Planting Season's Rainfall Trends and Droughts in the Forest Belt of Nigeria

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Abstract

The planting season for most food crops in the forest belt of Nigeria is mainly concentrated in the months of March and April. This paper, therefore, examined the planting season's rainfall trends and droughts using five synoptic weather stations (Benin, Ondo, Warri, Port Harcourt and Calabar) in the forest belt of Nigeria. The planting season's rainfall and rain-days covering between 1941 and 2012 were computed from the data for the months of March and April. The trends of the rainfall and rain-days were analyzed using simple linear regression, second order polynomial and correlation. The coefficient of variation was used to investigate rainfall and rain-days variability. Drought intensities in the planting season were computed as percentage deviation from the mean. The results, among others, revealed declining trends of the planting season's rainfall in Warri, Port Harcourt, and Calabar, with regression coefficients of -0.71, -1.94 and -0.31 respectively, while Ondo and Benin showed increasing trends with regression coefficients of 0.17 and 0.11respectively. Warri, Ondo, Port Harcourt and Calabar revealed decreasing trends of the planting season's rain-days with -0.07, -0.09, -0.12 and -0.05 regression coefficients respectively while only Benin showed increasing trends with regression coefficients of 0.02. Port Harcourt and Calabar witnessed the highest and lowest magnitudes of rainfall and rain-days variability. The planting season's drought intensities varied from slight to disastrous, but regardless of drought intensities, Port Harcourt was the worst hit while Ondo and Calabar were the least hit. The paper recommends irrigation during the planting season in the forest belt of Nigeria to reduce the incidences of poor germination and wilting. Drought tolerant crop varieties should be cultivated while rainfall prediction and extension services should be intensified to enable local farmers align planting of food crops with prevailing rainfall trends.

Keywords: Planting season, drought, rainfall, rain-days, coefficient of variation, forest belt

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Introduction

Climate constitutes a key component of the physical environment on which crops thrive. In the tropical environment where rain-fed agriculture is predominant, the onset and cessation of the rains dictate the cultural practices of farmers, such as land preparation, crop variety selection and planting to harvesting (Bello, 1989; Odekunle; Umar, 2010). Thus, the extent of vulnerability of crops to climatic variability depends essentially on the development phases of the crop at the period of weather abnormality (Fakorede, 2006).

The Inter-Tropical Discontinuity (ITD) provides a framework for following the south-north motions of the rain-producing southerly air whose depth and motion influence not only the rainfall rate but also the duration and spread of rain in Nigeria and the West African sub-region (Ilesanmi, 1971). The ITD is the zone of contact between southerlies and northerlies (Adefolalu, 2000; Olaniran, 2002). The mean position of the ITD oscillates between latitudes 6^0 and 8^0 of the Equator in April when most stations south of the aforementioned latitudes would have experienced their onset rainfalls (Adejuwon, 1991). Apart from the ITD, long-term rainfall variability in Nigeria is also influenced by the Tropical Easterly Jet (TEJ), the sea surface temperature anomaly (SSTA), the biogeophysical feedback mechanism and the El Nino Southern Oscillation (ENSO) (Adejuwon, 1991; Olaniran, 2002).

The import of rainfall to agriculture is particularly spectacular in the tropics due to the relatively high temperature all through the year with a persistently high rate of evaporation (Badnuka *et al*., 2015). Rainfall not only determines the length of the growing season of any location (Odekunle, 2004; Ayanlade *et al.*, 2009), but is also significant to planting, germination and the healthy growth of crops. Consequently, variations in crop yields have been linked with planting date (Ibrahim, 2010; Uzoma *et al*., 2010). There is a significant relationship between climatic variables (especially rainfall) and crop yield (Ayanlade *et al*., 2009; Akpenpuun and Busari, 2013; Badnuka *et al*., 2015). The availability of soil moisture during the planting season influences the root formation of crops and consequently the yield level. For instance, climate change and variability especially increasing irregularity in the onset, cessation and length of the rains and prevalence of dry spells in the early growth phases of yam have resulted in low output in many yam producing areas in Nigeria (Eruola *et al*., 2012). These variations in rainfall influence food crops such as tubers, grains, legumes and vegetables (Oluwasegun and Olaniran, 2010) which, in addition to tree crops, flourish in the forest belt of Nigeria. This underscores the importance of rainfall as a source of soil moisture to the overall performance of crops, especially under rain-fed system which is predominant in the forest belt of Nigeria. Moisture adequacy at the early phase of root crops is crucial to their overall yields.

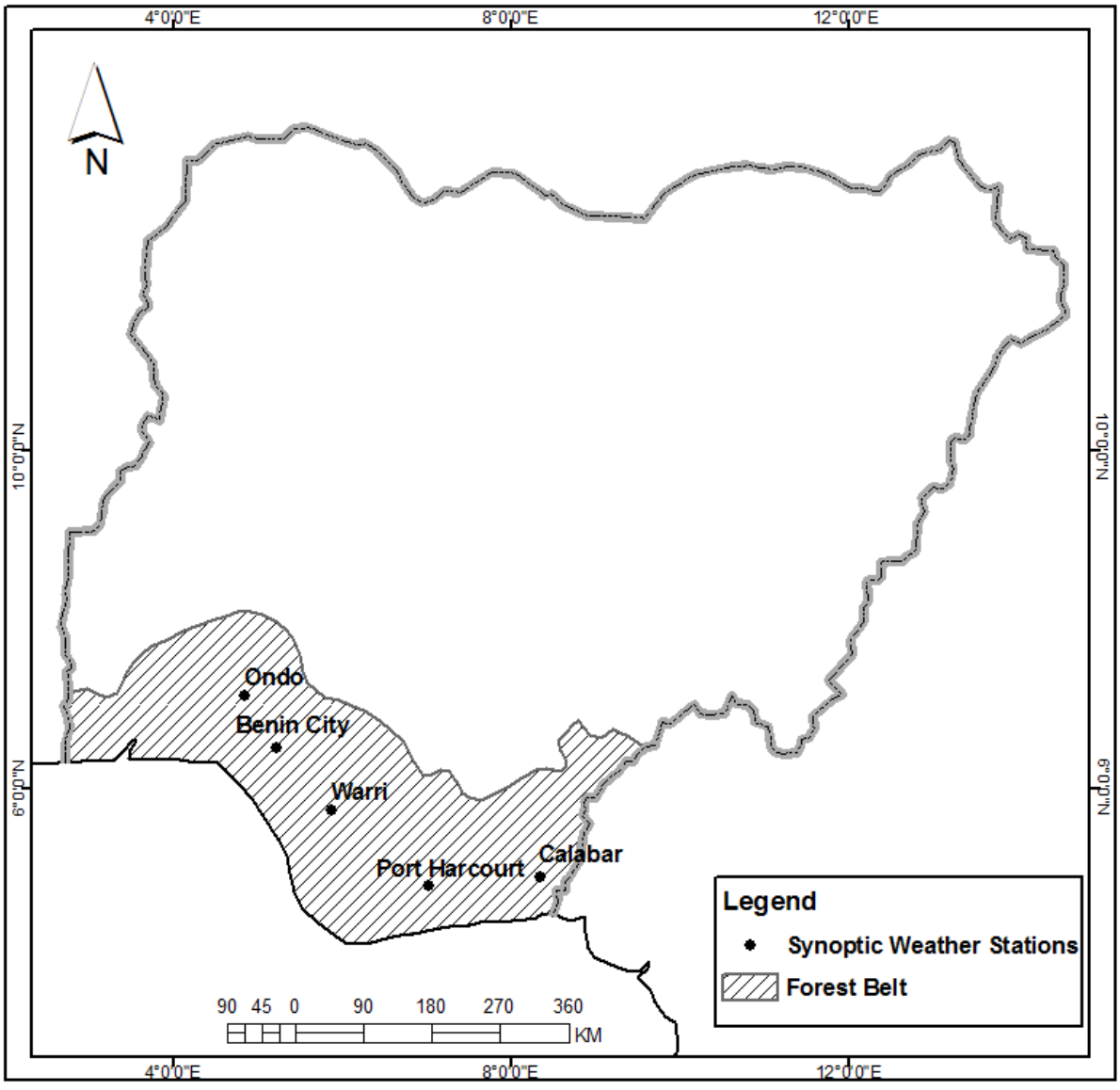
Previous studies have examined the growing season's rainfall (Odekunle, 2004; Umar, 2010) and drought with a focus on the semi-arid belt of Nigeria (Oladipo, 1991; Ati *et al*., 2010; Atedhor and Odjugo; 2012; Atedhor, 2014), while rainfall trends and drought in the planting season, which coincide with the planting and germination phase of crop production, remain uninvestigated. This paper, therefore, seeks to complement the existing studies by investigating the trends of the planting season's rainfall and rain-days and drought in the forest belt of Nigeria. The remaining sections of the paper cover a brief description of the forest belt of Nigeria, materials and methods employed in the study, the presentation of the results and discussion and finally the conclusions and recommendations.

Materials and Methods

Study Area

The study area covers the forest belt of Nigeria which is characterized by dense and heterogeneous vegetation. It falls within the Köppen's[i] Af climatic classification type. It is characterized by wet and dry seasons. The wet season lasts from March to October. Rainfall is usually up to 2000 mm per annum, with an annual average temperature of about 27 ^{0}C. Agriculture remains the main livelihood and it is predominantly rain-fed.

Figure 1: Location of the Study Area and Synoptic Weather Stations



Rainfall data comprising rainfall amount and rain-days for the months of March and April, which mark the planting season for most food crops in the forest belt of Nigeria, were collected from the archive of the Nigeria Meteorological Agency, Lagos. The data which range between 1941 and 2012 covered five synoptic weather stations as shown in Figure 1. The synoptic weather stations were selected on the basis of spread and continuous availability of rainfall and rain-days data.

Under rain-fed situations, increased unpredictability and abnormality in rainfall are key grounds for crop failure (ACPC, 2011). This variability and irregularity are particularly associated with the onset and cessation of the rainy season which, according to Odekunle (2004) and Umar (2010), marks the growing season. The planting season for most food crops in the forest belt of Nigeria mainly occur in March and April. This period refers to the early part of the growing season when rainfall is adequate to sustain the planting, germination and healthy growth of crops in their early stage. The planting season's rainfall and rain-days for the selected stations were computed from the March and April data. Simple linear regression, correlation, and second order polynomial were used to investigate the trends of the planting season's rainfall and rain-days. The mean March, April and planting season's rainfall were computed for each of the synoptic stations. The annual variability in the rainfall and rain-days for each of the synoptic stations in the months of March and April and for the entire planting season were analyzed using the coefficients of variation. Drought is a climatic variance measured by the deviation of actual rainfall from the amount essential for the usual function of the established economy of a region (Oladipo, 1991). The intensities of droughts in each of the selected stations in the planting season were computed as percentage deviation from the mean and classified based on Ayoade (1988; 2008).

Results and Discussion

The trends of the planting season's rainfall and rain-days in the selected synoptic stations are presented in Figures 1a-5a and 1b-5b respectively. The planting season's rainfall and rain-days exhibited inter-annual fluctuations in all the selected stations. The regression lines reveal declining planting season's rainfall and rain-days in Warri during the 1941-2012 period with slight curvilinear features. The planting season's rainfall and rain-days in Ondo reveal opposite trends with rainfall, having an upward trend while rain-days showed a downward trend during the 1941-2012 and 1961-2012 periods respectively. The second order polynomial line for rainfall in Ondo depicts an increasing trend from 1941 and stabilized around 1968 and 1992 before declining thereafter, while that of rain-days revealed an initial declining trend followed by a recovering tendency. The planting season's rainfall and rain-days for Port Harcourt experienced declining trends during the 1941-2012 and 1948-2012 periods respectively. The second order polynomial of rainfall and rain-days in Port Harcourt also portray a declining trend, but with slight tendencies toward recovery. In Benin, the planting season's rainfall and rain-days witnessed increasing trends during the 1941-2012 and 1961-2012 periods respectively, with the second order polynomial of the trends of the parameters showing a recovering tendency, but with that of rainfall being more pronounced. As in Port Harcourt, both the planting season's rainfall and rain-days in Calabar experienced declining trends during the period 1941-2012 with slight recovering tendencies. Overall, while the planting season's rainfall reveals declining trends in Warri, Port Harcourt and Calabar with regression coefficients of -0.71, -1.94 and -0.31 respectively, Ondo and Benin witnessed increasing trends with regression coefficients of 0.17 and 0.11 respectively. With the exception of Benin with an increasing trend of planting season rain-days depicted with regression coefficient of 0.02, Warri, Ondo, Port Harcourt and Calabar witnessed declining trends with regression coefficients of -0.07, -0.09, -0.12 and -0.05 respectively. The declining trends of the planting season's rainfall and rain-days in most stations in the forest belt of Nigeria corroborate Olaniran (2002), which reported a progressively delayed onset of the rains in southern Nigeria, which makes the area increasingly susceptible to crop failure. As in other parts of the tropics, rainfall is significant due to comparatively high temperatures all through the year and the resultant high evaporation and evapotranspiration, especially when rainfall is low (Ojo, 1991).

Moisture is particularly required during the planting season since it coincides with the phase of cultivation and germination of crops on the agricultural calendar. Apart from the fact that March and April precede the heavy rains (Ojo, 1977); the declining trends of rainfall across the forest belt of Nigeria during the planting season could be adverse to the germination, establishment and the healthy growth of crops, especially in the absence of irrigation.

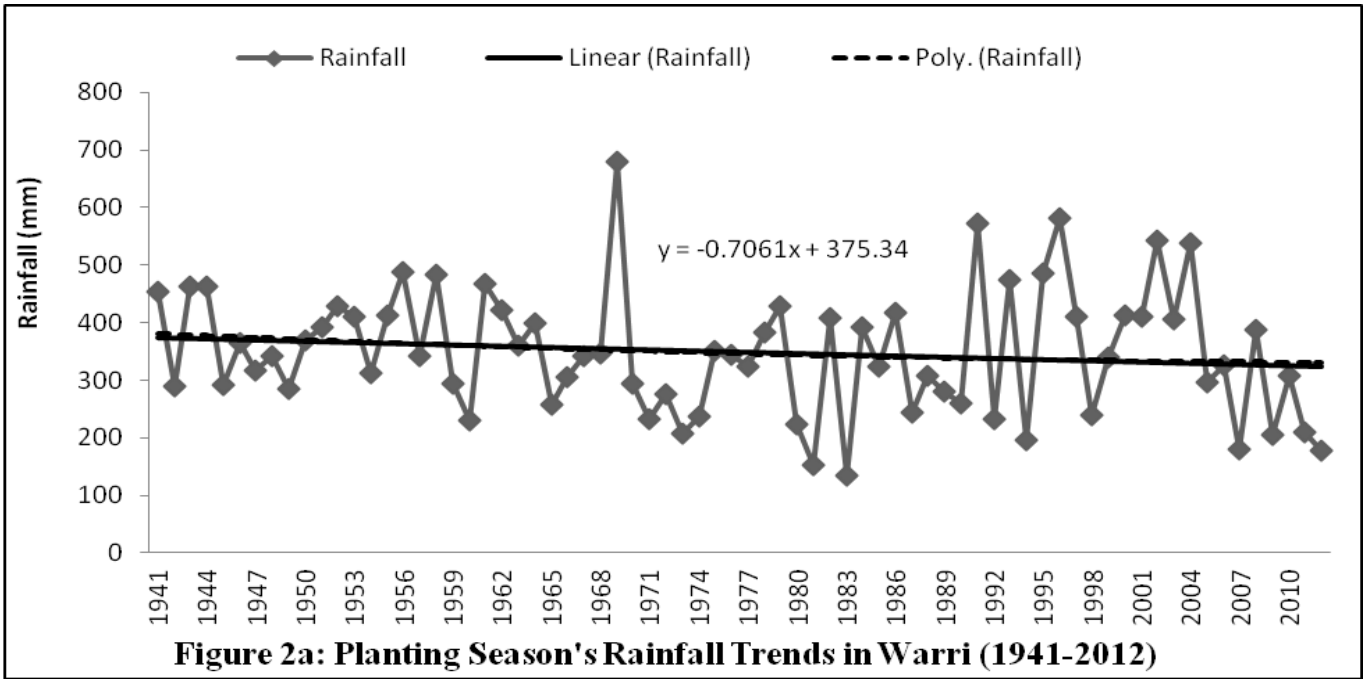


Figure 2a: Planting Season's Rainfall Trends in Warri (1941-2012)

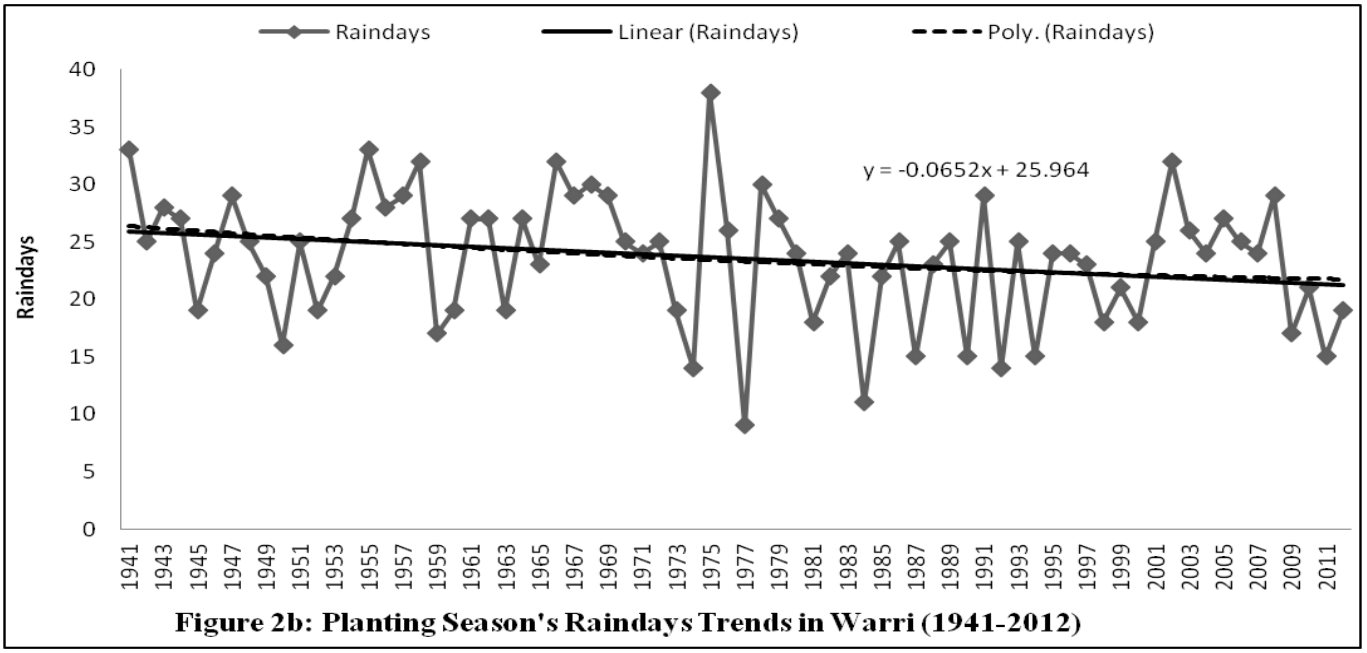


Figure 2b: Planting Season's Raindays Trends in Warri (1941-2012)

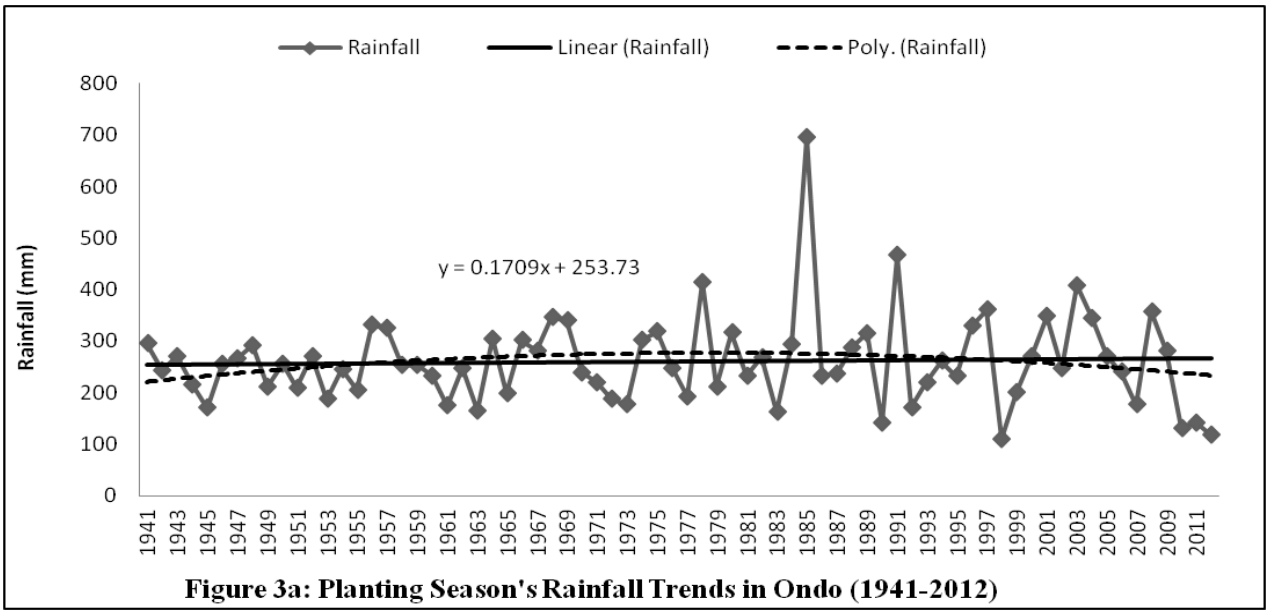


Figure 3a: Planting Season's Rainfall Trends in Ondo (1941-2012)

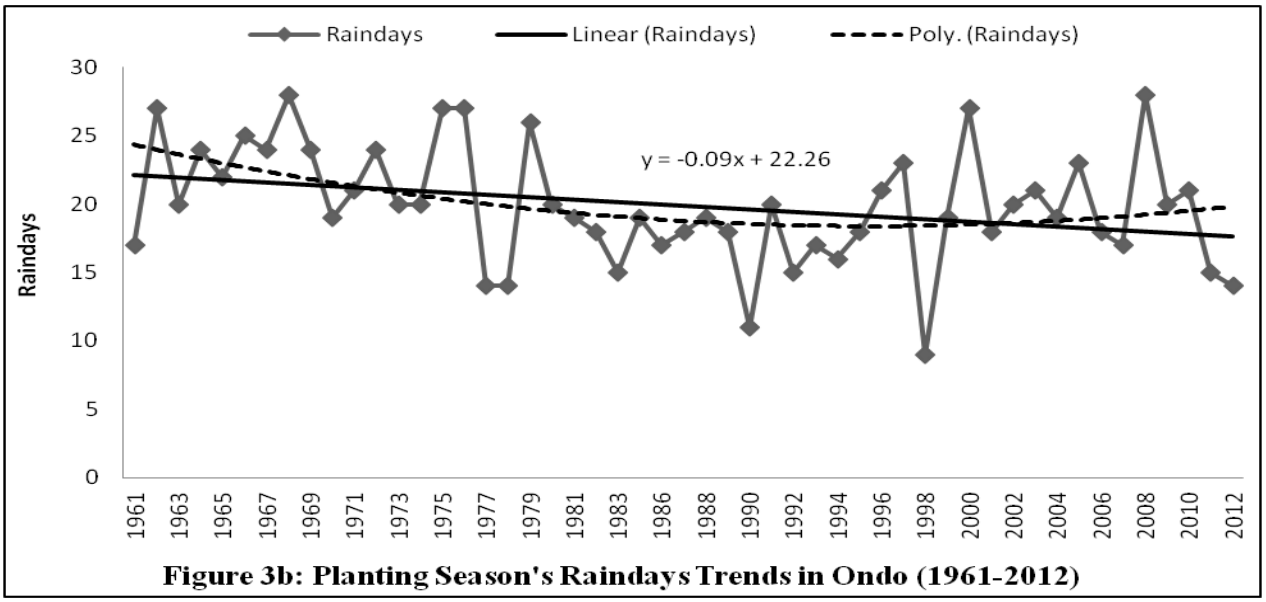


Figure 3b: Planting Season's Raindays Trends in Ondo (1961-2012)

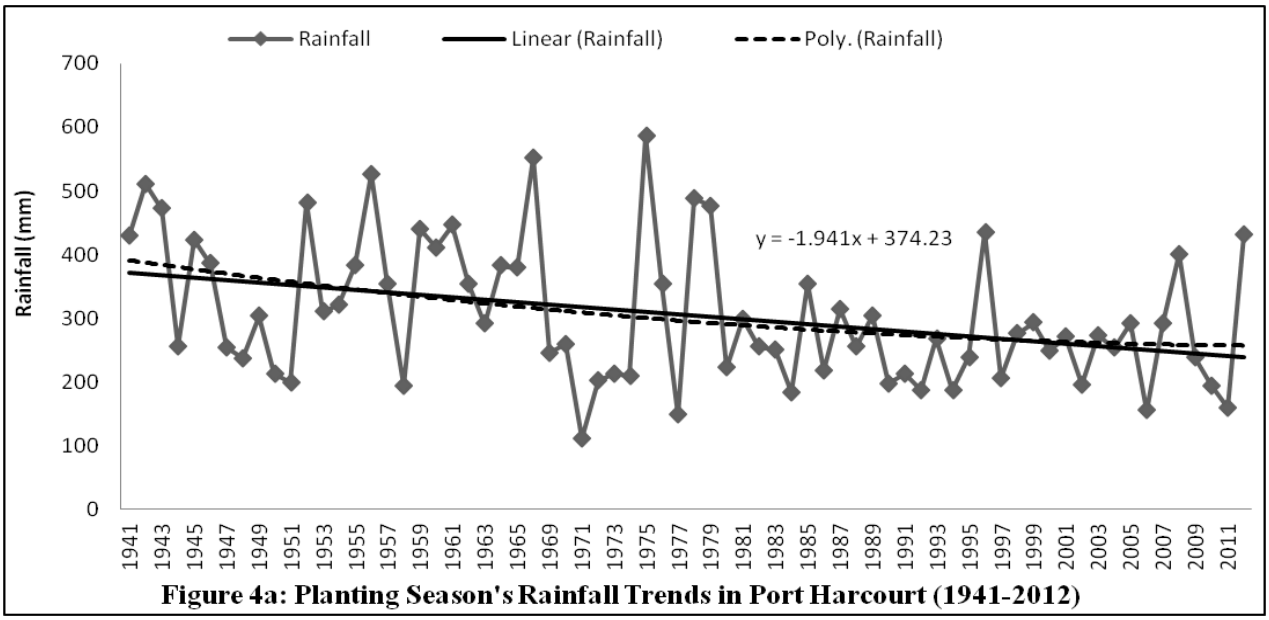


Figure 4a: Planting Season's Rainfall Trends in Port Harcourt (1941-2012)

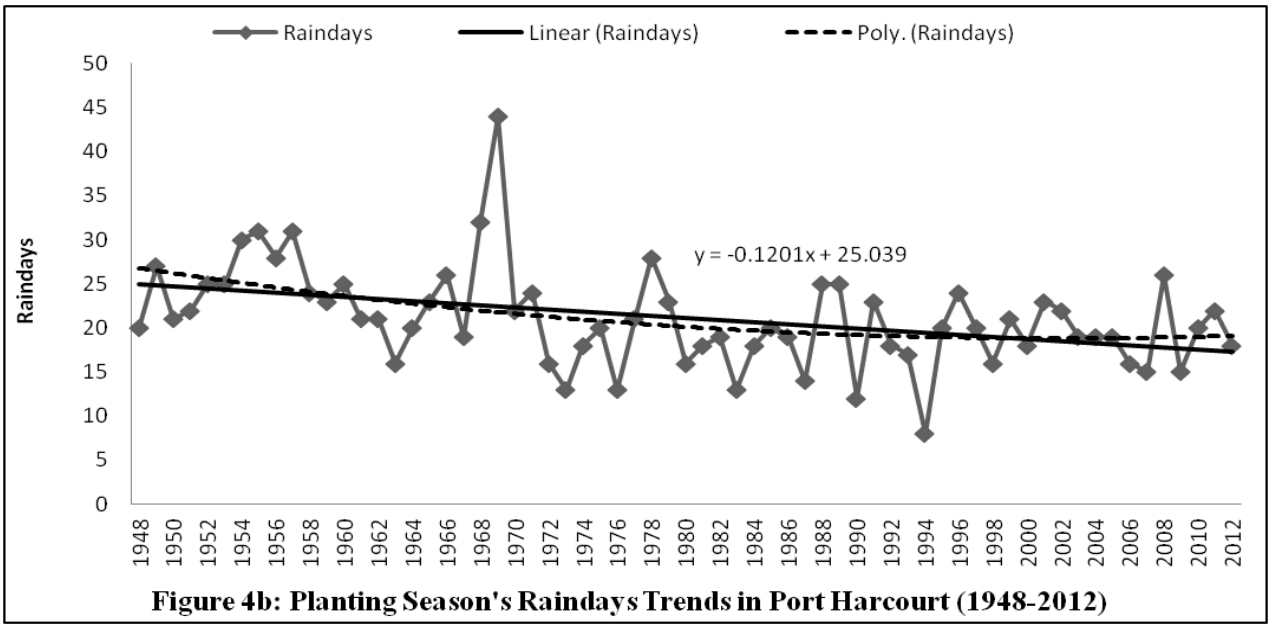


Figure 4b: Planting Season's Raindays Trends in Port Harcourt (1948-2012)

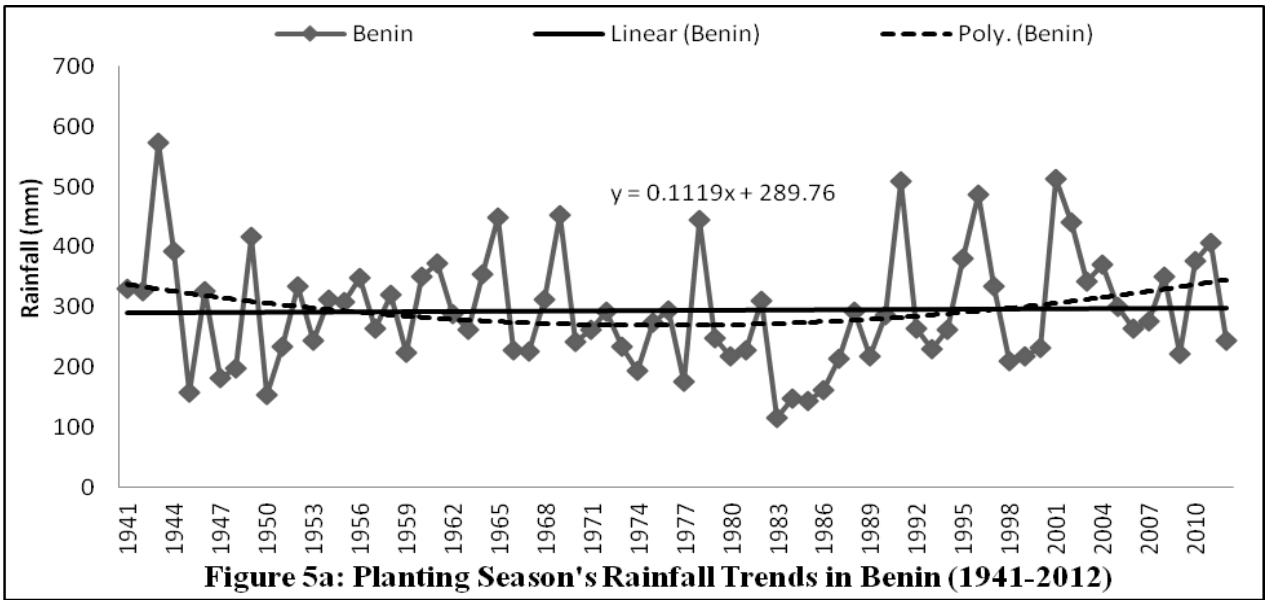


Figure 5a: Planting Season's Rainfall Trends in Benin (1941-2012)

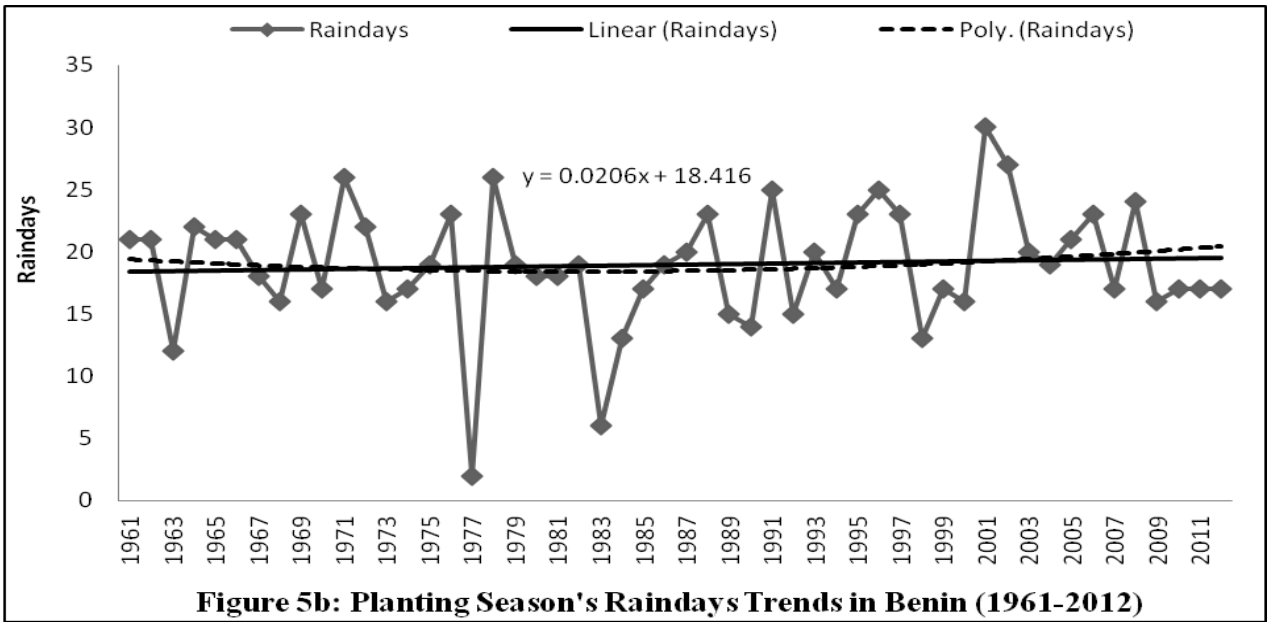


Figure 5b: Planting Season's Raindays Trends in Benin (1961-2012)

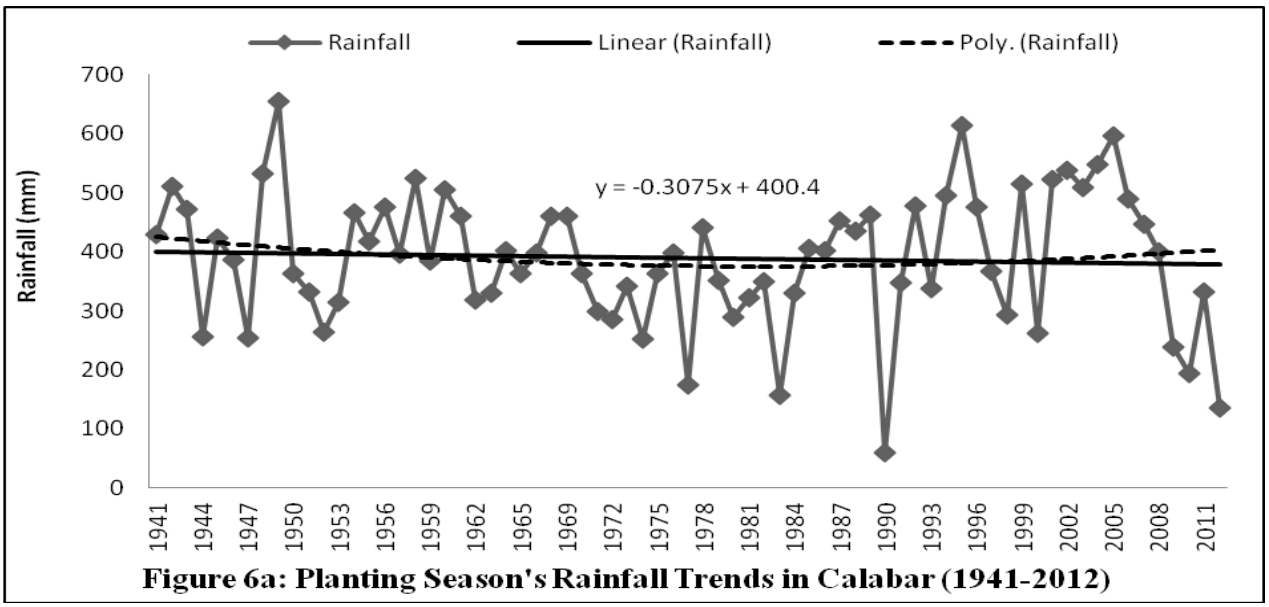


Figure 6a: Planting Season's Rainfall Trends in Calabar (1941-2012)

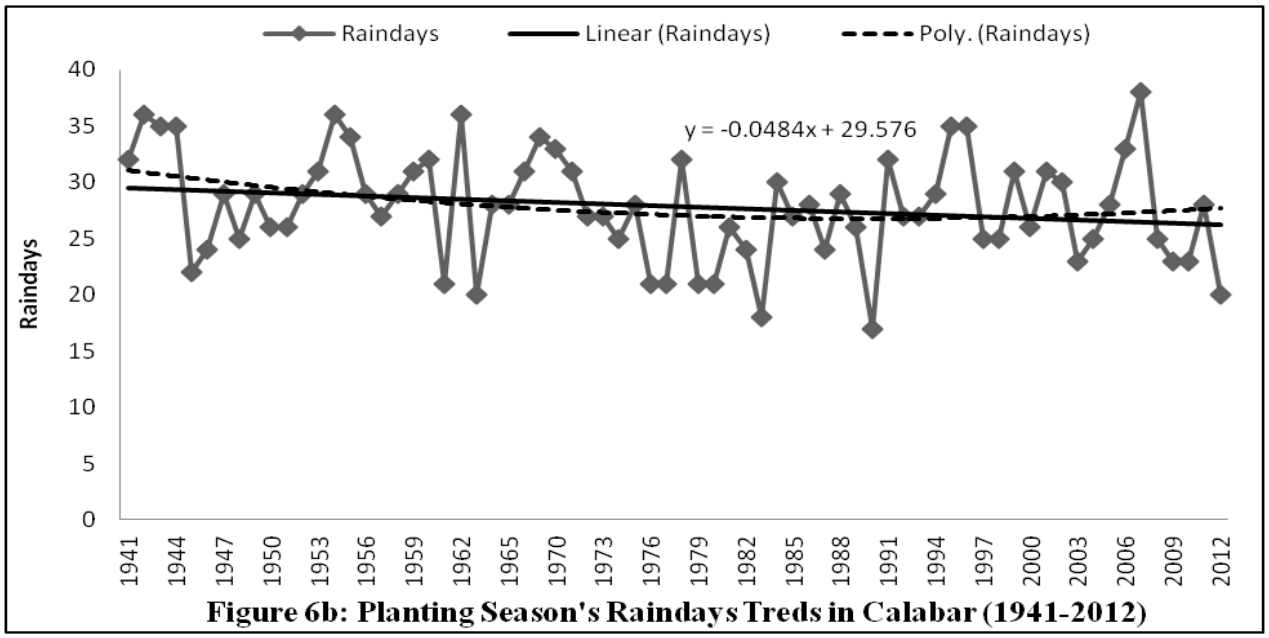


Figure 6b: Planting Season's Raindays Treds in Calabar (1941-2012)

Table 1 shows the mean rainfall and rain-days for March, April and the planting season. While Calabar appeared to be most wet in March, April and the planting season with mean rainfall of 160 mm, 229 mm and 389 mm respectively, Ondo emerged to be driest with mean rainfall of 106 mm, 154 mm and 260 mm in March, April and planting season. Similarly, Calabar witnessed more rain-days in the March, April and the planting season with mean values of 12, 16 and 28 respectively. However, Benin experienced low rain-days with mean values of 8, 11 and 19 in March, April and the planting season respectively.

Table 1: Mean Rainfall (mm) and Rain-days in March, April and Planting Season in the Forest Belt of Nigeria

Parameter	Warri	Ondo	Port Harcourt	Benin	Calabar
Rainfall (March)	133	106	133	115	160
Rainfall (April)	217	154	173	179	229
Rainfall (Planting season)	350	260	305	294	389
Rain-days (March)	10	9	9	8	12
Rain-day (April)	14	11	12	11	16
Rain-days (Planting season)	24	20	21	19	28

Table 2 reveals the coefficients of variation of rainfall and rain-days in March, April and the planting season for the selected synoptic stations. While the variability of rainfall appeared to be high in Port Harcourt (55.31%), Benin (55.22%) and Warri (51.52%) in March, Ondo witnessed the lowest variability. In April and the planting season, Port Harcourt witnessed the highest rainfall variability at 45.63% and 35.87% respectively while Calabar experienced the lowest variability at 35.79% and 29.45% respectively. The variability of rain-days was highest in Benin in March and April at 40.74% and 26.95% respectively. Port Harcourt experienced the highest planting season's variability of rain-days while Calabar appeared to have experienced the least variability in March, April and the planting season. According to Umar (2010), high rainfall variability means a high chance of crop failures in affected areas. Therefore, the implication of the high coefficients of variation is that Port Harcourt, in March, April and the planting season, is at the risk of poor crop germination and growth in their tender stages while Ondo in March and Calabar in April and the planting season are the least vulnerable. The relatively high rainfall variability in Benin in March (55.22%) and April (45.50%) is further complicated by a high rain-days variability at 40.74% and 26.95% respectively since the high rain-days values imply poor distribution. The same inference goes for Port Harcourt in the planting season with the highest rain-days variability of 26.76%. Odekunle (2011) has reported the highest degree of change of maximum temperature in the forest ecological zone of Nigeria at the rate of 0.52 ^{0}C between the period of climatological normal (1960-1990) and post climatological normal (1991-2007). Consequently, the susceptibility of crops to high variability of the planting season's rainfall and rain-days in the affected synoptic stations is further complicated by increasing air temperatures which can effectively deplete soil moisture through the combined effects of increasing evaporation and evapo-transpiration.

Table 2: Coefficients of Variation (%) of Rainfall in March, April and Planting Season in the Forest Belt of Nigeria

Parameter	Warri	Ondo	Port Harcourt	Benin	Calabar
Rainfall (March)	51.52	31.77	55.31	55.22	47.73
Rainfall (April)	37.27	43.46	45.63	45.50	35.79
Rainfall (Planting season)	31.17	33.81	35.87	32.67	29.45
Rain-days (March)	34.44	36.79	38.65	40.74	30.61
Rain-day (April)	26.52	22.31	25.81	26.95	16.31
Rain-days (Planting season)	23.88	21.79	26.76	25.90	17.16

The correlation coefficients of the trends in the March, April and planting season's rainfall and rain-days of the selected stations are presented in Table 3. Rainfall in Warri, Port Harcourt, and Benin witnessed insignificant downward trends while Ondo and Calabar witnessed insignificant upward trends in the month of March. Warri, Ondo, Port Harcourt and Calabar experienced downward trends, with only that of Port Harcourt being significant, while Benin witnessed an insignificant upward trend in the month of April. The trends of the planting season's rainfall were downward in Warri, Port Harcourt and Calabar, with only that of Port Harcourt being significant, while Ondo and Benin witnessed insignificant upward trends. Rain-days witnessed downward trends in all the selected stations in March, with only those of Ondo and Benin not having statistical significance. With the exception of Benin, rain-days trends in Warri, Ondo, Port Harcourt and Calabar witnessed downward trends, with only that of Warri not revealing statistical significance, while Benin witnessed upward but statistically insignificant trends in the month of April. Rain-days for the planting season witnessed statistically significant downward trends in Warri, Ondo, Port Harcourt and Calabar while Benin experienced upward but statistically insignificant trend.

Table 3: Correlations Values of the Trends in the Rainfall and Rain-Days in the Rainforest Belt of Nigeria

Parameter	Warri	Ondo	Port Harcourt	Benin	Calabar
Rainfall (March)	-0.04	0.11	-0.237	-0.156	0.017
Rainfall (April)	-0.149	-0.027	-.288*	0.151	-0.096
Rainfall (Planting season)	-0.136	0.041	-.389*	0.024	-0.058
Rain-days (March)	-.210*	-0.112	-.345*	-0.036	-.253*
Rain-day (April)	-0.179	-.394*	-.328*	0.142	-0.033
Rain-days (Planting season)	-.243*	-.310*	-.403*	0.064	-.209*

* Correlation is significant at 0.05 level (1-tailed).

The computed planting season's drought intensities for the selected synoptic stations are presented in Table 4. Overall, the drought intensities in the selected stations varied from slight to disastrous. The highest frequencies of droughts of slight intensity were recorded in Port Harcourt and Benin City while the least occurrence occurred in Ondo. Droughts of moderate intensity occurred most in Port Harcourt but least in Calabar. Droughts of severe intensity were most frequent in Ondo but also least in Calabar, while disastrous drought intensities occurred most in Calabar with no incidence in Ondo. Overall, regardless of intensities, Port Harcourt experienced the highest incidences of drought while Ondo and Calabar witnessed the lowest incidences of drought.

Since the period between the onset and cessation of the rains marks the length of the growing season (Umar, 2010), the declining trends of planting season rainfall and rain-days in Warri, Port Harcourt and Calabar as depicted by their respective negative regression coefficients could have negative implications for crop production. It is reiterated that the onset of the rains coincides with the period of land preparation, planting and germination in the agricultural calendar, particularly under rain-fed agricultural practice. The resultant moisture deficiency arising from the declining trends of rainfall could be exacerbated by the high temperatures which are usually associated with the onset of the wet season. Unfortunately, the already harsh cropping environment due to declining rainfall and rain-days trends, coupled with high evapo-transpiration resulting mainly from high temperatures, is further complicated with the frequent drought incidences which characterize the planting season in the forest belt of Nigeria. This hydrothermal scenario, as Makinde *et al.* (2010) observed, has negative effects on crop yield. A delayed onset of the rains (planting season), coupled with an early season, could induce accelerated maturation of crops. For instance, Akeh *et al* (2006) have reported a decrease in the yield of yam in Benin since its yield is related to the length of the growing season.

Table 4: Planting Season's Drought Intensities in the Forest Belt of Nigeria

Year	Warri	Classification	Port Harcourt	Classification	Ondo	Classification	Benin	Classification	Calabar	Classification
1942	17.32	Slight								
1944			16.12	Slight	17.26	Slight			34.22	Moderate
1945	16.58	Slight			34.53	Moderate	46.44	Severe		
1947			16.81	Slight			38.00	Moderate	34.76	Moderate
1948			22.54	Slight			32.86	Moderate		
1949	18.24	Slight			18.80	Slight				
1950			30.27	Moderate			47.46	Severe		
1951			34.69	Moderate	19.38	Slight	20.74	Slight	14.47	Slight
1952									32.35	Moderate
1953					28.11	Moderate	17.27	Slight	18.96	Slight
1955					21.26	Slight				
1958			36.63	Moderate						
1959	15.92	Slight					23.60	Slight		
1960	34.26	Moderate								
1961					32.88	Moderate				
1962									18.19	Slight
1963									15.11	Slight
1965	26.54	Moderate			23.41	Slight				
1966	12.32	Slight					22.72	Slight		
1967							23.43	Slight		
1969			19.69	Slight						
1970	16.07	Slight	14.91	Slight			17.71	Slight		
1971	33.80	Moderate	63.42	Disastrous	15.26	Slight			22.97	Slight
1972	21.16	Slight	33.87	Moderate	27.99	Moderate			26.54	Moderate
1973	40.75	Moderate	30.11	Moderate	31.99	Moderate	20.20	Slight	12.31	Slight
1974	32.09	Moderate	31.29	Moderate			33.88	Moderate	34.97	Moderate
1977			51.43	Severe	26.07	Moderate	40.34	Moderate	55.08	Severe
1979					18.80	Slight	15.57	Slight		
1980	36.06	Moderate	27.06	Moderate			25.74	Moderate	25.64	Moderate
1981	56.63	Severe					22.34	Slight	17.17	Slight
1982			16.42	Slight						
1983	61.64	Disastrous	17.92	Slight	37.72	Moderate	60.59	Disastrous	59.57	Severe

Table 4 Contd.

1988	12.15	Slight	16.42	Slight						
1989	19.87	Slight					25.78	Moderate		
1990	25.48	Moderate	35.38	Moderate	45.80	Severe			84.85	Disastrous
1991			30.40	Moderate						
1992	33.20	Moderate	38.53	Moderate	33.99	Moderate				
1993	35.91	Moderate	12.10	Slight	15.45	Slight	21.59	Slight	12.95	Slight
1994	43.61	Moderate	38.69	Moderate			11.11	Slight		
1995			21.92	Slight						
1997			32.50	Moderate						
1998	31.26	Moderate			58.03	Severe	28.74	Moderate	24.72	Slight
1999					22.61	Slight	25.85	Moderate		
2000			18.32	Slight			21.46	Slight	32.63	Moderate
2001			11.28	Slight						
2002			35.87	Moderate						
2004			16.98	Slight						
2005	15.52	Slight								
2006			49.10	Severe						
2007	48.25	Severe			32.11	Moderate				
2008	11.17	Slight								
2009	41.33	Moderate	22.05	Slight			24.59	Slight	38.87	Moderate
2010	11.77	Slight	36.46	Moderate	49.42	Severe			50.17	Severe
2011	39.92	Moderate	47.56	Severe	45.53	Severe			14.83	Slight
2012	49.34	Severe			54.88	Severe	17.27	Slight	65.09	Disastrous

Conclusion

The paper examined trends of the planting season's rainfall and rain-days and droughts in five selected synoptic weather stations in the forest belt of Nigeria using monthly data of rainfall (1941-2012) and rain-days which vary between 1941 and 2012. The results revealed declining trends of the planting season's rainfall in Warri, Port Harcourt, and Calabar, while Ondo and Benin showed increasing trends. Warri, Ondo, Port Harcourt and Calabar revealed decreasing trends of the planting season's rain-days, while only Benin showed increasing trends. The paper also revealed that the planting season has been plagued with droughts which varied from slight to disastrous intensities. The study showed that Port Harcourt and Calabar witnessed the highest and lowest magnitudes of planting season rainfall and rain-days variability. Regardless of intensities, Port Harcourt was worst hit, while Ondo and Calabar were the least affected by droughts in the planting season. The paper recommends irrigation during the planting season in the forest belt of Nigeria to reduce the incidences of poor germination and wilting. Drought tolerant crop varieties should be cultivated while rainfall prediction and extension services should be intensified to enable local farmers align planting of food crops with prevailing rainfall trends.

Acknowledgment

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[i] Based on Köppen's climatic classification scheme, Af represents the tropical rainforest climate which characteristically has mean temperature above 18 ^{0}C in the coldest month, no month without rainfall and annual rainfall in excess of the annual evapo-transpiration (Ayoade, 1993).