Effects of Planting Date on the Growth and Yield of Late Season Maize (*Zea Mays L.*) Cultivated in the High Rain Forest of South-South Nigeria

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Abstract

The Southern part of Nigeria experiences two cropping seasons for arable crops such as maize yearly. The early or first cropping season commences at the beginning of the rains in March while the late or second season commences towards the end of the rains in September. Field experiments were conducted from late August to January, during the 2017/2018 and 2018/2019 late cropping seasons, respectively, at the Rivers Institute of Agricultural Research and Training Farm, Rivers State University, Port Harcourt, Nigeria. The study aimed at determining best date of planting maize, based on growth and yield potentials, for late season production in the forest agro-ecology of South-South Nigeria. Three maize cultivars, Oba super 4, Oba 98 and Bori local, were sown on six different dates (20th August, 6th and 20th September, 6th and 20th October and 6th November) in a randomized complete block design (RCBD) with split plot arrangements and replicated thrice. The three maize cultivars formed the main plots while the planting dates were allocated to the subplots. Results show that maize cultivars exhibited significant differences in terms of growth, yield and yield attributes. Oba 98 had the highest grain yield (5.62 t/ha) followed by Oba Super 4 (4.78 t/ha) while Bori Local had the least (3.51 t/ha). With respect to date of planting, grain yield was highest when planting was early: on 6th September (5.55 t/ha), followed by 20th September (5.25 t/ha) and 20th August (5.02 t/ha). Delaying planting dates beyond 20th September reduced yield progressively to 6th October (52%), 20th October (79%) and 6th November (97%). Lowest grain number cob^{-1}, grain weight and grain yield values were obtained when planting was delayed to 6th, 20th October and 6th November, having their critical period of development (tasseling, silking, ASI and grain filling) in a period of stress, due to low or no rainfall and increased mean temperatures of the dry harmattan season which commences late November and last to late February. Total biomass and harvest index decreased progressively with delayed planting. Increased temperatures and little or no rainfall of the dry season exhibited larger impacts on grain yield than on vegetative growth. It is therefore recommended that late maize cultivation in the South-south ecology of Nigeria should be done between late August and late September for optimum grain yield.

Keywords: *Time of planting, Maize varieties, Oba super 4, Oba 98 and Bori local*

INTRODUCTION

Maize (*Zea mays L.*) is an important cereal crop in the Tropics and sub-Tropics. It is the most widely cultivated cereal crop in Nigeria with cultivation from the wet evergreen forest zone of the South to the dry ecology of the Sudan savanna in the North (Ammani, 2014). It is a staple and an important source of carbohydrate in human diet and also serves as a source of animal feed (Onasanya *et al*; 2009), an important source of industrial and pharmaceutical production in the country (Olaniyan, 2015).

Maize cultivation in Nigeria is mostly rain-fed, and therefore dependent on climate. Farmers are generally exposed to variability in climate and risks associated with weather fluctuations. Cultivation commences by March/April in the South and May/June in the North for early maize as the dry season gives way to regular rains. Late season planting, mainly in the south, is usually late August to early October with growth and yield progressing into the dry spell of the harmattan.

The late cropping season runs into the dry season of increased-heat stress and low precipitation, predisposes the cropping conditions to varying and unfavourable environmental factors of rainfall, temperature, relative humidity, sunshine hours and potential evapotranspiration which vary in some random manner around their seasonal mean trends, resulting in consequential influences on seed germination, crop development and yield during the cropping season (Bale *et al.*, 2002; Newton *et al.*, 2011' Babasaheb *et al.*, 2012; Adamgbe and Ujoh, 2013). Proper timing of crop planting for effective utilization of necessary resources of production in the face of adverse effects of the variables mentioned above, especially during the off season is indispensable.

Dates of planting maize significantly influence the growth, development and yield due to such climate changes that occur during the cropping season (Lansigan *et al.*, 2000; Casini, 2012; Dahmardeh, 2012). Progressive research activities across cropping zones have shown that there is an "ideal" planting window that exists, with a decline in yield with each additional day as less light and growing degree days are available to the plant (Ogbonna and Obi, 2010; Tsimba *et al.*, 2013; Ezeaku *et al.*, 2015; Gbaraneh, 2020). Efficient identification and utilization of such planting date window in the season is a critical factor for enhanced high yield of crop (Ijoyah *et al.*, 2015). It enables the crop to explore favorable conditions at critical crop growth stages. This "ideal window" may vary between zones due to environment variation. The biggest challenge therefore is to determine the ideal date for maize planting particularly with the short weather situation of the late season cropping with attendant management challenges. Because of differences in growing circle and maturity dates, the ideal planting dates (PDs) for maize hybrids vary among locations and seasonally within locations. This project was therefore designed to examine the effects of planting dates on growth, development and yield parameters of selected maize cultivars and to select a suitable variety that would enhance yield of maize in the South-South agro-ecology.

MATERIALS AND METHODS

Description of Experimental Site

The experiment was conducted from August to February, during the 2017/2018 and 2018/2019 cropping seasons at the Rivers Institute of Agricultural Research and Training Farm, Rivers State University, Port Harcourt, Nigeria. Port Harcourt situates in the rain forest zone of South-south Nigeria and is 15m above sea level. The area is characterised by a bimodal rainfall pattern with a range of 2,500 to 4500 mm per annum, guaranteeing two maize cropping seasons per year. The wet season commences about early-March and is usually interrupted by a short August break followed by a short rainy period from September to October while the dry season commences from late November to early March of the following year. The temperatures and relative humidity vary from 22-32^{0}C and 78%-89%, respectively. The soil of the experimental site was very acidic with low nitrogen and Organic matter content (Table 1).

Table 1. Physio-chemical composition of soil at the commencement of the study.in 2017 and 2018 late cropping seasons

Properties	Items	Soil depth (0-30 cm) 2017/2018	2018/2019
Physical	Sand (%)	76.60	77.12
	Silt (%)	9.40	9.26
	Clay (%)	14.00	13.68
Chemical	pH (1:2.5H_2O)	5.2	5.3
	Available P (mg/kg)	17.54	22.27
	Organic matter (%)	1.52	1.61
	Organic carbon (%)	0.88	0.88
	Nitrogen (%)	0.01	0.01
	Exchangeable K (cmol/kg)	0.23	0.28

Experimental Design and materials

The experiment was a split-plot arrangement fitted into a Randomized Complete Block Design (RCBD), replicated thrice. The three maize cultivars: Oba super 4 and Oba 98 (Hybrid) and Bori local (Open Pollinated Variety -OPV) formed the main plots while the planting dates (20th Aug, 6th Sep, 20th Sep, 6th Oct, 20th Oct and 6th Nov) were allocated to the sub-plots.

Table 2. Climatic Data for the Experimental period, August-February 2016/2017 and 2017/2018 cropping seasons.

Months	Average Monthly Rainfall (mm) 2016/2017 season	2017/2018 season	Average Monthly Temperature (°C) Minimum 2016/2017 season	Minimum 2017/2018 season	Maximum 2016/2017 season	Maximum 2017/2018 season	Average Relative Humidity (%) 2016/2017 season	2017/2018 season
July	399.3(22)	408.4(24)	21.2	21.5	27.8	29.4		
August	264.6(17)	308.3(14)	22.1	21.9	28.6	28.4	88.22	76.8
September	388.5(23)$^{+}$	422.6(21)	21.3	21.6	28.4	27.8	78.00	78.42
October	290.5(10)	291.3(11)	22.5	22.6	29.8	28.9	74.82	74.67
November	84.6 (4)	98.2 (7)	23.1	22.8	31.1	32.7	57.19	62.55
December	38.8 (3)	30.4 (4)	23.3	23.4	33.6	32.2	52.49	61.63
January	21.0(2)	10.1 (2)	23.4	23.8	34.0	34.6	61.27	62.31
February	11.0(3)	20.3 (2)	23.9	23.2	34.9	35.1	68.57	66.33

+Values in parenthesis indicate number of rainy days.
Source: Rivers State University, Crop/Soil Science Department Weather Station

Cultural Operations

The land used for the experiment had been under follow for one year after a cassava crop. The land was slashed, ploughed twice and harrowed once. Each sub-plot measured 4m x 3.75m. Maize cultivars Oba super 4, Oba 98 and Bori local were the test crops used for the experiment. Oba super 4 and Oba 98 are improved hybrid cultivars while Bori local is an open pollinated cultivar adopted by local farmers, used as the check. Sowing of the maize cultivars was done on 20th August, 6th and 20th September, 6th and 20th October and 6th November in 2017 and 2018 late cropping seasons, respectively, according to the design of the experiment. Planting was done on the flat at a spacing of 0.75m x 0.5m with three seeds per stand but seedlings thinned to two per stand at three weeks after planting (WAP), giving a population of 53,333 plants per ha. Missing stands were supplied at this period. All agronomic practices such as weeding, fertilizer application and pest control were done uniformly for all treatments except those practices under study. At maturity (15 WAP), dried maize cobs were harvested, de-husked and air-dried under a shade to 15% moisture content before shelling and weighing.

Data Collection
All plants on the three middle rows of each plot (excluding the border plants) were tagged for data collection. Data collected were on growth and yield which included number of days to 50% emergence, number of leaves per plant and leaf area at 6 and 8 WAP, plant height (cm) at 8 WAP, number of days to 50% tasseling and silking, anthesis-silking interval (ASI), stover yield (t/ha), grain yield (t/ha), number of grains per cob, grain weight (g), harvest index (HI).

Data Analysis
All data collected were subjected to analysis of variance (ANOVA) using the procedure GLM of SAS (SAS Institute, 2010). Treatment means were compared for significance using Duncan's Multiple Range Test (DMRT) at 5% level of probability (Wahua, 2000; Steel and Torrie, 1980).

RESULTS
Germination
Results of maize grains germination across the cultivars and planting dates are shown in Table 3. Number of days to 50% germination across the cultivars did not differ significantly ($P>0.05$) although it was slightly earlier with the hybrid (Oba Super 4 and Oba 98) and delayed in the Bori Local. The different planting dates did not also influence germination of the respective varieties significantly.

Vegetative growth
Vegetative growth characteristics of cultivars at 6 and 8 Weeks after Planting (WAP) for planting made from August to November, 2017 and 2018, respectively, are shown in Table 3. Number of leaves per plant across the cultivars were statistically similar at 6 WAP but differed significantly ($P\leq0.05$) at 8 WAP with Oba Super 4 followed by Oba 98 producing higher number of leaves than Bori Local in both years. Number of leaves per plant was significantly influenced by planting dates. Although number of leaves per plant did not differ significantly among the different planting dates 20th August, 6th, 20th September and 6th October, significant variation became obvious when planting was delayed to 20th October and 6th November. Similarly, leaf area did not differ significantly amongst plants of the different planting dates at 6 WAP except when planting was delayed to 20th October and 6th November. This observation slightly altered at 8 WAP as delaying planting beyond 20th September significantly reduced leaf area values among planting dates. Planting made between 20th August and 20th September did not differ significantly.

Plant height, days to tasseling and silking and anthesis-silking interval (ASI)
Plant height recorded at 8 WAP showed that maximum plant height was obtained when planting was done between 20th August and 20th September and declined significantly with

delayed planting beyond 20th September such that 6th November planting had the least plant height (Table 4). The local variety, Bori Local, had the tallest plants among the three cultivars.

There was a significant year x planting date x cultivar interaction for days to 50% tasseling and silking (Table 4). In both years, days to 50% tasseling, silking and Anthesis-silking interval (ASI) increased significantly as planting date was delayed beyond 20th September. The magnitude of the increase for tasseling, silking and Anthesis-silking interval (ASI) when planting was delayed beyond 20th September to 6th November was however higher in 2017 than 2018. The cultivar Bori Local, had the highest number of days to tasseling and silking with higher Anthesis-silking interval (ASI) values among the three cultivars in both years. Differences between Oba Super 4 and Oba 98 were in-significant in both years.

Maize Yield and Yield Components

Among the cultivars under evaluation, highest stover yield was obtained from the hybrid, Oba Super 4 which was statistically similar to Oba 98 and Bori Local, in a decreasing order of yield in 2017 (Table 5). Stover yield segregated significantly among the three cultivars in 2018 with Oba Super 4 followed by Oba 98 significantly out-yielding Bori Local. Stover yield was also significantly influenced by planting dates. Although yield did not differ significantly between planting made on 20th August, 6th, 20th September and 6th October, with delayed planting to 20th October and 6th November, yield was significantly depressed in 2017. In 2018, stover yield obtained from planting done between 20th August, 6th and 20th September were equally non-significant. Significant drop in yield commenced from 6th October planting to 6th November with the lowest yield.

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Similarly, planting dates showed statistical significance with respect to grain yield attributes of number of grains per cob and grain weight (g). Maximum number of grains per cob and grain weight (g) were obtained with planting made on 20th September in 2017 and on 6th September in 2018. Nevertheless, grains per cob and grain weight (g) values were statistically similar among planting done on 20th August, 6th and 20th September in both years, rather values progressively decreased significantly to the minimum when planting was delayed through 6th October to 6th November (Table 5). The result also showed that 200 grain weight of the cultivars under evaluation were statistically different. Oba 98 presented the maximum weight which was not significantly different from the weight of Oba Super 4 but differed significantly from cultivar Bori Local. Planting dates also exhibited significant effects on 200 grain weight. Mean maximum weight was produced by plants planted on 6th September which was statistically equivalent to planting made on 20th August and 20th September.

Table 3. Number of days to 50% emergence, Number of leaves and Leaf area per plant of maize cultivars planted in the late season months of August to November, 2017 and 2018.

Treatment	Number of days to 50% maize emergence			Number of leaves per plant at 6 WAP			Number of leaves per plant at 8 WAP			Leaf area per plant (cm^2) at 6 WAP			Leaf area per plant (cm^2) at 8 WAP		
	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
Cultivars															
Oba super 2	8.4a	8.6a	8.50	12.6a	11.8a	12.2	17.3a	17.5a	17.4	354.2a	352.4a	363.3	694.8a	714.8a	704.8
Oba 98	8.6a	8.5a	8.55	12.3b	12.1a	12.2	16.9a	17.2a	17.05	352.7a	348.1a	365.4	677.6a	699.2a	698.4
Bori	8.9a	8.6a	8.75	12.4ab	11.2a	11.8	15.2b	15.1b	15.15	311.6b	311.3a	311.45	532.8b	541.4b	537.1
Planting date															
20th Aug	8.7a	8.7a	8.70	12.6a	12.4a	12.5	16.9a	17.7a	17.1	349.3a	359.3a	300.8	688.2a	692.4a	693.3
6th Sep	8.7a	8.8a	8.70	12.6a	12.8a	12.7	17.1a	16.1a	16.6	343.4a	351.4a	346.4	698.4a	688.8a	693.6
20th Sep	8.7a	8.7a	8.70	12.4a	12.8a	12.3	17.8a	16.3a	17.1	313.6a	346.2a	322.4	673.8a	682.6a	678.2
6th Oct	8.8a	8.7a	8.80	11.3a	10.8ab	11.1	16.4ab	16.7ab	16.6	271.7b	278.6b	275.2	526.1ab	518.6ab	522.4
20th Oct	8.9a	9.0a	8.95	9.4ab	8.2b	9.8	14.8b	14.1b	14.2	238.6b	239.4b	249.0	335.2b	326.3b	330.8
6th Nov	8.8a	9.0a	8.95	7.6b	7.1b	7.4	11.6c	10.4c	11.0	222.3c	229.4	227.9	281.4bc	276.8bc	279.1

WAP = Weeks after planting; Mean followed by common letter (s) within each column are not significantly different ($p<0.05$) by Duncan's multiple Range Test.

Table 4. Plant height, number of days to 50% tasseling and silking and anthesis-silking interval in maize cultivars under varying planting date in 2017 and 2018 late cropping seasons, respectively.

Treatment	Plant height (cm) @ 8 WAP		Number of days to 50% tasseling		Number of days to 50% silking		Anthesis-Silking Interval (ASI)	
	2017	2018	2017	2018	2017	2018	2017	2018
Cultivars								
Oba super 4	182.2b	191.3a	55.1b	54.1b	58.6b	58.1b	3.5b	4.0b
Oba 98	188.6b	188.3b	56.5b	55.8b	59.3b	59.1b	1.8c	3.3c
Bori Local	194.2a	196.4a	62.3a	61.7a	66.5a	68.6a	4.2a	6.9a
Planting date								
20th Aug	195.3a	201.5a	55.7c	57.4c	58.2c	60.4c	2.5c	3.0c
6th Sep	190.1a	198.8a	57.5c	56.6c	59.7c	59.1c	2.2c	2.5c
20th Sep	187.3a	188.3a	55.8c	57.4c	61.3c	60.7c	5.5b	3.3c
6th Oct	171.2ab	176.9ab	59.6b	60.8b	64.1c	73.6b	4.5b	12.8b
20th Oct	157.6b	151.4b	64.1a	62.4b	77.4b	80.8a	13.3a	18.4a
6th Nov	133.2c	124.6c	69.3a	70.3a	84.3a	86.6a	15.0a	16.3a

Mean followed by common letter (s) within each column are not significantly different ($p<0.05$) by Duncan's multiple Range Test.

Table 5: Stover yield, Number of grains per cob and 200 grain weight of maize as influenced by cultivar and planting date in 2017 and 2018 late cropping seasons, respectively.

Treatment	Stover yield (t/ha)			Number of grains cob^{-1}			200 grain weight (g)		
	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
Cultivars									
Oba super 4	7.77a	8.83a	8.23	372.6ab	388.3a	380	94.3a	96.6a	93.5
Oba 98	7.74a	7.61b	7.53	394.3a	386.6a	390	97.2a	99.2a	98.2
Bori	7.34a	7.52b	7.03	322.6b	341.2b	332	84.7b	78.6b	81.7
Planting date									
20th Aug	6.59a	6.89a	6.59	359a	341a	350	83.4a	90.1a	86.8
6th Sep	7.11a	6.96a	7.04	361a	396a	379	93.8a	94.4a	94.1
20th Sep	6.89a	6.81a	6.85	399a	361a	380	96.4a	89.9a	93.2
6th Oct	5.36b	6.19a	5.78	236b	269b	253	62.6a	78.3a	70.5
20th Oct	5.03b	4.96b	5.00	143c	179c	161	54.7b	60.4b	57.6
6th Nov	3.16c	3.82b	3.49	74d	89d	82	53.2b	58.8b	56.0

Means followed by same letter (s) within same column are not significantly ($p<0.05$) different
by Duncan's multiple Range Test (DMRT).

During the two years of study, the maize cultivars under evaluation differed significantly in respect to grain yield (Table 6). The hybrid, Oba Super 4 gave the highest grain yield in 2017 while Oba 98 gave the highest in 2018. The lowest yield was produced by Bori Local (open pollinated variety) in both years. Grain yield produced by Oba 98 and Oba Super 4 were statistically similar but were significantly higher than the yield of Bori Local in both years. Planting dates equally influenced grain yield. The highest yield was observed from the planting of 6th September while the lowest yield was observed with 6th of November planting in both years. Planting on 6th September significantly increased grain yield over other planting dates in 2017 but was statistically similar to planting made on 20 August in 2018. Yields of 20th August and 20th September were statistically same in both years. Significant mean yield loss was observed when planting was delayed to 6th October (45%), 20th October (72%) and 6th November planting (86%).

The data presented in Table 6 show that significant differences for HI occurred among the cultivars under evaluation. Oba 98 presented the maximum HI, which was statistically similar to Oba Super 4 but significantly higher than Bori local in 2017. The hybrid Oba 98 also produced the maximum HI which was significantly higher than Oba Super 4, with the later in turn significantly out-yielded Bori Local, in 2018. With reference to planting dates, the plants planted on the 6th of September produced the maximum harvest index (HI) in both years which was statically similar to planting dates 20th September and 20th August. Delaying planting to 6th October and beyond significantly reduce the HI value, progressively, to the lowest at planting on 6th November.

Table 6: Grain yield and Harvest Index (HI) of maize as influenced by cultivar and planting date in 2017 and 2018 late cropping seasons, respectively.

Treatment	Grain yield (t/ha)			Harvest Index (HI)		
	2017	2018	Mean	2017	2018	Mean
Cultivars						
Oba super 4	5.55a	5.31a	5.43	40.14a	39.55b	39.85
Oba 98	5.46a	5.82a	5.64	41.36a	44.33a	42.84
Bori Local	3.16b	3.86b	3.51	30.48b	35.81c	33.24
Planting date						
20th Aug	4.86b	5.28ab	5.02	43.08a	43.39a	43.23
6th Sep	5.39a	5.71a	5.55	43.12a	45.07a	44.09
20th Sep	5.04b	5.46b	5.25	42.25a	44.50a	43.37
6th Oct	3.17c	2.97c	3.07	33.25b	29.34b	31.29
20th Oct	1.42d	1.66d	1.54	16.86c	20.26c	18.56
6th Nov	0.62e	0.76e	0.69	6.51d	6.37d	6.44

Means followed by same letter (s) within same column are not significantly ($p<0.05$) different by Duncan's multiple Range Test (DMRT).

Insect Pests Incidence

The results obtained (Table 7) showed no incidence of diseases but that of insects was low. The delay of planting dates to October and November allowed some level of insect infestation.

Table 7. Incidence of insect pests* on maize varieties during the late cropping season,

Treatment	Insect Pest Incidence			Disease Incidence		
	2017	2018	Mean	2017	2018	Mean
Cultivars						
Oba super 4	0	0	0	0	0	0
Oba 98	0	0	0	0	0	0
Bori Local	0	0	0	0	0	0
Planting date						
20th Aug	0	0	0	0	0	0
6th Sep	0	0	0	0	0	0
20th Sep	0	0	0	0	0	0
6th Oct	1	1	1	0	0	0
20th Oct	1	1	1	0	0	0
6th Nov	1	1	1	0	0	0

*Incidence of insects with 0 as absent and 5 highest;

DISCUSSION

Maize cultivars and dates of planting did not exhibit significant effects on number of days to fifty percent emergence. It could be assumed that soil moisture was not limiting at this critical stage of plant life (Tables 3). Generally, with the percentages obtained, optimum plant density could be maintained and hence higher crop yields (Mohammed *et al.*, 2008).

Plant height

Plant height is an important trait in crop production which is believed to be controlled by genetic characteristics but it may also be influenced by nutritional and environmental stress. A good plant height exposes the leaves to sunlight for photosynthesis, a function of the plant that determines the overall productivity and development of each yield character. In this study, Bori Local cultivar was taller than the hybrids (Oba Super 4 and Oba 98), attributed to genetic characteristics. Date of planting significantly influenced plant height of maize. Cultivars planted between 20th August and 20th September when there was adequate rainfall were significantly taller than those in which planting were delayed to 6th and 20th October and 6th November. The vegetative growth period of delayed plated plants fell into the harmattan stress and so could not perform effectively. Our findings were in line with Hussain *et al* (2019) who stated that the effects of drought stress were more severe for plant height, among other traits. Ibeawuchi *et al.* (2008) reported that under such stress condition, maximum plant height is only possible with narrow row spacing in plant competition.

Number of leaves and leaf area per plant

The number of leaves and leaf area per plant are indicators of plant development, which play a greater role in light interception for photosynthesis and transpiration which are all functions of yield. In this study, maize varieties did not differ significantly with respect to number of leaves and leaf areas which could be attributed to genetic characteristics. Planting date had a significant impact on number of leaves and leaf area (Table 4). Plantings made from August to September produced large number of leaves and leaf area than planting made from October to November, with November cultivation giving the least number of leaves and leaf area. The high number of leaves and leaf area per plant of September planting could be attributed to adequate rainfall and optimum temperature pattern during growth as shown by the monthly weather data for Port Harcourt (Table 2). The low number of leaves and leaf area of October to November planting might be due to the high stress effects due to low rainfall and high temperature during vegetative growth. This condition agrees with Adeniran (2004); Igbadum and Oyedebo (2000) working differently and observed that when water deficit falls below the critical water level, maize growth is adversely affected.

Tasseling, silking and anthesis-silking interval

The anthesis-silking interval (ASI) which is synonymous with the pollination and fertilization period, an interaction between tassels and silks, is the most critical stage for grains development in maize crop. Success during this stage ensures bumper grain yield in the crop, while any stress during the period can cause more yield loss than almost any other period in the crop's development.

The cultivar, Bori Local, took significantly higher number of days to achieve 50% tasseling and silking than the hybrid cultivars (Oba super 4 and Oba 98). That attribute was considered purely a genetic effect. (Tables 3). Delayed tasseling and silking observed when planting was delayed to October through early November was probably due to stress caused by very low rainfall and higher temperatures recorded during the vegetative growth of the plants. This environmental stress condition might have negatively affected initiation of reproduction characters. Delayed planting dates had detrimental effect on ASI. The result agrees with reports of Shrestha, *et al.,* (2018); Shrestha *et al.*, (2016); Kieran & Andrew, (2009) that under heat stress, there is delayed tasseling and silking and when they appear, there is reduced pollen viability and silk receptivity resulting to reduced silk capability of developing kernels and subsequence kernel abortion.

Stover yield

Oba super 4 produced the highest stover yield followed by Oba 98 while Bori Local had the least. Date of planting did not significantly depress stover yield except when planting was delayed to November which produced the least yield (Table 6). The low yield of November could be attributed to low rainfall of the incoming harmattan season. This agrees with Ayotamuno *et al*, (2000) that though there are many factors which serve to limit crop growth and biomass yield, water and temperature are the principal limiting factors. Hatfield and Pruege (2015) had also reported that impact of high temperature stress is more serious on grain yield than on vegetative growth.

Grain yield

Oba 98 had the highest grain yield followed by Oba Super 4 and Bori Local the least. The variation in yield was purely attributed to genetic effect. With regards to date of planting, maize grain yield was at its peak in the September planting (Table 6) followed by late August and late September in that order while delaying of planting to early October and beyond especially to early November significantly lowered grain production. Such high yield of September planting was however expected since there was optimum rainfall and temperatures supporting high grain yield. Planting done between 20th August and 20th September produced high grain yield compared to delaying of planting to October and beyond. November of every year ushers in the 'harmattan' season in Nigeria which lasts into the first two months of the following year. It is a period of dry and desiccating air. The temperatures are usually at the highest extreme with very little or no rainfall. These conditions probably explain why crop yield reduced progressively from 6th through 20th October to a 'provoked' lowest yield at 6th November planting compared to high yields of 20th August, 6th and 20th September planting, for all of the cultivars. This result is corroborated by reports of Azadbahkt *et al.* 2012; Casini (2012); Tsimba *et al.* 2013 that delayed planting beyond the planting window will result in serious reduction in yield. Similarly, delaying planting to 6th October and beyond would extend the critical period of ASI and grain-filling into the period of low moisture and high temperature of the harmattan. Such high temperatures and low humidity of the harmattan could excessive heat stress that cause desiccation of the silks, sterility and abortion of formed grains, resulting to poor grain-filling and a reduction in grain number per cob. This observation agrees with Hatfield and Pruege (2015); Schlenker and Roberts (2009) that extreme high temperatures with low moisture could produce detrimental effects on grain yield of all major grain crops. A recent review by Barlow *et al.* (2015) on the effect of temperature extremes, frost and heat in a sister crop, wheat (*Triticum aestivum* L.), clearly explains that excessive heat caused reduction in grain number and reduced duration of the grain-filling period. The effects were evident in an increasing rate of vegetative dryness which might have reduced the ability of the maize crop to efficiently fill the grain during the grain-filling period.

Harvest Index (HI)

Under favourable environmental conditions, harvest index (HI) acts as a scale of physiological productivity potential of crop. It is also used to determine the reproductive efficiency of the crop. Among the cultivars, the hybrid Oba 98 produced the maximum HI which was significantly higher than Oba Super 4, with the later in turn significantly out-yielded Bori Local. This could be attributed to varietal influence. Date of planting significantly influenced the HI such that the earlier the planting date the higher the HI as the plants were able utilize the environmental resources maximally for production whereas the longer the delaying of planting date beyond 20th September, the lower the HI values with 6th November producing the least value due to production under environmental stress.

Disease and Pests damage:

The level of incidence of insect pests on the maize crop (Table 7) was highest when planting was done on 6th November followed by 20th and 6th October planting while 6th September planting had the least damage followed by 20th August and 20th September. The high infestation could be a result of increased temperatures and little or no rainfall of the harmattan period (November to February) which may have triggered the rapid reproduction of insect pests. The insects caused characteristic perforations on stems and leaves destroying the stem tissues and reducing the photosynthetic area of the leaves, all resulting in poor maize yield. This result agrees with the reports of Petzoldt and Seaman, (2005); Bale *et al*, (2002); Reynolds and Ortiz, (2010); Legreve and Duveiller, (2010); Farrell and O'Keeffe, (2007) that insect pests prevail during high temperatures and moisture stress, destroy plants tissues, causing low yield of crops.

Conclusion

Time of planting any crop depends greatly on environmental factors, particularly temperature and humidity, which are key agents influencing plant growth, development and yield. In the present study using the late cropping season, optimum maize grain yield was attained from planting made before the temperature progressively increased to the highest and rainfall declined to the lowest for the zone, developments that ultimately ushers in the harmattan (a season of moisture and heat stress).

Maize grain yield was highest in late August to late September planting than when planting was delayed through early October to early November. Cultivar Oba 98 followed by Oba Super 4 topped Bori Local in grain yield. Similarly, Oba Super 4 followed by Oba 98 gave the highest stover (biomass) yield than Bori Local, making the former suitable as fodder for livestock. The best time based on this study recommended for planting late season maize for its economic and biomass yield is the month of September. The hybrid (Oba 98 and Oba Super 4) tolerated the short rainfall deficit and high temperature stress of the late season in the Niger Delta region to produce good yields. Any maize planting that projects the 'critical period of development' into the period of moisture and heat stress (the harmattan) is bound to experience tremendous yield loss.

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