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Hargreaves, George H.

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Utah State University
Department of Agricultural and Irrigation Engineering
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9. ABSTRACT
The Brazilian Northeast has been assigned priority status with respect to some types of agricultural research and development. Except for the Sao Francisco and the Parnaiba river basins, opportunities for irrigated agriculture are limited in extent. Agricultural development of other extensive areas is largely restricted to possibilities from rainfed agriculture. Various attempts have been made to develop a system for zoning the Northeast for agricultural purposes.

Several factors must be considered in an adequate zoning criteria. One of these is the amount and distribution of rainfall. An accurate evaluation of rainfall adequacies and deficits can provide a basis for eliminating areas of lowest potential from plans for investigations, research and development. Attention can then be given to those portions of the Northeast having more favorable rainfall conditions.

The Northeast has frequently been referred to as semi-arid. However, no one term is adequate to describe the wide range of climatic conditions encountered. Some parts should be considered to be very arid while others have adequate to excessive rainfall throughout the major portion of the year. This study attempts to define various degrees of moisture adequacy or deficit in statistical terms in such a manner as to provide a standardized description of moisture adequacy for agricultural production.

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CLIMATIC ZONING FOR AGRICULTURAL PRODUCTION IN NORTHEAST BRAZIL

by

George H. Hargreaves

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INTRODUCTION

The Brazilian Northeast has been assigned priority status with respect to some types of agricultural research and development. Except for the Sao Francisco and the Parnaiba river basins, opportunities for irrigated agriculture are limited in extent. Agricultural development of other extensive areas is largely restricted to possibilities from rainfed agriculture. Various attempts have been made to develop a system for zoning the Northeast for agricultural purposes.

Several factors must be considered in an adequate zoning criteria. One of these is the amount and distribution of rainfall. An accurate evaluation of rainfall adequacies and deficits can provide a basis for eliminating areas of lowest potential from plans for investigations, research and development. Attention can then be given to those portions of the Northeast having more favorable rainfall conditions.

The climate of Northeast Brazil is outstanding in the degree to which it is erratic and unpredictable. Variations within a given month of from zero to as much as 52 inches (1334 mm) have been recorded. In order to relate precipitation to potential crop production both amounts and distribution should be compared with water requirements for a satisfactory level of production.

The Northeast has frequently been referred to as semi-arid. However, no one term is adequate to describe the wide range of climatic conditions encountered. Some parts should be considered to be very arid while others have adequate to excessive rainfall throughout the major portion of the year. This study attempts to define various degrees of moisture adequacy or deficit in statistical terms in such a manner as to provide a standardized description of moisture adequacy for agricultural production.

METHODOLOGY

Studies relative to the Northeast were made in several stages. Monthly precipitation probabilities were calculated by a gamma distribution analyses for the rainfall data presented in the SUDENE publication, "Dados Pluviometricos Mensais, in Natura". These data comprise many long records, some of which exceed 100 years and many are of more than 50 years in length. Data are presented for 723 locations, providing good coverage of most of the geographic area. The analyses showing percentage probabilities of occurrence for these locations is presented in "Monthly Precipitation Probabilities for Northeast Brazil," Department of Agricultural and Irrigation Engineering, Utah State University, Logan, Utah, September 1973.

Temperature and relative humidity records were collected from as many locations as possible in the Northeast. These data, together with latitude were used in order to calculate potential evapotranspiration. The values of potential evapotranspiration together with the climatic data were published in "Potential Evapotranspiration and Irrigation Requirements for Northeast Brazil," Utah State University, February, 1974, (CUSUSWASH 74-A144). These calculated values of potential evapotranspiration were used to estimate potential evapotranspiration for each of the 723 precipitation stations. The estimated values of potential evapotranspiration were used to represent

indices of monthly values of water requirements at each location.

For the state of Ceara a study was made resulting in the publication of monthly moisture availability indices, MAI. For each precipitation station mean monthly precipitation, PM; the 75 percent probability of precipitation occurrence, PD, (that rainfall equaled or exceeded three years out of four); the estimated potential evapotranspiration, ETP; the evapotranspiration deficit, ETDF, (ETP - PD); and the moisture availability index, MAI, (PD/ETP) were published. These values are presented in "Disponibilidades e Deficiencias de Umidade para a Producao Agricola No Ceara, Brazil," Universidade do Estado de Utah, Agosto, 1973, (CUSUSWASH 74-A146).

Tables were completed under the title, "Disponibilidades e Deficiencias de Umidade para Piaui, Brazil" and the same title except for change in the name of the state for each of the states including Rio Grande do Norte, Paraiba, Pernambuco, Alagoas, Sergipe, Bahia, and Minas Gerais.

In this study it was assumed that rainfall at the 75 percent probability of occurrence is very deficient if it meets less than a third of potential evapotranspiration requirements. This would mean that MAI of from 0 to 0.33 would be classified as very deficient. Based on this consideration the following classification of climate was developed for Northeast Brazil.

Criteria	Climate Classification
All months with MAI in the range of 0.00 to 0.33	Very Arid
One or two months with MAI of 0.34 or above	Arid
Three or four consecutive months with MAI of 0.34 or above	Semi-arid
Five or more consecutive months with MAI of 0.34 or above	Wet-dry

The four climatic classifications are shown on a map of the Northeast, Figure 1. Although there is some overlapping and some inclusions, the areas classified are fairly distinct. Boundaries between one classification and another can be either gradual or very marked and sudden. For example, in Bahia there is a sudden change from the coastal area to the dry, very arid interior.

DISCUSSION

Except during unusual years the areas mapped as very arid are considered too dry for rain-fed cultivated crops. Those mapped as arid contain portions that are capable of producing a low level of subsistence agriculture during favorable climatic cycles. Beans and mandicoa can be produced under the more favorable soil conditions during better than normal rainfall amounts and distributions. However, crop production without irrigation is generally highly speculative. It is suggested that most forms of commercial agriculture and many types of subsistence agriculture be discouraged.

In the areas mapped as semi-arid rainfall is generally sufficient for at least a fair production of short season crops. Principal cultivated crops currently grown include corn and beans. For crops requiring more than three to four months of fair or better moisture availability irrigation is required.

In the area classed as wet-dry rainfall is usually fairly adequate and well distributed during five or more months. Sugar cane is a crop of major importance in this area. Yields can usually be substantially increased through the application of irrigation water during months of deficient rainfall.

Judgments relative to crop suitabilities are preliminary and need to be refined as more knowledge becomes available. Use of monthly rainfall

probabilities does not guarantee favorable distribution within the month. Rainfall may be fully adequate in amount during a month but crop failures can result providing a period without rain occurs of sufficient duration so as to cause the crops to wilt and die. Additional study needs to be done relative to correlations between monthly indices and distribution of daily data.

CONCLUSION

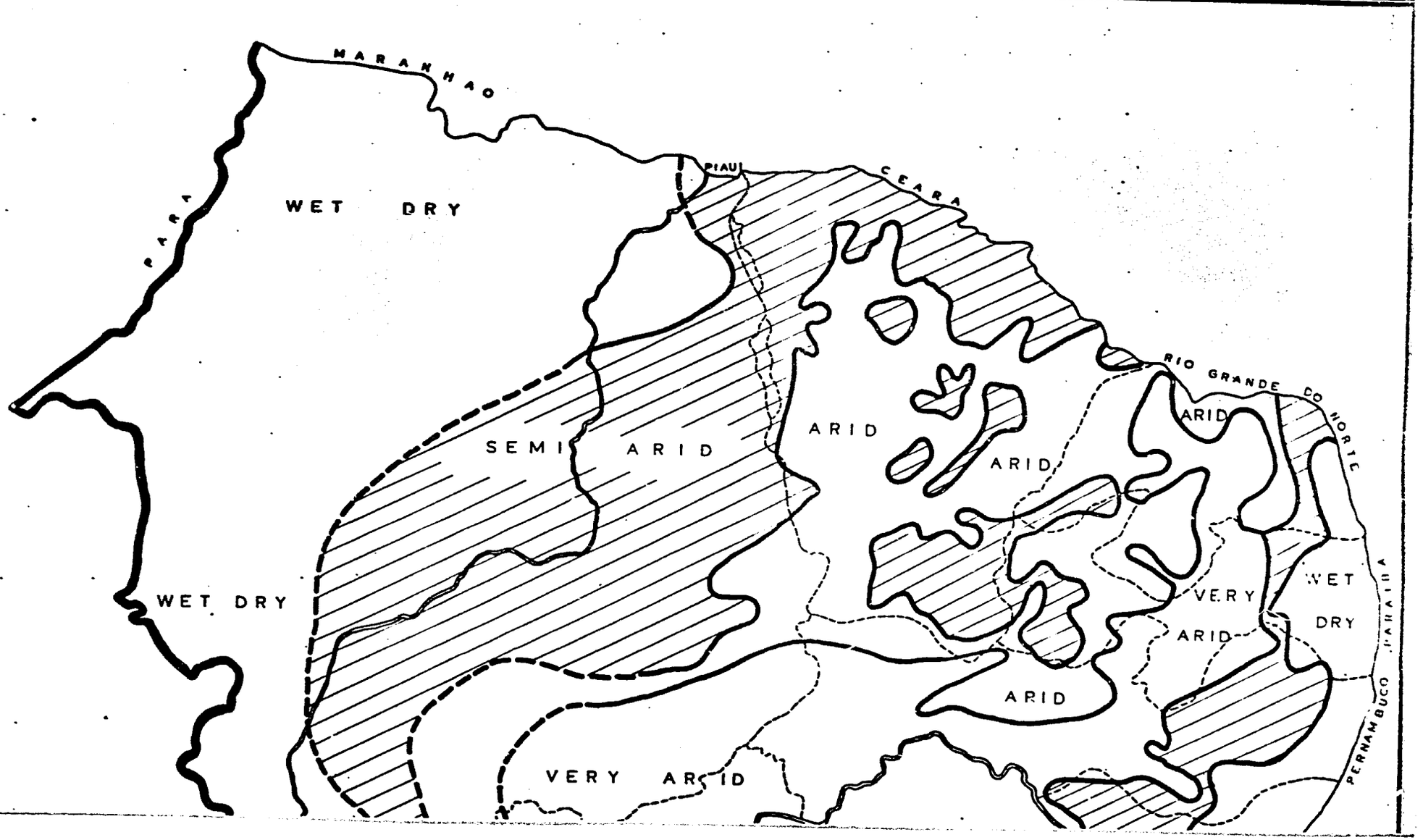
A proposed classification precipitation adequacy for agriculture production is based upon a probability analysis of monthly totals over long periods of years. Four classes of moisture adequacy from rainfall are proposed. These are:

Classification	Description
Very Arid	Not suited for rainfed agriculture
Arid	Limited suitability for rainfed agriculture
Semi-arid	Production possible of crops requiring a 3 to 4 month growing season
Wet-dry	Production possible for crops requiring a good level of moisture adequacy during 5 or more months.

Although more work is required relating these classifications to production records and to daily rainfall distributions, the map, Figure 1, presents a uniform comparison for the Northeast. It can be anticipated that good results on given soil types within a given classification can be approximately duplicated on areas of similar soils within the same climatic classification. However, some minor exceptions can be anticipated. This is mainly because there are some small areas of microclimate or unusual conditions within the classifications. These variations cannot be well

demonstrated at the map scale used. In general uniformity within classifications is good and boundaries between classifications are better defined than might be anticipated.

Further analysis using daily data is being carried out by SUDENE. A graduate student at Utah State University proposes to include a comparison between daily distribution and monthly indices as part of his thesis. This first trial classification should be considered as preliminary and should be updated and improved as additional data and experience become available.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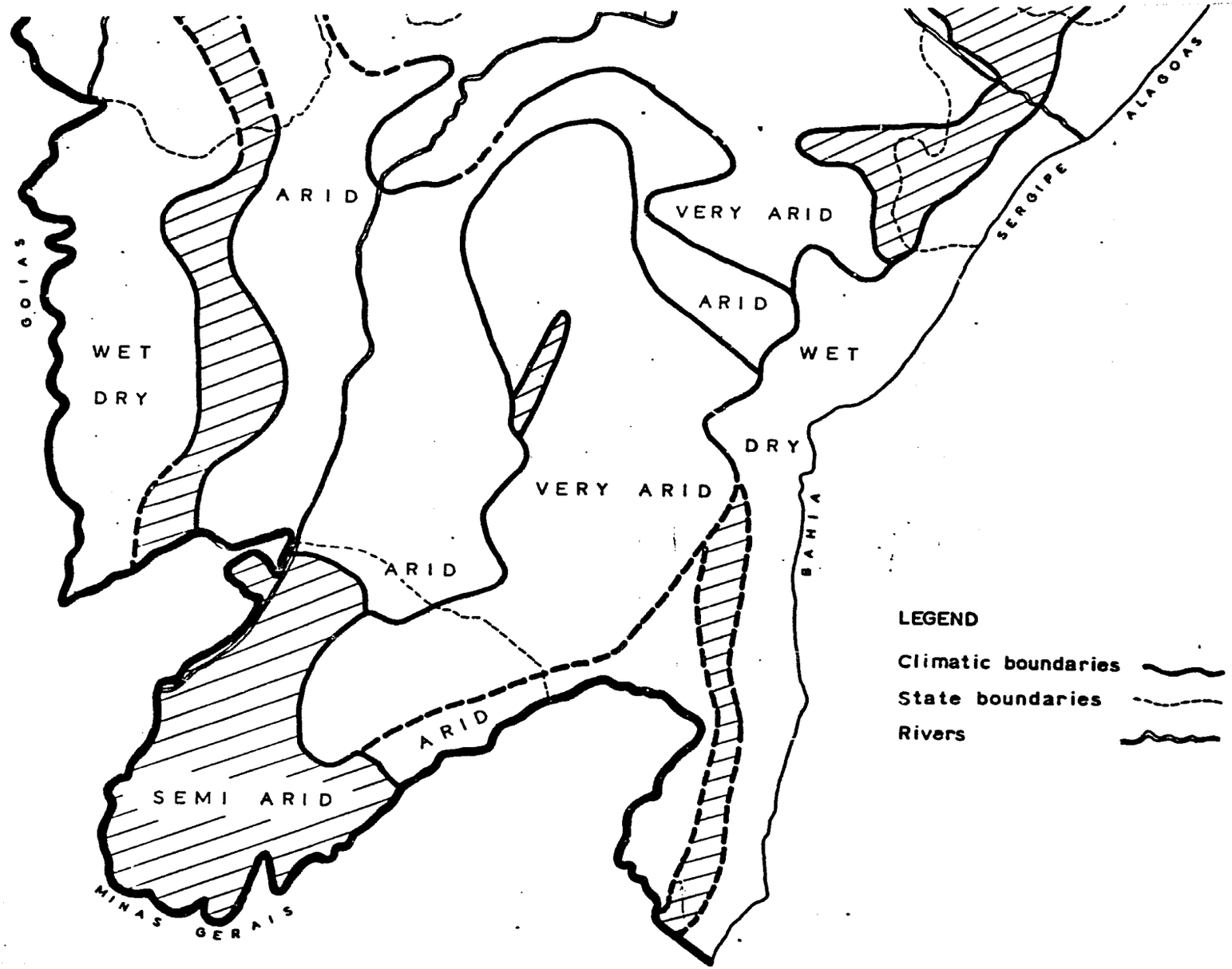

FIGURE 1. CLIMATIC CLASSIFICATIONS FOR NORTH-EAST BRAZIL

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