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AGROCLIMATOLOGICAL INDICES AND PERFORMANCE OF OKRA IN MIXTURES WITH SORGHUM AND MAIZE IN FOREST-SAVANNA TRANSITION ZONE OF NIGERIA.

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Abstract: Agroclimatological indices and performance of okra in mixtures with sorghum and maize in a Forest-Savanna transition zone of Nigeria was investigated at the Experimental Research Farmland of the National Horticultural Research Institutes (NIHORT), Ibadan during the 2009 and 2010 cropping seasons. Plants phenological stages formed the basic unit of time for the investigation. During these phenological stages, agroclimatological thermal and moisture indices were measured daily and processed into ten-day (decadal) averages likewise selected agronomic growth and yield parameters of the components crops were taken fortnightly. The results showed that the 2010 season crops had relatively longer growth duration, received more rainfall than 2009 season (692mm *vs* 487.2mm) while 2009 experienced warmer temperature during establishment and early vegetative stage than 2010 season (33.2°C *vs* 32°C), and (28.5°C *vs* 27 °C) during the reproductive phase for 2009 and 2010 season respectively. The mean pod yields of okra in both seasons were dependent on crop combination since pod yield in sorghum cultivars mixtures (Farin Dawa and Janare) (97.33 *and* 93.67 pods) was significantly higher than in maize mixtures (58.33 *and* 49.65 pods) in 2009 season likewise in 2010 season when okra pods in sorghum mixtures (Farin Dawa and Janare) had (309.67 *and* 232.33 pods) against (162.67 *and* 67 pods) in maize mixtures for the two sorghum cultivars. Result of correlation analysis showed that growing period rainfall contributes more to plant height and leaf area of the components crops than mean temperature.

Key words: Phenological stages, agroclimatological indices, okra, sorghum, maize

INTRODUCTION

In crop production, climate has direct effect on the rate and duration of growth of individual plant, which ultimately determines the final yield (Egli 2004). The extent of weather influence on crop yield depends not only on the magnitude of weather variables but also on the distribution pattern of weather over the crop season which as such calls for the necessity of dividing the whole crop season into fine intervals. According to Allen and Boote (2000), the climatic elements and their effects on plant growth are far more complex than is apparent from their isolated treatment in the literature, as the plant in the field is subjected to multiple climatic variables at any time during germination and physiological growth. Hence, climate should be understood either as a resource to be managed or a factor that needs to be manipulated and one of management strategies is intercropping system which has proved to be an effective option for this purpose.

Intercropping ensures efficient utilization of environmental resources and helps to maintain greater stability in crop yields. It also guarantees greater land occupancy and higher net returns. Although some researchers, Ikeorgu et al. (1983) and Olasantan (2005) have evaluated the effects of intercropping on common vegetable crops, there is still paucity of information on this. In particular, information on okra-sorghum-maize mixtures is not available from forest-savanna transition zone of Nigeria despite wide cultivation of okra in this zone. Kurt (1984) explained that specific intercropping systems have developed over the centuries in the different regions and they are closely adapted to the prevailing ecological and weather conditions.

The economic importance of okra cannot be overemphasized. Okra contains carbohydrate, proteins and vitamin C in large quantities (Adeboye and Oputa, 1996). The essential and nonessential amino acids that okra contains are comparable to that of soybean. Hence it plays a vital role in human diet. For consumption, young immature fruits are important fresh fruit – vegetable that can be consumed in different forms. They could be boiled, fried or cooked. In Nigeria, okra is usually boiled in water resulting in slimy soups and sauces, which are relished. The fruits also serve as soup thickeners (Schippers, 2000). The leaves buds and flowers are also edible. Okra seed could be dried. The dried seed is a nutritious material that can be used to prepare vegetable curds, or roasted and ground to be used as coffee additive or substitute. Okra leaves are considered good cattle feed, but this is seldom compatible with the primary use of the plant.

Sorghum is the most important cereal crop in Nigeria in terms of both the area and yield, (Agboola, 1979). The crop is grown primarily for human consumption in the form of flour or used in the brewing of beer. It is an important part of the diets of many people in the world, mainly those living in the drier areas of Africa and India (Datke *et al.*, 2003). Sugar is also extracted from its stems. Sorghum is one of the best crops for silage because of its high yields (and being a C4 plant it is an efficient source of biomass) and the sugar content and juiciness of its stalk along with its adaptability to areas receiving too little rain to ensure crops of maize (Bakici and Demirel, 2004) lends it to this. Sorghum is an important crop of the seasonally humid and dry savannas of Nigeria between latitudes 8 and 13æ%N (Doggett, 1988; Debrah, 1993). The length of the growing period varies from >200 days in the southern Guinea savanna at 8æ%N to <100 days in the northern Sudan savanna at 13æ%N (Kowal and Knabe, 1972).

Maize *(Zea mays)* is an important traditional food crop grown in nearly all the ecological regions of Nigeria (Agboola, 1979; IITA, 1988). Maize grains have been used to produce a large variety of food either for human consumption or food for livestock in the country. Maize consists of 65-84% carbohydrate, 9-10% protein, 12-15% moisture, 3-5% fibre and 3% ash. Green maize (fresh on the cob) is eaten baked, roasted or boiled and plays an important role in filling the hunger gap between the end of rain in a given year and early rains of the following year (IITA 2002). Ripe dry grains can also be cooked with peas or beans together with oil and other condiments and eaten as a meal. Most commonly, ripe dry grains are processed and prepared into 'Pap' a paste-like food, which may be taken as a meal along with other complements. In most part of Nigeria, Maize is grown as a sole crop as well as an intercrop. This work sorts to investigation impact of agroclimatological indices and performance of okra in mixtures with two sorghum cultivars and maize in a forest-savanna transition zone of Nigeria.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at Experimental, Teaching and Research Farmland of the National Horticultural Research Institutes (NIHORT), Ibadan (7° 22'N, 3° 50'E) during the 2009 and 2010 cropping seasons (Figure 1). The study area is characterized by a tropical climate with distinct wet and dry seasons. The wet season is associated relatively with the prevalence of the moist maritime southerly monsoon from Atlantic Ocean and the dry season by the continental North Easterly harmattan winds from the Sahara desert. The area is also characterized by bimodal rainfall pattern (April to July being the wettest months, followed by August to October). The annual rainfall ranges between 1400 and 1500mm in Ibadan and its environs. Isolated and scanty rains usually start in mid-March and steadily increase to reach the peak values in July followed by a short break in August and another peak in September. The dry season is normally from October to March and often characterized by hot days. The region is characterised by relatively high temperature with mean annual air temperature of about 30°C. The greatest variation in temperature is experienced between July (25.7°C) and February (30.2°C). The humidity is lowest (37-54%) at the peak of dry season in February and highest (78-85%) at the peak of the rainy season in June to September.

Planting and crop management

Two Sorghum cultivars; (*Farin Dawa* and *Janare*) , one maize(*suwan 1*) and okra(*NHAe 47-4*) cultivars were used in two field trails during 2009 and 2010 planting seasons. About three and four seeds of sorghum, maize and okra were planted at a depth of 2.5cm. Sorghum was planted three weeks after planting okra and maize to enable the okra and maize gain establishment. Sorghum spacing was 90 x 60cm (2 seedlings/stand), maize spacing was 90 x 30 cm (1 seedling/stand) and okra spacing was 90 x 30 cm (1seedling/stand). Each plot size was 6m by 3m; making a total plot size of 100 m x 20 m. The plots were hoe weeded at 3 and 6 weeks after planting. The experimental plots were arranged in a randomize complete block design (RCBD) fitted into split-plot design with three replicates. Three sets of data were collected based on critical phenological stages. These data sets were: agroclimatological indices, growth and yield parameters.

Agroclimatological data: This includes moisture base, thermal base and aerodynamic indices of the plant micro-environment measured daily from meteorological enclosure 200m from the experimental site and were later processed into decadal values. Moisture base indices include rainfall (P, mm) using simple rain gauge (M108005), relative humidity (%) using simple hygrometer (M108024) and open water evaporation (mm) using Pan Evaporimeter. Thermal base indices include maximum and minimum temperature (T, °C), and sun shine hour while aerodynamic indices measured is wind speed (Ws at a height of 2m (ms^{-1})) using cup counter (D7204/Z). All agroclimatological facilities are products of Casella Inc., Regent House, Britannia Walk, London.

Growth and yield parameters

The data were collected on the desired growth parameters of the components crops as per treatment by using standard procedures. Major growth parameters considered include: Plant height (cm), Leaf area (cm^2), Number of leaves and Stem diameter (mm) for each of the component plants. Yield parameters considered include grain yield (sorghum and maize), panicle length (sorghum), cob weight (maize), weight of 100 grains (maize), pods number/plant and pods weight, length and diameter of okra yield.

Leaf area (cm^2): The leaf area was determined by non destructive method. Ten leaves were measured for each treatment plot and the mean leaf area determined.

Okra leaf area was estimated, using a non-destructive method, from the equation;

$$Y = 115X - 1050$$

Where Y = leaf area (cm^2) and X = the length of mid rid (cm) (Asif, 1977).

The area of each individual sorghum and maize leaf blade (Y, in square centimetres) was computed as; length x maximum width x 0.75. The value of 0.75 was considered an acceptable average of reported values: 0.75 (Montgomery, 1911), 0.73 (Mckee, 1964; Dwyer and Stewart, 1986), 0.72 (Keating and Wafula, 1992), 0.79 (Birch *et al.,* 1998) and 0.74 (Stewart and Dwyer, 1999).

Y= (L x W) 0.75 (leaf area factor)

(Stewart and Dwyer, 1999)

Where L=length (cm) and W= maximum width (cm)

Statistical analysis

Analyses of variance were carried out by established methods (Steel *et al*. 1997) using the PROC GLM procedure of the SAS Statistics package (SAS Institute Inc. 2000). The cropping pattern and cultivars were considered as random effects, while the planting seasons were fixed effects. Cultivars and cropping patterns mean differences within each planting season were separated using Fishers' protected least significant difference (l.s.d.) test at *P* d" 0.05.

RESULTS AND DISCUSSION

Distribution of Agroclimatological indices

Agroclimatological indices for the growing seasons differed considerably at various stages of the crop growth. The 10-days values for rainfall, maximum and minimum temperature, relative humidity and wind speed for 2009 and 2010 seasons at National Horticultural Research Institute (NIHORT), Ibadan were related to the main phases of vegetative growth and reproductive development of sorghum in Fig. 1 and Fig. 2. Rainfall during stages of growth was much higher in 2010 cropping season than 2009 cropping season (i.e 692 *vs*. 487.2 mm). Consequently, rainfall during the vegetative growth stages was lower in the 2009 season than 2010 season crops (i.e 331.5 *vs* 537.5mm*)*. The same scenario was observed during the reproductive phase in 2009 season with 366.6mm against 560.2mm in 2010 season.

Temperature also varied during the two seasons (Fig. 1 and Fig.2) and was similar in its distribution to that found elsewhere in the savanna region (7° 49'N, 6° 03'E) of Nigeria (Olaniran and Babatolu, 1987). Minimum temperature varied between 22 and 24 °C in 2009 season while it ranged between 21.2 and 23.4 °C in 2010 season. Maximum temperature ranged between 28 and 33°C in 2009 season while it range between 27 and 32 °C in 2010 season. Temperatures were warmer during planting, establishment and early vegetative stages than during reproductive stage in 2009 season (24 v 22 and 33 v 28 °C) and similar trend was observed in 2010 season (23 v 22 and 31v 27 °C).

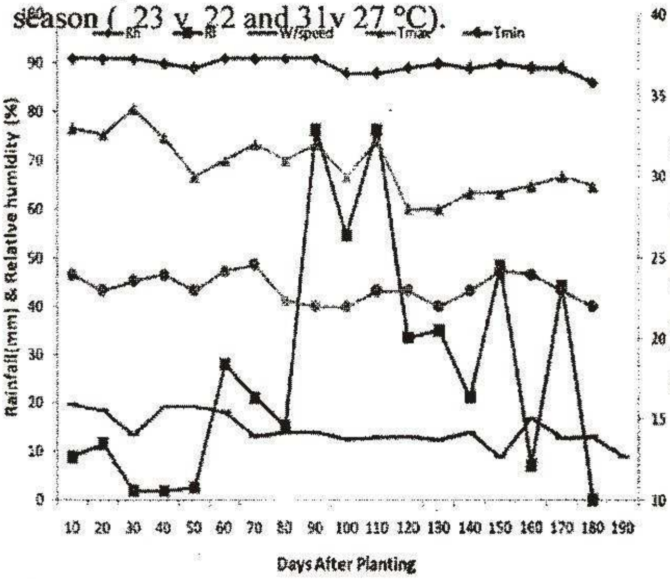


Figure 1: Distribution of Agroclimatological indices during different phenological stages of experimental crops in 2009 season (June-November) at NIHORT, Ibadan

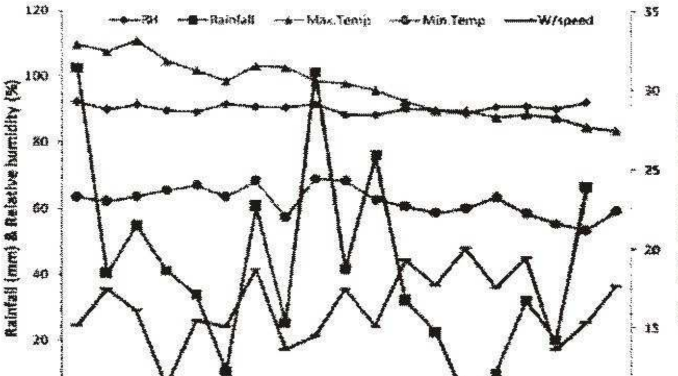


Figure 2: Distribution of Agroclimatological indices during different phenological stages of experimental crops in 2010 season (April-October) at NIHORT, Ibadan

Okra growth characteristics

Plant height (2009 season)

Figure 3 showed the difference in plant height of okra in monoculture and mixtures of maize/okra (MO), okra/white sorghum (S1O), okra/ red sorghum (S2O) and the combination of maize/okra/white sorghum (MOS1) and maize/okra/red sorghum (MOS2) at 4,6,8,10 and 12 weeks after planting (WAP). The result showed that there was generally no statistical difference in okra plant height in both monoculture and mixtures. Okra plant height in okra/red sorghum mixtures (S2O) increased from 15.48cm at 4WAP to 70.51cm at 12WAP while okra height in okra/white sorghum mixtures (S1O) increased from 16.44cm to 69.15cm at 4 and 12WAP respectively. In maize/okra/sorghum intercrop, okra height in maize/okra/white sorghum (MOS1) increased from 15.45cm to 55.86cm against okra height in maize/okra/red sorghum (MOS2) combination that increased from 14.73cm to 67.87cm at 4 and 12 WAP respectively.

Plant height in maize/okra mixture (MO) ranged from 16.06 to 68.03cm while okra plant height in okra/white sorghum (S1O) mixtures ranged from 16.44 to 69.15cm and okra/red sorghum mixtures ranged from 15.48 to 70.51cm. Though no significant difference was observed in the treatments means, the okra plants perform better in red sorghum (S2) than white sorghum (S1).

2010 season

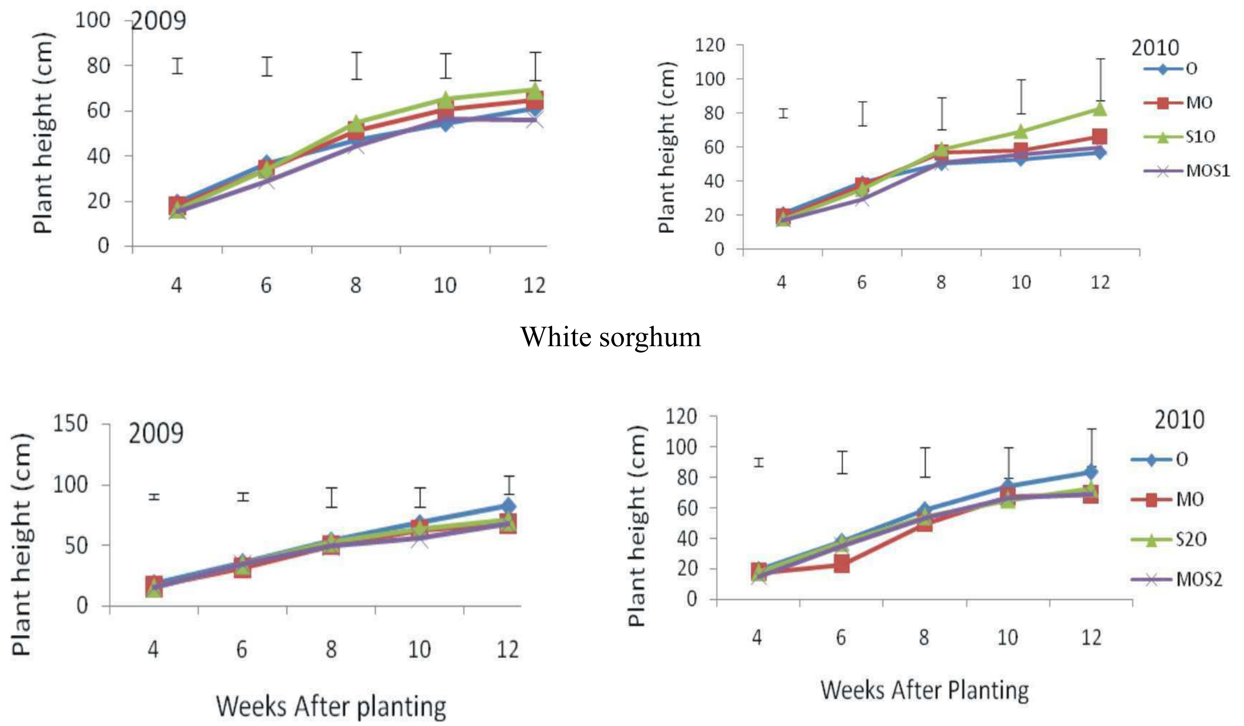
Okra height in okra/red sorghum mixtures (S2O) increased from 17.77cm at 4WAP to 73.00cm at 12WAP while okra height in okra/white sorghum mixtures (S1O) increased from 17.78cm to 82.78cm at 4 and 12WAP respectively. In maize/okra/sorghum intercrop, okra height in maize/okra/white sorghum (MOS1) increased from 17.25cm to 60.00cm against okra height in maize/okra/red sorghum (MOS2) combination that increased from 15.02cm to 69.22cm at 4 and 12 WAP respectively. Okra plant height in maize/okra mixture (MO) ranged from 17.46 to 68.89cm while okra plant height in okra/white sorghum (S1O) mixtures ranged from 17.78 to 82.78cm and okra/red sorghum mixtures ranged from 17.77 to 73.00cm.

Leaf area (cm^2) (2009 season)

Presented in figure 4 is the leaf area of okra in monoculture and mixtures of maize/okra (MO), okra/white sorghum (S1O), okra/ red sorghum (S2O) and the combination of maize/okra/white sorghum (MOS1) and maize/okra/red sorghum (MOS2) at 4,6,8,10 and 12 weeks after planting (WAP). The figure showed that leaf area of okra in both monoculture and mixtures was not statistically difference except at 12WAP for treatments containing white sorghum (S1) cultivar while the difference was significant ($p<0.05$) in treatment containing red sorghum (S2) at 6,10 and 12WAP. Leaf area of okra in okra/white sorghum mixtures (S1O) increased from 1288.9 cm^2 at 4WAP to 3839.3cm^2 at 12WAP while in okra/red sorghum mixtures (S2O) it increased from 829.1 to 4237.3 cm^2 at 4 and 8WAP respectively. In maize/okra/sorghum intercrop, okra leaf area in maize/okra/white sorghum (MOS1) increased from 904.5 to 3046.7cm^2 at 4 to 12WAP while the values in maize/okra/red sorghum (MOS2) combination increased from 766.2 to 3650.4 cm^2 at 4 and 8 WAP respectively.

2010 season

During the 2010 season leaf area of okra was not different significantly except at 12WAP for treatments containing white sorghum (S1) cultivar and similar trend was observed for treatments containing red sorghum (S2) except at 10WAP. Leaf area of okra in okra/white sorghum mixtures (S1O) increased from1301.4 cm^2 at 4WAP to 3811.8cm^2 at 10WAP while in okra/red sorghum mixtures (S2O) it increased from 941.8 to 3630.9 cm^2 at 4 and 8WAP respectively. In maize/okra/sorghum intercrop, okra leaf area in maize/okra/white sorghum (MOS1) increased from 986.7 to 2962.4cm^2 at 4 to 10WAP while the values in maize/okra/red sorghum (MOS2) combination increased from 815.7 to 2988.4 cm^2 at 4 and 8 WAP respectively.



Red sorghum

Figure 3: Effects of intercropping two sorghum cultivars and maize on plant height (cm) of okra in 2009 and 2010 seasons at NIHORT, Ibadan, Nigeria.

Okra yield frequency
2009 season

Shown in Figure 5 is the frequency of okra pod harvest during 2009 and 2010 seasons in both monoculture and mixtures of okra/maize (MO), okra/white sorghum (S1O) and maize/okra/white sorghum (MOS1). In 2009, fresh pod yield of okra intercropped with white sorghum (S1O) were significantly higher than okra yield in maize/okra (MO) mixtures. Number of fresh pod harvested from Sole okra (O) increased from 12pods at 8WAP through 26 pods at 10WAP and reach peak value of 26.33pods at 12WAP while the least harvest of 8.67pods was observed at 16WAP. Number of fresh pods harvested from maize/okra mixtures (MO) ranged from 5.67 pods at 8WAP through 12.67pods

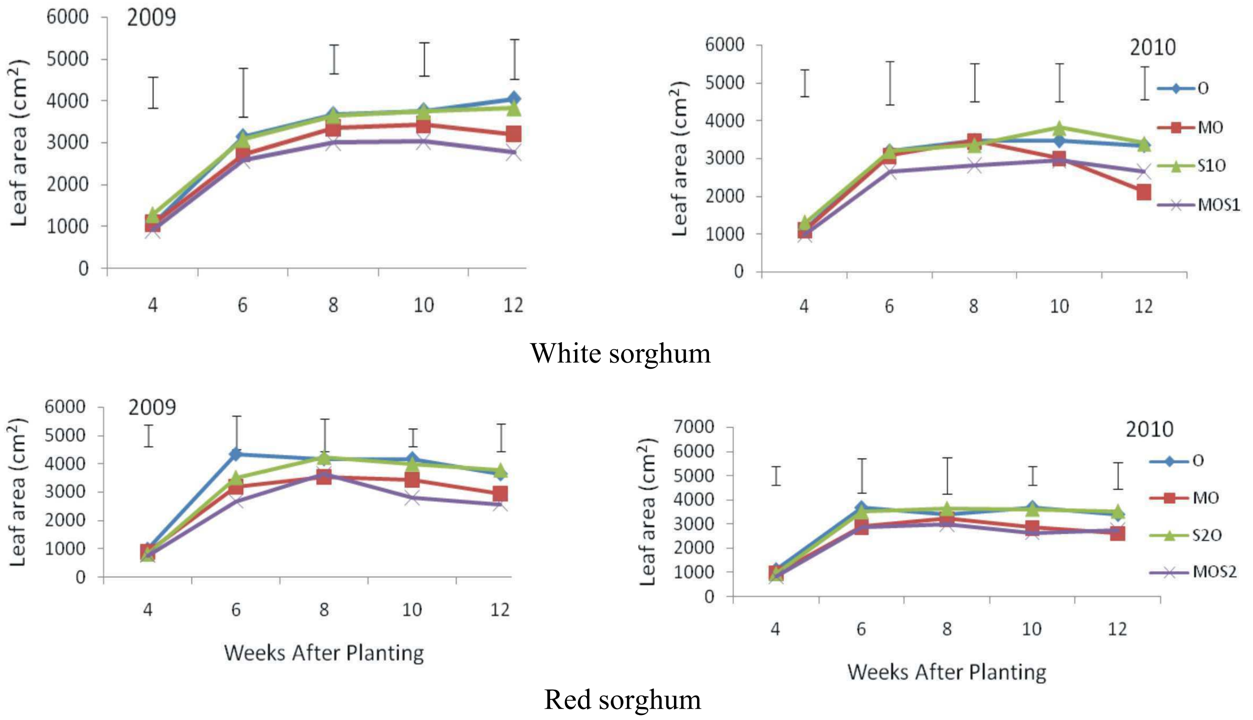


Figure 4: Effects of intercropping two sorghum cultivars and maize on the leaf area (cm^2) of okra in 2009 and 2010 seasons at NIHORT, Ibadan, Nigeria.
MOS1: Maize/okra/White Sorghum Intercrop; MO: Maize/Okra Intercrop; MOS2: Maize/Okra/Red Sorghum Intercrop; O: Okra (NHAe 47-4); S1O: White sorghum/okra intercrop; S2O: Red sorghum/okra intercrop.

at 10WAP and reach peak harvest of 21pods at 12WAP while the lowest yield of 5.33pods was also observed at 16WAP. The pod yield in white sorghum/okra (S1O) mixtures was 8.33, 20.33, 39 and 8pods at 8, 10, 12 and 16WAP respectively. Also, the pod yield in maize/okra/white sorghum (MOS1) mixtures was 7, 14.67,27 and 5pods at 8, 10, 12 and 16WAP respectively.

In treatments containing red sorghum, fresh pod yield of okra intercropped with red sorghum (S2O) were significantly higher than okra yield in maize/okra (MO) mixtures. Number of fresh pod harvested from Sole okra (O) increased from 9pods at 8WAP through 35 pods at 10WAP and reach peak value of 43pods at 12WAP while the least harvest of 8pods was observed at 16WAP. Number of fresh pods harvested from maize/okra mixtures (MO) ranged from 3.33 pods at 8WAP through 13.33pods at 10WAP and reach peak harvest of 16.66pods at 12WAP while the lowest yield of 4pods was also observed at 16WAP. The pods yield in red sorghum/okra (S2O) mixtures was 4.67, 27.67, 30 and 6pods at 8, 10, 12 and 16WAP respectively. Also, the pod yield in maize/okra/red sorghum (MOS2) mixtures was 2.33, 15.67,18 and 4pods at 8, 10, 12 and 16WAP respectively.

2010 season

In 2010 season, pod yield of okra intercropped with white sorghum (OS1) were significantly higher than okra yield in maize/okra (MO) mixtures. Number of fresh pod harvested from Sole okra (O) increased from 7pods at 8WAP through 13 pods at 10WAP and reach peak value of 42pods at 14WAP while 11pods was harvested at 20WAP. Number of fresh pods harvested from maize/okra mixtures (MO) ranged from 7.67pods at 8WAP through 19.33pods at 10WAP and reach peak harvest of 39.67pods at 18WAP while 6pods was harvested at 20WAP. The yield in white sorghum/okra (S1O) mixtures was 17.33, 25.67, 89 and 10pods at 8, 10, 14 and 20WAP respectively. Also, the yield in maize/okra/white sorghum (MOS1) mixtures was 6.33, 22, 40 and 5.67pods at 8, 10, 18 and 20WAP respectively.

In red sorghum treatment combinations, fresh pod yield of okra intercropped with red sorghum (S2O) were significantly higher than okra yield in maize/okra (MO) mixtures. Number of fresh pod harvested from Sole okra (O) increased from 6.67pods at 8WAP through 28.67 pods at 10WAP and reach peak value of 95pods at 18WAP while 13pods was harvested at 20WAP. Number of fresh pods harvested from maize/okra mixtures (MO) ranged from 2pods at 8WAP through 3.33pods at 10WAP and reach peak harvest of 21.67pods at 18WAP while 6pods was harvested at 20WAP. The yield in red sorghum/okra (S2O) mixtures was 4.33, 25.67, 61 and 11.33pods at 8, 10, 14 and 20WAP respectively. Also, the yield in maize/okra/ red sorghum (MOS2) mixtures was 2.33, 10.66, 38.67 and 5pods at 8, 10, 18 and 20WAP respectively.

Okra Pod weight

2009 season

The weight of fresh okra pods in monoculture and mixtures of okra/white sorghum (S1O), okra/ red sorghum (S2O), okra/maize (MO) and the combination of maize/okra/white sorghum (MOS1) and maize/okra/red sorghum (MOS2) at 8,10,12 and 14 weeks after planting (WAP) is presented in figure 6. The figure showed that the pods weight in both monoculture and mixtures was statistically difference at all sampled occasions except at 8WAP. Similarly pod weight of okra in red sorghum (S2) treatment showed significant difference ($p<0.05$) at all sampled occasions. Pod weight of sole okra (O) in white sorghum (S1) treatments ranged from 111.18 to 253.18g whereas pod weight of sole okra (O) in red sorghum (S2) treatment ranged from 80.67 to 324.00g. Pod weight of Okra (O) in okra/white sorghum mixtures (S1O) increased from 106.07 to 307.27g while the value in red sorghum (S2) treatment for okra/red sorghum mixtures (S2O) increased from 42.82 to 325.50g. In the mixtures of maize/okra (MO) in white sorghum treatment, the values ranged from 59.64 to 201.77g compared with that in red sorghum treatment that ranged from 25.20 to 170.50g. In maize/okra/sorghum mixtures, pod weight in white sorghum treatment for maize/okra/white sorghum (MOS1) increased from 60.65 to 192.94g while the values in red sorghum treatments for maize/okra/ red sorghum (MOS2) combination increased from 15.53 to 194.81g.

2010 season

Pod weight was significantly different at all sampled occasions except at 8 weeks after planting for treatments containing white sorghum (S1) cultivar. Similarly, the difference in pod weight was significant for treatments containing red sorghum (S2) at all sampled occasions. Pod weight of okra in white sorghum treatment for sole okra (O) ranged from 59.40 to 230.50g whereas the values in sole red sorghum treatments ranged from 52.08 to 387.20g. Pod weight in okra/white sorghum mixtures (S1O) ranged from 140.00 to 561.60g while the corresponding values in red sorghum treatment for okra/red sorghum mixtures (S2O) ranged from 52.47 to 356.02g. In the mixtures of maize/okra (MO), pod weight ranged from 71.45 to 200.00g compared to the values in maize/okra (MO) that ranged from 10.00 to 129.08g. In maize/okra/sorghum mixtures, pod weight in maize/okra/white sorghum (MOS1) ranged from 48.62 to 191.30g while the corresponding values in maize/okra/red sorghum (MOS2) combination from 15.28 to 162.00g. Generally, pod weight of okra in both sorghum cultivars was higher than the pod weight in sorghum/ maize intercrop during 2009 and 2010 season.

Yield components

Number of pods, pod weight and pod yield of okra in 2009 and 2010 seasons in both monoculture and mixed stands are presented in Table 1. These characters varied significantly among the treatments in both 2009 and 2010 seasons. Yield characters in 2010 season were generally higher than their corresponding values in 2009 season. Pods attributes in okra/sorghum mixtures regardless of the sorghum cultivars were significantly higher than pods attributes obtained in okra/maize mixtures in both 2009 and 2010 seasons.

Number of pods/plant

Number of pods per plant in white sorghum mixtures was generally higher than in red sorghum mixtures in both 2009 and 2010 season. In 2009 season, for white sorghum mixtures, the highest number of pods/plant was from S1O mixtures (10 pods/plant) followed by Sole okra (O) with 9 pods/ plant then MOS1 mixtures with 7 pods/plant while the least values came from MO mixtures with 6 pods/ plant. In case of red sorghum mixtures, numbers of pods were in the following order sole okra (12 pods/ plant), followed by S2O mixtures with 9 pods/plant then MOS2 mixtures with 6 pods per plant while MO mixtures had lowest number of pods per plant (5 pods/plant).

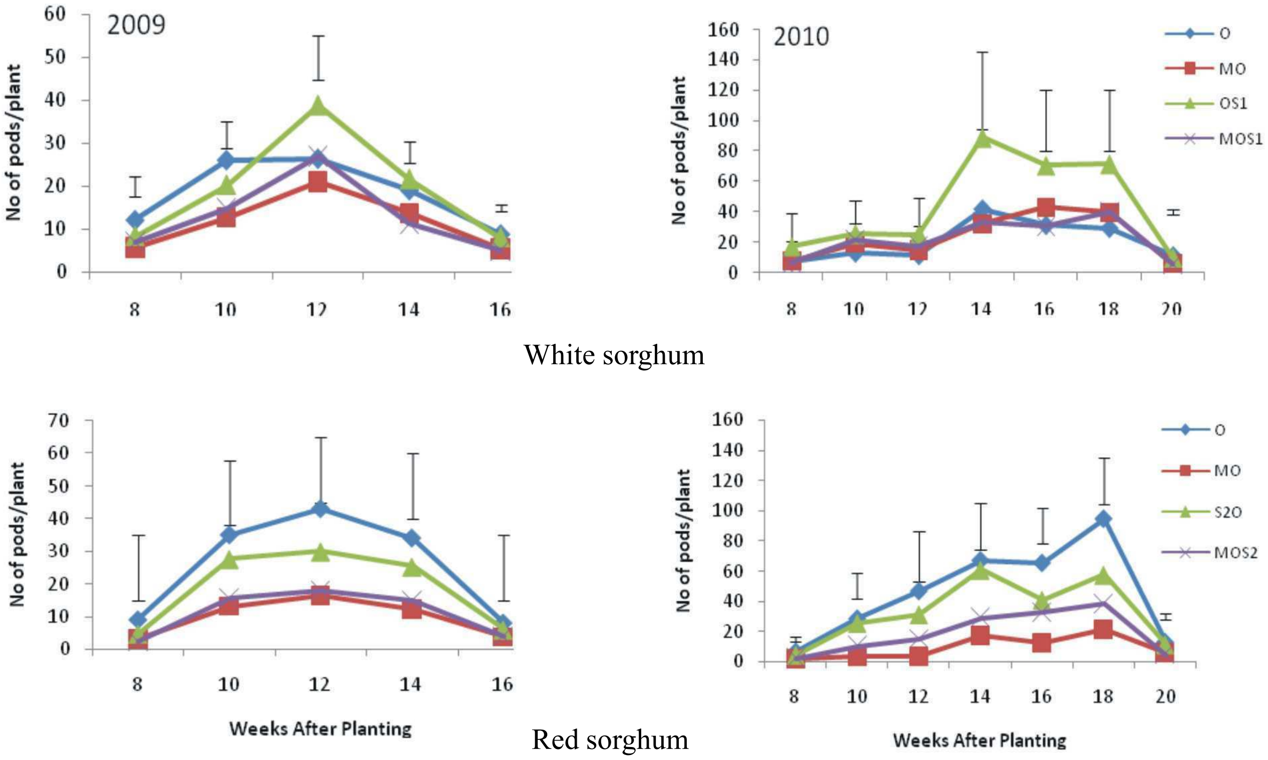


Figure 5: Effects of intercropping okra with sorghum cultivars and maize on the yield frequency of fresh okra pods during 2009 and 2010 seasons at NIHORT, Ibadan, Nigeria.

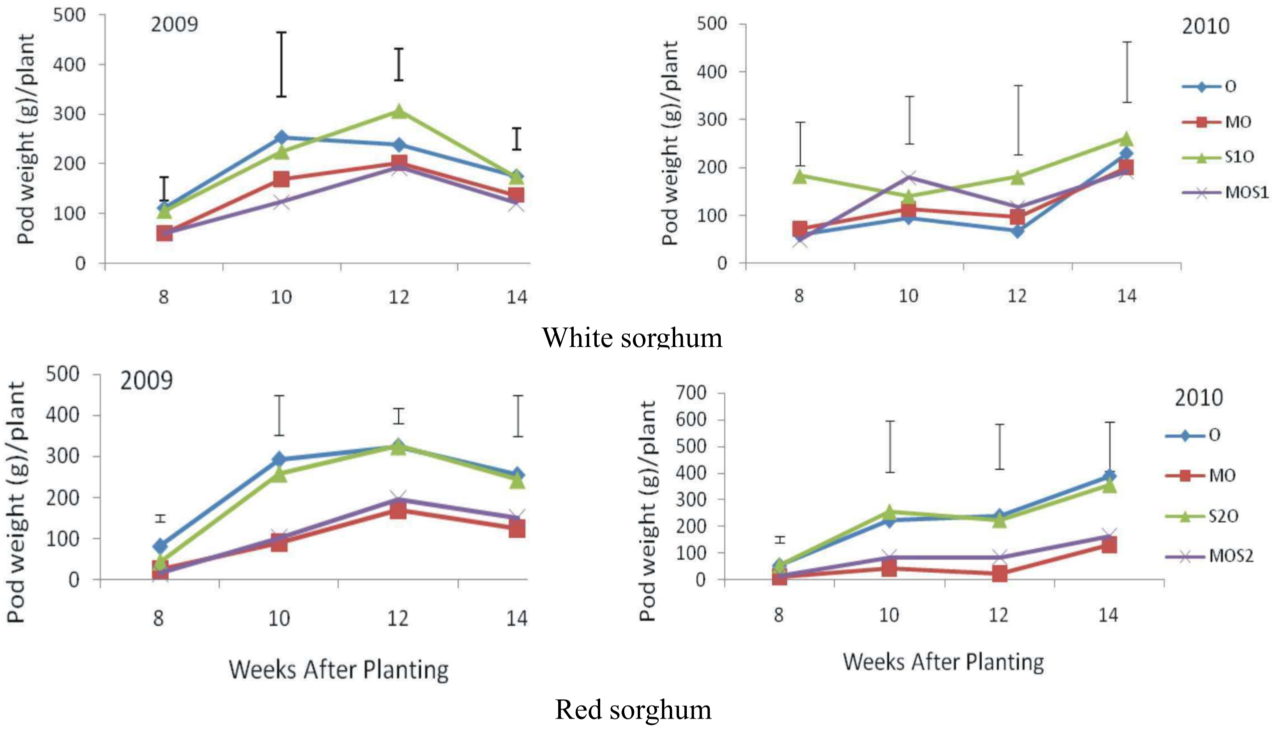


Figure 6: Effects of Intercropping two sorghum cultivars and maize on the weight (g) of fresh okra pods per plant in 2009 and 2010 seasons at NIHORT, Ibadan, Nigeria.

The trend of number of pods/plant in 2010 season revealed that in white sorghum mixtures, the highest pods/plant was from S1O mixtures with 22 pods/plant followed by MO mixtures with 12 pods/ plant then MOS1 with 11 pods/plant while sole okra (O) produced the least with 10 pods/plant. On the other hand, in red sorghum mixtures, sole okra (O) had highest pods/plant with 23 pods followed by S2O mixtures with 16 pods/plant then MOS2 mixtures which had 10 pods/plant while the lowest was from MO mixtures with 5 pods/plant.

Okra yield (tha^{-1})

In 2009 season, in white sorghum mixtures, the highest pod yield was obtained in okra/white sorghum mixtures (S10) (3.1tha^{-1}), followed by sole okra (O) (2.8 tha^{-1}), then okra/maize mixtures (MO) (2.0 tha^{-1}) while the least pod yield is from maize/ okra/white sorghum mixtures (MOSI) (1.9 tha^{-1}). The result showed that for red sorghum treatment combinations, the highest pod yield is obtained in sole okra (O) (4.2 tha^{-1}), followed by okra/red sorghum mixtures (S2O) (3.4 tha^{-1}), then maize/okra/ red sorghum mixtures (MOS2) (2.1 tha^{-1}) while the least pod yield was obtained in maize/okra mixtures (MO) (1.8 tha^{-1}) the mean yields were statistically different.

Similarly during 2010 season, in white sorghum combinations, the highest pod yield was recorded in okra/ white sorghum mixtures (S1O) (9.9 tha^{-1}), followed by sole okra (O) (5.5 tha^{-1}) then maize/okra/white sorghum mixtures (MOS1) (4.4 tha^{-1}) while the least yield was obtained in maize/ okra (MO) (4.3 tha^{-1}). Whereas in red sorghum combinations, the yield were in the following order, sole okra (O) (9.5 tha-1) followed by red sorghum/ okra mixtures (S2O) (7.1 tha^{-1}), then maize/okra/red sorghum mixtures (MOS2) (3.6 tha^{-1}) while the least yield in maize/okra (MO)(2.1tha^{-1}).

Table 1: Effects of intercropping sorghum cultivars and maize on the yield characters of okra in 2009 and 2010 seasons at NIHORT, Ibadan, Nigeria.

Treatment	2009			2010		
	No of pods/plant	Pod weight(g)	Pod yield (t/ha)	No of pods/plant	Pod weight (g)	Pod yield (t/ha)
White Sorghum						
O	9	38.9	2.8	10	22.7	5.5
MO	6	28.3	2.0	12	24.0	4.3
S1O	10	40.7	3.1	22	38.2	9.9
MOS1	7	24.9	1.9	11	26.8	4.4
Red Sorghum						
O	12	47.6	4.2	23	44.9	9.5
MO	5	20.6	1.8	5	10.2	2.1
S2O	9	43.5	3.4	16	44.3	7.1
MOS2	6	23.1	2.1	10	17.1	3.6
LSD (0.05)	5.63	15.35	0.82	9.26	18.21	4.67
White sorghum (mean)	9	33.2	2.5	14	27.9	6.0
Red sorghum (mean)	8	33.7	2.9	14	29.1	5.6
LSD (0.05)	2.05	7.65	0.75	3.80	9.82	0.51
Sole okra (mean)	11	43.2	3.5	17	33.8	7.5
Okra/sorghum (mean)	10	42.1	3.3	19	41.3	8.5
Okra/maize (mean)	5	24.4	1.9	8	17.1	3.2
Okra/maize/sorghum (mean)	6	24.0	2.0	10	22.0	4.0
LSD (0.05)	3.24	10.34	1.32	10.35	12.65	3.6

MOS1: Maize/okra/White Sorghum Intercrop; MO: Maize/Okra Intercrop; MOS2: Maize/Okra/Red Sorghum Intercrop; O: Okra (NHAe47-4); S1O: White sorghum/okra intercrop; S2O: Red sorghum/okra intercrops.

Relationships among agroclimatological indices and growth parameters

Figure 7 showed that mean decadal maximum temperature was weakly correlated with plant height of maize, sorghum and okra (r^2= 0.18, 0.42 and 0.24 respectively), so also was for leaf area of maize, sorghum and okra (r^2= 0.05, 0.19 and 0.01 respectively). Mean decadal rainfall was equally correlated with leaf area of maize, sorghum and okra (r^2= 0.40, 0.66 and 0.17 respectively) and with plant height of maize, sorghum and okra (r^2= 0.60, 0.77 and 0.71 respectively). This showed that growing period mean decadal rainfall contributes more to plant height and leaf area of the components crops than mean decadal maximum temperature. Quantification of the effects of mean decadal maximum temperature and mean decadal rainfall on plant performance is important to optimize the growing period.

CONCLUSION

The study proved that growing okra between sorghum rows rather than okra/maize mixtures is more valuable cropping option to diversify food production and improve economic returns for farmers and starch-based diets of the people in forest-savanna transition zone of Nigeria. This study also indicates that intercropping okra with sorghum varieties resulted in vegetative and yield comparable to the sole okra. Okra in monoculture or mixed stand showed great potential for environmental modification. Study also confirmed that minimal rainfall availability prolong harvesting period of okra as witnessed in the experiment and the optimum planting date for okra production must be the one which will make the period of harvest coincide with the period when minimal rainfall is steady and not the peak rainfall. Again, in order to reduce the risk

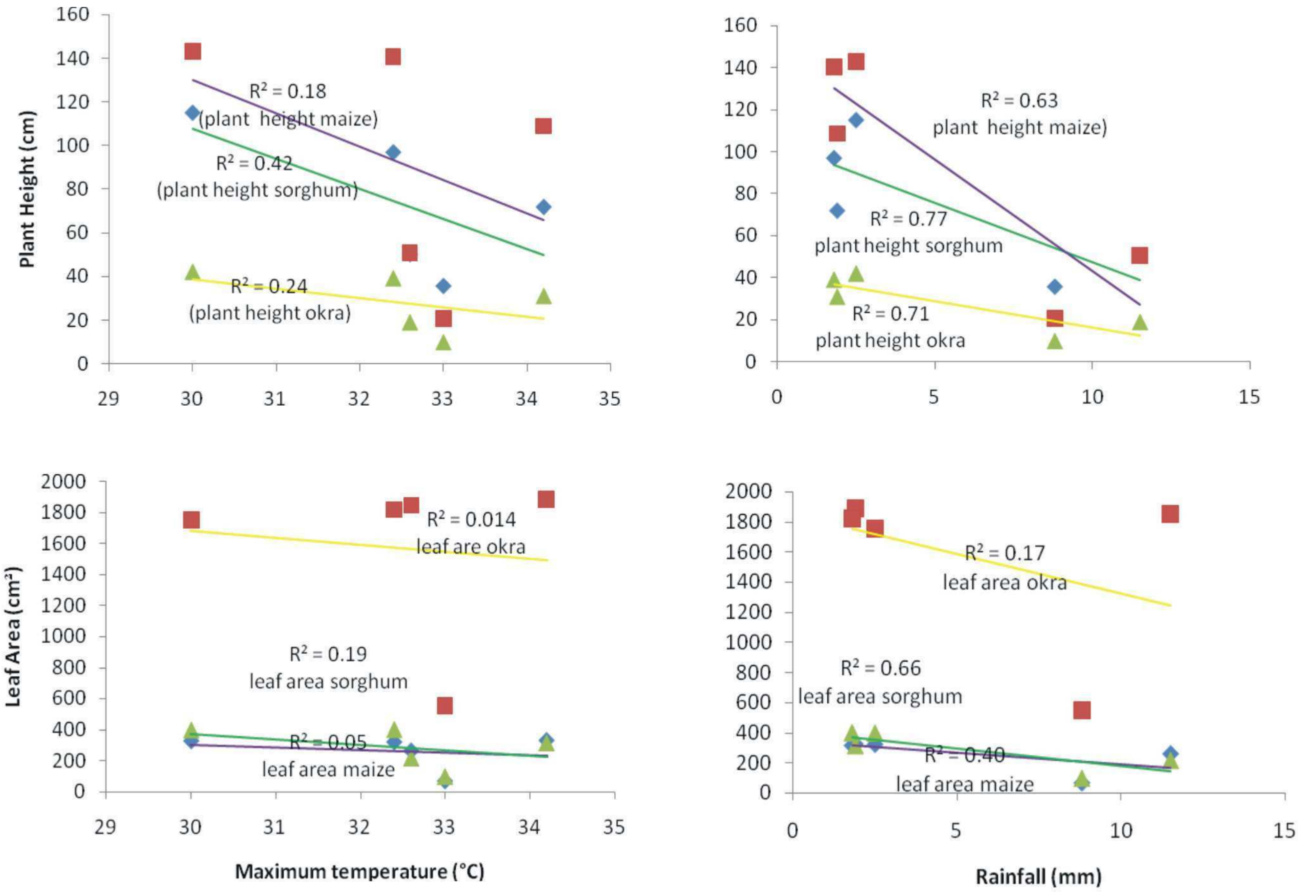


Fig.7. Correlations between mean decadal maximum temperature and mean decadal rainfall with plant height and leaf area of component crops (maize, okra and sorghum.) at NIHORT,Ibadan.

of total crop loss to peasant farmers due to unpredictable weather conditions, okra/sorghum intercropped is highly recommended as their combinations maximize the use of available environmental resources at all season and therefore reduce the potential negative impact of climate change on component crops. Quantification of the effects of mean decadal maximum temperature and mean decadal rainfall on plant performance is important for growers producing these crops for fresh market and also to optimize the growing period.

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