INVESTIGATING AGROCLIMATIC FEASIBILITY OF KENAF/MAIZE INTERCROP IN FOREST-SAVANNAH TRANSITION ZONE OF SOUTHWEST NIGERIA

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Abstract
Agroclimatic feasibility of intercropping kenaf with maize in kenaf/maize mixtures was determined. Tainung1, Ifeken400, DMR-LSR-Y, Tainung1/DMR-LSR-Y and Ifeken400/DMR-LSR-Y were randomized in a complete block design with three replicates in a field trial during the early planting season of 2007. The phenological stages of each of the crops formed the basis of investigation. Selected agrometeorological variables were measured daily. The distribution of the thermal indices, temperature and photoperiod were optimal for kenaf growth. Mean soil temperatures of 31.5ºC at planting encouraged over 80% of seed emergence. Mean air temperature fall within the temperature requirement for kenaf. During the phenological stages of kenaf and maize, the mean air temperature was adequate especially during the thermal sensitive stages. The fact that the mean relative humidity fall within the recommended values, insect pests attack occurred at the early stage of the vegetative period. On the basis of distribution of rainfall (827.4mm) and actual water availability (591.0mm) in relation to water requirement of kenaf (236.4mm), moisture indices were found to be optimum. Both the mean bast fibre yield and seed yield of Tainung1 were higher than Ifeken400 but no significant difference ($P<0.05$). Results also showed that the pattern of cropping system have effect on the yield components, as the yield of sole-planted kenaf was significantly ($P<0.05$) higher than the kenaf/maize intercropped. The grain yield recorded for sole-planted maize also indicated significant effect of cropping system. The results suggested that the study area supports the cultivation of kenaf/maize intercrop.

Keywords: Agrometeorological variables, intercropping, kenaf/maize, phenological stages

Introduction
In view of the global food crisis and the needs to pedal out food insecurity, it is essential to determine the agroclimatic potential of the different agro-ecological regions of the sub-humid tropics for food production. Furthermore, arising from the trend of the global

climate change and variability, there is no doubt that climate is critical to the production potential of crops. It affects food production directly through changes in agro-ecological conditions, and indirectly by affecting growth and distribution of incomes. The major climatic elements affecting crop production are the same as those which influence natural vegetation. This also implies that the potential of crop production in a given region depends critically on climate.

The Food and Agriculture Organisation (FAO) (1986) recommended that the agronomic conditions in Nigeria are suitable for kenaf cultivation and that production should be encouraged on small plot basis. Meanwhile, Raji (2007) reported that in early sixties when kenaf was introduced into Nigeria, agronomic studies were conducted only on sole kenaf. One of the ways of combating food insecurity is the practice of intercropping system. Since, the vagaries of weather have effects on crop growth and yield, but, through the practice of intercropping, these effects can be stemmed as crops response to weather conditions differently. Kenaf is gradually gaining relevance in the intercropping system in some parts of the country because of its economic potential and role in the cottage fiber industry (Kunchida and Ogunwole, 2000).

Kenaf (*Hibiscus cannabinus* L.) is a member of the malvaceae family and is closely related to okra and cotton. All the parts of kenaf plant vis-a-viz leaves, bast fibre and core fibre are of industrial importance. The leaves of kenaf are rich in protein (15 - 30%) and are used as animal feed while the bast fibre can be converted to pulp for newsprint, hydrocarbon free bags, ropes and textiles. The core can be used as animal beddings, soil amendments, and oil absorbents in chemical industries and in ethanol production (Webber and Bledsoe, 2002; Zhou, Bao-rong, Baldwin, Sameshima and Ken (2002); Liu, 2005, Agbaje, Saka, Adegbite, and Adeyeye (2008). Ethanol bio-fuel is a biodegradable energy source that can replace or partially substitute petroleum. Ethanol produced from kenaf ("kenafanol"), is currently being marketed in the United States of America (Agbaje *et* al., 2008). Kenaf can help to alleviate global warming by absorbing carbon dioxide gases due to its rapid growth rate (Rymza, 1999; Balogun Raji, Akande, and Ogunbodede, (2007). Also, the plant can absorb CO_2 and NO_2 three to five times than forests, and that is why in some Japanese cities, kenaf was planted by government to improve the air quality and clean the environment efficiently (Lam, 2000; Liu, 2000).

The usual time of planting kenaf in Nigeria coincides with the time maize, cowpea, sorghum, groundnut and some other food crops were planted (Katung *et al.,* 1999); and this has made it possible for studies to be carried out on intercropping kenaf with one of these crops. Notable examples are Akande *et al.,* (2006), Adeniyan *et al.,* (2007), Raji (2007) and Agbaje, *et al.,* (2008). However, agroclimatic evaluation of intercropping kenaf with other crops has not been established in the rest of the humid and semi-humid ecological zone of southwest Nigeria. Thus an attempt was made to evaluate the agroclimatic feasibility of kenaf/maize intercrop in a forest-savannah transition zone of southwest Nigeria.

Materials and Methods

The study was conducted at the Teaching and Research Farm of the Department of Water Resources Management and Agricultural Meteorology located around the vicinity of the agro-meteorological station of the Federal University of Agriculture, Abeokuta, Ogun-State (latitude 7^0 15`N; longitude $3^0$ 25`N; elevation of 141m) (Figure 1), during the early rain of 2007 planting season. The soil at the experimental site was classified as a well-drained, tropical ferruginous soil with a sandy-loam surface horizon underlain by a weakly developed clayey, mottled and occasionally concretionary sub-soil. It has 83.3% sand, 4.6% silt and 12.1% clay in the A-horizon (Adetunji, 1991).

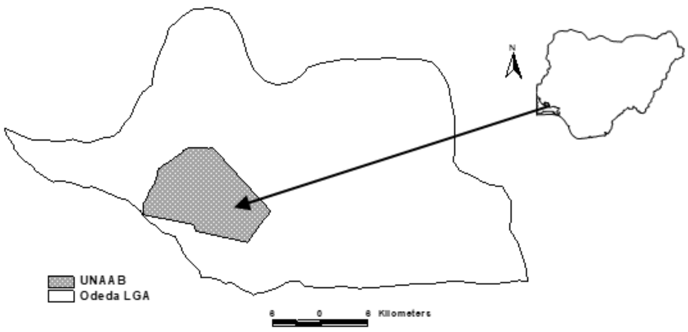


Figure 1: Location of study area

Experimental design and field measurement

Gross plot sizes of 30m by 12m were cleared, stumped and ridged manually with the use of cutlass and hoe. Planting was carried during the early planting season of 2007. The experimental design for the study was a Randomized Complete Block Design (RCBD) with three replications. Plot size was 5m wide and 3m long, with a walk-path of 1m.

Kenaf cultivars 'Tainung1' and 'Ifeken400' and maize cultivar 'DMR-LSR-Y' were planting materials used for the study. Four seeds of kenaf cultivars and two seeds of maize cultivar were sown per hole in their respective plots at a depth of 2.5cm. Kenaf and maize seedlings were thinned to two and one plants per stand respectively. The inter and intra row spacing in kenaf was 1 x 0.5m resulted in a plant population of 40,000ha^{-1}, while maize was 1 x 1 m resulted to plant population of 10,000ha^{-1}. The sole kenaf and maize spacing were 0.5 x 0.2m and 0.75 by 0.25m (Adeniyan *et al*., 2007) giving a plant population of 100,000ha^{-1} and 53,320 ha^{-1} respectively. Also, all plots received a post-emergence application of N.P.K 15:15:15 fertilizer at the rate of 120kg/ha. The plots were hand hoed and weeded manually at 3 and 7 WAS during the growing season. A mixture of Punch and Karate herbicides was applied at the rate of 4ml/l on equal basis to control the incidence of insects' pest attacked on the farm.

Data collection and analysis

During the phenological stages, agroclimatic, plant growth and yield data were collected. At each of the phenological stages, daily weather observations of air temperature (T, ^{o}C), soil temperature (at 5, 10, 15 and 20cm depth) (T, ^{o}C), rainfall (P, mm), relative humidity (%) and photoperiod (hours), were collected from UNAAB meteorological station located beside the study area and processed into a weekly (heptadal) means. Other climatic parameters measured were open surface water evaporation (E_o, mm) determined according to Penman's (1948) formula, actual water availability (AWA, mm) and consumptive water used by the crop (ET_{crop}, mm). Following Doorenbos and Pruitt (1984) crop consumptive water use is defined as:

$$ET_{crop} = Kc_o * E_o$$

Where, ET_{crop} = crop consumptive water use,
Kc_o = crop coefficient, and
E_o = open surface water evaporation

Kc_o also known as relative evapotranspiration is expressed as $ET.E_o^{-1}$, where ET and E_o were measured parameters. AWA is equivalent to the actual rainfall minus evapotranspiration (AWA = P - ET_{crop}).

The phenological stages during which growth characteristics were measured for kenaf cultivars are establishment stage, vegetative stage (stem girth and plant height) and reproductive stage (50% flowering, 50% anthesis and fruiting), while the most important phenological growth for maize were establishment stage, vegetative stage (stem girth, plant height and 50% tasselling) and reproductive stage (50% silking and grain filling). The yield components observed for kenaf cultivars at harvest includes numbers of capsules, seed and fibre yield, while ear weight per hectare and grains yield were collected for maize as the yield components.

Fibre yield was determined through hand-harvesting of the kenaf plants; and the plants were cut at a point immediately below the first capsule and 10cm near the stalks root. The yield was determined by tying plot by plot the whole stalk kenaf and placed in slow-moving stream for one week. The fibre was then stripped off the stem, washed, sun-dried and weighed. For the seed yield, the capsules were sun-dried, threshed and weighed. The data collected were subjected to Analysis of Variance (ANOVA) while differences among means were compared by Duncan's Multiple Range Test (DMRT) (SAS, 1999).

Results and Discussion

Agroclimatic thermal indices

Figure 2 shows the trends of mean heptadal air temperature and rainfall for kenaf/maize mixtures. The mean weekly (heptadal) air temperature varied between 26.8 - 27.3°C during the establishment phase and 25 - 27°C during the vegetative period. Also, the mean heptadal air temperature varied between 25 - 26.3°C and 25.9 - 26.6°C at flowering and fruiting periods respectively. It was observed that the mean heptadal air temperature during the flowering stage of kenaf is around 25°C.

The mean heptadal air temperature for maize in the mixtures varied between 25 - 27.3°C and 25.5 - 28°C while the mean heptadal temperature during the growing season was steadily decreased throughout the growing season. At establishment period, the mean temperature received was 26.7°C, followed by vegetative period (26.5°C); and 26.2°C and 25.1°C at silking and grain filling periods respectively (figure 2).

The mean heptadal soil temperatures varied from 25 - 31°C, 24.7 - 30°C, 24.5 - 29°C and 24 - 28.5°C for soil depth at 5, 10, 15 and 20cm respectively (figures 4) during the planting period. The mean heptadal daylength (photoperiod) during each phenological stage (figure 6) shows that photoperiod was within the range of 12.10 - 12.40hours. Maximum daylength was noticed during establishment and vegetative periods (12.40hours), followed by flowering period (12.20hours) while the least observed at grain filling period (12.10hours) during the growing period of kenaf cultivars in kenaf/maize intercrop. The trends of the daylength observed for maize in kenaf/maize production followed the same pattern. During the period, highest daylength was received at establishment period (12.40hours), followed by vegetative period (12.39hours) and silking period, which received a daylength of 12.35hours. The least daylength was noticed at the grain filling period, which had 12.30hours of daylength.

Agroclimatic moisture indices

The amount of rainfall received during the vegetative period (552.1mm) was highest followed by the flowering period (127.2mm) while the amount of rainfall recorded at establishment period (120.9mm) was higher than the fruiting period (27.2mm) (figure 2).

The trends of rainfall pattern for maize in kenaf/maize mixtures during the growing period, showed that rain was highest during the vegetative period (366.6mm) with the least rain noticed during the silking period (89.1mm). But, at the establishment and grain filling periods the amount of rainfall recorded were 120.9mm and 96.4mm respectively. Although, the highest amount of rainfall coincided with vegetative period in maize phenological stages.

Figure 5 shows the relationship between actual water availability (AWA) and consumptive water use (ETcrop) during the growing period. The AWA was consistently in excess of ETcrop during the early stage of the production. There were marked moisture deficit between 67 and 75 days; 85 and 94 days; and 102 and 112 days after sowing, and these periods coincided with the vegetative stage, flowering stage and fruiting stage.

The mean heptadal relative humidity during each phenological stage of (figure 6) reveals that the mean relative humidity consistently increased throughout the growing season in early planting. The mean range increased from 79.8% at establishment period to 84.7% at harvesting stage. It was obvious that the mean relative humidity throughout the growing period was 81.7%. The trend of the relative humidity in maize followed the same pattern expect where there was a dropped in the relative humidity at silking period. The mean range increased from 79.8% at establishment period to 81.9% at harvesting stage.

Prevailing air temperature and photoperiod at floral initiation of kenaf/maize intercrop

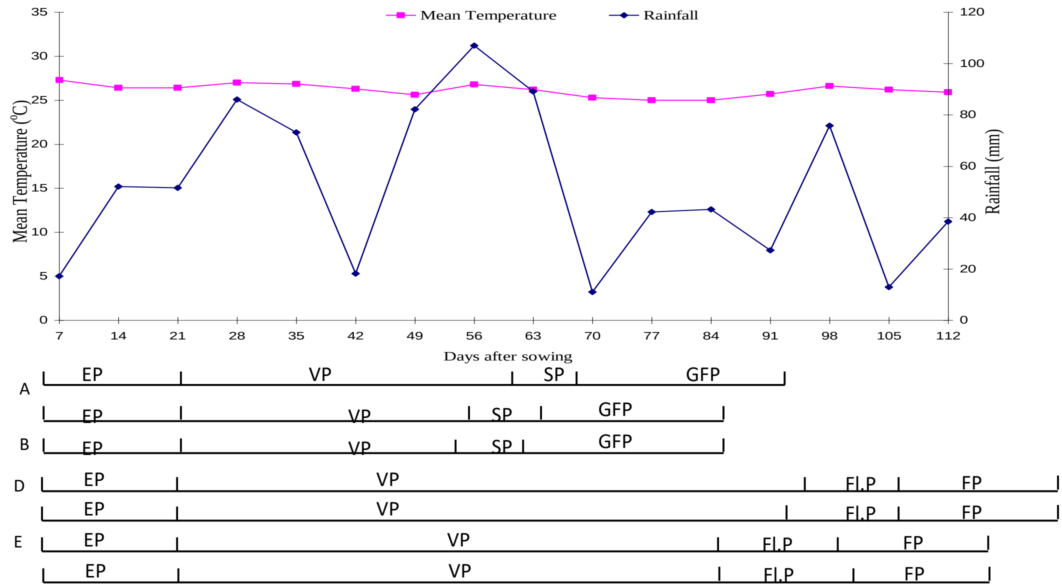
Table 1 show that the prevailing photoperiods at flowering for both kenaf cultivars in monoculture and mixed pattern during the early season were 12.27hours and 12.30hours respectively. Similarly, the prevailing air temperature at flowering for monoculture and mixed kenaf were 25.8^{o}C and 25.2^{o}C respectively. There were significant differences ($P<0.05$) in the values of the air temperature recorded at flowering between the cropping system but no significant different in daylength observed during the planting period.

There was no significant difference between the sole and mixed maize. During the growing period, flower initiation started in sole planted maize when the daylength was12.27 hours while the kenaf/maize intercrop flowered at 12.37 (Table 2). The air temperature observed at 50% flowering was 26.2^{o}C for both the monoculture and mixed cropping patterns.

Days to 50% flowering, 50% fruiting and days to harvesting of kenaf cultivars

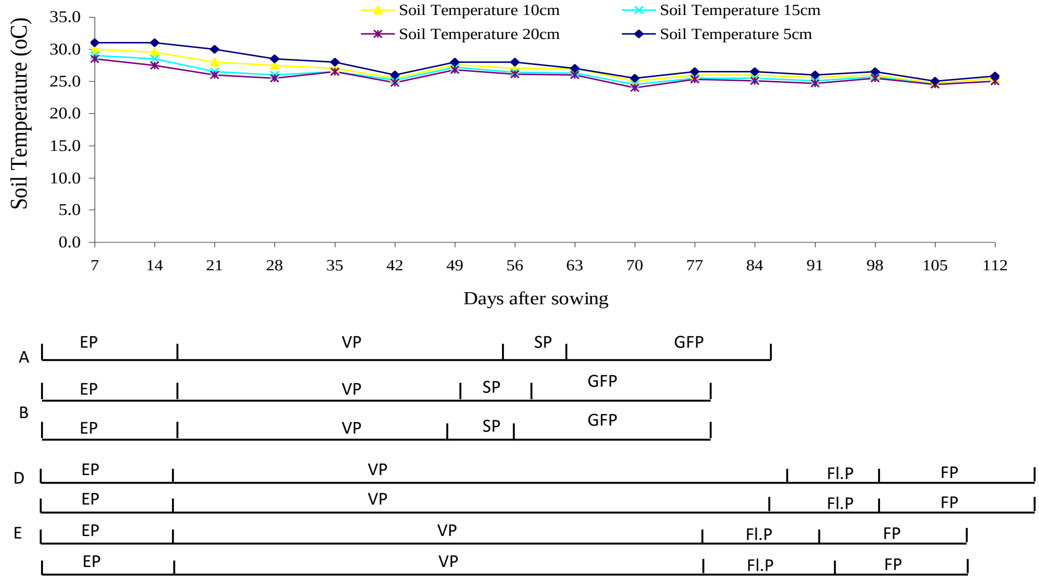
Days to 50% flowering were significantly ($P<0.05$) in the sole and mixed kenaf. Sole Tainung1 attained flowering stage at 86 days after sowing followed by Ifeken400 at 84 days after sowing while the mixture of kenaf cultivars with maize reached flowering stage at 77 days after sowing.

There was also significant difference in the days to 50% fruiting and days to harvesting between the cropping patterns. The two sole planted kenaf cultivars attained 50% fruiting and harvesting at 96DAS and 112DAS respectively. Although, Tainung1/maize and Ifeken400/maize were both harvested at 105 days after sowing, but reached 50% fruiting at different days (89 days after sowing and 92 days after sowing respectively).



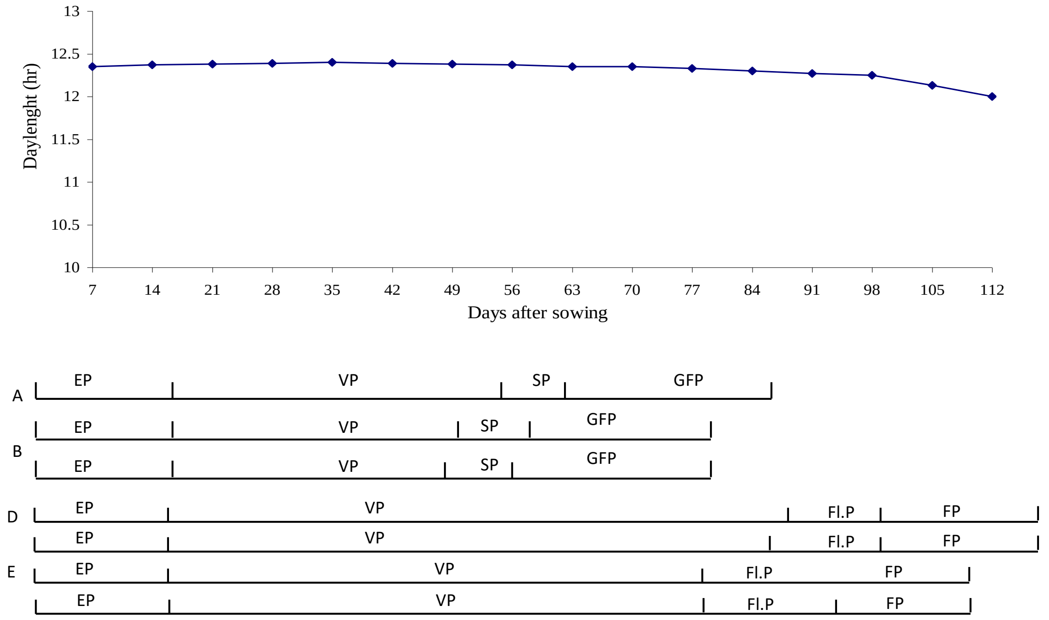
EP = Establishment Period, VP = Vegetative Period, Fl.P = Flowering Period, FP = Fruiting Period, SP = Silking Period, GFP = Grain Filling Period
A – Sole Maize, B – Maize/Tainung1, C – Maize/Ifeken400, D – Sole Tainung1, E - Sole Ifeken400, F – Tainung1/Maize, G – Ifeken400/Maize

Figure 2: Mean heptadal values of air temperature and rainfall during the growing season kenaf/maize intercrop

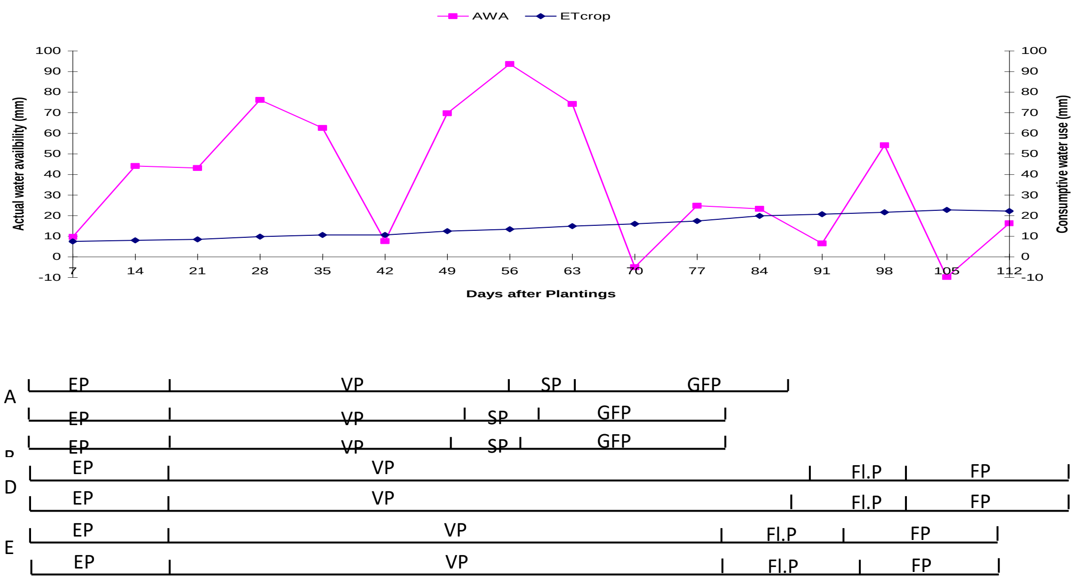


EP = Establishment Period, VP = Vegetative Period, Fl.P = Flowering Period, FP = Fruiting Period, SP = Silking Period, GFP = Grain Filling Period
A – Sole Maize, B – Maize/Tainung1, C – Maize/Ifeken400, D – Sole Tainung1, E - Sole Ifeken400, F – Tainung1/Maize, G – Ifeken400/Maize

Figure 3: Mean heptadal soil temperatures during the growing season of kenaf/maize intercrop

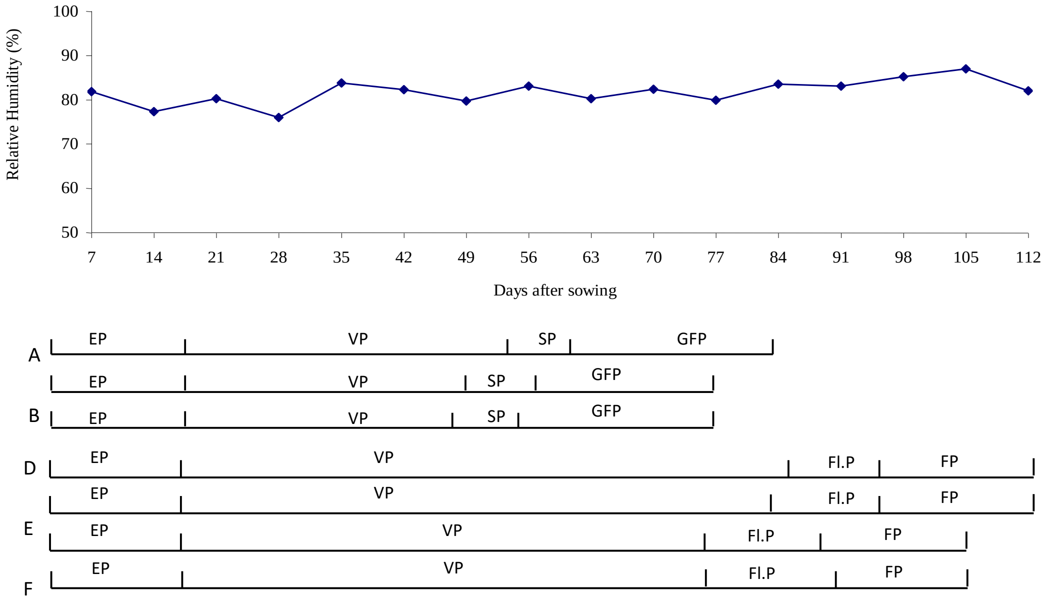


EP = Establishment Period, VP = Vegetative Period, Fl.P = Flowering Period, FP = Fruiting Period, SP = Silking Period, GFP = Grain Filling Period
A – Sole Maize, B – Maize/Tainung1, C – Maize/Ifeken400, D – Sole Tainung1, E - Sole Ifeken400, F – Tainung1/Maize, G – Ifeken400/Maize
Figure 4: Mean heptadal daylength during the growing season of kenaf/maize intercrop



EP = Establishment Period, VP = Vegetative Period, Fl.P = Flowering Period, FP = Fruiting Period, SP = Silking Period, GFP = Grain Filling Period
A – Sole Maize, B – Maize/Tainung1, C – Maize/Ifeken400, D – Sole Tainung1, E - Sole Ifeken400, F – Tainung1/Maize, G – Ifeken400/Maize

Figure 5: Relationship between actual water availability (AWA) and consumptive water use (ETcrop) by kenaf/maize intercrop



EP = Establishment Period, VP = Vegetative Period, Fl.P = Flowering Period, FP = Fruiting Period, SP = Silking Period, GFP = Grain Filling Period

A – Sole Maize, B – Maize/Tainung1, C – Maize/Ifeken400, D – Sole Tainung1, E - Sole Ifeken400, F – Tainung1/Maize, G – Ifeken400/Maize

Figure 6: Mean heptadal relative humidity during the growing season of kenaf cultivars in kenaf/maize intercrop

Days to 50% tasselling, 50% silking and 50% maturity of maize

It took sole maize 55 days to reach tasselling stage, while Tainung1/maize and Ifeken400/maize attained tasselling stage at 52 days and 50 days respectively. There was significant difference ($P<0.05$) at 50% tasselling in the mixtures. Moreover, during the study period, sole maize attained 50% silking at 62 days after sowing and 50% maturity at 82 days after sowing. Maize in Tainung1/maize and Ifeken400/maize reached 50% silking at 59 days after sowing and 50% maturity at 77 days; and 50% silking at 57 days and 50% maturity at 77 days after sowing respectively. There were significant differences between the cropping patterns at 50% silking and maturity.

Growth performance

Plant height and stem girth of maize

Table 3 shows the plant height of maize in monoculture and mixed pattern from establishment to harvesting stage (3 to 11 WAS). It was evident that the plant heights of maize in both monoculture and mixture were significantly increased. The highest plant height was observed in Tainung1/maize (227 cm), followed by Ifeken400/maize and maize with 213 cm and 203.17 cm respectively at 11WAS. There were significant differences ($P<0.05$) in plant heights of maize between monoculture and mixed throughout the growing period.

The stem girths of maize in monoculture and mixed pattern from 3 to 11 weeks after sowing (Table 4) shows that the stem girth of sole maize varied between 2.64cm to 6.20cm at establishment and harvesting stage respectively. Meanwhile, in the mixtures, the stem girth ranged between 2.60cm to 6.73cm and 2.81cm to 6.60cm for Tainung1/maize and Ifeken400/maize respectively. Also, stem girth of maize mixed with

Tainung1 and Ifeken400 reached peak value of 6.96cm and 6.83cm respectively at 7weeks after sowing, while stem girth of sole maize was 6.46cm at the same week after sowing. Thereafter, the stem girth in both sole and mixed plantings started diminishing in values. There were significant differences ($P<0.05$) in the stem girths of maize plant between monoculture and mixed patterns. Stem girths of maize in Tainund1/maize and Ifeken400/maize from 7WAS to 11WAS were not significantly different ($P<0.05$) from each other.

Plant height and stem girth of kenaf cultivars

Table 5 shows the effect of cropping sequence on plant height of kenaf cultivars in kenaf/maize intercrop from 3WAS to 16WAS. The highest plant height (334.8cm) of kenaf was recorded in monoplanted Ifeken400 followed by monoplanted Tainung1 with 325.1cm at 16 WAS, while the mixtures of kenaf/maize produced a plant height of 329.4cm and 321.2cm for Tainung1/maize and Ifeken400/maize respectively at 15WAS. There were significant differences in the values of plant height of kenaf cultivars obtained in monoculture pattern at 14WAS, 15WAS and 16WAS. Although, the values of plant height of Tainung1 observed in kenaf/maize intercrop were significantly ($P<0.05$) increased from 3WAS to harvesting stage (15WAS). There was significant difference in plant height of kenaf in monoculture and kenaf/maize intercrop at 3 to 15 WAS; expect 9, 10 and 12WAS where the monoculture kenaf were not significantly different from Ifeken400 in mixed kenaf/maize.

In table 6, stem girths were consistently increased throughout the growing season. The widest stem girth was noticed in Tainung1/maize (6.89cm) at 15WAS. The stem girth in monoplanted kenaf were significantly ($P<0.05$) increased at 3, 4, 5, 6, 8, 9, 10, 11 and 16WAS. In mixed cropping (kenaf/maize), the stem girth showed no significant difference at the early stage of cultivation (3 to 5WAS), however, at 6WAS to harvesting stage (15WAS) there were significant ($P<0.05$) difference in the values of stem girth obtained for the kenaf cultivars.

Yield of kenaf/maize intercrop

The result of the yield components of kenaf cultivars in kenaf/maize sown is presented Table 7. It was noticed in kenaf/maize intercrop during the study period that Tainung1 produced the highest yield results (1.01t/ha and 2.43t/ha for seed and fibre respectively), followed by Ifeken400 with 0.92t/ha and 2.35t/ha for seed and fibre yield respectively. There was no significant difference between yield components of kenaf cultivars ($P<0.05$) planted during growing period. The pattern of cropping sequence thus affected the yield. It was also observed that the yield results were higher in the sole planted kenaf than the intercrop kenaf/maize.

Table 8 reveals that the mean grain yield of maize is 1.58t/ha. Sole planted maize had the highest grain yield (3.20t/ha), followed by Ifeken400/Maize and Tainung1/Maize with 0.79 and 0.78t/ha respectively. There was a significant difference ($P<0.05$) between the sole maize and the kenaf/maize intercrop.

Table 1: Mean values of prevailing temperature and photoperiod at floral initiation, and days to fruiting, flowering and harvesting of kenaf cultivars in kenaf/maize intercrop

Cropping system	Daylength at flowering (hr)	Air temperature at 50% flowering (°C)	Days to 50% Fruiting	Days to 50% flowering	Days to Harvesting
Tainung1	12.27^{a}	25.8^{a}	86^{a}	96^{a}	112^{a}
Ifeken400	12.27^{a}	25.8^{a}	84^{a}	96^{a}	112^{a}
Tainung1/maize	12.30^{a}	25.2^{b}	77^{b}	89^{c}	105^{b}
Ifeken400/maize	12.30^{a}	25.2^{b}	77^{b}	92^{b}	105^{b}
SEM	0.09	0.17	2.40	1.70	2.02

Means having the same letter(s) in a column are not significantly ($p<0.05$) different

Table 2: Mean values of prevailing temperature and photoperiod at floral initiation, and days to tasselling, silking and maturity of maize in kenaf/maize intercrop

Cropping system	Daylength at flowering (hr)	Air temperature at 50% flowering (°C)	Days to 50% tasselling	Days to 50% silking	Days to maturity
Maize	12.37^{a}	26.2^{a}	55^{a}	62^{a}	82^{a}
Tainung1/maize	12.36^{a}	26.2^{a}	52^{b}	59^{b}	77^{b}
Ifeken400/maize	12.36^{a}	26.2^{a}	50^{c}	57^{c}	77^{b}
SEM	0.03	0.00	1.45	1.45	1.67

Means having the same letter(s) in a column are not significantly ($p<0.05$) different

Table 3: Effect of cropping system on the plant height of maize in kenaf/maize intercrop

Cropping system	3*	4*	5*	6*	7*	8*	9*	10*	11*
Maize	24.2^{a}	38.4^{b}	65.3^{b}	101.7^{b}	138.9^{c}	178.5^{c}	190.3^{c}	201.2^{c}	203.2^{c}
Tainung1/maize	22.8^{b}	39.4^{a}	69.2^{a}	108.9^{a}	165.5^{a}	202.3^{a}	214.3^{a}	225.3^{a}	227.0^{a}
Ifeken400/maize	21.1^{c}	38.0^{b}	65.4^{b}	99.9^{b}	151.7^{b}	188.3^{b}	200.4^{b}	211.9^{b}	213.0^{b}
SEM	0.90	0.42	1.28	2.74	7.68	6.91	6.96	6.97	6.91

Means having the same letter(s) in a column are not significantly ($p<0.05$) different
* - Weeks after sowing

Table 4: Effect of cropping system on the stem girth of maize in kenaf/maize intercrop

Cropping system	3*	4*	5*	6*	7*	8*	9*	10*	11*
Maize	2.64^{b}	3.72^{c}	4.46^{b}	5.28^{c}	5.84^{b}	6.46^{b}	6.35^{b}	6.23^{b}	6.20^{b}
Tainung1/maize	2.60^{b}	3.81^{b}	4.54^{b}	5.32^{b}	6.33^{a}	6.96^{a}	6.88^{a}	6.77^{a}	6.73^{a}
Ifeken400/maize	2.81^{a}	3.90^{a}	4.72^{a}	5.35^{a}	6.21^{a}	6.83^{a}	6.78^{a}	6.73^{a}	6.60^{a}
SEM	0.06	0.05	0.08	0.20	0.15	0.15	0.16	0.17	0.16

Means having the same letter(s) in a column are not significantly ($p<0.05$) different
* - Weeks after sowing

Table 5: Effect of cropping system on the plant height of kenaf cultivars in kenaf/maize intercrop

Cropping system	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*	13*	14*	15*	16*
Tainung1	17.5^{c}	30.9^{c}	58.1^{c}	89.4^{c}	123.8^{c}	154.8^{c}	183.0^{b}	204.7^{b}	220.9^{c}	243.1^{b}	268.5^{c}	297.5^{b}	312.2^{c}	325.1^{b}
Ifeken400	16.1^{c}	29.0^{c}	53.1^{c}	87.0^{c}	114.1^{d}	155.6^{c}	184.9^{b}	204.8^{b}	222.4^{c}	247.8^{b}	269.3^{c}	291.7^{c}	318.4^{b}	334.2^{a}
Tainung1/maize	24.4^{a}	46.6^{a}	84.1^{a}	118.4^{a}	152.0^{a}	183.7^{a}	205.0^{a}	224.9^{a}	245.0^{a}	264.8^{a}	290.8^{a}	313.4^{a}	329.4^{a}	
Ifeken400/maize	21.8^{b}	39.5^{b}	76.0^{b}	109.2^{b}	140.9^{b}	170.6^{b}	188.8^{b}	207.4^{b}	230.2^{b}	248.1^{b}	271.8^{b}	299.5^{b}	321.2^{b}	
SEM	1.92	4.01	7.32	7.64	8.48	6.87	5.01	4.86	5.52	4.75	5.28	4.60	3.57	4.55

Means having the same letter(s) in a column are not significantly ($p<0.05$) different

* - Weeks after sowing

Table 6: Effect of cropping system on the stem girth of kenaf cultivars in kenaf/maize intercrop

Cropping system	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*	13*	14*	15*	16*
Tainung1	0.92^{a}	2.05^{a}	2.87^{a}	3.66^{b}	4.28^{b}	4.70^{c}	5.07^{c}	5.53^{b}	5.73^{c}	6.07^{b}	6.33^{a}	6.50^{b}	6.68^{b}	6.77^{a}
Ifeken400	0.89^{b}	1.62^{c}	2.35^{b}	3.48^{c}	4.30^{b}	4.87^{b}	5.30^{b}	5.77^{a}	5.87^{b}	6.20^{b}	6.33^{a}	6.52^{b}	6.65^{b}	6.74^{b}
Tainung1/maize	0.84^{c}	1.95^{b}	2.95^{a}	3.71^{b}	4.52^{a}	4.97^{a}	5.60^{a}	5.83^{a}	6.13^{a}	6.37^{a}	6.55^{a}	6.67^{a}	6.89^{a}	
Ifeken400/maize	0.82^{c}	1.88^{b}	3.03^{a}	3.78^{a}	4.13^{c}	4.60^{d}	4.97^{d}	5.23^{c}	5.57^{d}	5.77^{c}	5.97^{b}	6.12^{c}	6.22^{c}	
SEM	0.02	0.09	0.15	0.06	0.08	0.08	0.14	0.14	0.11	0.13	0.12	0.12	0.14	0.02

Means having the same letter(s) in a column are not significantly ($p<0.05$) different

* - Weeks after sowing

Table 7: Yield components of kenaf cultivars in kenaf/maize intercrop

	Yield components	
Cropping system	Seed yield (t/ha)	Fibre yield(t/ha)
Tainung1	1.01^{a}	2.43^{a}
Ifeken400	0.92^{a}	2.35^{a}
Tainung1/maize	0.39^{b}	0.88^{b}
Ifeken400/maize	0.40^{b}	0.89^{b}
SEM	0.17	0.44

Means having the same letter(s) in a column are not significantly ($p<0.05$) different

Table 8: Yield components of maize in kenaf/maize intercrop

	Yield components	
Cropping system	Ear weight (t/ha)	Grain yield (t/ha)
Maize	1.68^{a}	3.20^{a}
Tainung1/Maize	0.43^{b}	0.78^{b}
Ifeken400/Maize	0.45^{b}	0.79^{b}
SEM	0.41	0.81

Means having the same letter(s) in a column are not significantly ($p<0.05$) different

Discussion

In this study, intercropping kenaf with maize did have effect on the phenological growth stages and yield of the kenaf and maize. The rate of plant growth is mainly dependant on plant variety and agronomic factors such as season of grown, quality of soil, fertilizer, temperature and rainfall (Rowell and Han, 1999).

Rainfall distribution during the year was bimodal. Unlike temperature, the occurrence of rainfall was erratic indicating that rainfall was the least predictable and most important consideration in agriculture (Kowal and Knabe, 1972). The fact that the total amount of rainfall (894.6 mm) received during the study area was outside the range is not enough evidence to discard the study area for investigation. Dry spells of five days occurred 1 week after sowing, and between 3 and 4 weeks after sowing, thereafter the rain was well-distributed through the growing season; and a mean monthly rainfall (223.85mm), although above the range (100 - 125mm per month) favours the vegetative growth. This could probably be a factor responsible for the fiber production as revealed by Liu (2005). Rainfall distribution during the study period was similar to that of actual water availability (AWA) between sowing and planting is an indication that AWA was also variable.

High mean relative humidity (76 - 87%) was observed during the study period. Contrary to this finding, several authors have reported lower mean relative humidity. Dempsey (1966) reported that the recommended mean relative humidity is 68 - 82%. This implies that the high values of relative humidity in the study area favoured insect pests (*Podagrica spp.*) attack from 2WAS to harvesting period. According to Ayoade (2002), the incidence of insects, pests and diseases are high under high humidity condition. This corroborates the result of the findings which revealed that the range value of humidity was above the recommended limits (Dempsey, 1966).

The plant experienced shortening of daylength and reduction in temperature during the vegetative growth period. The air temperature ranges (25 - 27.5^{o}C) observed in the present study area agrees with the work of Dempsey (1966) and also similar to the air temperature found elsewhere within the kenaf cultivation area. This indicates that temperature was never a treat to the production of kenaf/maize intercrop in the present study area.

Kenaf mixed with maize reached maturity stage faster than sole kenaf. The growth development and fibre yield of kenaf could be attributed to the amount of air temperature and daylength. The result observed in the present study agrees with the work of Balogun *et.al;* (2007). Duke (1983) reported that flower initiation occurred when the daylength falls to 12.5 hours; otherwise the plant remains vegetative and thus, delays its flowering period. This support the result of the present study which revealed that daylength was below 12.5hours.

During the planting season, average plant heights at harvesting for kenaf and maize were 333.6cm and 224.4cm. This could be as a result of variation in the amount and distribution of rainfall, amount of temperature and length of photoperiod.

The prolonged vegetative growth of kenaf in the present study resulted to longer plant height and robust stem girth, thereby giving higher fibre yield. The result in the study is similar to that obtained elsewhere within and outside the region (Webber *et al.*, 2002). Despite the cropping pattern, the average retted bast fibre yield obtained (1.64 t/ha) in the present study was still higher than the average expected from commercial kenaf varieties (Baker, 1970). The seed yield was higher in the sole planted kenaf than the intercrop. The report of Webber and Bledsoe (2002) that plant components of kenaf are affected by many factors including cultivar, planting date, photosensitivity, length of growing season, plant populations and plant maturity; corroborates the results of the study area. However, results similar to the present study findings were reported by Adeniyan *et al.,* (2007) and Katung *et al.,* (1999). In the same vain, reports from different researchers in United State, showed that the seed yield ranged between 0.997 to 1.92t/ha (Webber and Bledsoe, 2002), and this also agree with the results of the present study.

Conclusion and Recommendations

The present study shows that agroclimatic feasibility of cultivating kenaf with maize in forest-savannah transition zone of Nigeria is viable. Thus, it is considered worthwhile to integrate kenaf into the existing cropping sequence in the forest-savannah transition zone as their combination gives results commensurate with that of maize intercropped with other crops within and outside the zone.

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