1000 grains, average ear length, average weight of ear/plant and grain yield of maize in both cropping seasons. The values, 0.37 and 0.36 g, 20.3 and 20.0 cm, 193 and 187 g and 3.26 and 3.21 t/ha for the weight of 1000 grains, average ear length, average weight of ear/plant and grain yield in in both cropping seasons for sole maize were the highest. Intercropping affected the plant height at harvest, weight of tuber per plant, average weight of tuber per plant and tuber yield of cassava in both cropping seasons. The highest values, 229.5 and 225.4 cm cassava plant height at harvest observed under cassava/maize/kenaf intercrop in this study. The values, 3.30 and 3.17 kg, 747.8 and 733.5 g and 19.8 and 20.6 t/ha for the weight of tuber per plant, average weight of tuber per plant and tuber yield in 2013 and 2014 respectively for cassava/kenaf relayed with maize were not significantly different from the values, 3.70 and 3.56 kg, 728.8 and 721.8 g and 21.3 and

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19.7 t/ha for the weight of tuber per plant, average weight of tuber per plant and tuber yield in both cropping seasons for cassava/maize relayed with kenaf. Plant height at harvest and basal diameter at harvest were significantly affected by cropping system in both years of the experimentation with the kenaf plants under sole cropping in both years attaining highest plant height and basal diameter, these were not significantly different from plants under cassava/kenaf relayed with maize in both cropping seasons. The least values, 228.4 and 227.6 cm recorded for plant height at harvest and 1.73 and 1.67 cm recorded for basal diameter in 2013 and 2014 respectively were obtained from cassava/maize/kenaf intercrop. Kenaf plants grown under cassava/maize relayed with kenaf gave the significantly highest seed yield values,856.7 and 879.9 kg/ha in 2013 and 2014 respectively compared to sole cropping of kenaf that gave seed yield values 707.9 and 712 kg/ha in 2013 and 2014 respectively. On average, the three crops combination systems recorded the least values for the fiber yield followed by cassava/maize relayed with kenaf. Mixture productivity (LER) indicated that the cassava/maize/kenaf intercrop recorded the highest values, 1.68 and 1.66 in in 2013 and 2014 respectively. The values were not significantly different from the values recorded for relayed intercropping systems in both years. Whenever either high yield and good quality fiber or high yield and good quality seeds is important in intercropping system that consists kenaf as one of the component crops, relay intercropping system is essential for adoption. Either cassava/kenaf relay with maize or cassava/maize relay with kenaf is recommended to the farmers in the study area.

Keywords: Cassava/maize/kenaf intercrop; cropping season; field experiment; land equivalent ratio; relay intercropping; yield.

1. INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is a short-day, annual, herbaceous plant. The plant belongs to the family Malvaceae, an important plant that possesses both horticultural and economic values [1,2]. Kenaf is commercially cultivated in more than 20 countries [3]. FAO [4] reported that ninety percent of the sown area and more than 95% of total production of kenaf in the world comes from China, India and Thailand, it is also commercially cultivated in Vietnam, Iran, Russia, Mozambique, Taiwan, El Salvador, Guatemala, Ivory Coast and Nigeria [1]. Kenaf is a fast growing plant which serves as a source of natural and bio-degradable fiber. It is a valuable plant of the future, which can provide raw materials for industrial purposes. The traditional and industrial uses of kenaf comprising of its use as a source of fiber for making ropes, sacks, canvas, and carpets [1]. Kenaf biomass is useful in pulp and paper making, oil and chemical bio-absorbents [5] and oil spill bio-remediation, paper-board products, a substitute for fiber glass, filtration media making, and food and bedding material for livestock keeping [6,7]. Some literatures have studied the adaptability and biomass productivity of few kenaf varieties under mono-cropping system [8-15]. Crop productivity and yield are important factors which differ among varieties and even cultivars of plant [16,2]. Information regarding productivity and growth characteristics of kenaf under intercropping systems are very few and have not been explored in detail, such knowledge of growth and biomass characteristics under intercropping can hold the better perceptive of kenaf production under the existing traditional farming systems of developing countries of Africa. Intercropping, rather than mono-cropping, is the prevalent farming system in developing countries of Africa [17]. Intercropping is a system in which different crop mixtures are grown at the same time on the same piece of land [18]. There are other forms of this system such as relay cropping, which has a marked time of planting component crop, and multiple cropping, in which more than one crop harvest per season is obtained [18,19] and in some cases recommendation had been made [20]. According to Gomez and Gomez [21], intercropping brings about increase in crop yields, crop diversity and stability of crop production. In the developing countries of Africa, maize is commonly grown in mixtures of intercropping systems. Okigbo and Greenland [22] reported that about seventy-five percent of the area of maize in Nigeria is in association with other crops. Cassava is a significant component of cropping systems across a wide range of the tropical environment. According to Carter et al, [23] cassava is widely accepted by the peasant farmers and this this is attributed to its width of ecological amplitude, such as its adaptability to a wide range of ecological and agronomic conditions. It seems that differences in the maturity time and growth habit of the component crops are important determinants of the productivity under

intercropping systems [24]. Therefore, the objective of the study was to investigate the growth and yield potentials of kenaf to different planting date in relayed intercropping system with maize in cassava/maize/kenaf intercrop and to assess the yield response of the component crops to intercropping using land equivalent ratio (LER).

2. MATERIALS AND METHODS

A field trials to investigate the growth and yield potentials of kenaf to early and late cropping seasons in relayed intercropping system with maize in the cassava based intercropping systems were carried out during the early and late cropping seasons of 2013/2014 and 2014/2015 at Ibadan station of the Institute of Agricultural Research and Training (IAR&T), Obafemi Awolowo University, Moor Plantation Ibadan. The sites are located in the rain forest-savanna transitional agro-ecology which lies between Latitude 7° 39″ N and Longitude 3^0 92″ E of south west Nigeria. The climate of Ibadan is tropical with distinct wet and dry seasons and a mean minimum annual temperature of 21℃ (68.8℉). In consonance with seasonal variations in radiation, sunshine and cloud cover the mean annual temperature could change. Between March and October, the prevalent wind in the city is the moist maritime South-west monsoon which blows inland from the Atlantic Ocean; this is the period of rainy season. November to February is the period of dry season when the dry dust laden winds blow from the Sahara desert. The mean annual rainfall of about 1,205 mm, falling in approximately 109 days with two rainfall peaks in June and September. Kenaf variety Ife Ken DI 400 an improved variety newly developed by the Institute of Agricultural Research and Training (IAR&T), Obafemi Awolowo University, Moor Plantation Ibadan, maize variety (DMR-ESR Yellow) and cassava variety (TMS 30572) were used as planting materials for the experiments in both cropping seasons. The experimental design was a randomized complete block design with 7 treatments and three replications. The treatment combinations were three sole crop of kenaf, maize and cassava and three intercropped combinations of the three crops; cassava/ kenaf/maize, cassava/kenaf relayed with maize, cassava/maize relayed with kenaf and one intercropped combination of the two crops; maize/kenaf. The plot size was 25 m^2. Kenaf and maize seeds were planted on the second week of May and the second week of August of experimental years for early cropping season and late cropping season. Cassava cuttings were planted as early crop on the same date as in the case of either maize or kenaf in the intercropping systems. Under sole cropping, the spacing adopted for kenaf was 50 x 20 cm at 2 plants/stand giving 200,000 plants/ha, for maize was 75 x 45 cm at 2 plants/stand giving 59,259 plants/ha and for cassava was 100 x 100 cm giving 10,000 plants/ha. Under relay intercrop with two crop combination, the spacing adopted for kenaf was 100 x 20 cm at 2 plants/stand giving 100,000 plants/ha, for maize was 100 x 45 cm at 2 plants/stand giving 44,444 plants/ha and for cassava was 100 x 100 cm giving 10,000 plants/ha. Under intercrop with three crop combinations, the spacing adopted for kenaf was 200 x 20 cm at 2 plants/stand giving 50,000 plants/ha, for maize was 200 x 45 cm at 2 plants/stand giving 22,222 plants/ha and for cassava was 100 x 100 cm giving 10,000 plants/ha. Single row of each kenaf and maize was established within six inter-row spaces of cassava under intercrop combinations. The first manual weeding using hoe was done at 3 weeks after planting (WAP) after which 400 kg/ha NPK 20-10-10 fertilizer was applied to intercrop combinations while 200 kg/ha NPK 20-10-10 fertilizer was applied to sole crops. The second and third manual weeding was done 4 and 6 months after planting. In order to assess the growth and some yield attributes of kenaf and maize, ten plants were randomly selected and tagged at 4 WAP within the middle rows on plot basis and sampled. Parameters evaluated with maize and kenaf included plant height at harvest, number of capsules per plant, 1000 seed/grain weight, harvest index and fiber yield, seed yield and grain yield. On cassava data were collected on parameters such as number of tubers per plant, weight of tubers per plant, mean tuber weight and tuber yield. Mixture productivity was assessed using land equivalent ratio (LER). LER indicates the efficiency of intercropping for using the resources of the environment compared with sole cropping [25]. Fisher [26] from his study estimated the productivity of mixture using the following equation.

$$LER = Ya + Yb + Yc = \frac{Ya}{Xa} \_ \frac{Yb}{Xb} \_ \frac{Yc}{Xc}$$

Where:

Ya + Yb + Yc is the total plot yield per unit land area.

Ya, Yb and Yc are the component yields for the three crops.

Xa, Xb and Xc are the yields per unit land area where a, b and c are grown under those conditions with which comparisons are to be made.

2.1 Data Analysis

All data collected from the growth and yield parameters of component crops were subjected to analysis of variance to test the effects of the cropping systems separately using the MSTATC package [27]. The ANOVA was performed on crop basis by using a randomized complete block design and where effects were statistically significant ($P < 0.05$; *F*-test), treatment means were separated using standard error of the difference between them in post-ANOVA *t*-tests.

3. RESULTS AND DISCUSSION

Cropping system significantly (*P = 0.05*) affected plant height, weight of 1000 grains, average ear length, average weight of ear /plant and grain yield of maize in 2013 and 2014 (Table 1). It was observed that maize plant height at harvest in 2013 and 2014 in sole maize were significantly higher than that under intercropping systems. Under intercropping systems, the plant height at harvest in cassava/maize relayed with kenaf and kenaf/maize intercrop were not significantly different from each other but differed significantly from cassava/kenaf relayed with maize and cassava/maize/kenaf intercrop. However, the least values; 145.2 and 147.9 cm were recorded for cassava/maize/kenaf intercrop in 2013 and 2014 respectively. The values (0.37 and 0.36 g, 20.3 and 20.0 cm, 193 and 187 g and 3.26 and 3.21t/ha) for the weight of 1000 grains, average ear length, average weight of ear /plant and grain yield in 2013 and 2014 respectively for sole maize were the highest compared to least values (0.22 and 0.21g, 15.3 and 16.8 cm, 155 and 146 g and 2.06 and 2.03 t/ha) for the weight of 1000 grains, average ear length, average weight of ear /plant and grain yield in 2013 and 2014 respectively for cassava/maize/kenaf intercrop. The overall superior performance of sole cropping compared to intercropping systems had been similarly reported by other workers [28,29]. The depressed yields of component crops when intercropped had been attributed mainly to competition for basic growth resources like nutrients, light and space [29,30,31]. The values for grain yield (2.30 and 2.34 t/ha) under cassava/kenaf relayed with maize, (2.58 and 2.49 t/ha) under cassava/maize relayed with kenaf and (2.61 and 2.54t/ha) under kenaf/maize intercrop were not significantly different. This may be primarily attributed to the ability of maize to be grown successfully either during the first cropping season as first maize crop or second season as second maize crop [32].

Table 2 shows that cropping system significantly (*P = 0.05*) affected the plant height at harvest, weight of tuber per plant, average weight of tuber per plant and tuber yield of tuber in 2013 and 2014. The tallest plants were observed under intercropping systems, while the shortest plants were observed under cassava sole cropping. The highest values (229.5 and 225.4 cm) cassava plant height observed under cassava/maize /kenaf intercrop in this study could be due to the fact that the three component crops were planted at the same time. Hence, the maize grew faster followed by the kenaf and both stayed above the cassava at the early stage. This is because in intercropping system, competition for

Table 1. Plant height, yield and yield characteristics of maize intercropped with kenaf and cassava in 2013 and 2014

Cropping system	Plant height (cm)		Weight of 1000 grains (g)		Average ear length (cm)		Average weight of ear/Plant (g)		Grain yield (t/ha)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Cassava/kenaf relayed with maize intercrop	154.2c	150.4c	0.24c	0.24b	17.2d	17.0d	161b	155b	2.30b	2.34b
Cassava/maize relayed with kenaf intercrop	171.7b	172.8b	0.28bc	0.28b	18.9bc	18.5bc	170b	164ab	2.58b	2.49b
Kenaf/maize intercrop	177.7b	173.7b	0.29b	0.28b	19.7ab	19.2ab	171b	163ab	2.61b	2.54b
Cassava/maize/ kenaf intercrop	147.9d	145.2d	0.22d	0.21d	15.3d	16.8d	155c	146c	2.06c	2.03c
Sole maize	196.9a	193.6a	0.37a	0.36a	20.3a	20.0a	193a	187a	3.26a	3.21a

Means in a column followed by the same letter(s) are not significantly different according to DMRT (P = 0.05)

light by component crops favours component crops with its leaf area higher in the canopy. Therefore, cassava in intercropped with maize and kenaf was at advantage because of its rapid growth rate due to competition for light when compared with cassava sole cropping. It was reported that plant height and internodes length increased with increasing plant population because of competition for light [33-37]. The cassava under sole cropping system produced significantly (*P = 0.05*) higher weight of tuber per plant, average weight of tuber per plant and tuber yield in 2013 and 2014. The values (3.30 and 3.17 kg, 747.8 and 733.5 g and 19.8 and 20.6 t/ha) for the weight of tuber per plant, average weight of tuber per plant and tuber yield in 2013 and 2014 respectively for cassava/kenaf relayed with maize were not significantly different from the values (3.70 and 3.56 kg, 728.8 and 721.8 g and 21.3 and 19.7 t/ha) for the weight of tuber per plant, average weight of tuber per plant and tuber yield in 2013 and 2014 respectively for cassava/maize relayed with kenaf. Consequently, both the maize and kenaf investigated exerted the same kind of depressant effects on cassava yield component and yield of cassava when it is in intercrop and two other component crops were in relayed intercropped with the one another. On average the three crop combination systems (cassava/maize/kenaf) recorded the least values (2.20 and 2.10 kg, 548.9 and 511.5 g and 13.2 and 14.8 t/ha) for the weight of tuber per plant, average weight of tuber per plant and tuber yield in 2013 and 2014 respectively suggesting severe competition for growth resources (light, water and soil nutrients) by component crops. Reduction in cassava tuber characters was also reported in cassava/maize/ okra/melon [38], cassava/okra [36], soybean/ maize/cassava [32] and cassava/maize/melon [37].

Plant height at harvest and basal diameter at harvest were significantly (*P = 0.05*) affected by cropping systems in both years of experimentation with the kenaf plants under sole cropping in both years attaining highest plant height and basal diameter, these were not significantly different from plants under cassava/kenaf relayed with maize in 2013 and 2014 (Table 3). The least values (228.4 and 227.6 cm) recorded for plant height at harvest and (1.73 and 1.67 cm) recorded for basal diameter in 2013 and 2014 respectively were obtained from cassava/maize/kenaf intercrop. In this study, plant height and basal diameter of kenaf decreased significantly with increase in population density of component crops from two in relayed intercropping to three component crops in cassava/maize/kenaf intercrop. Similar findings have shown that plant height of kenaf in association with cowpea [39] was significantly depressed by intercropping relative to sole cropping. From his study, he reported that intercropping of kenaf with cowpea resulted in reduction of kenaf height by 28.49 and 14.22% in both experimental years. Cropping system significantly (*P = 0.05*) affected kenaf seed yield and fiber yield in both 2013 and 2014 (Table 3). Kenaf plants grown under cassava/maize relayed with kenaf gave the significantly highest seed yield values (856.7 and 879.9 kg/ha) in 2013 and 2014 respectively compared to sole cropping of kenaf that gave seed yield values (707.9 and 712 kg/ha) in 2013 and 2014 respectively. However, the least seed yield values (560.2 and 586.6 kg/ha) in 2013 and 2014 respectively were recorded for three component crops cassava/ maize/kenaf intercrop. Field observations from this study indicated that when planting for seed production, kenaf in intercropping with other component crops is best suited to the late season and kenaf should be after maize (relay intercropping). Agbaje et al, [40] observed that time of planting and rainfall pattern had significant effect on higher seed weight and seed yield. Kenaf is a short day plant like jute, therefore, there is a possibility of producing kenaf seed by sowing the crop during July to September as like as late jute seed production technology. The late season is the preferred season because the dry weather provides dry and conducive environment for post-harvest handling of harvest produce unlike the wet conditions in the latter part of the early season. The results indicated that regardless of the cropping system, the performance and yield of kenaf seed is affected by the date of planting. It has been noted also that the quality and quantity of kenaf seed is very much affected by climatic condition from the time of planting to the time of harvesting. This is an indication that the yield of kenaf seed grown during the first cropping season of the year as in the case of cassava/kenaf relayed with maize, kenaf/maize and cassava/maize/kenaf intercrop systems will be reduced compared to the one grown during the second cropping season as in the case of cassava/maize relayed with kenaf. The frequent and or prolonged rainfall during the first season would extend or prevent the ability of the plant to flower. This would encourage the vegetative growth of the plant to the disadvantage of seed production. Conversely, from this study it was

Table 2. Plant height, yield and yield characteristics of cassava intercropped with maize and kenaf in 2013 and 2014

Cropping system	Plant height (cm)		Weight of tuber/Plant (kg)		Average weight of tuber/Plant (g)		Tuber yield (t/ha)	
	2013	2014	2013	2014	2013	2014	2013	2014
Cassava/kenaf relayed with maize intercrop	217.1b	219.8b	3.30b	3.17b	747.8b	733.5b	19.8b	20.6b
Cassava/maize relayed with kenaf intercrop	213.6b	209.9b	3.70b	3.56b	728.8b	721.8b	21.3b	19.7b
Cassava/maize/kenaf intercrop	229.5a	225.4a	2.20c	2.10c	548.9c	511.5c	13.2c	14.8c
Sole cassava	191.8c	190.9c	4.07a	3.97a	841.1a	804.5a	25.2a	24.1a

Means in a column followed by the same letter(s) are not significantly different according to DMRT (P = 0.05)

Table 3. Plant height, yield and yield characteristics of kenaf intercropped with maize and cassava in 2013 and 2014

Cropping system	Plant height at harvest (cm)		Basal diameter at harvest (cm)		Seed yield (kg/ha)		Fiber yield (kg/ha)	
	2013	2014	2013	2014	2013	2014	2013	2014
Cassava/kenaf relayed with maize intercrop	283.9a	279.4a	2.67a	2.62a	686.1c	664.0c	2393.4b	2391.8b
Cassava/maize relayed with kenaf intercrop	264.7b	266.6b	2.37b	2.34b	856.7a	879.9a	2055.9c	2045.7c
Kenaf/maize intercrop	240.4c	248.2c	2.08c	2.03c	635.4c	660.0c	2369.8b	2383.7b
Cassava/maize/kenaf intercrop	228.4d	227.6d	1.73d	1.67d	560.2d	586.6d	1208.9d	1205.8d
Sole kenaf	292.8a	289.0a	2.80a	2.73a	707.9b	712.7b	2814.7a	2810.7a

Means in a column followed by the same letter(s) are not significantly different according to DMRT (P = 0.05)

observed that cropping systems significantly (*P = 0.05*) affected the fiber yield of kenaf in 2013 and 2014. Sole cropping of kenaf gave the highest values (2814.7 and 2810.7 kg/ha). The better performance of sole cropping of kenaf in the both year of experimentation could be attributed to more favourable climatic conditions of the early cropping season and enhanced maximum plant population density compared to intercrop with one or two component crops. On average the three crop combination systems recorded the least values for the fiber yield followed by cassava/maize relayed with kenaf suggesting severe competition for growth resources (light, water and soil nutrients) by component crops and unfaourable climatic conditions of the second planting season of the year.

As for mixture productivity, all the crop combinations, cassava/kenaf relayed with maize, cassava/maize relayed with kenaf, kenaf/maize and cassava/maize/kenaf were significantly advantageous in the land use efficiency (i.e. LER>1.00) with the cassava/maize/kenaf intercropping recording the highest values, 1.68 and 1.66 in 2013 and 2014 respectively. The values were not significantly different from relayed intercropping systems values in the both years. The values indicated advantage in intercropping the three crops either in three crop combinations or two crop combinations in relay-intercropping systems. LER values recorded in this study are higher than the range of 1.15–1.20 earlier reported to be of significant economic advantage in intercropping [41].

Table 4. Land equivalent ratio (LER) of cassava/maize/kenaf intercropping systems in 2013 and 2014

Cropping system	LER	
	2013	2014
Cassava/kenaf relayed with maize intercrop	1.62a	1.59a
Cassava/maize relayed with kenaf intercrop	1.64a	1.56a
Kenaf/maize intercrop	1.21b	1.17b
Cassava/maize/kenaf intercrop	1.68a	1.66a

Means in a column followed by the same letter(s) are not significantly different according to DMRT (P = 0.05)

4. CONCLUSION

The results of the study have shown that intercropping of the three crops, cassava, maize and kenaf either in the three crop combination (cassava/maize/kenaf intercrop) or two crops combination relayed with the third crop (cassava/kenaf relayed with maize and cassava/maize relayed with kenaf) is a worthwhile cropping system. Under intercropping system, where kenaf seed yield and quality are the primary concerns of the farmers, kenaf could be planted during the second season as in the case of cassava/maize relayed with kenaf. Also, where kenaf fiber yield is the primary concern of the farmers, kenaf could be planted during the first season as in the case of cassava/kenaf relayed with maize, kenaf/maize and cassava/maize/kenaf intercropping systems. These cropping systems could be incorporated in the existing farming systems of food crops producing farmers. The harvested kenaf seeds and fiber could be used as raw materials for industries. Therefore, high yield quality fiber or high yield quality seed is important in intercropping system that consists kenaf as one of the component crops; relay intercropping system is essential for adoption. Either cassava/kenaf relay with maize or cassava/maize relay with kenaf is recommended to the farmers. This will go a long way in popularizing kenaf which is an industrial crop among the food crops producing farmers; thereby enhance agro-industrial relationship and development.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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