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Full Length Research Paper

Hydrothermal effects on the performance of maize and cucumber intercrop in a tropical wet and dry climate in Nigeria

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Maize and cucumber were intercropped in a simple randomized complete block design (RCBD) with three replicates in two field trials in early and late planting seasons of 2004. The result showed that mean soil temperatures of 33 and 31°C at 5 and 10 cm respectively during late season could be said to have enhanced the productivity of cucumber yield by about 50% compared to early season with mean soil temperatures of 30 and 29°C at 5 and 10 cm below soil surface. The mean cucumber yield of 9 t/ha and 6.1 t/ha for mono and mixed crop respectively during early season trial was significantly lower (P <0.05) than the mean cucumber yield of 15.34 t/ha and 12.34 t/ha for late season. However, early season maize fresh cob weight (178.4 g/ha) and weight of seeds per cob (122.4 g/ha) were significantly higher than that recorded for late season with 152.2 g/ha and 64.1 g/ha respectively. This could be attributed to suitably high rainfall of 27.0 and 324.6 mm during establishment and vegetative phenological stages respectively during the early cropping season compared with corresponding values of 12.6 and 206.5 mm during late season trial.

Key words: Hydrothermal, agro-meteorological, precipitation.

INTRODUCTION

Tropical wet and dry climate is characterised by distinct wet and dry seasons with the wet relatively longer than the dry season. It is characterised by bimodal rainfall (double maximal regime) distribution pattern with a short dry period separating the two rainfall peaks (Allaby, 2002) . This short dry period occurs around July and Aug-ust in areas within the south-western part of the country. In most parts of the tropical wet and dry climate, hydro-thermal meteorological parameters are critical considera-tions in crop production. Hydrothermal (hydro and ther-mal agro-meteorological) parameters are important com-ponents of the plant environment in a tropical wet-and-dry climate. The critical indices for maize crop among the hydro-agrometeorological indices are rainfall, evaporation and evapotranspiration while the thermal-agrometeoro-logical parameters include air and soil temperatures, radiation and sunshine hour/photoperiod, to mention a few. For instance major hydrothermal parameters influen-ced the timing of phenological events; this was clearly correlated with air temperature, soil temperature, precipi-tation, solar radiation, evapotranspiration, day length and snow cover, etc. (Wielgolaski, 2001). Many investigators have also shown that accumulated temperature was recognized as the main factor influencing year-to-year variations in phenological stages (Galan et al., 2001; Schaber and Badeck, 2003). Also phenoclimatic models are based on the relationships between the phenological phases of the crop species and the various hydrothermal parameters (Garcia-Mozo et al., 2002). Consequently,

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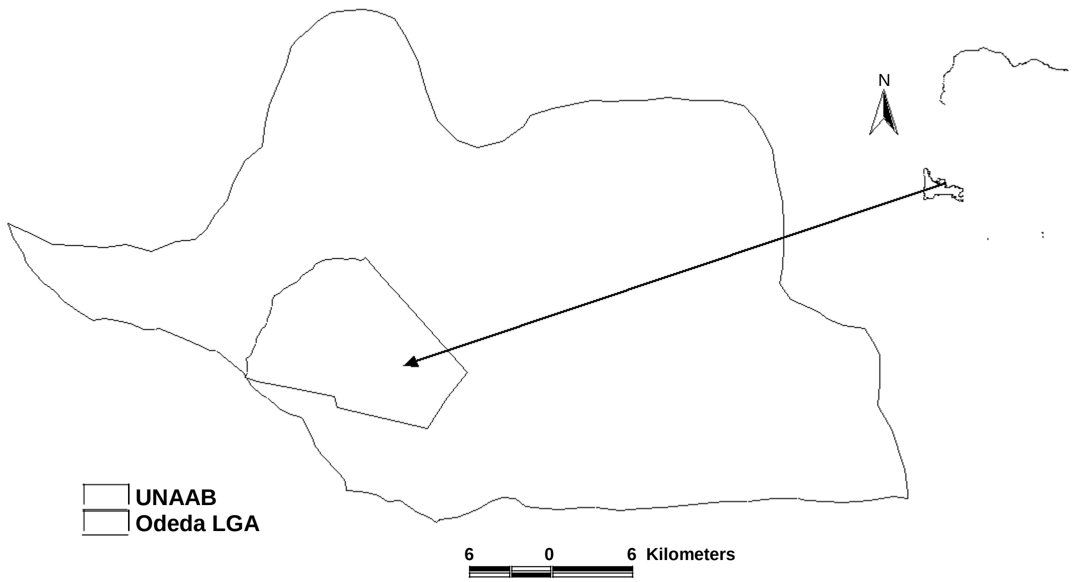

Figure 1. Location of University of Agriculture, Abeokuta within Odeda local government area in Ogun state, south-west Nigeria.

the present study sought to investigate the hydrothermal effects on performance of two grown crops (maize and cucumber) in the study area using the inter-cropping system which occupies a great percentage of cultivated land in West Africa (Wahua, 1986).

Maize and cucumber are two important food crops in Nigeria as well as in other parts of the world. Over the years maize has been useful as food, feed, construction material, fuel and as a medicinal or decorative plant. With industrial development, it increasingly became an Industrial raw material for the production of starch, gluten, oil, flour, alcohol and lignocelluloses for further processing into a whole range of products and byproducts. On the other hand, cucumber is a major fruit vegetable that is eaten raw (in salad) or cooked. It can also be put in vinegar; the crop serves as a major source of vitamins for people in developing countries. In spite of their importance, these crops are still in low productivity owing to several factors but water has been observed to be the principal yield limiting factabtor (Ayotamuno et al., 2000).

MATERIALS AND METHODS

Study area

Location of the experiment: The experiment was conducted at the University of Agriculture, Abeokuta along Alabata road in Odeda local government area of Ogun state, south western Nigeria (Figure 1). The field experiment was conducted during the early and late growing seasons of 2004 at the Agro Meteorological Teaching and Research Farm land located adjacent to the meteorological station within the vicinity of the College of Environmental Resources Management, University of Agriculture (7°15^{1}N, 3°25^{1}E).

Planting and crop maintenance

Maize cultivars, Suwan1 (M1) and TZ Comp4 (M2) and cucumber (C) were intercropped in two field experiments in early and late planting seasons of 2004. Early planting was done in May 2004 while late planting was done in August 2004 planting season, usually after the establishment of rains. According to Stern et al. (1981) the time of establishment of the rains is marked by the period when two days were not followed by a continuously dry period of say 5, 7 or 10days. Between three and four seeds of maize and cucumber were planted at a depth of 2.5 cm in each stand and the stands on the row for maize were spaced at 2.5 cm between stands while between stands for cucumber were spaced at 50 cm.

Three weeks after planting, the maize and cucumber seedlings were thinned to two and one per stand respectively following the recommended thinning procedure (Kowal and Andrews, 1973) and this resulted in a plant population of 26,666 and 13,333 plant ha^{-1} for maize and cucumber, respectively. The plots were hand hoed and weeded manually at 3 and 6 weeks after planting. All plots received a basal dressing of 70 kg N/ha urea.

Lay out of experimental plot

Experimental plots were arranged in simple randomized complete block design (RCBD) with three replicates for early and late growing seasons in 2004. Cropping systems, early and late planting seasons are the main factors. Each plot was 5 × 2.25 m with 1 m walking path between the adjacent plots.

Data collection and analysis

During the phenological stages, three sets of data were collected and these were: hydro and thermal agrometeorological data, phenological crop growth parameters and yield characters.

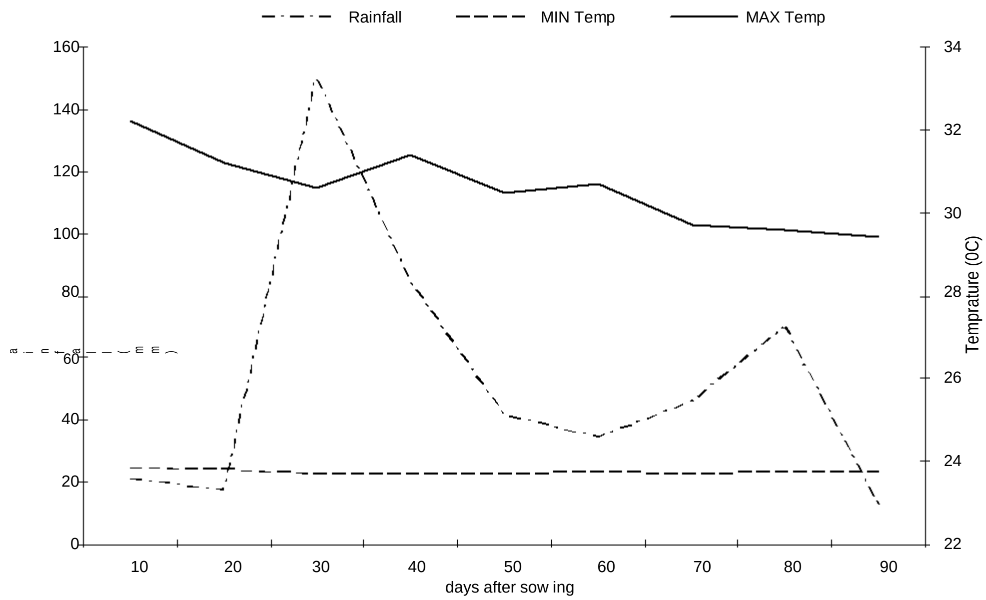

Figure 2. Decadal rainfall, minimum and maximum air temperatures during the growth of cucumber/maize at Alabata, UNAAB in the early season (May – July) of 2004.

Hydrothermal agrometeorological parameters

Hydro and thermal agrometeorological data involved daily observation of rainfall (P, mm) characteristics, air and soil temperatures (T, °C) at 5 and 10 cm on each plot, wind speed (Ws) at a height of 2 m (ms^{-1}) and relative humidity (%) were observed at a meteorolo-gical station adjacent to the experimental field except soil tempera-tures that were measured on the experimental plots.

Growth parameters

Plant height: This was taken from a sample of four plants (maize) tagged within the two central rows of each plot. The mean from the four plants was then determined.

Leaf area: The leaf area shall be determined by the non destructive length x width method described by Saxena and Singh (1985) using the relation: Leaf area = 0.75 (length x width), where 0.75 is a constant. Five leaves were measured for each treatment plot and the mean leaf area determined. The leaf area for cucumber was measured by the girth system whereby graph sheets were used to trace the area (surface) of five leaves in each treatment plot and the mean determined.

Days to 50% flowering: The effect of treatment on the flowering period of maize and cucumber were measured by recording the days from planting to when 50% of both plants flowered.

Yield parameters

Fruit length: The lengths of five fruits weighed were measured and the mean determined.

Fruit weight: Five cucumber fruits from each plot were weighed separately and the mean determined. Also, weekly harvest totals were recorded for analyses.

Fresh cob weight: Five fresh maize cobs from each plot were weighed separately and the mean determined. This was done to give a good estimate of the total yield of fresh maize.

Weight of seeds per cob: Five maize cobs from each plot were allowed to dry in the field to 14% moisture content and then harvested. The seeds were removed from the cobs and weighed. The mean was then determined.

Data analysis

Data collected were subjected to analysis of variance (ANOVA) to evaluate the effects of seasonal variations and their interactions on the response variables. The significant difference of treatment means were determined using least significance difference (LSD) at 5% level of probability (Steel and Torrie, 1988).

RESULTS

Hydrothermal characteristics during the early cropping season of 2004

Decadal rainfall and air temperature for the early season were related to the main phases of vegetative growth and reproductive development of maize-cucumber (Figure 2). The peak rainfall (150 mm) was observed at about 30 days after planting and this period coincided with the plant establishment and vegetative stages during the early life of maize and the flowering stage of cucumber plants revealing that moisture was not limiting at these critical stages of plant life. Another lesser peak of 69.8 mm was also observed at about 80 days after planting which also showed that at the maturity stage of maize plants, life moisture stress was also not pronounced while cucumber had completed its life cycle and was no more

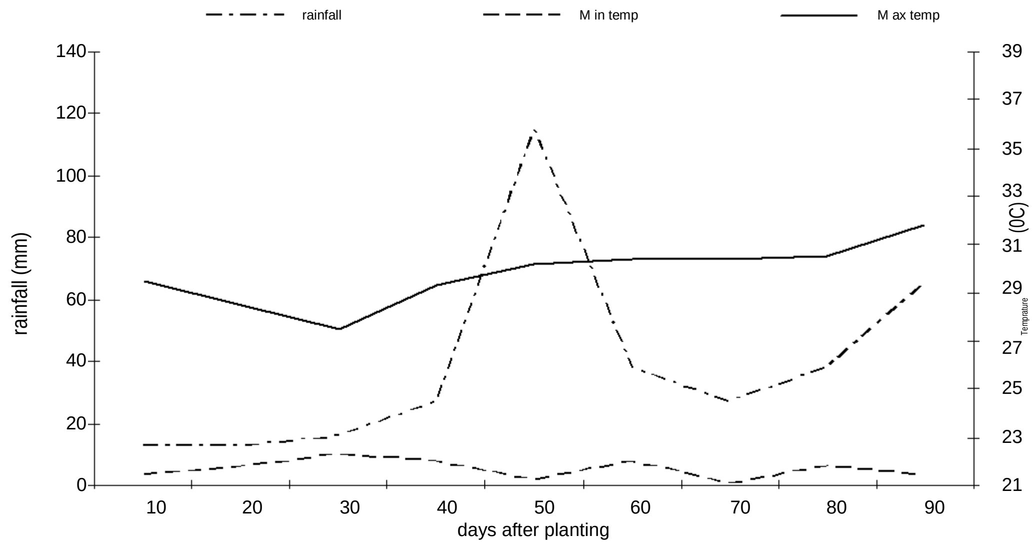

Figure 3. Decadal rainfall, minimum and maximum air temperatures during the growth of cucumber/maize at Alabata, UNAAB in the late season (August – October) of 2004.

on the field. The critical rainfall for maximum yield at these periods could be said to range between 150-69.8 mm. Temperature also differed slightly during maize-cucumber growth stages in the early cropping season of 2004. Minimum and maximum temperatures varied between 22-24 and 29-32°C respectively. Temperature was higher during planting, establishment and early vegetative growth (32°C –29°C) than during reproductive growth in the early cropping season (24-22°C). The cumulative amount of rainfall for the period between sowing and 50% flowering was 324.6 mm, accordingly the rainfall for the period between 50% flowering and maturity (reproductive phase) was 261.4 mm in the early season crops. Minimum and maximum temperatures of 23 and 32°C were recorded in the early season at planting.

Hydrothermal characteristics during the late cropping season of 2004

As shown in Figure 3, late season rainfall trends revealed lowest rainfall amount was observed for the period between the 3rd and 9th decades corresponding to 30 days after planting to 90 days after planting (16 mm to 64.6 mm) with peak rainfall at 50 days after planting (5th decade) (114.9 mm). This implies that moisture stress at the later part of the plant's life was less pronounced than that at the initial stage of the plant's life during the late growing season. Temperature differed slightly in the late cropping season. Minimum and maximum temperatures varied between 21-23°C and 28-32°C respectively. Temperature was low during planting, establishment and early growth than during flowering that is, 21-22°C and 29-32°C respectively. The amount of rainfall for the period between sowing and 50% flowering was 176.30 mm. Accordingly, the rainfall for the period between 50% flowering and maturity (reproductive phases) was 214.10 mm. Rainfall was therefore much larger during both vegetative and reproductive phases in the early season than late-season. The late-season can be defined as dry since the rainfall curve remains below the maximum temperature curve for most periods during both the vegetative and flowering phases (Figure 2). The minimum and maximum temperatures at planting in the late-season were 22 and 28°C respectively.

Figure 4 shows the amount of rainfall at each phenological stage. Rainfall at pre-sowing period, establishment, flowering, 50% maturity and first harvest for early season were 27, 11, 324.6, 84.5 and 76.8mm respectively and against 12.6, 16, 206.5, 64.6 and 37.8mm respectively for late season. This showed that early season moisture maize–cucumber plants experience no moisture deficiency throughout the entire period**.**

Figures 5 and 6 show soil temperature at 10 cm below soil surface during the growth of cucumber/maize at Alabata, UNAAB in the 2004 cropping season. Soil temperature did not vary significantly under both mono and mixed cropping. Highest temperature (32°C) was recorded at the vegetative and flowering stages followed by that at the maturity stage of about 26°C. Soil temperature was however higher at the early stage than at the later stage of plant life. This means that soil heat flux was higher at the vegetative and flowering stages than at the maturity stage; this is an indication that water absorption rate was higher at these periods.

Figures 7 and 8 show soil temperature at 5 cm during the growth of cucumber/maize at Alabata, UNAAB in the 2004 cropping season. Soil temperature on both mono and mixed cropping was similar at all sampling occasions. During the early season, slight differences started

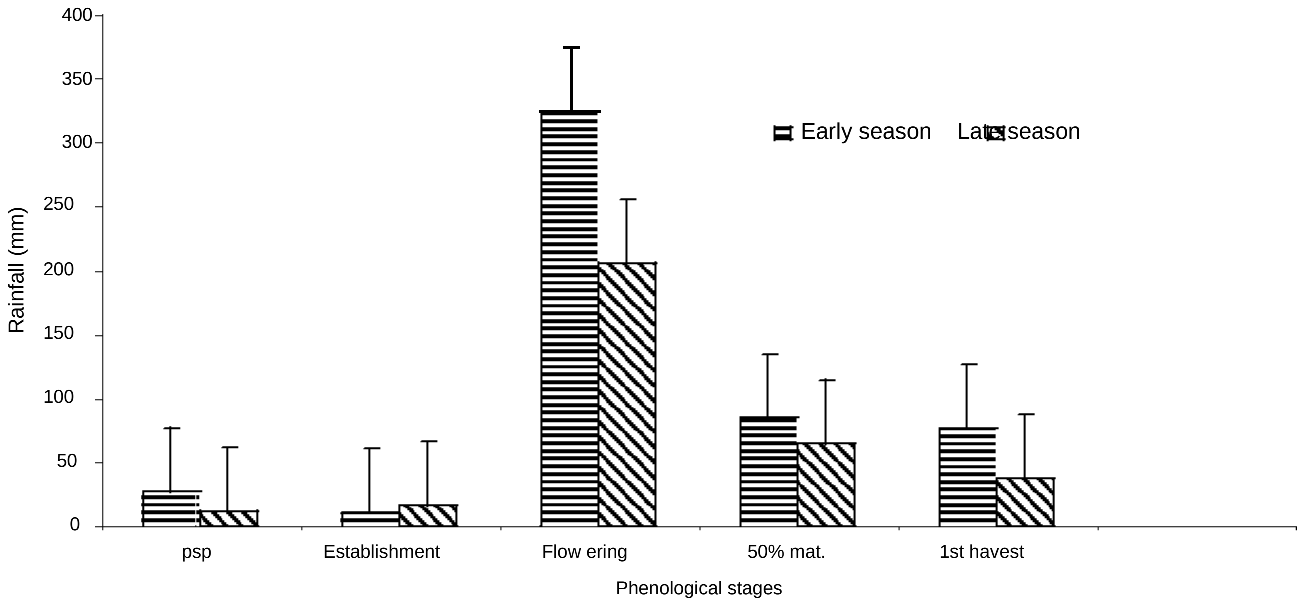

Figure 4. Rainfall at major phenological stages during the growth of cucumber/maize at Alabata, UNAAB in 2004 cropping season.

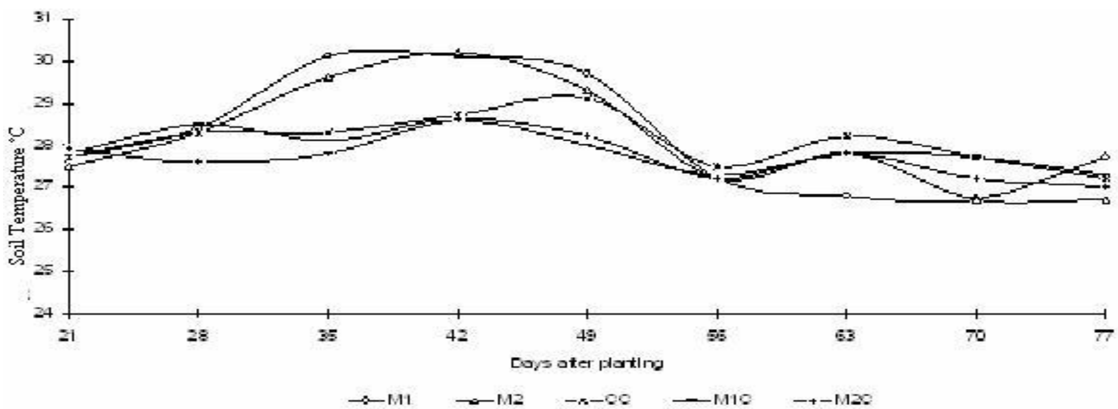

Figure 5. Soil temperature at 10cm depth during early season of 2004.

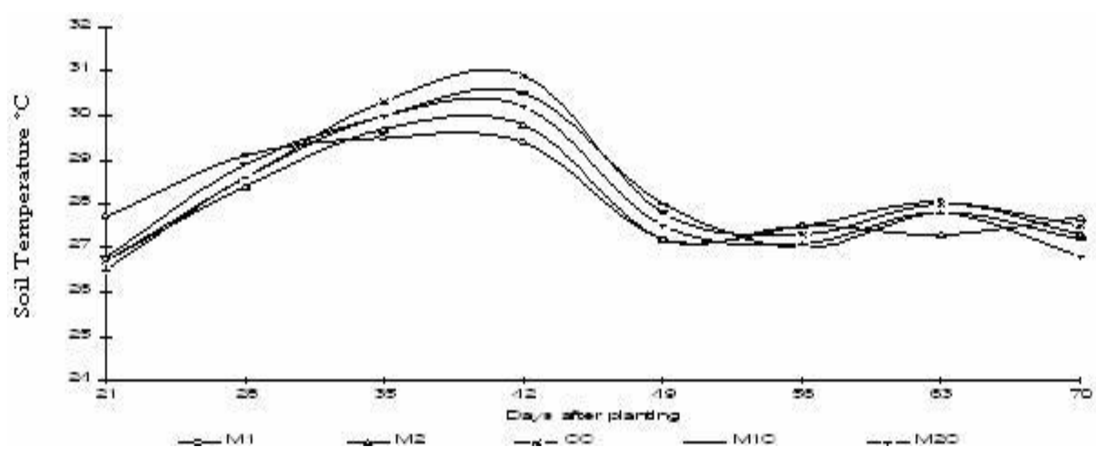

Figure 6. Soil temperature at 10cm depth during late season of 2004.

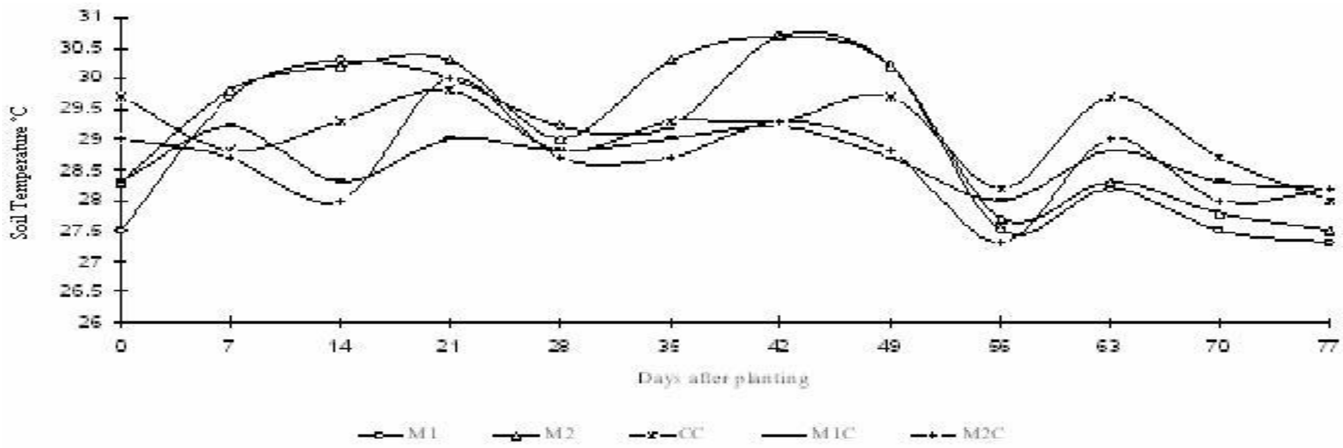

Figure 7. Soil temperature at 5cm depth during early season of 2004.

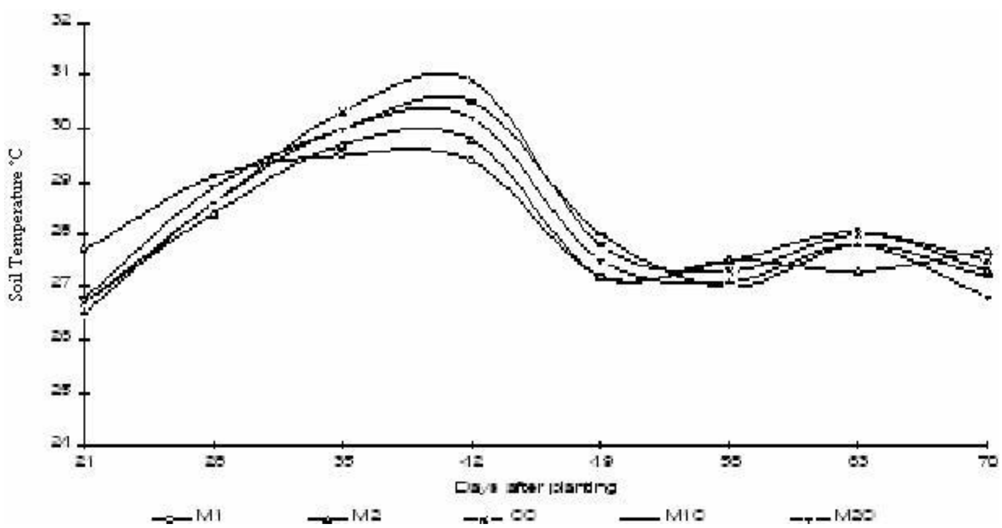

Figure 8. Soil temperature at 5cm depth during late season of 2004.

at the vegetative and flowering stages. Late season soil temperature at 5 cm was almost the same on both mono and mixed cropping especially at the sowing, establishment and vegetative stages; slight differences were observed around the flowering stage and this was maintained till harvest. The result showed that mean soil temperatures of 33 and 31°C at 5 and 10 cm during late season may be said to have enhanced the productivity of the cucumber crop.

Growth Parameters

Leaf area of maize (early season)

Leaf area of maize in monoculture and mixed stands at 3, 4, 5, 6, 7, and 8 weeks after planting for both early and late seasons is presented in Table 1. The table shows differences between the leaf area of the maize cultivar Suwan-1 in monoculture and mixed stand at 3 weeks after planting while the difference was not statistically significant in the leaf area of TZECOMP4. The difference was not significant at 4, 5, 7 and 8 weeks after planting. Cultivar TZECOMP4 had a much bigger leaf area than its counterpart Suwan-1 in both monoculture and mixed cropping at all the sampling periods. In monoculture from 3 weeks after planting to 8 weeks after planting, the leaf area of TZECOMP4 ranged between 230.94 to 535.00 cm^2 while it was between 224.77 to 518.04 $c.m^2$ for the leaf area of cultivar Suwan-1. In the mixed stand, the leaf area of TZECOMP4 ranged between 217.82 to 522.82 cm^2 while for Suwan-1 it ranged between 180.15 to 476.67 cm^2. Also in monoculture, TZCOMP4 reached its largest value (535.12 cm^2) at 7 weeks after planting while Suwan-1 attained a peak value of (518.04 cm^2) at 8 weeks after planting. However, in the mixed stand, Suwan-1 attained peak (477.00 cm^2) at 8 weeks after plant-

Table 1. Effect of seasons and cropping system on the leaf area (cm^2) of maize at Alabata (UNAAB), 2004 cropping season.

	Early season						Late season					
Cropping system	**3***	**4***	**5***	**6***	**7***	**8***	**3***	**4***	**5***	**6***	**7***	**8***
M1	225	241	300	486	444	518	130	309	519	572	589	574
M2	231	258	374	491	535	530	151	332	580	637	614	613
M1C	180	208	321	398	448	477	128	338	550	567	589	546
M2C	218	234	314	445	504	523	183	364	645	683	686	670
LSD (0.05)	35**	55	77	94**	96	61	57	60	129	120	99	127

* Weeks after planting; M1- sole maize (Suwan-1); M2- sole maize (TZECOMP 4) ;M1C- Suwan 1/Cucumber M2C- TZECOMP4/Cucumber; **significant.

Table 2. Effect of season and cropping system on the plant height of maize at Alabata, (UNAAB) 2004 cropping season.

Cropping systems	Early season					Late season				
	3*	4*	5*	6*	7*	3*	4*	5*	6*	7*
M1	56	72	101	141	187	33	72	109	152	216
M2	58	81	103	149	202	28	78	105	146	207
M1C	58	73	105	167	192	28	72	103	143	201
M2C	58	66	90	122	171	33	81	119	160	211
LSD (0.05)	5	18	21	56**	29**	7	13	19	23	17

ing while TZECOMP4 attained peak (524.82 cm^2) at 8 weeks after planting.

Late season

Table 1 also shows that the difference in leaf area of mai-ze in monoculture and mixed stands was not significant in all the sampling occasions. Cultivar TZECOMP4 (M2) had a much bigger leaf area than its counterpart Suwan-1 (M1) in both monoculture and maize/cucumber mixtures at all the sampling periods. In monoculture, from 3 weeks after planting to 8weeks after planting, the leaf area of TZECOMP4 (M2) ranged between 150.59 to 636.91 cm^2 while it was between 129.64 to 588.61 cm^2 for the leaf area of cultivar Suwan-1 (M1). In TZECOMP4-cucumber mixtures (M2C) it ranged between 182.56 to 686.42 cm^2 while for Suwan- 1-cucumber mixture (M1C) it ranged bet-ween 128.04 to 588.61 cm^2. Also in monoculture, TZE-COMP4 (M2) reached its largest value (636.91 cm^2) at 6 weeks after planting while Suwan- 1(M1) attained peak value (588.61 cm^2) at 7 weeks after planting. However, in the mixed stand Suwan-1 (M1C) attained peak (588.61 cm^2) at 7 weeks after planting so also did TZECOMP4 (M2) attain peak (686.42 cm^2) at 7 weeks after planting.

Plant height (early season)

Presented in Table 2 is the plant height of maize in monoculture and maize/cucumber mixtures at 3, 4, 5, and 7 weeks after planting. The difference was not significant at 3, 4, and 5 weeks after planting. In monoculture from 3 weeks after planting to 7weeks after planting, the plant height of TZECOMP4 (M2) ranged between 58.00 to 201.58 cm while it was between 55.72 to 186.67 cm for the plant height of cultivar Suwan-1 (M1). In the mixed stand from 3 weeks after planting to 7 weeks after plan-ting, the plant height of cultivar TZECOMP4 (M2C) ran-ged between 57.78 to 170.83 cm while for Suwan-1 (M1C) it ranged between 57.77 to 192.17 cm. Also in monoculture, TZECOMP4 (M2) and Suwan-1 (M1) rea-ched peak values of 201.58 and 186.67 cm respectively at 7 weeks after planting. In the mixed stand Suwan-1 (M1C) attained peak (192.17 cm) while TZECOMP4 (M2C) attained peak (170.83 cm) also at 7 weeks after planting.

Late season

The result on Table 2 also shows no significant difference in plant height of both Suwan-1 (M1) and TZECOMP4 (M2) in monoculture and maize/cucumber mixtures at all observation points. Cultivar Suwan-1 (M1) was generally taller than its counterpart TZECOMP4 (M2) in monocul-ture except for the 4th week whereas TZECOMP4 was higher in mixed cropping than Suwan-1 at all the samp-ling occasions. In monoculture from 3 weeks after plant-ing to 7 weeks after planting, the plant height of TZE-COMP4 (M2) ranged between 28.37 to 207.48 cm while it was between 32.80 to 216.03 cm for the plant height of

Table 3. Maize yield characteristics in mixed and monoculture.

	Early season		Late season	
Cropping system	Weight of seeds / cob (g)	Fresh cob weight (g)	Weight of seeds / cob (g)	Fresh Cob Weight (g)
M1	84	253	58	224
M2	93	240	66	350
M1C	107	263	61	263
M2C	91	203	72	266
LSD (0.05)	27	68	17	131

Table 4. Cucumber yield characteristics in mixed and monoculture.

	Early season		Late season	
Cropping system	Fruit weight (g)	Fruit length (cm)	Fruit weight (g)	Fruit length (cm)
CC	296	21	321	25
M1C	167	15	292	18
M2C	200	13	271	18
LSD (0.05)	98**	5**	55	5**

cultivar Suwan- 1 (M1). In maize/cucumber mixtures the plant height of cultivar TZECOMP4 (M2C) ranged between 32.83 to 211.30 cm while for Suwan-1 (M1C) it ranged between 28.03 cm to 200.77 cm. Also in monoculture, TZECOMP4 (M2) and Suwan-1(M1) reached peak values of 207.48 and 216.03 cm respectively at 7 weeks after planting. In the mixed stand suwan-1 (M1) attained peak (200.77 cm) while TZECOMP4 (M2) attained peak (211.30 cm) also at 7 weeks after planting.

Yield parameters

Weight of maize seeds/cob

Early season weight of seeds/cob of the two maize cultivars (Table 3) were not significantly different in sole maize and maize-cucumber intercropped. Grain yield/ear of Suwan- 1 mixed with cucumber (M1C) had the highest amount (107 g) while sole Suwan-1 (M1) had the lowest (84 g). Between these extremes are sole TZECOMP4 (M2) and TZECOMP4 mixed with cucumber (M2C) of 93 and 91 g respectively. Late season grain yield/ear of TZECOMP4 mixed with cucumber (M2C) had the highest amount (72 g) while sole Suwan-1 (M1) had the lowest (58 g) followed by sole TZECOMP4 (M2) (66 g) and Suwan-1 mixed with cucumber (M1C) of 61g. Differences of means were not significant at P < 0.05.

Fresh maize cob weight

Early season cob weight is another maize yield character presented in Table 3. Suwan-1 mixed with cucumber (M1C) had the highest cob weight (263 g) followed by sole Suwan-1 (M1) (253 g) and sole TZECOMP4 (M2) (240 g) while TZECOOMP4 mixed with cucumber (M2C) had the lowest of 203 g. Late season yield of TZECOMP4 mixed with cucumber (M2C) had the highest cob weight (266 g) followed by Suwan-1-cucumber mixtures (M1C) (263 g) and sole TZECOMP4 (M2) (250 g) while sole Suwan-1 (M1) had the lowest of 224 g.

Cucumber fresh fruit characteristics

Early season fruits yield revealed that the variation in the fruit weight of cucumber was significantly different at P < 0.05 with fruits from sole cucumber (CC) having much bigger fruit weight (296 g) followed by cucumber-TZE-COMP4 mixtures (M2C) (200 g) while cucumber-Suwan-1 mixtures (M1C) had the lowest fruit weight of 167 g (Table 4). Fruit length is another fruit characteristic showed in Table 4. Fresh fruit from sole cucumber (CC) plot was highest (21cm) followed by fruit from cucumber-Suwan-1 mixtures (M1C) (15cm) while its counterpart; cucumber-TZECOMP4 mixtures (M2C) had the lowest fruit length of 13 cm. The differences in fruit length between cucumber sole and cucumber-maize mixtures was significant at P<0.05.

Late season

Late season fruit yield in Table 4 showed that the variation in the fruit weight of cucumber was not significantly different (P<0.05) with fruits from sole cucumber (CC) having bigger fruits (321 g) followed by cucumber-Suwan -1 mixtures (M1C) (292 g) while cucumber-TZE- COMP4 mixtures (M2C) has the lowest fruit weight of 271 g.

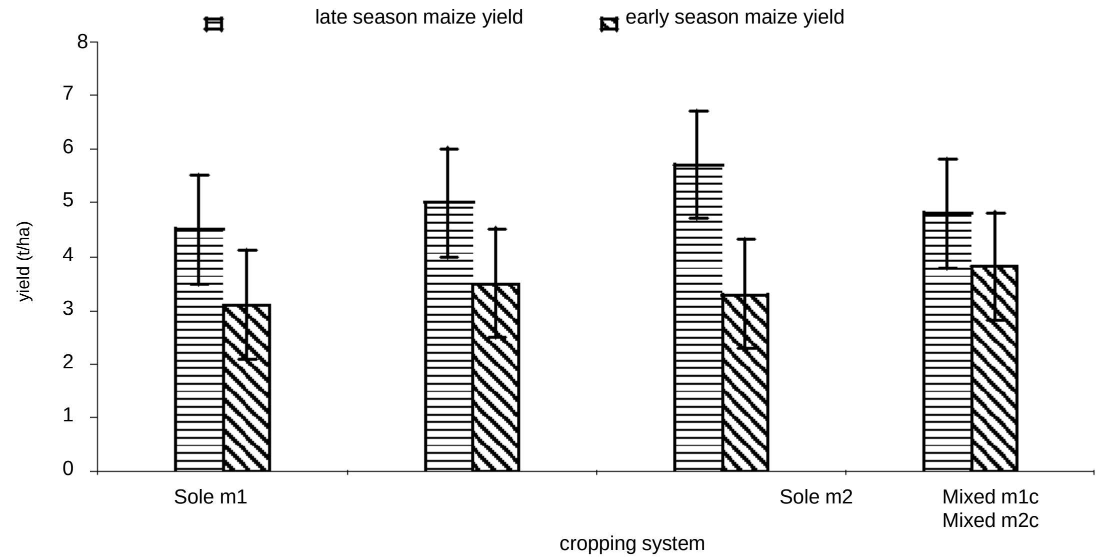

Figure 9. Maize yield under mono and maize-cucumber mixtures.

Fruit length is another fruit characteristic shown in Table 4. Fresh fruit from sole cucumber (CC) plot also maintained the highest (25 cm) followed by fruit from cucumber-TZECOMP4 mixtures (M2C) (18 cm) while its counterpart, cucumber- Suwan-1 mixtures (M1C) had the lowest fruit length of 18cm. The differences in fruit length between cucumber sole and cucumber-maize mixtures was significant at $P<0.05$.

Figure 9 shows yield in t/ha of maize across the seasons. Early season maize yield of Suwan-1 mixed with cucumber (M1C) has the highest grain yield (5.69 t/ha) followed by sole TZECOMP4 (M2) (4.98 t/ha) then TZECOMP4 mixed with cucumber (M2C) had a yield 4.48 t/ha while sole Suwan-1 (M1) had the lowest of 4.5 t/ha. However, late season maize yield of TZECOMP4 mixed with cucumber (M2C) has the highest grain yield (3.81 t/ha) followed by sole TZECOMP4 (M2) (3.50 t/ha) and Suwan-1-cucumber mixtures (M1C) (3.25 t/ha) while sole Suwan-1 (M1) had the lowest yield of 3.10t/ha.

Figure 10 shows fresh cucumber yield in t/ha across the seasons. Early season cucumber yield of sole cucumber (CC) has the highest yield (13.53 t/ha) followed by cucumber mixed with TZECOMP4 (M2C) (6.08 t/ha) while cucumber mixed with Suwan-1 (M1C) had the lowest yield of 3.09 t/ha. A similar trend was observed during late season cucumber yield with sole cucumber (CC) having the highest yield (23.01 t/ha) followed by cucumber mixed with TZECOMP4 (M2C) (10.33 t/ha) while cucumber mixed with Suwan-1 (M1C) had the lowest of 8.92 t/ha. Generally cucumber yield in the late season was higher than the early season yield across both mono and mixed cultures.

DISCUSSION

The present study agreed with Ayotamuno et al. (2000) that though many factors serve to limit crop growth including soil type, nutrient contents and climate, water has been observed to be the principal yield limiting factor. The early season rainfall amount was higher across most of the phenological stages than their corresponding amo-unt recorded during the late season period. This pattern was favourable to maize plant but not too favourable for cucumber as it does not require high humidity for optimal performance. Minimum temperature for both the early and late planting seasons falls within the optimal temperature range required by cucurbits (minimum temperature of 18°C during early growth is preferred with 24-27°C being optimum) as this is in agreement with the work of Larkcom (1991) and Desai and Musmade (1998). This range has been confirmed with prolific growth occurring at day/night temperatures of 28-35 and 20-25°C and severe reduction in growth at night temperatures of 16°C. Cucumber therefore requires heat to produce maximum yield replicate of which was prevalent during the late cropping season. In both seasons, the effects of high daily mean temperatures were greater on cucumber plants grown in monoculture than mixed stands. Particularly, the intercropped cucumber produced about the same numbers of fresh fruits during the later stages of growth with the monoculture. It thus appears that the cool environment observed in mixtures with maize provided a favorable period conducive for cucumber flowers to open and probably for pollination and fruit formation to take place. The increased and prolonged vegetative growth of the late-season crops, lengthened periods of flowering and fruiting, probably increased the assimilates available for fruit formation and development. Conversely, in the early-season crops the more shortened vegetative growth period resulting in fewer leaves and smaller leaf area possibly decreased radiation interception and photosynthesis. Also, the shorter periods of flowering and fruiting in the early-season crops probably decreased the amount of assimilate available for reproduction growth.

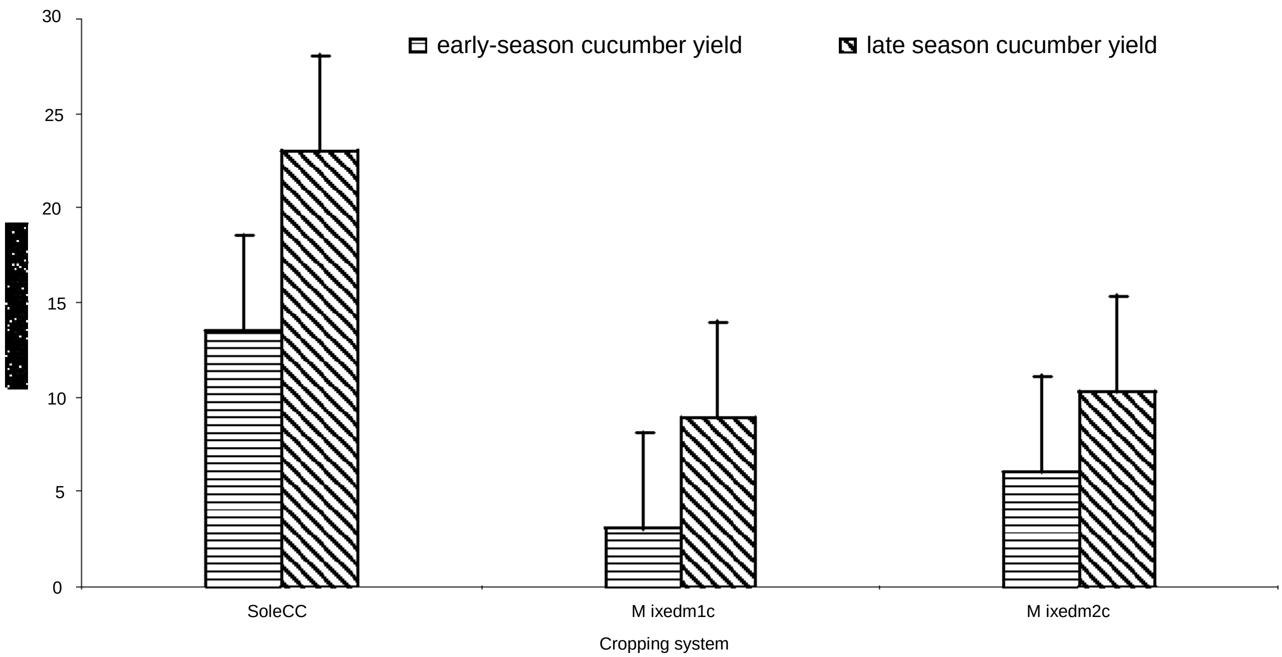

Figure 10. Cucumber yield under mono and maize-cucumber mixtures.

Furthermore, the yields of fresh edible fruit of cucumber in both cropping systems were higher in the late-season crops than in the early-season crops perhaps due to higher mean soil temperatures of 33 and 31°C at 5 and 10 cm during the late season which enhanced the productivity of cucumber yield by about 50% compared with the early season when mean soil temperatures were 30 and 29°C at 5 and 10 cm respectively. However, relatively lower yields of cucumber in the early season can be attributed to heavy rainfall that coincided with the flowering stage thereby leading to flower abortion. Thus the maximum economic returns from cucumber in either monoculture or mixed stand were greater in late-season crops than early-season crops. The seasons of cultivation therefore, need to be taken into account when growing cucumber for maximum edible fruit and economic returns.

Intercropping with cucumber did not affect phenological growth stages (that is vegetative growth, flowering and fruiting) of the cucumber, and growth and grain yield of associated maize in both seasons. This may be probably due to the differences in the stages of growth and development in relation to resources requirement and utilization of both crops. Cucumber had largely reached physiological maturity before growth of maize was maximal. Similar observation was made by Olasantan and Bello (2004) on intercropping okra with cassava. Moreover, maize was able to grow properly after cucumber harvest to fully benefit from full sunlight, extra residual soil nutrient and moisture. Part of the nutrient removed by cucumber during crop association would also be released to the soil by the decomposition of cucumber residue for maize to use.

Furthermore, there are reasonable ecological benefits in intercropping cucumber with maize in relation to soil environment modification and weed control. Growing cucumber between maize rows suppressed weed growth and maintained cooler and moister soil and canopy environments in maize. This may have been due to the ground cover provided by the associated cucumber, which reduced radiant flux to the soil surface and minimized water loss by evaporation during the day, and the inversion of soil temperature at night (Olasanatan, 1988). Such environmental conditions favored growth and fruit formation in intercropped cucumber when planting was later, particularly during late-season crops in 2004. It seems that the associated cucumber largely utilized the solar radiation, water and nutrients, which presumably otherwise would have been wasted and/or used by weeds in the maize inter-row space. Growing cucumber between maize rows thus appears to be an effective complementary biological method for weed control, soil and canopy environment improvement, judicious land use and increasing land productivity. It also generates income for resource-poor farmers and improves starch-based diets of the people.

In conclusion, the result indicated that the pattern in the distribution of hydrothermal parameters led to a reduction in maize yield during late and early seasons cucumber yield for both sole and mixed crops.

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