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Full Length Research Paper

Rainfall instability difference in the effects of planting dates on growth and yield of maize *(Zea Mays)* in forest savannah eco-climatic zone of Nigeria

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Rainfall instability difference in the effects of planting dates on growth and yield of maize in forest savanna eco climatic zone of Nigeria was investigated in this study to assess the reliability of the rain vis-à-vis optimum planting date for effective growth and good yield of the crop. Three planting date at 2 weeks interval between 13th march and 10th April were adopted for the experiment conducted at the research farm of the Federal College of Agriculture, Ibadan during 2004 through 2006 planting season using completely randomized design. The results of the analysis showed that planting dates have significant effects on the growth and yield parameters of maize ($P < 0.01$). In the same vain, there were significant effects due to all other sources of variation (year and weeks after planting) as well as their interaction. Irrespective of the significance of these planting dates there were similarities between the multivariate correlations of the growth parameters for the different planting dates. Highest variation was recorded for the early planting date (13th March) while the least was recorded for the latest planting date (10th April).

Key words: Planting dates (PD), Weather Parameter Pattern (WPP), Rainfall Instability Difference (RID).

INTRODUCTION

Long term fluctuations in weather parameters round the world have been linked to the effects of global warming, (Stott, 2004; Ayoade, 2002). Consequently, all farming activities (such as planting, weeding, harvesting, e.t.c) depend on these weather parameters which were greatly dominated by these instabilities. Instability can be defined as lack of determination of fixedness, that is the quality of being fixed in a place as by some firm attachment, (Fischer et al., 2002). Fixedness referred to object/phenomenon that is not subjected to change or variation, (Stott, 2004). Weather and climate act both as a resource and constraints to agricultural production and need to be studied to alleviate the consequences of the global warming. Crop adapt to diverse environment through considerable plasticity of phenology (that is time from sowing to maturity) and morphology (growth habit), the main determinants of which is rainfall (Udungwu and Summerfield, 1985). One of the ways of manipulating the climatic factor is the adequate knowledge of optimal planting dates so as to accurately synchronize rainfall incidences with agricultural calendar of crops. Rainfall records monitored by the meteorological unit of the Institute of Agricultural Research and Training Ibadan, Nigeria, showed that rainfall pattern in the forest savannah eco-climatic (rainforest region in the last 15years but due to human activities have been turned to secondary regrowth having some characteristics of savanna region) region have been characterized by instability. This instability is expected to have impact on the growth and yield pattern of agricultural crops most of which are rainfall dependent. Most of these crops are

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usually planted when rainfall has established (that is when rainfall is in excess of 51mm, the effective rainfall).

Effective rainfall is defined as the fraction of the total amount of rainwater useful for meeting the water need of the crops, (Walter, 1967). Instability difference can be defined as the differences between the variances, σ^2 of different related data. The data sets might be of the same type but the difference might be periods, (Tofani et al., 2008). Rainfall instability difference on the other hand, can be defined as the variability differences in the rainfall pattern of the different growth and development period of the different planting date, (Qiaoyan, 2007). That is let μ_i {i = planting date – 1st, 2nd and 3rd planting date} be the rainfall variability difference of the different planting dates, this study hypothesized that μ_i are equal (that is there is significant difference in the effects of these rainfall variabilities).

Maize (Zea *Mays*) is mainly cultivated in the rainforest and derived savannah zones of Nigeria. Maize has been in the diet of Nigerians for centuries and is also a versatile crop on which many agro-based industries depend as raw materials. Many studies have examined the effects of water deficit as well as some other agro-meteorological indices on the growth and yield of maize. Gidney, (1989) discovered that increase in air-temperature combined with decrease rainfall lowered the grain yield of maize. Although the increase in water use efficiency associated with carbon dioxide concentration ameliorated the response in a green-house experiment. Oguntoyinbo (1987) however discovered that the optimum temperature for germination of maize is18 – 21°C. At 60 days after planting and before pollination temperature range (Igbekele, 1975) is required with 100 - 125mm of rainfall, (Gidney, 1989).

One of the factors affecting maize production in southwestern Nigeria is wrong timing of the planting regime due to rainfall variability as a result of global warming effects. Early maize planting in the forest-savannah eco-climatic zone is March to April, (Ugochukwu et al., 2000). The successive crop production depends not only on the total, seasonal and annual rainfall but also on proper distribution of rainfall, (Igbekele, 1975). Bauder (2003) reported that 2 - 5% drops in grain yield of maize was noticed when planting date is moved 12 days before and after the optimum planting date. The first attempt at agricultural research in Nigeria was made in 1899 and a lot of work has since been carried out on the breeding of the crop. However, not enough work has been done on the optimum planting date vis-avis obtaining optimum yield of maize. The need to carry out this type of study becomes imperative in order to optimize maize growth and yield through appropriate planting date. This would reduce occasional scarcity of grain market in Nigeria in recent times. In the light of the above, the main objective of the study was thus to investigate the instability difference(s) in the effect of variations in planting dates on the growth and yield of maize in forest-savannah eco-climatic zone of Nigeria.

MATERIALS AND METHODS

This research was conducted at the research farm of the Federal College of Agriculture, (7°16′N: 3°24′E) Ibadan, Nigeria. The soil of the experimental site was wet, well- drained tropical ferruginous soil classified as sandy- loam with pH of 5.79. The land was ploughed twice and harrowed once during 2004, 2005 and 2006 planting season. The experimental design was completely randomized design replicated thrice. Recommended maize planting space of $75cm \times 50cm$ was adopted on a $6m \times 5m$ plot. Three planting dates were selected at two weeks interval between the onsets of rainfall (13th march) to 10th April according to Walter (1967). Three seed per hole were planted and was later thinned to 2 plants per hole one week after planting. Weeding was done manually with hoe at two weeks after planting and subsequently at two weeks interval. No insect infestation was noticed throughout the growing period.

Two types of data, (growth as well as yield data and climatic data) were collected for this study. The growth and yield data collected includes, plant height, number of leaves, leaf area and yield per hectare, while the climatic data includes rainfall, relative humidity and air – temperature. The plant height was determined using ruler and tape rule, stem girth using vernier caliper and leaf area using the following relationship,

Leaf area = $x \times y \times 0.75$, (Sexena and Singh, 1965).

(Where x = leaf length and y = maximum width of the leaf)

The climatic data were obtained from the meteorological station of the Institute of Agricultural Research and Training, Ibadan which is adjacent to the experimental site. The crop – growth data were collected weekly starting from one week after planting and subsequently at weekly interval. The data sets were first subjected to descriptive statistics as well as analysis of variance irrespective of the year. Mean separation of the different treatment using Duncan Multiple Range Test (*DMRT*) was equally computed. Correlation analyses as well as Variance-covariance matrix which showed the variability of the data for each date and of any two plant's parameters in combination were computed for all the year. Zero covariance implies that the corresponding components are independently distributed, (Hogg and Craig, 1970). Also rainfall intensity was computed using $RI = \sum R / N$ (where RI = rainfall intensity and N = number of days, 90 days). Lastly the regression model of the weather parameters on the basis of the planting dates were estimated and plotted. The regression models hypothesized a dependent relationship between some of the weather parameters and the different planting date. That is,

$$y = f(x_i, i = 1,\ 2,\ and\ 3).$$

Where y is the different weather parameters. and x = the ordinal (1st, 2nd and 3rd) planting date. The statistical packages used for these analyses are SAS and SYSTAT.

RESULTS

The results of the preliminary soil survey as shown in Table 1 indicated that the experimental sites were sufficient

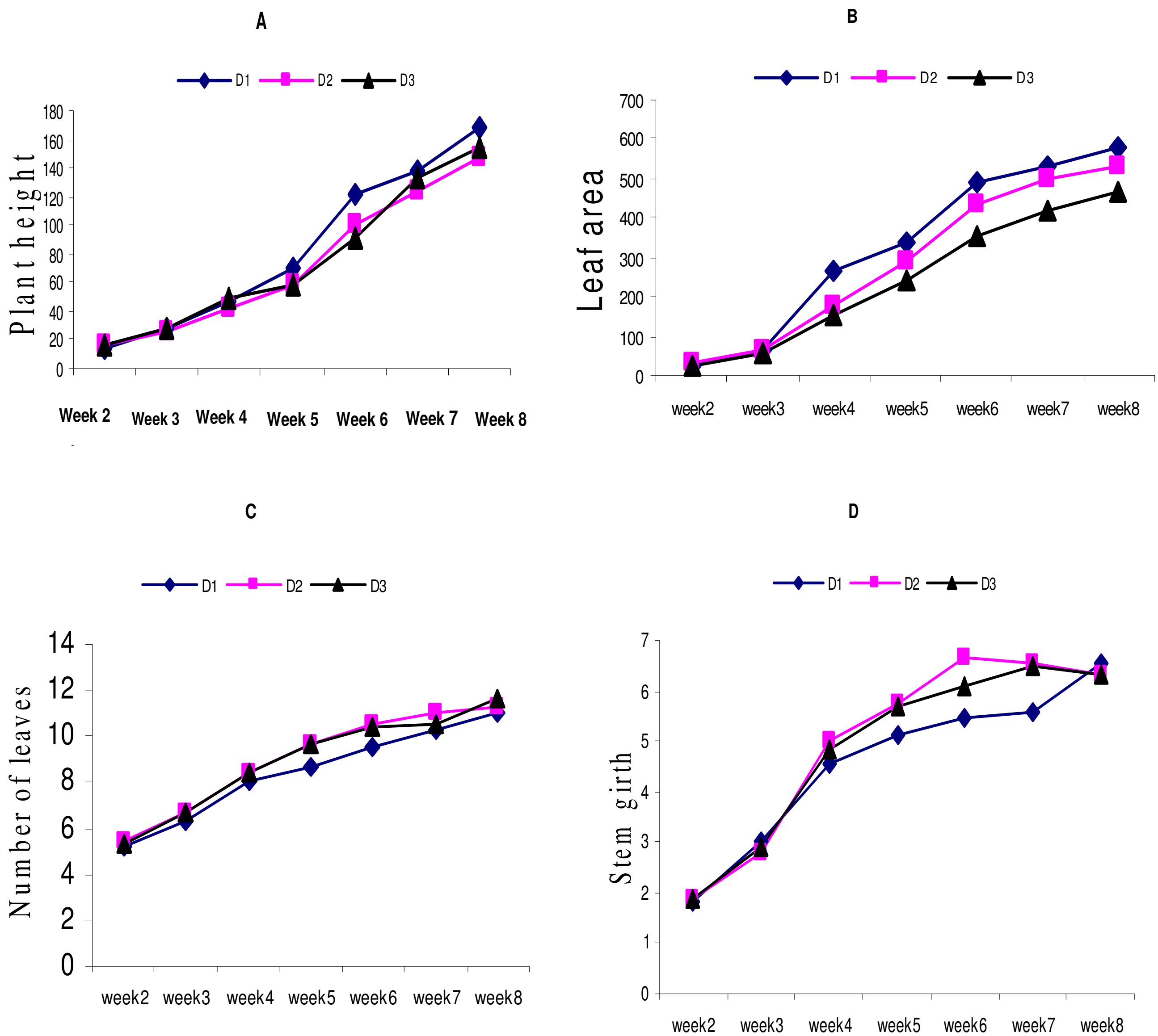

Figure 1. Growth Parameters by the weeks after Planting for the different Planting date. NB. A=Plant Height, B = Leaf area, C = No of Leaf and D = Stem Girth.

Table 1. Result of preliminary soil analysis.

s/n	Parameters	Quantity
1	pH	5.79
2	% Organic Carbon	0.68
3	%Organic matter	1.17
4	Ca (cmolkg^{-1})	1.36
5	Mg (cmolkg^{-1})	1.92
6	K (cmolkg^{-1})	0.36
7	C.E.C (cmolkg^{-1})	3.75
8	% sand	0.78
9	% Silt	0.14
10	% clay	0.08
11	Textural class.	Sandy loam

in term of nutrient requirements and similar in soil properties. These soils were slightly acidic (pH 5.79) with organic matter and organic carbon of 1.17% and 0.68% respectively. The exchangeable bases are Ca (1.36 cmolkg^{-1}), Mg (1.92 cmolkg^{-1}), K (0.14 cmolkg^{-1}), Na (90.36 cmolkg^{-1}) and cation exchange capacity of 3.75 cmolkg^{-1}, (Table 1). The soils were found to be sandy loam in texture (with 78% sand, 14% silt and 8% clay). This result implied the sufficiency of the soil properties across the different planting date. The descriptive statistics of the growth parameters showed that instability exist in the trend of the growth parameters over the period of measurement, (Figure 1A, C and D). The only exception to this is the leaf area where there exist regular growth pattern 4 weeks after planting, (Figure 1B). Irre-

Table 2. Analysis of Variance for both growth and yield parameters.

	Df	Plant height	No of Leave	Stem Girth	L area	Yield	Grain/cob
Date	2	10.75**	44.63**	37.61**	28.06**	8.32**	6415.35**
Year	2	17.09**	11.97**	8.25**	12.02**	0.29	304.37**
Week	6	403.38**	262.18**	116.33**	298.33**		
Year*Date	4	4.35**	2.73*	2.75*	1.42	0.54	1013.33
Date*week	12	2.00*	4.42**	2.10*	2.15**		
Year*week	12	3.11**	0.76	0.92	1.68		
Y*D*week	24	0.89	0.67	0.39	0.26		
Error	126						
Total	188						

gular pattern of growth were obtained for all other growth parameters, thus implying the instability in the growth parameters.

The results of the analysis of variance returned for the plant height and all the sources of variations are significant at 0.01 level of significance except the interaction between the year planting dates and weeks. Also, the interaction between the different planting dates and the weeks after planting is significant at 0.05 level of signify-cance. So, it is advisable to reject the null hypothesis which states that the different planting dates produces the same plant height. For the number of leaves, the results obtained for the different date, year, and weeks after planting and the interaction of planting date and weeks after planting were all significant at 0.01 level of significance. Their F statistics, 44.63, 11.97, 262.18 and 4.42 were all greater than $F_{(2, 126; 0.01)} = 4.61$, $F_{(6, 126; 0.01)} = 2.8$ and $F_{(12,126; 0.01)} = 2.18$ respectively. Hence, it can be inferred that there existed significant differences in the means returned for the different (mentioned) factors in term of plant height. Similar trends were obtained for stem girth when the planting dates, year and weeks after planting were all significant at 0.01 level of significance. Their Fisher's statistics 37.61, 8.25 and 116.33 are greater than $F_{(2, 126;0.01)} = 4.61$ and $F_{(6, 126;0.01)} = 2.8$. The interaction between year and dates as well as that between planting dates and weeks after planting were only significant at 0.05 level of significance. Hence, it can be inferred that there existed significant differences in the means returned for the different (mentioned) factors in term of stem girth. The F statistics returned for both the interaction between year and weeks after planting as well as the interactions between year, date, and weeks after planting were not significant at 0.05 level of significance. The planting date, year, weeks after planting and the interaction of planting date by weeks after planting are not significantly different from one another at 0.01 level of significance for the leave area. 28.06, 12.02 and 298.33 obtained respectively are greater than $F_{(2, 126;0.01)} = 4.61$, and $F_{(6, 126;0.01)} = 2.8$. Also, it could be obtained from these results that weeks after planting gave the highest significant source of variation for both growth and yield parameters. This was followed by the planting date and the year, (Table 2). This could be hinged on the facts that weekly mean growth of plant is said to be cumulative.

Duncan's Multiple Range Test showed that the mean height (84.082^a), number of leaf (9.301^a) stem girth (5.0405^a) and leaf area (326.790^a) obtained for planting date 1 (13th March) are significantly different from mean height (73.318^b), number of leave (8.938^b) stem girth (4.748^b) and leaf area (20.31^b) obtained for planting date 2 (27th March). These means height returned for planting date 2 is however not significantly different from that returned for planting date 3, 10th April (Table 3). The mean number of leave, stem girth and leave area returned for planting date 2,(27th March) was not signify-cantly different from the mean number of leave (8.14^c) , stem girth (4.116^c) and leave area (246.550^c) returned for planting date 3 (10th April)

For the yield parameters, the mean yield \ tonne $\left(6444.4^a\right)$ for planting date 1 (13th march) is significantly different from yield\tonne (4000.0^b) for both planting date 2(27TH march) and planting date 2 in turn is different significantly from planting date 3 (10th April, 22.447^c). Lastly, it could be established that the more the delay in planting, the lesser the performance of the plant in terms of growth and yield.

Correlation analysis and variance covariance matrices

The correlation matrices revealed that highest and significant correlation (0.951) was obtained for relationship between height and leaf area for planting date 2 while the least but significant correlation (0.759) was obtained for the relationship between height and stem girth for planting date 1(13th March). Similar results were obtained for the planting date 2 (27th March) where the highest correlation (0.953) existed between leaf area and height and the least correlation (0.831) existed between height and stem girth. Highest and significant correlation (0.946) was equally obtained for leaf area and height for planting date 3 (10th April) while the least corre-

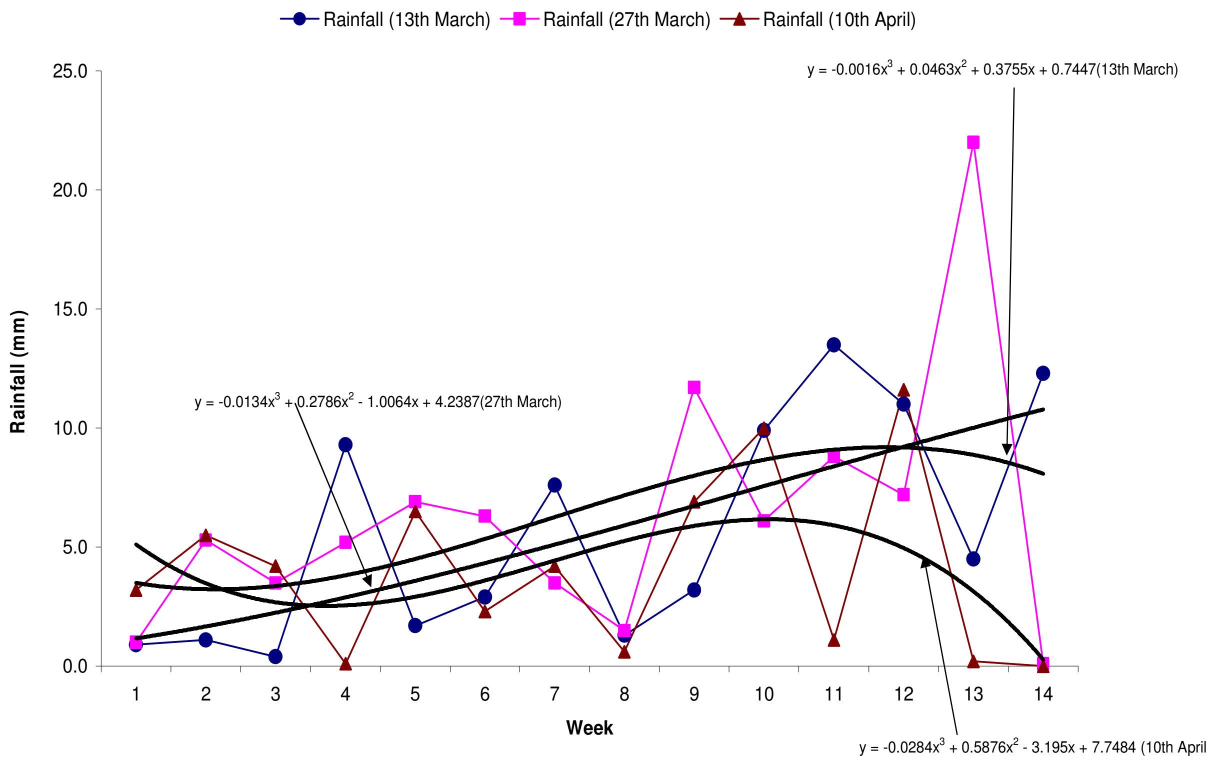

Figure 2. Rainfall distribution for different planting dates.

lation (0.785) was obtained for height and stem girth for the same planting date. It worth noting that planting date 2 had the overall highest correlation (0.89799) while the planting date 1 had the least correlation of 0.875, (appendix 1). Also, stability was noticeable in the correlating parameters regardless of the spatial differences in the planting dates although the values were indeed different from one another. The planting date 2 returned 0.5 of the highest correlation for the pairing parameters while planting date 3 returned 0.333 of the highest. Planting date 2 had the overall highest correlation (0.89799) while planting date 1 had the least correlation (0.875). It is noteworthy that planting date difference does not affects relationships between the plant parameters.

The variance covariance analysis showed that planting date 3 (10th April) had highest variance because, 71% of the variance covariances component of the planting date were the highest. This was followed by both planting date 1 (13th march), and planting date 2 (27th march) return the highest variance-covariance components each in 14.3% of variance – covariance matrix. Similarly, 0.286 of both planting date 1 and 2 covariance had negative values while only 0.071 of the planting date 3 had negative values. It is thus obvious that the datasets obtained for planting date 3 is more stable compared to other planting date, (appendix II). Similarly, none of the covariance returned zero values indicating dependencies between the weekly growths of the parameters. Similarly, the variances for the different weeks increases as the weeks after planting increases but later drop at the latter stage of growth. This is attributable to the fact that as the values of the growth parameters increases, the variance gets lager.

Weather variability

The total rainfall for the different planting dates were, 332mm (13th March), 350.4 mm (27th March) and 374 mm (10th April) while the rainfall intensity were respectively, 3.689, 3.893 and 4.157mm/day. This showed that the more the delay in the planting date, the more the rainfall intensity. The rainfall pattern of the planting date 2 and 3 followed a sigmoidal pattern when subjected to the 3rd order polynomial regression (Figure 2). This is almost close to the requirements. This is because maize needs substantial rainfall at growing stage and moderate rain at maturity and storage stage. The rainfall pattern for the planting date 1 (13th March), however showed a better pattern which favours optimum growth and yield. This is high rainfall at the planting \ early stage of growth followed by higher rainfall at growing and cob production stage and a drop at the maturity stage. This pattern $\left(y = 0.028x^3 + 0.5876x^2 - 3.195x + 7.7484\right)$ is the best \most favorable rainfall requirements for maze production. The pattern of air temperature for the 3rd planting periods showed a decreasing trend, (Figure 3). Variations in the planting date thus bring no differences in the trends

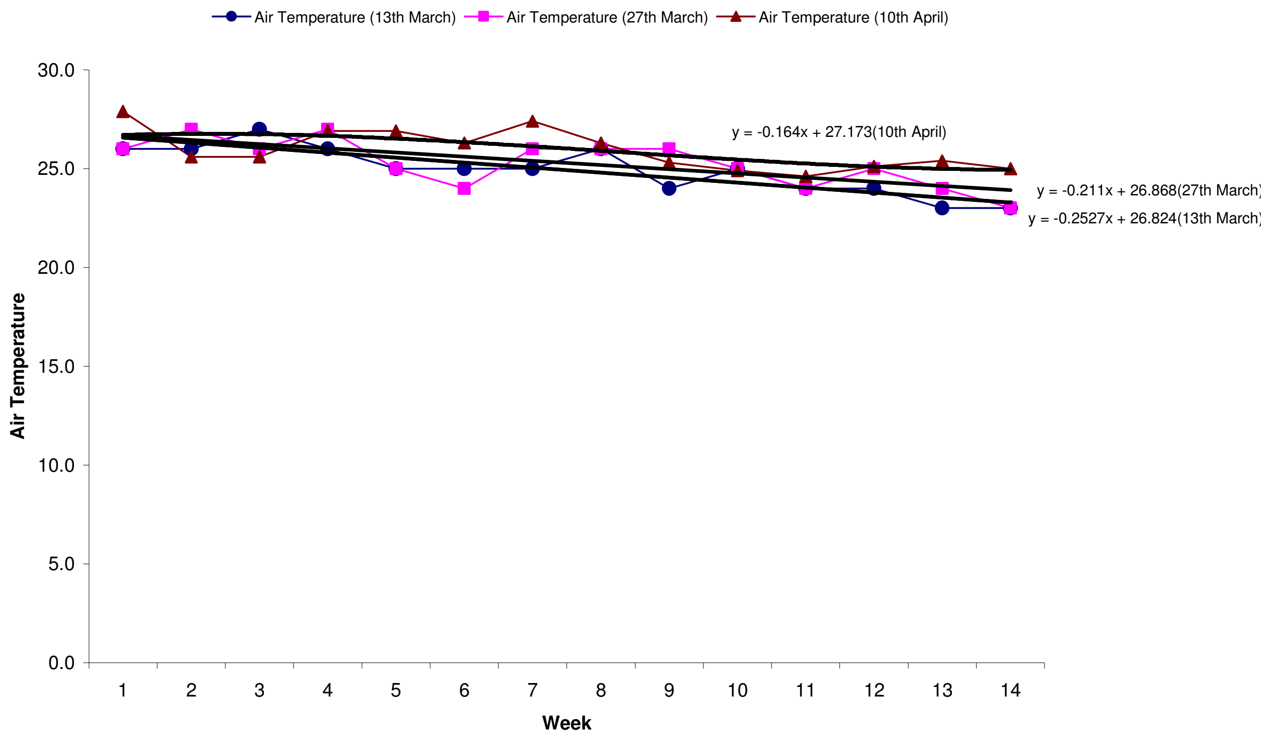

Figure 3. Air temperature distribution for different planting dates.

of air temperature. The air temperature could be expressed by these models.

$Y=-0.16x + 27.173$ (10^{th} April).
$Y=-0.21x + 26.868$ (27^{th} April).
$Y=-0.25x + 26.824$ (13^{th} march).

For relative humidity (Figure 4) however, different patterns formed were the increasing sigmoidal for both planting date 1 (13^{th} march) and date 2 (27^{th} march). The sigmoidal pattern of the planting date 3 (10^{th} April) is a decreasing one. These patterns could be represented by these models;

$y = 0.0067x^3 – 0.1399x^2 + 0.9153x + 91.972$ *(13^{th} March)*
$y = - 0.0064x^3 + 0.171x^2 - 0.883x + 91.377$ *(27^{th} March)*
$y = - 0.0192x^3 + 0.452x^2 – 3.192x + 95.616$ *(10^{th} April)*

From these results, planting date 1(13^{th} March) and planting date 2 (27^{th} march) experienced similar and suitable weather parameters' pattern (WPP) over the growing and maturity period.

DISCUSSION AND CONCLUSIONS

The main feature of these results is that variation in both growth and yield parameters of maize were not due to variation in the edaphic factors. This was implied from the sufficiency of the nutrients and uniformity of the soils of the experiment. This is consistent with Raymond et al., (2003); Butron et al., (2004) and Vega and Hall (2002). The direction of instability in the growth and yield parameters was in contrast with the rainfall intensity. This therefore connotes that rainfall instability is not the sole cause of instability in the growth and yield of the crop (maize). Similarly, the existence of irregular growth pattern of the parameter trends suggests instability which may possibly be linked with planting date. Also, highest source of variability was obtained with the week after planting. This was followed by the planting date and the year. Weekly growth of maize is cumulative hence could contribute significantly to the magnitude of variation. Also, the higher variability obtained with the planting date could be hinged on the differences in the rainfall pattern for the different planting date. This was also confirmed by the different 3^{rd} order polynomial generated from the rainfall distributions of the different planting date. It is thus noteworthy, that planting date (PD) constitutes the major source of variability. This is consistent with Vega and Hall (2002) who established that sowing date has significant effect on oil yield of sun flower

Similarly, for all the planting date the rainfall followed almost the same sigmoidal pattern but with different shapes. This is traceable to the fact that the planting were affected after effective rainfall day (13^{th} March and 10^{th} April). Although the first planting date returned the highest yield but the rainfall pattern for the second planting date (that is 27^{th} March) was the most suitable. In addition, the least yield producing planting date (10^{th} April) experienced most stable growth parameters.

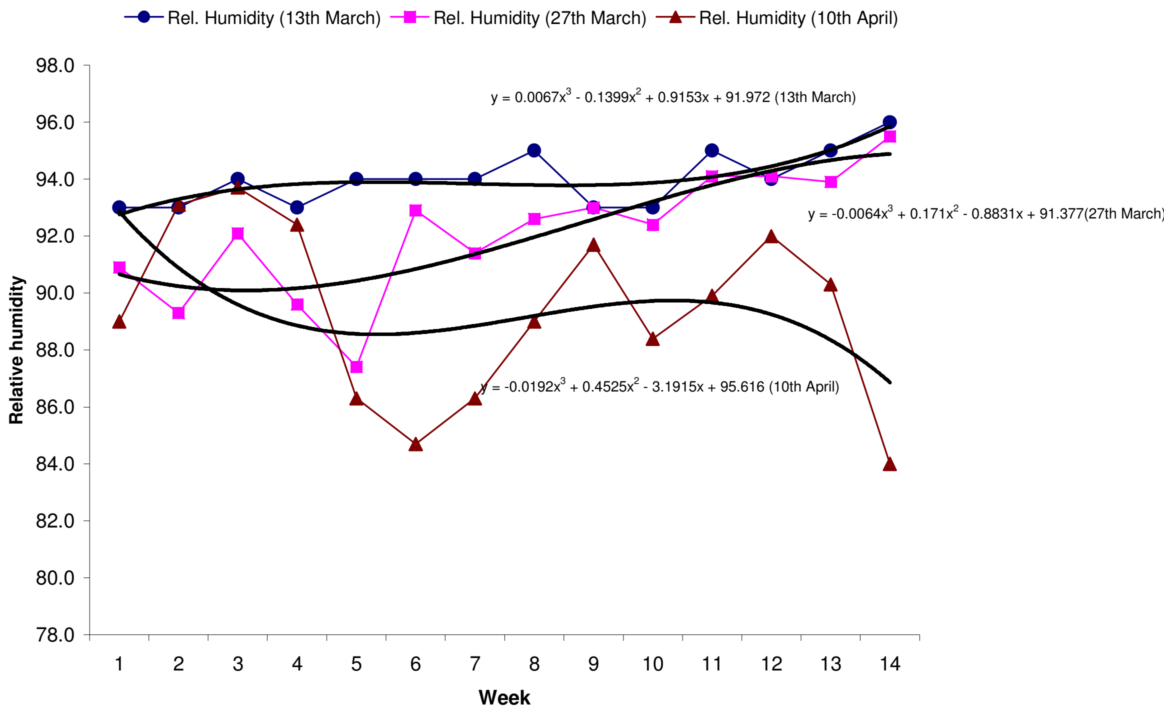

Figure 4. Relative humidity distribution for different planting dates.

Indeed, the rainfall pattern for the second planting date would also be suitable for contamination free harvest. This could be hinged on the fact that early harvest have been employed to control fumonism contamination, (Bush et al., 2003). However, since the harvesting/maturity period falls with the August break, sun drying can be promptly and appropriately done with the rainfall trend of the planting date 2 (27th March). Early planting date (planting date 1- 13th March) gave the highest growth and yield parameters but it was characterized by higher variability and not very suitable weather pattern. Based on the foregoing therefore, 27th March (planting Date 2) or thereabout remain the best planting date for maize because it was characterized by less growth instability, suitable climatic trend and a higher yield. Similarly, the yield can be improved through good management practices, good hybrid selection, and appropriate fertilizer. Thus, it worth recommending that the rainfall instability difference in the effects of planting date should be tested along with some other weather parameters as well as on different varieties of maize.

REFERENCES

Ayoade JO (2002). Introduction to Climatology For the Tropics. Chichester: John Willey and Son, p. 346.

Bauder TR, Waskom J, Schneekloth I, Alldredge J (2003). Best Management practices for Colorado Corn. Bull; XCM574A. Colorado State University Cooperative Extension, Fort Collins.

Bush BJ, Carson MA, Cubeta MA, Hagler WM, Payne GA (2003). Infection and Fumonism Production by *Fusarium verticillioides* in Developing Maize Kernels. Phytopathol. 94: (1): 88 – 93.

Butron DA, Hickey M, Clive K (2004). Common Families of Flowering Plants. Cambridge University Press, 307pp.

Fischer G, Shah M, van Velthuizen H (2002). Climate Change and Agricultural Vulnerability" International Institute for Applied System Analysis. Report prepared under UN Institutional Contract Agreement 1113 for World Summit on Sustainable Development, Laxenburg, Austria.

Gidney BA (1989). A crop growth Model for Predicting Corn (*Zea mays* L) Performance in the Tropics. PhD thesis, University of Havaii, Honolulu, 138pp.

Hogg RV, Craig AT (1970). Introduction to Mathematical Statistics. London; Macmillan Publishing Co., Inc. 4th Edition, 437pp.

Igbekele JO (1975). Crop – Climate Relationship in Western Nigerian. Niger. Geogr. J. 5: (1)21 -32.

Nielsen RL, Thomison PR, Brown GA, Halter AL, Wells J, Wuethrich KL (2002). Delayed Planting Effects on Flowering and Grain Maturation of Dent Corn. Agron. J. (Am. Society of Agron.), 94: 549 – 558.

Oguntoyinbo JS (1987). Climatic Variability and Food Crop Production. West Africa Geo J. 5 (2): 139 – 149.

Qiaoyan W (2007). Interannual Variations of Tropical instability waves observed by the Tropical Rainfall Measuring Mission. Geophysical Research Letters, Vol. 34, L09701, doi:10.1029/2007GL029719, p.3.

Raymond SO, Lagoke STO, Adeosun JO, Iwuafor ENO (2003). Effects of Sowing Date and Nitrogen Level on the Reaction of Varieties of Level to *Striga hermonthica*. Paper presented at the 17th Annual Conference of Weed Science Society of Nigeria, Lagos, pp. 3 -7.

Saxena ML, Singh Y (1965). A note on Leaf Area Estimation on Intact Maize Leaves. Indian J. of Agron. 10: 437 – 439.

Sttot HJ (2004). General Climatology, 3rd edition. New Jersey; Prentice Hall, p. 548.

Tofani V, Wang F, Gasagh N, Falomi G, Nocentini M, Fukuoka H (2008). Instability Conditions of the Landslides Triggered by the 2006 Rainfall events in Ischia Island, Italy. Geography Research Abstract, vol 10, EGU, 2008-A-09391, pp. 1-5.

Vega AJ, Hall AJ (2002). Effects of Planting Date, Genotype and Their Interactions On sunflower yield: II component of oil yield. Crop Sci.J. 1202 -1210.

Udungwu BJ, Summerfield RJ (1985). Comparatory Laboratory Studies of Maize under Tropical Temperature Conditions. East Afr. Agric. and Forestry J. 41: 68 – 74.

Ugochukwu BJ, Summerfield RJ (1985).Comparatory Laboratory Studies of Maize under Tropical Temperature Condition. East Afr. Agric. and Foretsry J. 41; 68 – 74.

Ugochukwu OC, Otegbade JO, Patrick I, Okeke EU, Suleiman AI (2000). STAN Agricultural Science for Senior Secondary Schools, p. 457.

Walter MW (1967). Length of Rainy Season in Nigeria. Niger. Geogr. J. 8: 123 – 126.