# A STUDY OF SOIL MOISTURE CONDITIONS IN PARAIBA STATE

**KAMADA KARUNA KUMAR[1], DANTAS. P. R. C.[2], AND BRAGA, C. C.[3]**

## ABSTRACT

Results of a climatological study of soil moisture conditions in Paraiba state are presented in this paper. Monthly mean temperature and daily precipitation data for a minimum period of twenty five years at twenty seven stations in the state are used in the study. Daily values of soil moisture content are computed based on Thornthwaite's procedure for five field capacity values. A first order Markov chain model is applied to the daily soil moisture data and the initial and conditional probabilities of dry and wet soil days are derived..Soil moisture averages and probabilities are used to evaluate the crop growing periods and irrigation needs at the stations.

**KEY WORDS**

Soil moisture content, crop growing periods, irrigation needs.

## INTRODUCTION

Agroclimatic studies based on soil moisture information can yield better results than those based on precipitation data since soil moisture is more directly related to crop growth than precipitation. Longterm soil moisture records are not often available and models of varying degrees of complexity have been developed in the past for the estimation of soil moisture conditions (De Jong and Shaykewich, 1981; Baier and Robertson, 1966; Holmes and Robertson, 1959). For agroclimatic purposes it is preferable to use models which are simpler than the complex mathematical models and still yield better results than those based on averages of rainfall and potential evapotranspiration. In the present study Thornthwaite's water balance procedure (Thornthwaite 1948, Thornthwaite and Mather 1957) is used to compute daily values of soil moisture content for a minimum period of twenty five years at twenty seven stations in Paraiba state. The soil moisture data obtained is used to evaluate crop growing periods and irrigation needs at the stations.

## METHODOLOGY

The evaluation of daily soil moisture values is based on the procedure suggested by Thornthwaite and Mather (1957). The variation of mean monthly potential evapotranspiration (PE) values during the year is used to obtain PE values for each decade of the year.Each month is divided into three decades for this purpose the last decade having 8,9,10 or 11 days depending on

[1] PH.D.Professor. Department of Atmospheric sciences.Federal university of Paraiba,Campina Grande-PB.CEP 58.109-970. E-mail: karuna @dca.ufpb.br.
[2] MS Student.Department of Atmospheric sciences.Federal university of Paraiba,Campina Grande-PB.CEP 58.109-970.
[3] MS Professor. Department of Atmospheric sciences. Federal university of Paraiba, Campina Grande-PB. CEP 58.109-970.

the month.From the decadal PE values daily values are obtained and these together with daily precipitation data are used to evaluate the daily soil moisture values.At each station daily soil moisture values are evaluated for the entire study period for each of five assumed field capacity values (25,100,150,200 and 250 mm). In this paper the term ‘field capacity’ is used to denote the maximum root zone moisture content.. Soil moisture values based on field capacity of 25 mm are used to determine the start of the growing period when moisture content only in the speedbed is of importance.

A first order Markov chain model is applied to the estimated soil moisture data and 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 the previous day is dry and P(W/W) is the probability of soil on a given day being wet given that the previous day is wet. The threshold soil moisture content separating a dry from a wet day is taken to be 50% of the field capacity value assumed. Using the initial and conditional probabilities the probability of five consecutive wet days in a decade (P(5W)) are obtained for each decade of the year.

It is assumed that (a) five consecutive wet days in each decade during the growing period are necessary for crop growth, (b) successful agriculture is based on good crops being produced in atleast seven out of ten years and (c) sowing is normally done rain has moistened the soil and five successive wet days are needed for germination and early seedling growth.

Based on these assumptions and using the initial and conditional probabilities the start and duration of crop growing periods at the stations are evaluated for different field capacity values.

The amounts of irrigation required to maintain the soil moisture content above 55%FC during the growing period are evaluated by means of a simple modification of the program for daily water balance computations (Karuna Kumar and Virgínia de F. Bezerra, 1996).

## RESULTS AND DISCUSSION

Soil moisture conditions in Paraiba state during the months March-June for a field capacity value of 150 mm are shown in Figures 1 to 4 . At many stations these months represent the optimum crop growing periods. Crop growing periods for two field capacity values(100 and 250 mm) are given in Table 1. Irrigation needs during the growing periods for two field capacity values are presented in Table 2.The irrigation values in the table represent the amount of supplementary irrigation necessary to maintain the soil moisture content above 55%of the field capacity throughout the respective growing periods.

Some of the significant results of the study are as follows:

There is a significant phase postponement 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 length of the growing season increases with increase in the field capacity value adopted. This implies that at a given station with a given soil type the growing season for deep rooted crops will be longer than for shallow rooted crops.To maintain similar moisture levels in the soil less irrigation water seems necessary for higher field capacity values than for lower.

## CONCLUSIONS

Crop growing periods evaluated using soil moisture information will be more reliable than those based on precipitation data. At a given station the growing season for deep rooted crops will be different from that for shallow rooted crops.

## REFERENCES

BAIER,W and G.W.ROBERTSON. A new versatile soil moisture budget. **Can.J.Plant.Sci.,46**, p.299-315.1966.

DE JONG, R., and C. F. SHAYKEWICH. A soil water budget model with a nearly impermeable layer. **Can. J. Soil .Sci 61**, p.361-371. 1985.

HOLMES, R. M., and G. W. ROBERTSON. A modulated soil moisture budget. Mon. **Weather Rev., 87**, p.101-106. 1959.

Karuna Kumar, K. and V. de F. Bezerra. Irrigation requirements of corn crop at some stations in northeast Brazil**. Proceedings of the 10th Brazilian meteorolical congress**. Campos do Jordao. p.488-491. p.1996.

THORNTHWAITE, C.W. An approach toward a rational classification of climate. **Geogr. Rev. 38**, p.55-94. 1948

THORNTHWAITE, C. W. and J. R. MATHER, 1957: Instructions and tables for computing potential evapotranspiration and the water balance. Climatology 10(3), Drexel, **Inst. of Technol, N.J.,** p.311.

TABLE 1 – CROP GROWING PERIODS IN PARAIBA STATE

| STATION | FIELD CAPACITY (mm) | CROP GROWING PERIOD | | |
|---|---|---|---|---|
| | | START | END | DURATION (DAYS) |
| BARRA DE JUA | 100/250 | 10 MAR | 31 MAY/30 JUNE | 80/110 |
| ANTENOR NAVARRO | 100/250 | 20 FEB | 20 MAY/20 JUNE | 90/120 |
| NOVA OLINDA | 100/250 | 10 FEB | 10 MAY/10 JUNE | 90/120 |
| SERRA GRANDE | 100/250 | 01 MAR | 20 MAY/10 JULY | 80/130 |
| PIANCO | 100/250 | 01 MAR | 10 MAY/20 JUNE | 70/110 |
| PORCOS | 100/250 | 10 FEB | 10 MAY/20 JUNE | 90/130 |
| CATOLE DO ROCHA | 100/250 | 20 FEB | 31 MAY/30 JUNE | 100/130 |
| ALHANDRA | 100/250 | 10 APR | 20 SEPT/31 OCT | 160/200 |
| JOAO PESSOA | 100/250 | 10 APR | 30 SEPT/30 OCT | 170/200 |
| IMACULADA | 100/250 | 20 MAR | 20 *MAY*/10 *AUG* | 60/140 |
| B. B. CRUZ | 100/250 | 20 FEB | 10 MAY/10 JUNE | 80/110 |
| BOM JESUS | 100/250 | 10 MAR | 20 MAY/30 JUNE | 70/110 |
| ITAPORANGA | 100/250 | 10 MAR | 20 MAY/20 JUNE | 70/100 |
| PRINCESA ISABEL | 100/250 | 01 MAR | 31 MAY/20 JULY | 90/140 |
| AGUIAR | 100/250 | 01 MAR | 10 MAY/10 JUNE | 70/100 |
| ARARUNA | 100/250 | 01 APR | 30 SEPT/30 OCT | 180/210 |
| SAO GONCALO | 100/250 | 20 FEB | 20 MAY/20 JUNE | 90/120 |
| AGUA BRANCA | 100/250 | 20 FEB | 20 MAY/31 JULY | 90/160 |
| CAJAZEIRAS | 100/250 | 10 FEB | 10 MAY/20 JUNE | 90/130 |
| PILOES | 100/250 | 10 MAR | 20 MAY/20 JUNE | 70/100 |
| CONDADO | 100/250 | 10 MAR | 20 MAY/20 JUNE | 70/100 |
| PATOS | 100/250 | 10 MAR | 20 APR/10 JUNE | 40/90 |
| TEIXEIRA | 100/250 | 10 MAR | 10 MAY/20 JUNE | 60/100 |
| UMBUZEIRO | 100/250 | 10 JUN | 31 AUG/30 SEP | 80/110 |
| POMBAL | 100/250 | 20 MAR | 20 MAY/20 JUNE | 60/90 |
| ALAGOA NOVA | 100/250 | 01 MAR | 10 OCT/20 NOV | 220/260 |
| CAMPINA GRANDE | 100/250 | 01 MAY | 31 SEP/30 OCT | 150/180 |

TABLE 2 – IRRIGATION NEEDS AT THE STATIONS

| STATION | PERIOD | FIELD CAPACITY (mm) | IRRIGATION NEED (mm) |
|---|---|---|---|
| BARRA DE JUA | MAR – JUN | 100 / 200 | 108 / 104 |
| ANTENOR NAVARRO | MAR – JUNE | 100 / 200 | 148 / 112 |
| NOVA OLINDA | MAR – JUNE | 100 / 200 | 168 / 144 |
| SERRA GRANDE | MAR – JUNE | 100 / 200 | 92 / 88 |
| PIANCO | MAR – JUNE | 100 / 200 | 152 / 120 |
| PORCOS | MAR - JUNE | 100 / 200 | 144 / 128 |
| CATOLE DO ROCHA | MAR – JUNE | 100 / 200 | 108 / 96 |
| ALHANDRA | MAR – OCT | 100 / 200 | 176 / 160 |
| JOAO PESSOA | APR – OCT | 100 / 200 | 96 / 80 |
| IMACULADA | MAR – JULY | 100 / 200 | 120 / 104 |
| B. B. CRUZ | MAR – MAY | 100 / 200 | 124 / 104 |
| BOM JESUS | MAR – JUNE | 100 / 200 | 112 / 104 |
| ITAPORANGA | MAR – JUNE | 100 / 200 | 132 / 88 |
| PRINCESA ISABEL | MAR – JUNE | 100 / 200 | 108 / 88 |
| AGUIAR | MAR – MAY | 100 / 200 | 96 / 88 |
| ARARUNA | APR – OCT | 100 / 200 | 124 / 104 |
| SAO GONCALO | FEB – JUNE | 100 / 200 | 168 / 160 |
| AGUA BRANCA | APR - JULY | 100 / 200 | 88 / 72 |
| CAJAZEIRAS | FEB – JUNE | 100 / 200 | 168 / 144 |
| PILOES | MAR – JUNE | 100 / 200 | 144 / 120 |
| CONDADO | MAR – JUNE | 100 / 200 | 148 / 128 |
| PATOS | MAR – JUNE | 100 / 200 | 168 / 144 |
| TEIXEIRA | MAR – JUNE | 100 / 200 | 120 / 104 |
| UMBUZEIRO | JUNE – SEP | 100 / 200 | 48 / 88 |
| POMBAL | APR – JUNE | 100 / 200 | 108 / 88 |
| ALAGOA NOVA | MAR – NOV | 100 / 200 | 160 / 128 |
| CAMPINA GRANDE | MAY – OCT | 100 / 200 | 104 / 96 |

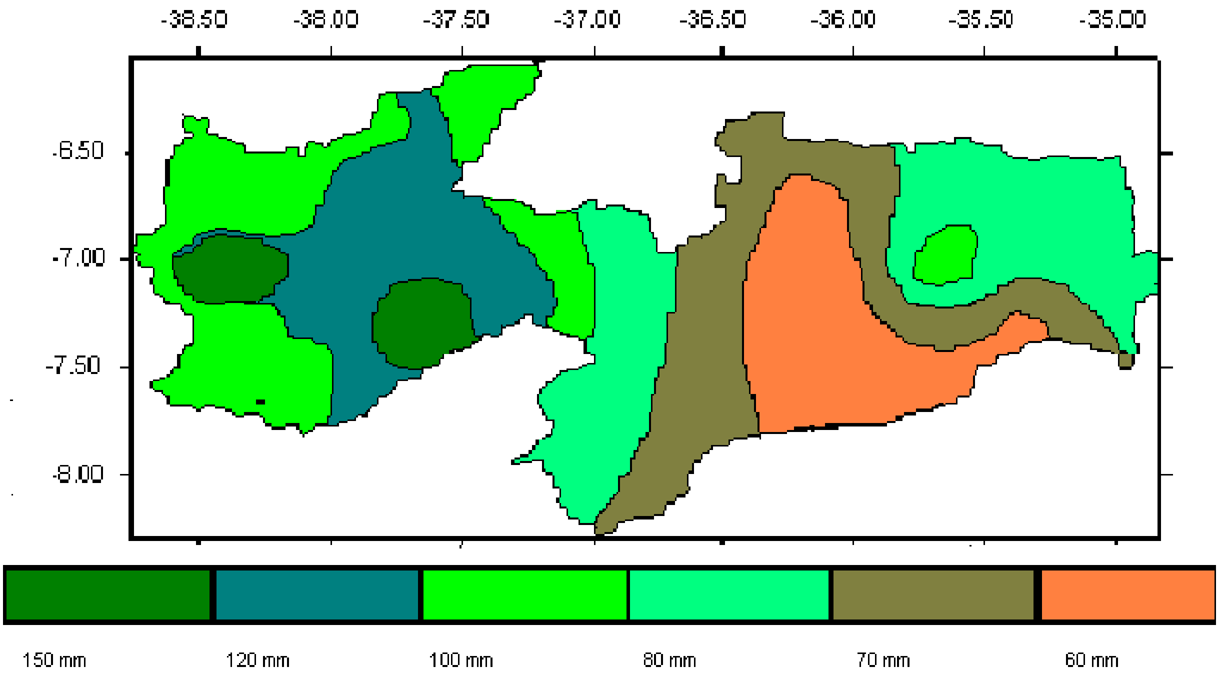


Fig.1 - Soil moisture conditions in Paraiba state during the month  March.

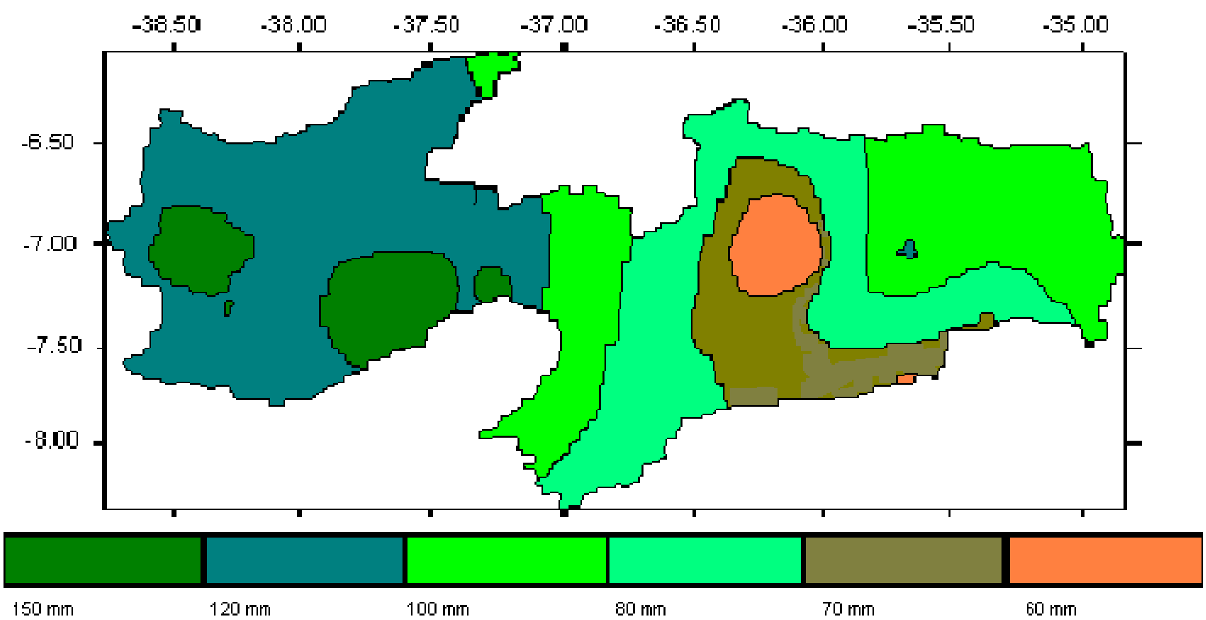


Fig.2 - Soil moisture conditions in Paraiba state during the month  April

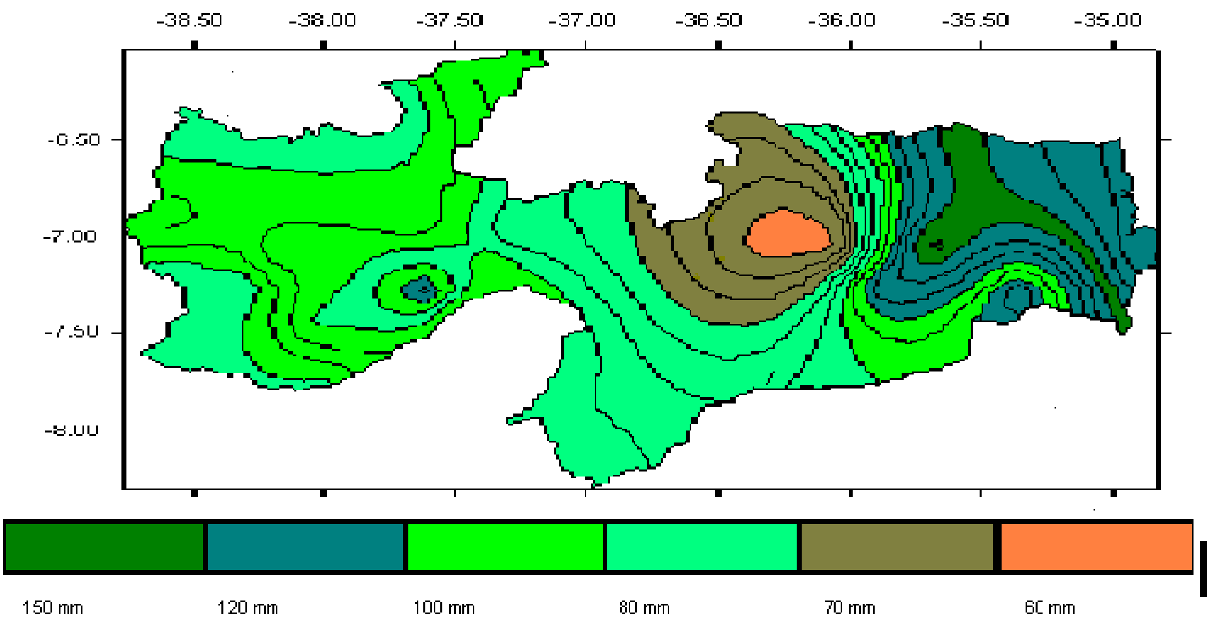


Fig.3 - Soil moisture conditions in Paraiba state during the month  May.

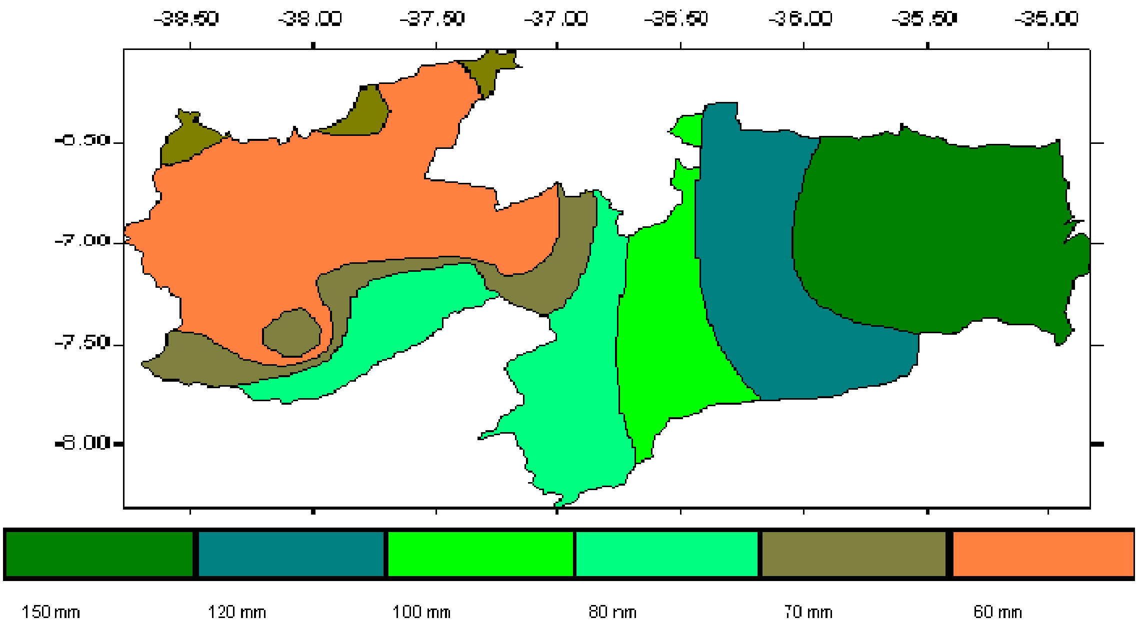


Fig.4 - Soil moisture conditions in Paraiba state during the month  June.