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Journal

Katsina Journal of Natural and Applied Sciences, Volume 2 Number 2: March 2012

Faculty of Natural and Applied Sciences

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RAINFALL VARIATION TRENDS IN DETERMINING THE LENGTH OF THE HYDROLOGICAL GROWING SEASON (HGS) IN NORTHWESTERN STATES, NIGERIA

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ABSTRACT

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Keywords: [illegible]

INTRODUCTION

It needs not be over-emphasized that of all agro-meteorological parameters, rainfall is the most critical to agricultural activities in the tropics, but "the main problem lies in accurately predicting the time of onset and cessation of the rains (Fadairo, 1983:[illegible]).

However, in Nigeria until the [illegible] droughts, planners give little or no attention to rainfall characteristics indices. Emphasis was laid on variation in total annual rainfall values which provide inadequate basis for planning. As stated by Adefolalu (1980), it is not the total annual rainfall that is important but its seasonal variability as a function of its characteristics: onset, peak, cessation, length of the rainy season and precipitation intensity during onset and cessation phases. Onset and cessation dates of the rains are derived parameters from which the effective length of the rainy season, which in this study is synonymous with the Hydrologic Growing Season (HGS) can be estimated (Ilesanmi, 1972; Ojo, 1977; Adefolalu, 1986; Olaniran, *et al* (1990).

It is important to note that if in a given year, there is late onset and early cessation of the rains there will be a shortfall in the normal length of the Hydrologic Growing Season which might consequently lead to poor yield or total crop failure.

A significant shortening in the length of the Hydrologic Growing Season has been mentioned by several authors who have analysed Sudano-Sahelian precipitation data for the last 20 years (Demaree and Chadilly, 1988). The realization of this therefore called for a sub-synoptic study of rainfall effectiveness indices of onset and cessation dates of the rains from which the length of the Hydrologic Growing season shall estimate for improved crop production and planning in N6rthWestern States.

THE STUDY AREA

North-Western States is located to the extreme north-western part of Nigeria. It lies between latitudes 12°00 and 13°58 north of the equator and between longitudes 4°08' and 6°54' east of the Greenwich Meridian. It shares boundary with Zamfara State to the east and Kebbi State to the South and West. The State has an international boundary with the Niger Republic along its northern side. It has a land area of about 32,000sq.km.

The State is divided into 23 Local Government Areas and has a tropical wet and dry climate. Dry season lasts for seven months (October to April) while the wet season spans from May to September. Mean annual rainfall in the State ranges from 500mm in the north to 700mm in the extreme southern part of the State. The mean monthly temperature varies from 13°C in December through February to as high as 90% in August. The vegetation of the area is characteristically sudan-savanna type.

METHODOLOGY

Daily rainfall data from Sultan Abubakar Airport and Sokoto Agricultural Development Project (SADP) for ten rainfall stations spread over the two agro-climatic zones of the State were collected and analyzed. The Stations serve as representatives of their respective ecological zones. The daily data were used to derive the onset and cessation dates from which the length of the Hydrologic growing season was derived in accordance with the following methods.

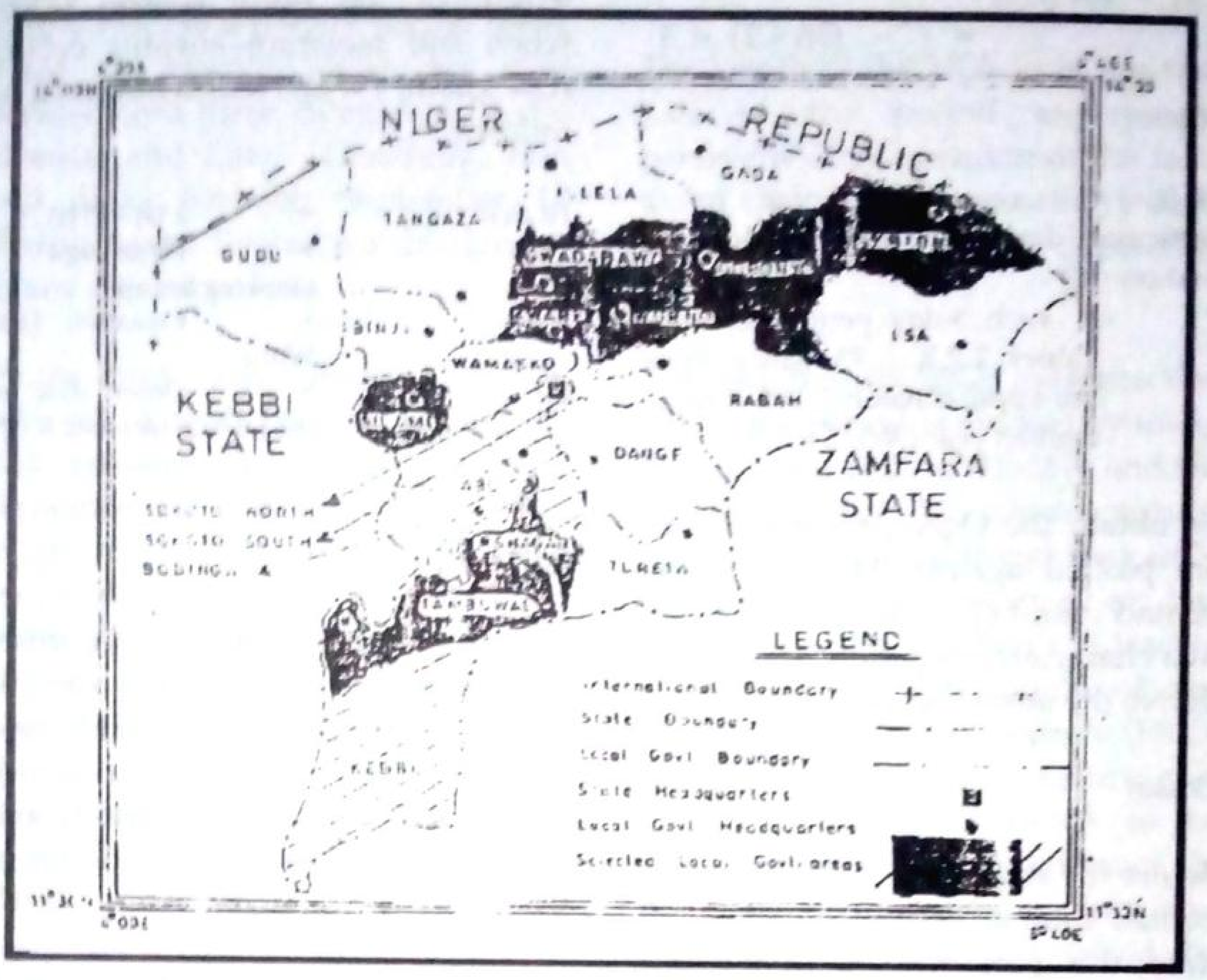

Fig. 1: Map of North-western States

Onset, Cessation and Length of Hydrologic Growing Season (HGS)

Onset refers to that time when a place receives an accumulated amount of rainfall adequate for planting of crops provided that a dry spell of five days or more did not occur in the week following and preceding the date of onset (Bello, 1996). It is therefore not the first day rain falls.

Cessation is the termination of the effective rainy season when rainfall can no more be assured and does not imply the day rain fell. The length of the rainy season that in this study is synonymous with the Hydrologic Growing Season is the difference between the cessation date and the onset date.

Computational Techniques

Various statistical methods have been employed to determine these rainfall parameters from either monthly or daily rainfall data (Walter, 1967; Oshodi, Griffith, 1972; Ilesanmi, 1972; Adefolalu, 1989). A tested statistical method of rainfall Ogive used by Adefolalu (1989) which utilizes 5-day pentad rainfall is adopted in this study because of its accuracy. The five-day rainfall (PR) cumulative frequency value is written in the form:

t = 5 (n – 1) + 5

PR (S.P = n) = PR (S.P = n – 1) + RR (t, s)

1 = (5n – 1) = 1

Where:

PR (t, s) = recorded rainfall for a particular day (day = t) at location (station = S)

P = each 5-day pentad ascribed values 1,2,3,.....73 (since there are approximately 365 days in a given year (365/5 = 73)

To obtain the Ogive, rainfall values are plotted against the appropriate pentad number. From the Ogive, two characteristics points are used to derive the onset and cessation dates.

Onset

Before the start of rains, the five days pentad rainfall values has zero and thus the plot will be along the abscissa and shall remain zero until the first recorded rainfall amount is computed for the appropriate pentad number. After this initial positive value the next pentad rainfall values will increase in response to additional rainfall values. The onset is at the first point of inflexion.

Cessation

As earlier explained in this paper, cessation refers to the effective rainy season. It is marked by the last inflexion point on the Ogive before it becomes parallel for the second (and last) time to the abscissa. Thus, it normally lies somewhere before the last day rain is received.

Length of the Hydrologic Growing Season (HGS)

Hydrologic Growing Season which in this study is synonymous with the length of the rainy season (LRS) when soil moisture surplus occurs (Duckham, 1974), HGS is obtained as follows:

HGS(s) = ε (s) – $\varnothing$ (s)

HGS = Hydrologic Growing Season

ε = Cessation Date

While

$\varnothing$ = Onset date of the rains at location, S

RESULTS

As suggested by Bello (1996), onset and cessation of the rains can be categorized into Early, Normal and Late. Results reveal that rains will start between May 10 (Earliest) and June 24 (Latest) in any onset dates of the rains.

Earliest onset is between May 20 and May 30, normal onset is between May 30 and June 15. There are variations within the two zones under study.

In the central part of the State comprises Dange, Tureta, Yabo, Kware, Bodinga, Binji, Wammako, Sokoto and Silame Local Government Areas, the onset is between May 20 to May 30.

In the northern zone made up of Wurno, Kware, Goronyo, Rabah, Sabon Birni, Isa Tangaza, Ilela, Gada, Gwadabawa and Gudu Local Government Areas, the rains are expected between May 30 and June 10 (Earliest), Late onset is between May 30 and June 24.

Cessation Dates of the Rains

The cessation dates of rains appear to follow the same pattern as the onset dates. Cessation dates are also divided into three categories, Early, Normal and Late. Generally, rain will cease between September 14 (Earliest) and September 26 (Latest) in any cessation dates.

In the study area cessation date is between August 09 and August 28. Late cessation dates occur between September 30 and October 10. The length of the Hydrologic growing season varies from less than 100 days in the extreme northern part to over 120 days in the extreme southern part of the State.

Variations and Trend in the Length of the Hydrology Growing Seasons (HGS)

Table 1 and figure 2a-d show the yearly computed dates of onset, cessation and HGS for Sokoto State for a 30-year period and to observe the trend.

The graphs for the dates of onset of the rains over the State indicate a persistent early onset of rains during the period 1975-81. The succeeding years of 1982-86 are characterized by persistent early onset of the rains. The rest of the years up to 2003 experience fluctuating trend in the onset dates within the mean onset date of June 15.

The curve for the dates of cessation of the rains indicate that except for the years 1976, 1984, 1986, 1987, 1995 and 1999, the remaining years in a 30-year period experienced persistent early cessation of the rains than the normal cessation dates around the mean date of September 14.

The length of the HGS indicates that half of the period experienced persistent early cessation of the rains than the normal cessation dates around the mean date of September 14.

The length of the HGS indicates that half of the period is marked by lower than normal HGS of 91 days and the remaining half by above normal HGS. It should be noted that early onset and early cessation or late onset and early cessation can lead to a shortfall in the length of the Hydrologic Growing Season (HGS) and consequently crop failure and poor harvest. This needs to be carefully taken into cognizance in planning for crop performance and water harvest as rightly noted by Suleiman (1998).

The linear trend defined by the equation of $y = 96 - 0.32x$ indicate a decreasing pattern of occurrence in the length of the hydrologic growing season (Fig. 2d).

DISCUSSION

It has been noted that the Hydrologic Growing Season in the Sahel is synonymous to the Length of the Rainy Season (LRS). In terms of soil-carrying capacity, it is the period of surplus soil moisture when rainfall exceeds evapo-transpiration (Adefolalu, 1989). Be that as it may, it is an important parameter for agricultural and water resources management.

Table 1: Onset (A), Cessation (B) Dates in Pentads and Lengths of the Hydrologic Growing Season (HGS) in Days

YEAR	A	B	HGS
1981	34.4	51.2	85
1982	27.8	50.8	116
1983	32.8	56	116
1984	32.8	50	87
1985	32.4	51.6	96
1986	31.8	54	87
1987	29.6	48.4	95
1988	28.4	49.6	108
1989	37.2	48.8	58
1990	33.4	48.4	76
1991	32.8	53.6	105
1992	33.6	50.6	86
1993	35	52.4	88
1994	31.2	54.8	118
1995	32.2	50	90
1996	33	49.8	85
1997	33	49.2	82
1998	28.4	49.2	105
1999	32.8	51.2	93
2000	31	49.4	93
2001	37.8	50.2	62
2002	37.6	51.8	71
2003	30.6	49.2	94
2004	27	48.2	107
2005	35.4	50	74
2006	34.8	51.6	85
2007	31.2	51.2	101
2008	29.6	48.8	96
2009	30.8	49.6	95
2010	33.4	48.8	78
2011	32.4	50.6	91
Mean			

Source: Compiled by the Authors

In his study(Olaniran, 1987a) points out that planting simultaneous with the defined onset dates of the rains is positively correlated to crop yield even in the transition zone from the Guinea-Sudan (to the South) to the Sudan-Sahel belt (to North where the Hydrologic Growing Season is fairly coincident with the Length of the Rainy Season (LRS).

It has also been observed that there is higher tendency for occurrence of early cessation of the rains following each other in succession than either normal or late cessation (Figure 2b). This implies that the early cessation of the rains is more consistent than normal and late cessation (Figure 2b).

However, in the case of the onset of the rains, normal onset of the rains appeared to be more consistent than either early or late.

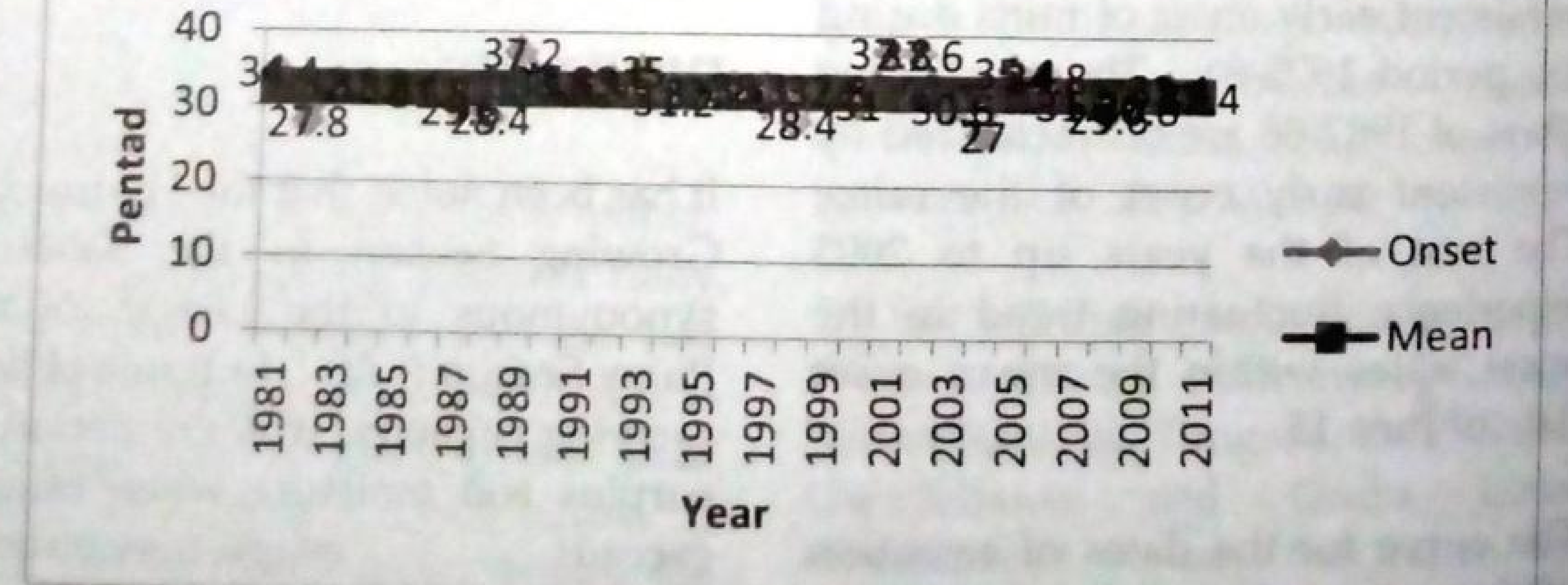

Figure 2a: Onset

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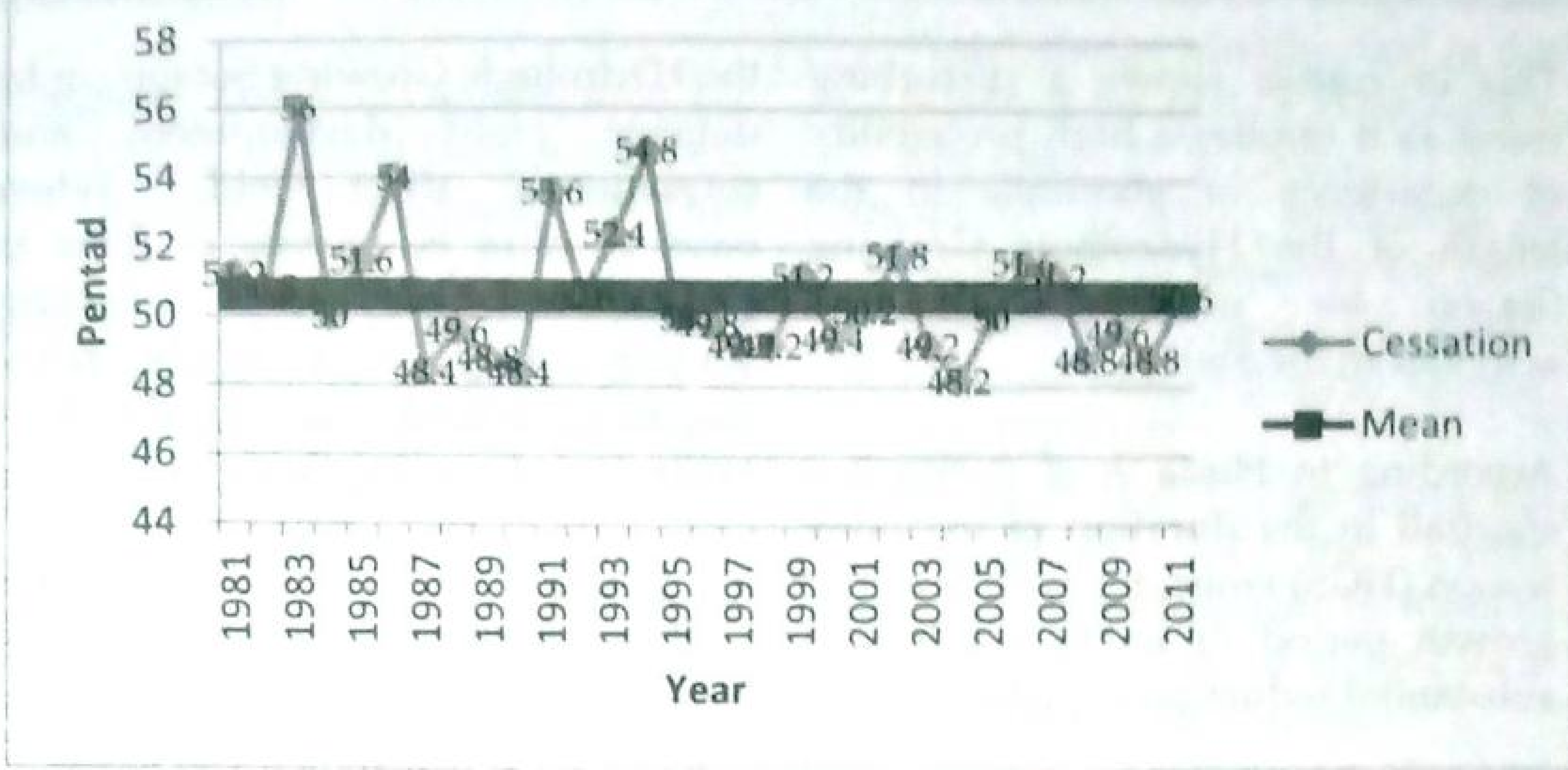

Figure 2b: Cessation

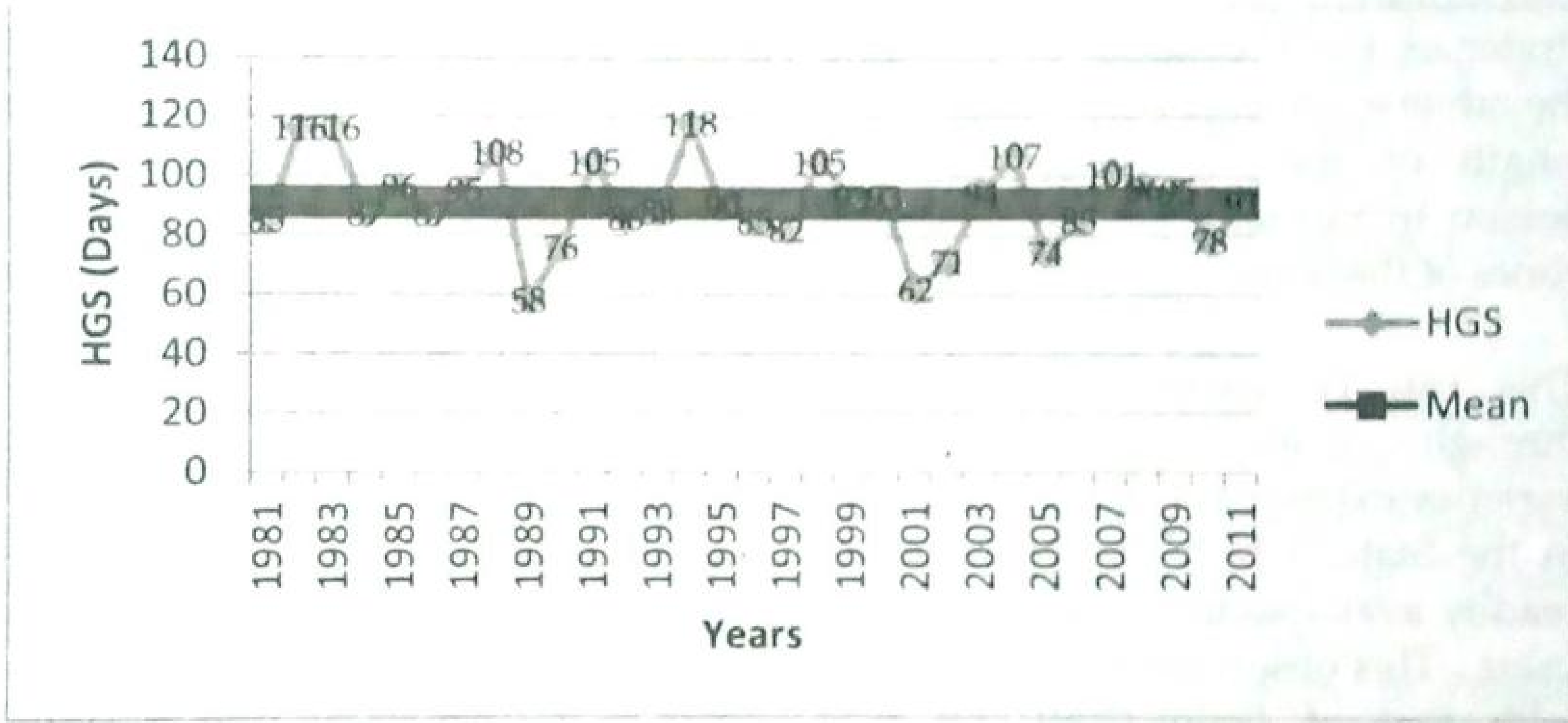

Figure 2c: Length of Hydrologic Growing Season

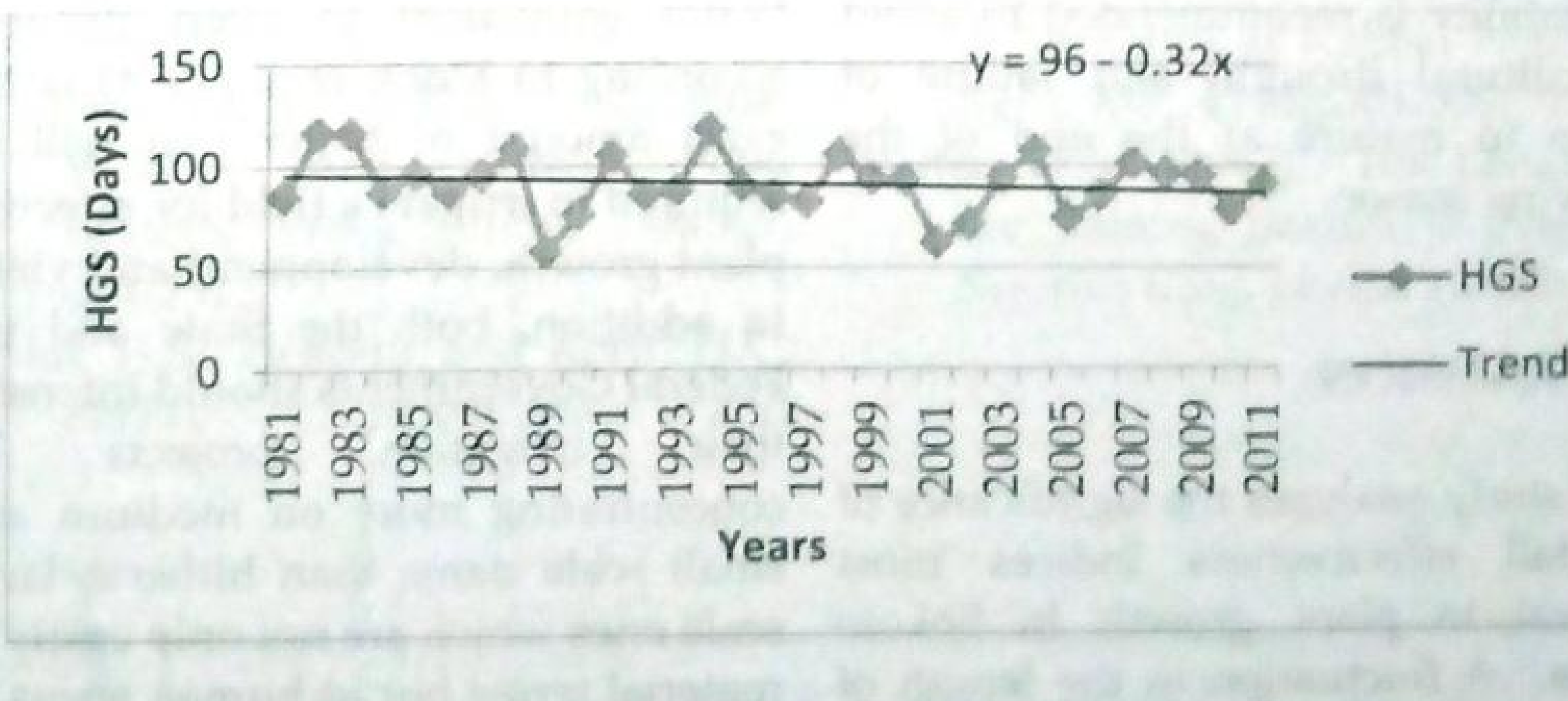

Figure 2d: The Linear Trend of Hydrologic Growing Season

This of course shows a disturbing trend as it implies a high probability of occurrence of shortfalls in the length of the Hydrologic Growing Season for normal agricultural activities in the State.

According to Huda *et al* (1981) if a shortfall in the duration of the rainy season (HGS) coincides with the crop growth period, it might result in a substantial reduction in yield.

The agricultural implication of the above is that there should be intensification on the adoption of strategies for alleviating or avoiding the adverse effects of shortfalls in the length of the Hydrologic Growth Season in virtually all the ecological zones of the State.

This can be particularly achieved through manipulation of crop varieties extended to all crops grown in the State, which should be made readily available to the local resource users. This observation is in corollary with that of Bello (2001:137) who noted that "Selection of cultivars with appropriate phonologies that synchronize the crop's growth cycle with the period of effective water availability is recommended to avoid agricultural drought and failure of crops to mature at the end of the growing season.

CONCLUSION

The study analyzes the significance of rainfall effectiveness indices most critical to plant growth in Sokoto State. A fluctuation in the length of the Hydrologic Growing Season is analyzed. It has also been emphasized that shortened length of the Hydrologic Growing Season could damage plant development and consequently affect yield. When onset of rains is delayed or there is premature cessation occurring simultaneously in a singly rainy season, it can lead to abnormally short Hydrologic Growing Season.

In general, since there is higher tendency for normal onset and early cessation of the rains in the State; the beginning of the growing season in the State should be concentrated around the mean onset date of the rains in order to avoid crop failure arising from incidence of dry spells that is a normal characteristic at the commencement of rainy season. This is in addition to the selection of crop cultivars that are drought resistant and making these available to local farmers.

Furthermore, for more efficient supplemental irrigation, knowledge of the estimation of the water equivalent to avert drought which is a criterion for satisfying the potential evapo-transpiration condition of each ecological zone in the State is required for optimum crop production.

Water equivalent to avert drought according to Flohn *et al* (1974) is the exact amount of water that will be required to irrigate a field for effective plant growth, development and yield. In addition, both the State and the Federal Governments should intensify their irrigation projects by concentrating more on medium and small scale dams than hitherto large scale ones which are not only costly in material terms but in human terms as well.

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