Dry and wet spells in dryland agriculture

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Agriculture in dryland regions is largely determined by climatic and edaphic features. Development of an improved crop-production technology to increase and stabilize food production in these areas requires a complete and quantitative understanding of the time and spatial variation of the natural resources, and their influence on crop growth and productivity

The distinctive characteristics of the tropical environment have major influence on the distribution of natural resources viz., soils, rainfall, and climate. These areas are well supplied with radiant energy; however, due to variations in the weather systems and orographic influences, a variety of rainfall patterns are produced. Because of the high evaporative demand during most of the growing season, variations in the timing and amount of precipitation are generally the key factors influencing the agricultural production potential of a given region.

Several researchers have laid stress on the need for the quantification of the variability of climatic factors. For semi-arid tropical areas, the most commonly considered element is precipitation. These are characterized by seasonally wet and dry climates. The crop growing season, which usually coincides with the length of the humid period, is subject to great fluctuations. Therefore for agricultural development planning, knowledge of the reliability of the duration and characteristics of humid season are very essential.

The principal characteristics of the climate at any location, meteorologists tend to base their observations on average values, which are convenient for calculation. However for agroclimatologists this advantage is lost in that the averages often tend to conceal true phenomena of biological importance by masking inter-annual fluctuations. Climatic descriptions based on averages might be suitable for stations where the climate for each of the individual years follows the average climatic pattern. However, this generality is not often true because of uncertainties inherent in rainfall patterns. The presentation of rainfall data in the form of simple arithmetic averages therefore provides a very general understanding for a generalized application. Considerable difficulty is experienced if one has to apply the data for certain specific operations.

For example the quantity of rainfall received over a period of time at a particular place provides a general picture regarding its sufficiency to meet crop needs. But, more often one is faced with the problem of persistency in receiving a specific amount of rainfall for a short interval. Many agricultural operations revolve around the probability of receiving given amounts of rainfall. Large-scale operational planning often requires decision making with respect to resources, manpower needs, available work days, and several other factors. The probabilities of rainfall can be used for a number of agricultural planning purposes, such as land-use planning (should an area be used for range or for crop 1 and?); choice of crops, cropping system (what are the phenological characteristics of the suited crops? Can these be fitted into intercropping system?); and resource-allocation problems - (What are the general
risk levels associated with dryland farming in the area of concern?). Such knowledge could greatly help in the transfer of Farming Systems Technology.

Generally, dry spells occur due to inadequate rainfall throughout the rainy season. The evaporative demand of the atmosphere varies from 40 mm/week during the beginning of the season and decreased to 30 mm/week during the active rainy season. A week receiving rainfall of about 20 mm will be able to meet 0.5 to 0.75 times the evaporative demand. During the early stages of crop growth, the crop water requirement will be about half the evaporative demand and subsequently increases to total evaporative demand during reproductive stage of growth. Therefore, a week with rainfall less than 20 mm was considered as a dry week. However, during a dry week, the crop may meet its water requirement through the moisture available in the soil. If the rainfall is less than 20 mm/week for two or more consecutive weeks, the crops are likely to be subjected to moisture stress in the absence of adequate stored soil moisture.

Markov chain probability model has been found suitable to describe the long-term frequency behavior of wet or dry weather spells. It has found wide application in studies on daily rainfall distribution. Markov chain probability model assumes that the probability of rainfall occurring on any day depends on whether the previous day was wet or dry. Rainfall amount is involved only in the definition of occurrence or non-occurrence of rain. In the first order Markov chain the probability of an event that would occur on any single day depends only on the conditions during the preceding day and is independent of events of further preceding days. The model calculates the initial probabilities of getting a dry spell / wet spell in a given standard meteorological week. The calculation of conditional probabilities provides the information on the dry spell followed by dry spell or wet spell vice versa. The calculation of initial and conditional probabilities are given below;

I. Initial Rainfall Probability (%) (W or D)

Initial rainfall probability of getting > 20 mm rainfall of week = Wx

\[
W_x = \frac{\text{Number of years during which } \text{ > } 20 \text{ mm rainfall in } x \text{ week}}{\text{Total number of years}} \times 100
\]

II. Conditional rainfall probability (%) (W/W)

Conditional rainfall probability (%) of getting > 20 mm rainfall during next week also when there was rainfall of > 20 mm during this week (x)

\[
\frac{W_{Wx}}{W_x} = \frac{\text{Number of years during which next week Received } > 20 \text{ mm rainfall when this week}}{\text{Number of years during which this}} \times 100
\]
week (Wx) received > 20 mm rainfall

III. Conditional Rainfall probability (%) (W/D)

Conditional rainfall probability (W/D) of getting > 20 mm rainfall during next when this week was dry rainfall < 20 mm

Number of years during which next week received > 20 mm rainfall when this week(x) received < 20 mm rainfall

\[ \text{W/Dx} = \frac{\text{Number of years during which this Week was dry (< 20 mm rainfall)}}{\text{Number of years during which this Week was dry (< 20 mm rainfall)}} \times 100 \]

For example, the analysis of rainfall data (1970-2006) using the above formulae for calculating probabilities of dry, wet weeks conditional probabilities of dry week preceded by a dry week, wet week preceded by a wet week of Anantapur district in the arid region of Andhra Pradesh shows that the initial probability of getting dry spell is high during early part of the season and the probability decreases with the progress of rainy season from 34th week onwards. In the conditional probabilities getting a wet week followed by wet week is high from 35 week onwards.

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While a 100% probability is seen in the 39 week for the occurrence of dry spell followed by dry spell. Hence a comprehensive idea regarding the probability of rainfall receipts is essential in view of the economic implications of certain weather-sensitive operations. This becomes all the more important since the present attempts at forecasting weather patterns over a long period of time are yet to achieve some degree of perfection.