CROP GROWING PERIODS AT SOME STATIONS IN BAHIA STATE

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Apresentado no XVI Congresso Brasileiro de Agrometeorologia – 22 a 25 de setembro de 2009 – GranDarrell Minas Hotel, Eventos e Convenções – Belo Horizonte – MG.

ABSTRACT: Results of a study of crop growing periods in Bahia state are reported in this paper. The study is based on the estimation of daily values of available soil moisture content at twenty six stations selected from different parts of the state. Thornthwaite's water balance procedure is used for the estimation of soil moisture content. Markov chain probabilities of days with dry and wet soil are computed for each decade of the year. Soil moisture averages and probabilities are used to determine the optimum crop growing periods at the stations.

KEY WORDS: Soil moisture, Markov chain probabilities, Crop growing periods

RESUMO: Resultados de um estudo de estações de cultivo para diferentes localidades no estado da Bahia estão apresentados neste trabalho. O estudo é baseado na avaliação dos valores diários de umidade do solo em vinte e seis localidades. O procedimento do balanço hídrico do Thornthwaite é usado para avaliação de umidade do solo. As probabilidades da cadeia de Markov para dias com solo seco e úmido são computados para cada um dos 36 decêndios do ano. Médias e probabilidades de umidade do solo são usados para determinar as épocas ótimas de estação de cultivo para as localidades.

PALAVRAS-CHAVE: Umidade do solo, probabilidades de cadeia de Markov, Necessidades de irrigação.

INTRODUCTION: The semiarid zone of Northeast Brazil is 860000 Km^2 in extent and contains nearly 10% of the country's population. The main climatic characteristics are: annual rainfall of 400-800 mm with a coefficient of variability of up to 80%, high air temperatures and high potential evapotranspiration rates (averaging 2000 mm).

In the semiarid zone the main constraint to crop production is the rainfall and its extreme variability. Results of a climatological study of crop growing periods in the state of Bahia are presented in this paper.

Agroclimatic studies based on longterm soil moisture information would be superior to those using rainfall averages and probabilities since soil moisture information can be related to crop growth and production. Longterm soil moisture records are not often available. Models of varying degrees of complexity have been developed in the past for the evaluation of soil moisture conditions.

In the present study a simple water balance model is used to convert historical rainfall information to soil moisture data. The estimated daily soil moisture data is subjected to various types of analysis. Evaluation of crop growing periods at the stations is the main objective of the study.

METHODOLOGY: Daily precipitation data and climatological mean monthly temperatures at the stations are used in this study. Mean monthly potential evapotranspiration (PE) values at the stations are computed using Thornthwaite's procedure (Thornthwaite 1948, Thornthwaite and Mather 1957). Daily values are obtained from the monthly PE values and these together with the daily precipitation values are used to evaluate daily values of available soil moisture. A more accurate method of estimating PE such as that of FAO Penman-Monteith (Allen et al., 1994) could not be used due to lack of the necessary input data.

Each month is divided into three decades the last decade having 8,9,10 or 11 days depending on the month. A first order Markov chain model is applied to the estimated soil moisture data. Using the daily soil moisture values the initial and conditional probabilities P(D), P(W), P(D/D), and P(W/W) are determined for each decade of the year. Here P(D) is the probability of soil on a given day being dry, P(W) the probability of soil being wet, P(D/D) the probability of soil being dry given that soil on the previous day is also dry and P(W/W) the probability of soil on a day being wet given that the previous day is wet too. The threshold moisture content separating a dry from a wet day is 50% of the AWC value adopted.

Mean soil moisture contents in individual decades and the corresponding probabilities for different AWC values are used to evaluate the growing periods at the stations.

RESULTS AND DISCUSSION: Decadal mean values of soil moisture at Cicero Dantas for different AWC values are averaged over all the years of the study period and results for four AWC values are shown in Fig 1. The period with the maximum soil moisture content seems to vary with variation in the AWC value. For example for AWC_{25} the three decades with the highest moisture content are the 19-21st decades, for AWC_{100} 20-22nd decades, for AWC_{150} and AWC_{200} 21-23rd decades and for AWC_{250} 22-24th decades. On the other hand the three decades with the maximum precipitation total are the 14-16th decades.

A preliminary estimate of the growing season at Cicero Dantas can be obtained from Fig 1 on the assumption that for favorable crop growth the moisture content must be at least 50% of the AWC. Fig 1 shows that the growing season at this station has duration of 170, 180 210 and 230 days respectively for AWC values of 100,150,200 and 250mm.

The above information is based on mean soil moisture patterns. A better understanding of the soil moisture conditions can be obtained from the probabilities of sequences of days with dry and wet soil.

The probability of occurrence of five consecutive days with wet soil in each decade of the year is shown in Fig 2 for four AWC values. We now assume that a five day wet spell in each decade is sufficient for productive crop growth and that successful agriculture is based on good crops being produced in at least seven out of ten years. From Fig 2 we notice that the growing season at Cicero Dantas extends from the 16th to 26th decades for AWC_{100} and from 15th to 28th decades for AWC_{150}. For AWC_{200} and AWC_{250} the period starts in the 17th decade and lasts till the 29th and 30th decades respectively. These results can be considered as the second estimate of the crop-growing period at the station. However it is necessary to define the optimum period for planting. We assume that the seedbed holds 25 mm of available moisture and that germination and early seedling growth requires half of this amount for at least five days after sowing. We further assume that sowing is normally done after rain has sufficiently moistened the soil. From the mean decadal soil moisture content for AWC_{25} it is seen that for decades 12-25 the mean moisture content is more than half of the maximum value. The probability of occurrence of at least one wet day and of five consecutive wet days after a wet day are computed for decades 12-16 and it is found that for the 15th decade is the most suitable one for planting. For this decade the probability of at least one wet day is 83% and that of five consecutive wet days after a wet day is 77%. With planting done in the 15th decade the crop growing periods will have durations of 120,140,150 and 160 days respectively for AWC values of 100,150,200 and 250 mm.

Crop growing periods at the selected stations evaluated as discussed above are given in Table 1 for two AWC values. Based on the results for all the stations the following conclusions are arrived at:

There is a significant phase difference between the variation during the year of mean decadal values of precipitation and soil moisture content. This suggests that crop growing periods evaluated on the basis of precipitation data alone may not yield reliable results.

The period of the year with the maximum moisture content varies with the AWC value assumed. The length of the growing season increases with increase in the AWC value adopted. This implies that at a given station with a given soil type the growing period for deep-rooted crops will be longer than for shallow rooted crops.

CONCLUSIONS: optimum crop growing periods for twenty-six stations in the state of Bahia are evaluated for different values of available water capacity. It is found that estimation of crop growing periods using precipitation data alone may lead to erroneous conclusions. At a given station the growing period for deep-rooted crops will be longer than for crops with shallow root depth.

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Table 1. Crop growing periods in Bahia

	STATION	AWC (mm)	CROP GROWING PERIOD		
			Start	End	Duration (Days)
1	Paulo Afonso	100	10 May	10 Sept.	120
		200		30 Sept.	140
2	Formosa do Rio Preto	100	20 Nov.	10 Apr.	140
		200		10 May	170
3	Campo Largo	100	20 Nov.	20 Apr.	150
		200		20 May	180
4	Mansidão	100	10 Nov.	10 Apr.	150
		200		30 Apr.	170
5	Pindobacu	100	1 Apr.	10 Sept.	160
		200		30 sept.	180
6	Saude	100	20 Apr.	10 Sept.	140
		200		30 Sept	160
7	Jacobina	100	1 May	30 Aug.	120
		200		30 Aug.	120
8	Itapicuru	100	1 Apr.	20 Sept.	170
		200		20 Oct.	200
9	Jaguara X	100	10 May	30 Aug.	110
		200		20 Sept.	130
10	Barreiras	100	20 Nov.	10 Apr.	140
		200		30 Apr.	160
11	Cotegipe	100	10 Nov.	31 Mar.	140
		200		10 May	180
12	Mariquita	100	20 Nov.	20 Apr.	150
		200		20 May	180
13	Santana	100	20 Nov.	20 Mar.	120
		200		10 May	170
14	Correntina	100	10 Nov.	20 Fev.	100
		200		10 May	180
15	Rio de Contas	100	20 Nov.	28 Feb.	100
		200		10 June	200
16	Itiricu	100	10 Feb.	30 Aug.	200
		200		10 Oct.	240
17	Caetite	100	20 Nov.	10 Mar.	110
		200		31 May	190
18	Cicero Dantas	100	20 May	20 Sept.	120
		200		20 Oct.	150
19	Paripiranga	100	1 May	10 Oct.	160
		200		31 Oct.	180
20	Serrinha	100	10 May	30 Sept.	140
		200		10 Nov.	180
21	Esplanada	100	1 May	30 Sept.	150
		200		10 Nov.	190
22	Irara	100	20 Apr.	30 Sept.	160
		200		30 Oct.	190
23	Sto. Antonio de Jesus	100	1 April	30 Sept.	180
		200		10 Nov.	220
24	Feira de Santana	100	10 May	20 Sept.	130
		200		30 Sept.	140
25	Ubaira	100	10 Apr.	20 Sept.	160
		200		10 Nov.	210
26	Ipiau	100	10 Apr.	20 Sept.	160
		200		10 Oct.	180

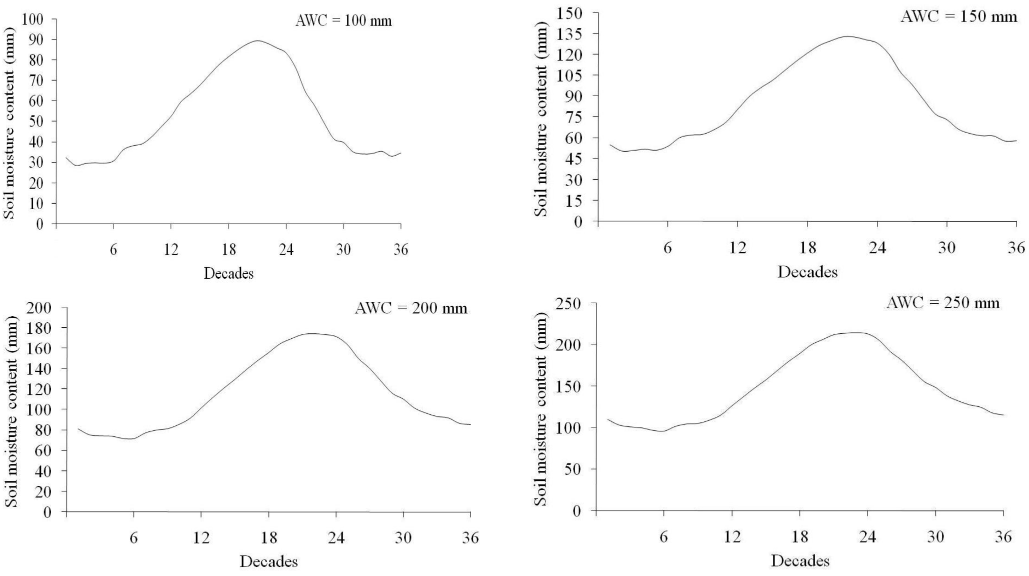

Fig. 1. Mean values of available soil moisture at Cicero Dantas.

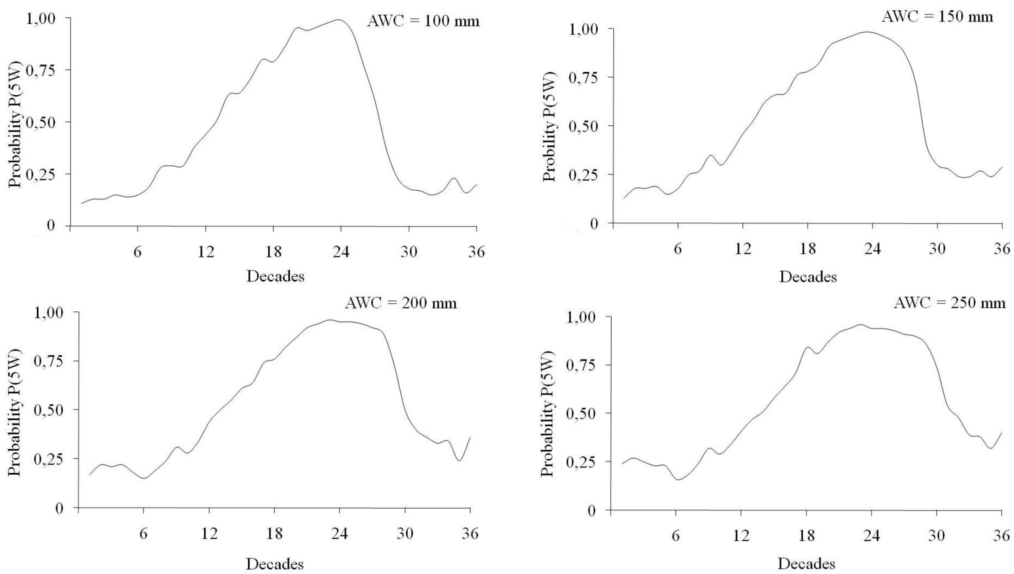

Fig. 2. Probability of occurrence of five consecutive wet days in each decade at Cicero Dantas.