CLIMATIC DROUGHT CHARACTERISTICS OF NORTH WEST REGION OF BANGLADESH

by

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In partial fulfilment of the requirement for the Degree of Master of Engineering (Water Resources)

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DHAKA

June, 1994

CERTIFICATE

This is to certify that this project work has been done by me and neither this project nor any part thereof has been submitted elsewhere for the award of any degree or diploma.

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June, 1994

We hereby recommend that the project work prepared by **A.K.M. SHAMSUL ALAM** entitled **CLIMATIC DROUGHT CHARACTERISTICS OF NORTH WEST REGION OF BANGLADESH** be accepted as fulfilling this part of the requirements for the degree of Master of Engineering (Water Resources).

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ABSTRACT

This study deals with statistical characteristics of climatic drought which is defined as the difference between potential evapotranspiration and rainfall. Droughts have been a matter of serious concern to man since ancient times and even today it is an outstanding example of man's helplessness before nature's large-scale and formidable phenomena. To the meteorologist, drought is a rainless situation for an extended period of time during which some precipitation should have been normally received depending upon the geographical location of the region and season of the year. To the agriculturist, climatic or agricultural drought is a shortage of moisture availability for crops.

Analysis begins with calculation of daily drought values. Then 10-day yearly drought maxima is calculated for the period of record obtained for five meteorological stations in the Teesta Barrage Project area. The reason for choosing 10-day interval is that irrigation requirement is usually calculated on 10-day basis. Extreme Value Type 1 (EV1) distribution is to fitted to 10-day drought maxima for each station and goodness-of-fit is judge by visual inspection of probability of plots on extreme value paper. Overall, EV1 distribution seems to fit the drought data reasonably well. Frequency relationships have also been presented and using these relationships the magnitude of 10-day drought can be calculated for a given return period. Method of calculating irrigation requirement using these drought values has also been illustrated. The analysis of drought was performed both

for growing season of T.Aman (July 15 to November 15) and for the critical growing period of the same crop (October 15 to November 15).

Another important parameter in the description of climatic drought is the dry spells or sequences of dry or non-rainy day and wet or rainy days. So the next part of the analysis deals with frequency of wet- and dry-day sequences having rainfall greater than or equal to and less than specified threshold rainfall values, respectively. Threshold rainfall values for this study were chosen as 6.0 mm, 3.0 mm and 1.0 mm for each station. For each year the consecutive dry- and wet-day sequences having maximum length(days) was selected. This Yielded one dry-day and one wet-day sequence in each year. Results obtained show that the yearly maximum length of consecutive wet-day and dry-day sequences can be approximated by normal distribution.

Finally seasonal distribution of dry-day sequences has been studied. First average length of consecutive dry-day sequences for each month over the entire period of record was calculated for each threshold and plotted against respective months as a line graph. The largest dry-day sequences occur in January, February and March and again in October, November and December.

The frequency of dry-day sequences having length greater than or equal to 25 days was also calculated for each month for the period of record for each threshold. Largest frequency of such sequences was found to occur in January through March and again in October through December.

ACKNOWLEDGEMENT

The author gratefully acknowledges his profound gratitude and indebtedness to his supervisor, Dr. M. Fazlul Bari, Professor and Head of the Department of Water Resources Engineering, Bangladesh University of Engineering and Technology(BUET), Dhaka for his supervision, guidance and encouragement throughout the course of the research. His active interest in the topic and valuable advice throughout the study were of immense help.

Sincere thanks are also due to the staff of the Department of water Resources Engineering of BUET, for their assistance .

Finally the author wishes to express his sincere gratitude to his friends and colleagues for their moral support during the entire period of study.

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CHAPTER - I

INTRODUCTION

1.1. General

To a large extent agriculture exists in a climatic environment of uncertainty. A normal climate, as given by the mean values, is not often experienced and information concerning the extremes is often more important for agriculture than average conditions. Thus, it is important to know how often such extremes occur. It is generally accepted that floods and droughts which are the extremes in the fluctuation of hydrologic phenomena, represent some of the most dangerous natural disasters with which humanity has lived and struggled in all of recorded history. Being a rapid evolving disaster, floods have been causing loss of property and human life since time immemorial. On the otherhand, the unprecedented increase in population, industry and living standard of modern time, give rise to significant water shortage. So, prediction and analysis of drought conditions are of great importance in water resources management. Of all the devastating effects of drought the total or partial loss of agricultural products is probably the most widespread. Study of drought is especially important for supplementary irrigation project planning and design.

There is no qualitative definition of drought that is universally acceptable. Most of the criteria used to identify drought have been arbitrary because a drought is a "non-event" as opposed to a distinct event such as a flood. Drought has no distinct onset and is recognizable only after a period of time.

In a general sense a drought may be defined as an abnormal moisture deficiency in relation to some need. The engineer relates drought to a set of variables which describe rainfall, runoff and water storage. The economist relates drought to factors which affect human activities. Thus there may be an agricultural drought related to shallow or deep rooted plants, a water supply drought, etc. The geophysicists talk of climatological droughts, and so on. A summary of definitions of droughts is given by Subrahmanya (1967). A meteorological drought may be defined as a period of time with no rain or with rain less than some particular value, e.g., one mm per month. A climatological drought refers to long periods, such as sequences of years, with precipitation less than some base value, for example, less than 25% of the mean annual precipitation. An atmospheric drought refers to conditions of air temperature and humidity etc. Sequences of low streamflows, lake levels and groundwater levels constitute a hydrological drought. This can be thought of a period during which the actual water supply is less than the minimum water supply necessary for normal operation in a particular region. Droughts may be further subdivided into regional and continental droughts.

There is no simple explanation for the occurrence of droughts. In general, the factors which combine to produce droughts are related to atmospheric and oceanic circulation, and to the influence of continental areas . If, for example, climatic conditions are such that the annual rainfall is derived from a few intense rainstorms, then the failure of such storms to occur over an extended period produces the drought. The attempts at explanation of droughts are based on the physical relationships and interactions of the drought affecting factors, while the descriptions of droughts are based on statistical and analytical methods.

1.2 Need for Climatic Drought Analysis

Climatic drought analysis is essential because the irrigation to fulfil its purpose is dependent on how accurately the project hydrologist can estimate the amount of water available. If the estimate is too large the project features are likely to have been designed larger than optimum and the project might be in financial difficulties. On the other hand, underestimation may cause under development of potential and consequent wastes of resources. Some of the usages to which such analysis may be put are as follows:

a) Projection of future rainfall through probabilities making use of past rainfall records;

b) Planning and execution of programs like afforestation, sand dune stabilization and establishment of grass land etc.

c) Drought mapping

d) Crop and Irrigation Planning in following ways;

i) A three-week to three-month runoff deficit during the period of germination and plant growth. This could be catastrophic for farming that is dependent upon irrigation drawn directly from river without the support of reservoirs.

ii) A minimum discharge significantly lower or more prolonged than the normal minimum but not necessarily advanced much in its position relative to the growing season. Because the germination period is not affected by this type of drought and is of less consequence to agriculture.

iii) Selection of more drought resistant varieties or hybrids could improve the performance on dry land provided the minimum amount of rainfall expected and rainfall distribution in time is taken into consideration during crop growth period.

e) Effect of climatic drought on crop yields.

1.3 Selection of Study Area

The selection of study area for drought analysis was based mainly on the availability and continuity of data. In this study Teesta Barrage Project area was selected, which generally represent the North-West region of Bangladesh.

The Teesta Barrage Project, currently under implementation is the largest irrigation project undertaken by Bangladesh Water Development Board (BWDB). The project is bounded by the Teesta river on the north, the Atrai river on the west, Shantahar-Bogra railway line on the south and Bogra-Kaunia railway line on the east. It is being implemented for irrigation, flood control and drainage for a command area of 750,000 ha. of which 540,000 ha. are irrigable. The project covers partly the areas of Nilphamari, Rangpur, Gaibandha, Dinajpur, Joypurhat and Bogra districts (Fig. 1.1).

The average annual rainfall over the area varies from around 1500 mm in the south to over 2250 mm in the North. Around 85% of it falls during the monsoon from May to October. The temperature in the area varies from 46°F in the winter to around 107°F in the summer. The average annual evaporation in the area also varies significantly from around 900 mm in the north to 1150 mm in the south.

The project area in situated in the great alluvial plain which extends from the Himalayan Range to the Bay of Bengal. It has a gentle slope down North to South, averaging 1 in 2,000 in the northern part and decreasing to about 1 in 10,000 in the southern part. Two main soil types are represented the area: typical flood plain and the Barind Tract. The former consists of silty sandy material normally found in the alluvial delta. The latter consists of deeply weathered alluvial clays and generally lies at an elevation slightly raised above adjacent flood-plain.

The source of water supply for meeting the needs of agriculture in the project area are rainfall, surface water and groundwater. For surface water the main source is the Teesta river. The project features include construction of a barrage across the river Teesta, canal head works to divert water under gravity to the canal system and development of irrigation and drainage networks throughout the entire project area to deliver irrigation water to the farms and to drain excess water from the area properly. However, there are seven internal river systems that flow within the project area.

The main objective of the project is to increase agricultural production through irrigation and thereby create employment opportunities for the jobless millions. The vast area of northern Bangladesh suffers from acute shortage of water every year. Drought is a regular phenomenon in the project area even during pre-monsoon and post-monsoon periods. After some studies the project is being planned mainly for the supplemental irrigation for Kharif-II crops i.e., Transplanted Aman(T. Aman). The purpose of the project is to provide insurance of crops against post monsoon (April-May) and pre-monsoon (July through November) droughts i.e. to ensure water during seedling, transplantation and at the maturing stage of crops. Irrigation to the Rabi winter and Kharif-I crops to a limited area might be provided depending on the availability of water.

1.4 Objective of the Study

The purpose of this study is to compute the climatic drought characteristics for the north-western region of Bangladesh. The selected area is the Teesta Barrage Irrigation Project area.

There have been many attempts to define drought in terms of an index derived from hydrologic variables (Palmer, 1964) or as a period of deficit in water supply or precipitation (Yevjevich, 1967). The climatic drought D is computed by means of the following equation (Lowing, 1987).

$$D = ET_p - P \quad \ldots\ldots\ldots\ldots \quad (1)$$

where ET_p is the potential evapotranspiration and P is precipitation.

Even though subnormal rainfall is not the only factor involved in drought development, it is by far the most important from agricultural point of view. Thus it appears worthwhile to analyze the non-rainy day statistics (i.e. the sequence of days on which rainfall in excess of a certain value did not fall) provides useful parameters in drought investigations and therefore can be used as a measure of drought. The main objective of this research is to compute climatic drought parameters for the selected area. The specific objectives are as follows:

i) to compute climatic drought as defined by equation (1)

ii) to fit empirical and theoretical distributions to drought maximum during the growing period (15 July to 15 November) of Kharif-II crop (T.Aman) which needs supplementary irrigation.

iii) to repeat analysis (i) and (ii) for the critical growing period (15 October to 15 November).

iv) to fit empirical and theoretical distributions to annual number of non-rainy or dry-day and length of dry-day sequences.

CHAPTER - II

LITERATURE REVIEW

2.1 General

In this chapter, first, different types of droughts as found in hydrologic literature are discussed. This is followed by a review of previous studies related to drought. Finally some statistical measures of drought are discussed.

2.2 Types of Drought

Generally, hydrologist are involved in several kinds of drought studies. They may be concerned with meteorological drought which is sometimes defined as a prolonged and abnormal moisture deficiency. They may also be concerned about climatic or agricultural drought. The climatic drought is said to exist when soil moisture is depleted so that the yield of plant is reduced. It is computed as the difference between potential evapotranspiration and precipitation (Lowing, 1987). This type of drought is more relevant for supplementary irrigation project development. A third type of drought, known as low flows, which would be limiting for a water supply served by diversion without storage and may be critical in water pollution problem. Low flow is not considered in this study.

2.3 Extent of Drought

Drought that affects agriculture are much more complex. Drought must be related to the particular crops or animals in the agrarian system. The lack of precipitation during both the growing and non-growing seasons can have many adverse ramifications on present and future agricultural activities. Also the lack of rains and the presence of high winds may cause soil erosion resulting in the loss of crops. In addition, crops normally planted in early spring and summer, will have to be omitted because; the soil will not hold the seed.

Rainfall is not the only factor that is involved in drought development, but it is the most important from the agricultural point of view. Thus, it appears worthwhile to analyze the time intervals between rainfall of a particular magnitude, keeping the unit of time short enough so that it can be related to vegetation or other agricultural requirements.

2.4 Review of the Previous Studies

A brief review of previous studies related to drought and low flows is presented in this section. This is followed by the statement of the objectives of the present study.

Representative research on drought was performed by Yevjevich in 1967 on following aspects; duration, probability of occurrence, severity (total deficiency of water relative to some reference level and duration), time of occupancy in the annual cycle, and areal extent. Climatologists have generally preferred maps which depict measured or statistically desired estimates of precipitation amount to show drought characteristics. Such maps of lower decile (10%) of annual precipitation was used by Gibbs & Maher (1967).

In Floods and Drainage seminar (1972), Hershfield, Brakensiek and Comer studied about several measures of agricultural drought. Their studies showed that, the frequency of dry day sequences is proposed as a measure of agricultural drought. The occupancy and severity of the drought depend upon the length of sequence in combination with the water content and water holding capacity of the soil and the water-use pattern of the crop. Bidwell (1972) studied about the methodology for analyzing agricultural drought. In this study he introduced techniques of constructing and analyzing models to simulate the relationship between hydrologic drought to crop yields. Some results were given for the relationship between corn yield and precipitation during the growing season.

Smart (1983) studied about drought analysis and soil moisture prediction. There he concluded that, (i) conceptual soil moisture models could give accurate results that were statistically similar to field soil moisture measurements and verification of soil moisture data produced by such a model would allow compilation of detailed drought statistics where sufficient field data were not available. He also gave a straightforward procedure for evaluating expected drought frequency (monthly occurrence), duration (in days), and severity (defined by soil moisture) that have been proved workable for a practical situation.

Many Indian hydrologists did research on drought. Some of those are briefly discussed here. Victor and Sastry (1984) made an evaluation of agricultural drought using probability distribution of soil moisture index for some Kharif crop. Sastry & Chakravarty (1984) gave an idea about dry-day and dry week concept and severity of atmospheric drought. Here, they said, in the Delhi region a day with rainfall less than 6.0 mm in 24 hrs has been defined as a "dry day" and a week with seven sequential dry days is proposed as a characteristic of a 'dry week'. Prem Narain, Bhargava & Saksena (1984) performed a statistical study on incidence of drought in relation to agricultural production. Here they showed how yield declined with increase of probability of drought.

Khan (1985) presented a paper on drought analysis of aquifer-recharge using probability distribution. Here the author applied the commonly used distributions for low flow analysis in case of drought recharge analysis for the unconfined chalk aquifer of the river Itchen catchment in Hampslire, United Kingdom. Saltability of the distributions for estimating drought recharge for the study area based on some statistical list are discussed in his paper.

Few studies relating to drought that have been undertaken in Bangladesh, seen to be of localized interest.

Karim (undated paper) presented a research paper on drought stress estimate in Bangladesh. He made an analysis to show how water-deficit can have effects on crop yield. He gave within some hydrological concept the effect of soil moisture on crop yield that can be quantitatively calculated by using crop susceptibility factor and stress-day index, which is the product of stress day factor and crop susceptibly factor. He calculated stress day (SD), stress day index (SDI), stress index (SI) and drought yield (Yd_i) of crops like T.Aman, B.Aus and Wheat at a particular stage of crop for Comilla, Bogra, Jessore, Dhaka, Sylhet and Rajshahi. He showed how crop yield decreases with stress and drought. He also showed the percentage of yield loss.

The approach is manageable and it gives a reasonable estimate of crop due to drought. The parameters used in the equation to calculate SD can be verified by adapting research which shall enable researcher to generate appropriate technology to arrest a large reduction of crop yield due to drought in Bangladesh.

Ahmed (1982) studied the return period of the Ganges drought. The study compared the results of drought frequency analysis made by several methods and appraised the relative reliability of these methods. Four theoretical distributions had been applied to the same set of drought data of Ganges. The distribution used are the Extreme Value Type-I, Pearson Type-III, Log-Pearson Type-III and the Lognormal. He showed that the log-Pearson Type-III distribution of the four distributions fitted the drought data best and recommended this distribution for the statistical analysis of droughts in Bangladesh.

2.5 Statistical Measures of Drought

Several methods of analyzing drought frequencies and duration are based on the assumption that meteorological conditions recorded in the past will be repeated. The absence of long records in many places, the long-term variations in rainfall and the topographical changes brought about by man militate against precise forecasts. However, the reliability of statistical methods, first applied to forecast drought frequencies in 1914, has improved with the availability of longer and more widespread data. These longer records in some parts of the country reduce the need for forecasting extreme droughts by extrapolation. In many instances, statistical methods are more useful for estimating the probable frequency or return period of a drought of stated severity than for forecasting the worst drought to be expected over a long period of years.

2.5.1 Probability distribution function

One of the major problems encountered in the analysis of extreme value data is the selection of proper procedure for the probability distribution and curve fitting technique. Many litterateurs have dealt with this subject but as yet there is little consensus among the investigators about the selection of a particular method. There may exist relative merits of the different procedures in different locations.

Considering these facts, frequency analysis for drought may be done by various methods. In this study two types of distributions were made. For climatic drought analysis extreme value type 1 (EV1) distribution and for dry day sequence normal distribution was employed.

Extreme value type 1 (EV1) distribution :

This distribution is often called Gumbel's distribution, the extreme value distribution, the Fisher-Tippett type 1 distribution and the double exponential distribution. The cumulative distribution function of this distribution can be written by as

$$P(X \leq x) = \exp(-\exp(-(x-u)/\alpha))$$

Where $P(X \leq x)$ is the probability that the value X is less than or equal to x i.e. probability of non-exceedance, X is a random variable and in our case it is the maximum drought.

The parameters u and α are estimated by the method of moments and are given by

$$u = \bar{x} - 0.45\, s, \quad \alpha = 0.78\, s$$

Here, $\bar{x} = {}^{\Sigma x}/_{N}$ and $s = \sqrt{{}^{\Sigma(x-\bar{x})^2}/_{(n-1)}}$ are the sample mean and standard deviation respectively.

The Normal Distribution :

This is a symmetrical, bell-shaped, continuous distribution, theoretically representing the distribution of accidator errors about their mean or the so called Gaussian law of errors. That's why it is called Gaussian distribution. The cumulative distribution function of this distribution can be written by as

$$P(X \le x) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{x} e^{-(x-\mu)^2/2\sigma^2} dx$$

Here $P(X \le x)$ is the probability that value is less than or equal to x i.e. probability of non-exceedance. X is the random variable, x is the variate, μ is the mean value and σ is the standard deviation. For sample data $\mu = \bar{x}$ and $\sigma = s$.

2.5.2 Recurrence Interval and Return Period

The primary objective of the frequency analysis of hydrologic data is to determine the recurrence interval of the hydrologic event of a given magnitude x. For probability of exceedance it is the average interval of time within which the magnitude x of the event will be equal or exceeded once is known as recurrence interval, return period or simple frequency to be designated by T. Similarly for non-exceedance probability it is the average interval of time within which the magnitude x of the event will be less than or equal once is known as recurrence interval, return period or simple frequency and it is also designated by T.

If a hydrologic event equal to or greater than x occurs once in T years, the probability $P(X \geq x)$ is equal to 1 in T cases or by equation

$$P(X \geq x) = 1/T$$

2.5.3 Frequency Analysis

A. Graphical Approach

The frequency analysis of hydrologic data can be made by graphical method. The cumulative probability of a distribution may be represented graphically on a various types of graph paper known as probability paper which is designed for the distribution. On such paper the ordinate usually represents the value of x in certain scale and the abscissa represents the probability $P(X \geq x)$ or $P(X \leq x)$ or the recurrence interval T. The ordinate and abscissa scales are so designed that the distribution plots as a straight line and the data to be fitted appear close to the straight line. In this study the normal and the Gumbel probability papers was used.

Plotting Position

When a probability paper is chosen for use the plotting of data on the paper requires the knowledge of plotting positions. Numerous methods have been proposed for the determination of plotting positions. Most of them are empirical. For any extreme value the Weibull's formula is suitable. In this formula

$$\text{Plotting Position} = P(X \geq x) = m/(N+1)$$

Where, m is the rank of the observation beginning with m=1 for the largest or smallest value and N is the number of years of record or the number of observations. When the data are ranked from the largest (m = 1) to the smallest (m = N) the plotting position determine the above equation. If the data are ranked from smallest (m = 1) to the largest (m = N) the plotting position formula is still valid; however, the plotting position now corresponds to the probability of non-exceedance i.e. $P(X \leq x)$. Probability paper may contain scales of $P(X \geq x)$, $P(X \leq x)$, T or combination of these.

After getting plotting position the hydrological data is plotted on the probability paper and a straight line is drawn by eye estimation.

B. Analytical approach

Hydrologic frequency analysis can be made by analytical method. This method does not necessarily require data plotting on a probability paper.

Chow (1951) has shown that many frequency analysis can be reduced to the form

$$x_T = x(1+C_v K_T)$$

Where x_T is the magnitude of the event having a return period T, C_v is the coefficient of variance and K_T is a frequency factor. For Normal Distribution K_T can be found from normal probability Tables. For extreme value Type 1 distribution Chow (1951) has presented the following relationship for frequency factor.

$$K_T = -0.7797\ [0.5772 + \ln\{\ln[T/(T-1)]\}]$$

For best-fit curve one should use the above equation in graphical approach.

CHAPTER - III

DATA COLLECTION AND ANALYSIS

3.1 Source of Data

Hydrological data are available from a number of organizations like, Bangladesh Water Development Board (BWDB), Bangladesh Agricultural Research Council, Bangladesh Meteorological Department (BMD), Master Plan Organization (MPO) etc. For this study daily rainfall, evaporation and crop coefficient for T.Aman (HYV) is needed. The main source of daily rainfall and evaporation data are the BWDB and crop co-efficient data is the MPO. Directorate of Surface Water Hydrology of the BWDB is responsible for the collection, compilation and storage of rainfall, evaporation and some other hydrological data. Rainfall records of 24 hr. duration are available in BWDB for a considerable time period for a large number of stations. In order to have a longer record of rainfall for analysis BWDB always preserve the 24-hr amount in the form of data index cards which were collected from more than 200 raingauge stations in different hydrological districts. For a particular water-year, annual rainfall data, number of rainy days in a year, monthly rainfall data, minimum depth-duration data etc. are also available in the data index card.

Daily evaporation data are also available in the data index card.

3.2 Study region and stations

On the basis of hydrological unit, Bangladesh may be divided into four regions: a) North-West b) South-West c) South-East and d) North-East. The selected Teesta project is in the North-West region. The stations for analysis were selected on the basis of data availability. The climate of the above stations is representative of the project area. Most of the rainfall occurs during May to September with the peak rainfall occurring in the month of July. From November to May evaporation greatly exceeds the rainfall. Much information about vegetative cover is not available.

There are as many as 94 rainfall recording stations in the North-West region of which 29 stations are located within or close to the Teesta Project area. Out of these 29 stations, the data of five stations namely i) Kaliganj (R-177), ii) Mohipur (R-188), iii) Rangpur (R-206), iv) Nowabganj (R-196) and v) Shibganj (R-215) were selected. The first station is in Nilphamari district, the second and the third stations are in Rangpur district & the forth station is in Dinajpur district and the fifth one in Bogra district.

Daily evaporation data are also available at five evaporation stations namely i) Kaliganj (E-18), ii) Mohipur (E-22), iii) Rangpur (E-32), iv) Dinajpur (E-11) and v) Bogra (E-5). For climatic drought analysis concurrent rainfall and evaporation data are needed. Nowabganj and Shibganj stations have no evaporation data. But the evaporation in North-West region follows the same trend. So far as this study is concerned nearest evaporation station data is used for Nowabganj and Shibganj.

3.3 Data Collection and Presentation

The hydrologic sample data are generally presented in chronological order. There are four common types of sample data; complete duration series, annual series, partial duration series, and extreme value series. The complete duration series consists of all the available data. The annual series consists of one value per year such as the maximum peak rainfall of each year. The partial duration series consists of all values above (below) a certain base or threshold value. The extreme value series consists of the largest (smallest) observations in a given time interval.

All the stations within the study area were first verified for the entire gauge records. Stations to be used in this study were then selected. For rainfall data, the principal criteria being that the record from 1970/71 to 1990/91 and 1965/66 to 1985/86; should be complete or nearly so. This exercise provided five stations out of 29 in the Teesta Project Area. The criteria for extracting the evaporation data was the same as rainfall data. But complete series of data is not available in BWDB. The evaporation data for different years follow the same trend. So it was repeated for the missing year. The crop-coefficient data for T.Aman is constant for every year.

3.4 Analysis of Data

The severity of climatic drought may be measured by various parameters: deficiencies in rainfall and runoff, decline in soil moisture, reduction of groundwater level and the storage required to meet prescribed drafts or demands. Because droughts are the results of a cumulative deficiency, records for individual days, and in some cases, even years are not significant. A cumulative plotting of rainfall or a mass diagram of runoff will show the effect of extended dry periods. Early hydrologic practice depended on analysis of hydrologic records to find the most severe period record. In recent years practice includes in addition to evaluation of extreme drought severity, estimates of the probability of occurrence of a drought of given severity and duration.

3.4.1 Daily Drought:

The main objective of this study is to investigate the climatic drought for Kharif II crop, generally grown between June and November, and perform statistical analysis of dry-day sequences.

The first objective is to calculate the climatic drought. As defined earlier, the climatic drought is the difference of potential evapotranspiration and precipitation. The data index card of BWDB for evaporation gives only the evaporation per day. It was assumed that this equals the reference crop evapotranspiration. Crop evapotranspiration was found by multiplying the reference crop evapotranspiration by the crop co-efficient for T.Aman. It was assumed that this crop-evapotranspiration is equal to potential evapotranspiration. The rainfall values was obtained from daily rainfall data. Finally daily climatic drought was taken as the difference of potential evapotranspiration and rainfall. The negative value was assumed as zero. Then 10-day drought maxima was found for further analysis as explained later in this chapter.

3.4.2 Distribution of Ten-day Drought for Growing Period

The second objective was to fit empirical and theoretical distributions to 10-day drought maxima during the growing period of Kharif II crop i.e. T.Aman which needs supplementary irrigation. By fitting a distribution to a set of hydrologic data, the climatic drought for Kharif II crops in the present case, a great deal of the probabilistic information in the sample can be compactly summarized in the function and its associated parameters. Probability distribution was fitted in the following way:

(i) Usually T.Aman is grown under rainfed condition, but occasionally there is a drought in September or October during the critical growing stages of panicle initiation or booting. In Teesta project area for T.Aman sowing/planting period is generally July-August and harvesting period is November-December. In this study the **growing period** of

T.Aman was taken as 15 July to 15 November and **critical growing period** was taken as 15 October to 15 November.

(2) Ten-day drought values were found by computing moving totals of daily droughts for 10-day periods, such as 15-24 July, 16-25 July, ... 6-15 November and thus the entire growing season for T.Aman extending from 15th July to 15th November was covered. In this way 115 values of 10-day droughts values for growing period (Total 124 days) were obtained. Out of these values, the 10-day maximum drought value in growing season was found out. The same procedure was repeated for every years. The 10-day maximum drought values were tabulated with corresponding years and stations as given in Table 3.1 to 3.5.

(3) For frequency analysis all the maximum drought totals were arranged in descending order of magnitude and a rank 'm' was assigned to each value i.e. for the largest one m=1 and for the smallest one m=N.

(4) For plotting of drought total in an extreme value probability paper, the plotting position is needed. The plotting position of each item was computed by Weibull formula. The plotting position for non-exceedance probability $P(D_{max} \leq d_m)$ by Weibull's formula is

$$P_m = 1 - {}^{m}/_{(N+1)}$$

when data are ranked from largest to smallest.

The empirical return period T_m of a drought of magnitude d_m is given by

$$T_m = {}^{1}/_{(1-Pm)}$$

Computedplotting position, return period and non-exceedance probability for 10-day droughtvalues for the growing period are also given in Tables 3.1 to 3.5. A vertical scale was given for 10-day drought-total and horizontal scale for non-exceedance probability on Gumbel or extreme value probability paper. The plots are shown in Figures 3.1 to 3.5.

(5) After plotting each point a best fit curve was drawn by the theoretical frequency relationship

$$x_T = x(1+C_v K_T)$$

3.4.3 **Distribution of Ten-day Drought for Critical Growing Period**

The third objective was to fit empirical and theoretical distribution to drought maxima during the critical growing period of Kharif II crops (T.Aman). The critical growing period for T.Aman, as defined earlier, is from 15 October to 15 November. The procedure of analysis is the same as stated earlier for growing period of T.Aman. Ten-day drought values together with plotting position, return period and non-exceedance probability are tabulated in Tables 3.6 to 3.10 and the plots are shown in Figures 3.1 to 3.5.

3.4.4 Distribution of Dry-day and Wet-day Sequences

The fourth objective of this study is to fit empirical and theoretical distributions to annual number of non-rainy or dry-days and length of dry-day sequences. The frequency of dry-day sequences for both rainfall and streamflow will be used as a drought discriminant or as an indicator of the reliability of rainfall input to the agricultural system in time. The analysis is based on the premise that sequence lengths, as statistical properties of time series, provide useful parameters in drought investigation and, therefore, can be used as a measure of drought. As mentioned earlier, only rainfall is considered for drought analysis in this study.

The term sequence, as used in this study, is defined as a number of similar events preceeded and succeeded by different events. Duration analysis of dry-day statistic (i.e. the sequence of days on which rainfall in excess of a certain value did not fall) and wet-day statistic (i.e. the sequence of days on which rainfall in excess or equal of a certain value did fall) provides useful comparisons of risk which relates to specific time. However, the computational threshold used in this method is fairly arbitrary. For this study the threshold values were taken as 6.0 mm 3.0 mm and 1.0 mm as were used by D.M. Hershfield, D.L. Brakensiek and

G.H. Comer. The analysis for 6.0 mm threshold was done in the following way:

(1) In order to assess the frequency of dry-day sequences of various lengths, daily rainfall data were analyzed for five selected stations in the Teesta Project area. From daily rainfall data, days having less than 6.0 mm (dry-day) and equal or more than 6.0 mm (wet-day) rainfall was chalked out. Then the number of consecutive days with rainfall < 6.0 mm and ≥ 6.0 mm was counted throughout the year. The maximum number of consecutive days will represent one data for frequency analysis per year. These year-wise data are tabulated in Tables 3.11 to 3.15.

(2) Then for constructing frequency histogram the annual number of days with rainfall ≥ 6.0 mm were grouped in several classes and the number of observations belonging to each class, was determined. The resulting arrangement is shown in Tables 3.26 to 3.30 and frequency histograms are plotted in Figures 3.6 to 3.10. An inspection of these histograms show that the data follow normal distribution. As such normal distributions were fitted next.

(3) To fit normal probability distribution to the sample of annual maximum number of days with rainfall more than or equal to 6.0 mm, the raw data were rearranged in order of magnitude and a rank number was indicated by 'm'. As

arranged in ascending order the smallest item has a rank equal to m=1 and the largest one m=N.

(4) Then the plotting positions were computed by Weibull formula (Tables 3.11 to 3.15), and points were plotted on normal probability paper (Figures 3.11 to 3.15).

(5) Then a best fit curve or theoretical normal lines was drawn through mean plus standard deviation at 84.1% and the mean minus standard deviation at 15.9% probability.

3.4.5 Seasonal Distribution of Dry-day Sequences

Seasonal distributions of dry-day sequences are shown by means of line graphs as well as bar graphs. For line graph a plain graph paper was taken, horizontal scale denotes month (January to December) and vertical scale denotes average length of dry-day sequences(days). The average length of dry-day sequence is equal to the sum of all maximum dry-day sequences of each year divided by the number of years of record. The computed values are tabulated in Tables 3.31 to 3.35 and the plots are shown in Figures 3.21 to 3.25.

For bar graphs, frequency of dry-day sequences ≥ 25 days are given in vertical scale and month is plotted in horizontal scale. The plots are shown in Figures 3.26 to 3.30.

Next the analyses was performed for dry-day sequences having rainfall < 6.0 mm. This was done using normal probability paper. The method is the same as that of frequency analysis of sequence days with rainfall ≥ 6.0 mm (Tables 3.11 to 3.15 and Figures 3.16 to 3.20).

Similar analyses werw repeated for rainfall thresholds 3.0 mm and 1.0 mm (Tables 3.16 to 3.25 and Tables 3.36 to 3.45 and Figures 3.11 to 3.20).

CHAPTER - IV

RESULTS AND DISCUSSIONS

Analyses carried out in this study can be discussed under the following headings : a) analysis of climatic drought with its frequency distribution and b) analysis of wet-day and dry day sequences.

For climatic drought analysis five rainfall and evaporation stations in the Teesta Barrage Project area were selected. The summary of computed results is given in Table 4.1. The table contains, for each of the five selected stations, the 10-day drought values for both the growing period and critical growing period of T.Aman with corresponding standard deviation, coefficient of variation and frequency equation. Using this frequency equation the 10-day drought values for a given return period can be computed. From the figures (Figures 3.1 to 3.5), it is revealed that the drought value in the critical growing period is less than that in the entire growing period. The reason for this is that at the beginning of the growing period i.e. in the month of July, August and September the rate of evaporation is comparatively higher and the value of crop co-efficient is 1.1 which is also higher than that in critical growing period i.e. in October and November. There are occasions when drought maxima, computed considering the entire growing season, reaches such a magnitude that supplementary irrigation will be necessary.

Again towards the end of the year i.e. during the month of October and November, the values of crop co-efficient are lower and are seen to be at 1.05 and 0.95, respectively and at this time both the evaporation and the rainfall are comparatively lower. The overall effect is that the magnitude of the drought values are less than that of the entire growing season and this is shown in Tables 3.6 to 3.10. Although the drought in the critical growing period is less in magnitude compared to that of the entire growing season, the drought is seen to be consistently present in the critical growing period. The magnitude of critical growing period drought remains more or less the same. Also at this time, the water requirement is the highest for the high yield of crops. Therefore, supply of water as per requirement should be ensured and as such supplementary irrigation is even more often becomes necessary in the critical growing period.

For wet- and dry-day sequence analysis, the number of rainy and non-rainy days is considered. It is an important parameter in the investigation of drought. Again the analysis was carried out for five stations in the Teesta Barrage Project area. The summary of the analyses is given in Table 4.2. In greater than or equal threshold, the means, obviously decrease with increasing threshold, but the relative variability from year to year as expressed by the co-efficient of variation, increases only slightly. Reverse case takes place during analysis of lesser threshold. The histograms of number of maximum consecutive days with rainfall ≥ 6.0, ≥ 3.0 and ≥ 1.0 mm show that these follow the normal distribution trend. The mean value occurs with the maximum frequency. The number of maximum consecutive days with rainfall ≥ 6.0, ≥ 3.0 and ≥ 1.0 mm and rainfall < 6.0, < 3.0 and < 1.0 mm is plotted on normal probability paper. It is observed from Figures 3.11 to 3.15 that if line is drawn with greater or equal threshold in normal probability paper, the slope of the line of upper threshold is less than that of the lower threshold. Again if line is drawn with lesser threshold the opposite figure comes out (Figures 3.16 to 3.20). An inspection of these normal plots reveals that the dry-day sequences appear to be approximated by a normal distribution.

The seasonal distribution of dry-day sequences for five selected stations are shown in Figures 3.21 to 3.25. Here the average length of dry-day sequence in days for each month are plotted against respective months for chosen thresholds. The longest sequences occur in January, February and March and again in October, November and December. Frequency of dry-day sequences having lengths greater than or equal to 25 days for three threshold rainfall for each of five stations values are shown as bar graphs in Figure 3.26 to 3.30. It is seen that the largest frequency of such dry-day sequences occurs once in the beginning of the year i,e. in the months of January through March and again towards the end of the year i.e. in October through December.

CHAPTER - V

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In this study an attempt has been made to compute and study the statistical characteristics of climatic drought, defined as the difference between potential evapotranspiration and rainfall, for five selected stations in the Teesta Barrage Project area. The basic information used here included rainfall, evaporation, crop coefficient of T.Aman with its growing season and critical growing period from consideration of panicle and flowering stage and consecutive wet- and dry-day sequences.

Climatic drought characteristics are investigated using 20 years of rainfall and evaporation data. Separate analyses were performed covering the entire growing season extending from July 15 to November 15 and the critical growing period from October 15 to November 15. Extreme value type 1 distribution seems to fit the computed 10-day yearly drought maxima for both the period.

From this study it is observed that 10-day drought value of growing season for T.Aman is higher than that of 10-day drought value of critical growing period. At the growing season it is observed that the 10-day drought value increases much if there is no rainfall for successive 10 days, because the quantity of evaporation is high at this period. If it rains sufficiently even one day before of these 10 days still the harmful effect of the later drought on the crops falls very little and the possibility of rainfall is high at this period.so the farmers do not remains anxious.

Again, the drought value of critical growing period is comparatively less. But this drought remains more or less throughout the critical growing period. The drought at this period is very harmful to crops, because at this stage the crops yield flower and milk is accumulated in the rice. Having no water at this time the yield may be substantially reduced or even crop may fail entirely. So the farmers remain anxious for adequate water supply for their crops.

Wet- and dry-day sequences are also investigated using 20 years of rainfall data. The threshold rainfall value are taken as 6.0 mm, 3.0 mm and 1.0 mm for each of the five stations. The frequency of wet- and dry-day sequences is proposed as a measure of climatic/agricultural drought. However, the occurrence and severity of drought depend upon the length of the consecutive days in combination with the water content and water holding capacity of soil and water use pattern of the crop.

The following conclusion can be drawn from analysis of the climatic drought and wet- and dry-day sequences.

1. The drought value-return period/probability curve as shown in figures 3.1 to 3.5 may be useful for designing irrigation projects. For computation of irrigation water requirement and design of irrigation system including distribution network, the drought value of growing period may be used, because this is generally higher than that of the critical growing period. On the other hand the critical growing period drought maxima may be used for computing irrigation need at the panicle and flowering stage.

2. For any of the five selected stations, the drought values for a given return period can be obtained from frequency equations presented in Table 4.1 by putting appropriate K_t factor.

3. The wet-day and dry-day sequence-return period/probability curves as shown in figures 3.11 to 3.20, can be used to obtain the length of consecutive wet or dry days for different return period. Such information is necessary in planning of irrigation projects.

5.2 Recommendations for Further Study

Further studies in the following directions should prove to be fruitful.

i) Continuing study of drought frequency analysis and updating of results will be prove useful as more data become available in future.

ii) Instead of annual maximum series similar type of study may be conducted for partial duration series.

iii) Similar analysis of drought may be made for other regions of Bangladesh such as South East, South West, North East etc.

iv) During such studies spacial attention may be paid in evaluating the effect of other meteorological factors that might cause zonal variation of drought parameter.

v) Study of drought due to human interference, such as diversion of water in upper reaches may be worthwhile.

vi) Possible effect of climate change due to global warming on drought may also be studied.

REFERENCES

Ahmed, M.U. 1982 Return period of the Ganges drought. Journal of the Institution of Engineers, Bangladesh. Vol. 10, No. 2.

Bidwell, V.J. 1972. A Methodology for Analysis of Agricultural Drought in Floods and Droughts, Proc. of 2nd International Symp. in Hydrology, Sept. 11-13, Fort Collins, Colorado, U.S.A. pp. 515-522.

Binnie & Partners, U.K. 1969. Teesta Project Memorandum.

Boonyatharukul, W. 1980 Crop Water requirement. Water Resources Division AIT, Bangkok, Thailand.

BRTC, BUET. 1988 & 1989. Review and optimization of planning and design of irrigation and drainage system of Teesta Barrage Project.

BRTC, BUET & Design Circle VII, BWDB. 1987. Report of the study of water availability of Teesta Barrage Project.

BARC. 1984 Net irrigation requirement of rice and evapotranspiration of wheat and potato for different locations of Bangladesh. Dhaka.

Chow, V.T. 1964. Handbook of Applied Hydrology. McGraw Hill Book-Company, New York, U.S.A.

FAO, 1984. Irrigation and Drainage Paper No. 24. Rome Italy.

Gibbs, W.J. and Maher, J.V. 1967. Rainfall deciles as drought indicators, Commonwealth Bureau of Meteorology, Bulletin No. 48, Melbourne, Australia, pp.33.

Haan, C.T. 1977. Statistical Methods in Hydrology. The Iowa State University, Ames, U.S.A.

Hershfield, D.M. Brakensiek, D.L. and Comer, G.H. 1972. Some measures of Agricultural Drought, in Floods and Droughts, Proc. of 2nd International Symp. in Hydrology, Sept. 11-13, Fort Collins, Colorado, U.S.A.,pp. 491-502.

Howell, W.E. and Grant, L.O. 1972, The Role of Weather Modification in Drought Relief,in Floods and Droughts, Proc. of 2nd International Symp. in Hydrology, Sept. 11-13, Fort Collins, Colorado, U.S.A. pp. 551-560.

Karim. 1983. Drought stress estimate in Bangladesh.

Khan. 1985. Drought analysis of aquifer-recharge using probability distribution. Bangladesh Journal of Water resources research, Vol. 6, No. 1 pp. 19-31.

Lowing, M.J. (ed.) 1987: Casebook of Methods for hydrological parameters for water projects, Studies and Reports in Hydrology, No. 48, UNESCO, Paris.

Narain, P., Bhargava, P.N. and Saksena, A. 1984. A statistical study on incidence of drought in relation to agricultural production. Mausum, Vol. 38. No. 3. pp. 391-396.

Palmer, W.C. 1961. Meteorological drought, its measurement and classification, US Dept. of Commerce, Weather Bureau, Washington D.C., pp. 98

Rao, G.R. and Phulari, D.G. 1984. Extreme probability analysis of drought periods in monsoon in relation to water need of crop stages. Mausum, Vol. 38. No. 3. pp. 397-402.

Rodda, J.C. 1976, Facets of Hydrology, John Wiley & Sons, London/New York, pp.10-14.

Sastry, P.S.N. and Chakraverty, N.V.K. 1984. Assessment of atmospheric drought during monsoon cropping season. Mausum, Vol. 38. No. 3. pp. 267-272.

Subrahmanya, V.P. 1967, Incidence and spread of continental drought, WMO-IHD Projects., Rep. No. 2.

Thornthwaite, C.W. 1948. An approach toward a rational classification of climate, Amer. Geophysical Review, Vol. 38, 55-94.

Victor, U.S. and Sastry, P.S.N. 1984. evaluation of agricultural drought using probability distribution of soil moisture index. Mausum, Vol. 38. No. 3. pp. 259-260.

Yevjevich, V.M. 1967, An objective approach to definitions and investigations of continental hydrologic droughts, Hydrol. Paper No. 23, Colorado State University, Fort Collins, Colorado.

Yoshida,S. 1981. Fundamentals of rice crop science. International Rice Research Institute, Manila Philippines.

TABLES

Table 3.1 : Observed 10 day drought during growing period of T.Aman and frequency of occurrence at Kaliganj.

Year	Maximum 10-day drought, x mm	Period	Drought values in descending order, mm	Rank m	Plotting position m/(N+1), %	Return period Year	Non-exceedance probability $P_m = 1 - m/(N+1)$, %
1990	23.10	Oct21 - Oct30	31.37	1	4.76	20.01	95.24
1989	24.36	Aug18 - Aug27	31.01	2	9.52	10.50	90.48
1988	23.10	Oct21 - Oct30	28.76	3	14.28	7.00	85.72
1987	19.03	Oct21 - Oct30	27.61	4	19.05	5.25	80.95
1986	28.76	Aug06 - Aug15	27.46	5	23.80	4.20	76.20
1985	27.61	Aug03 - Aug12	27.405	6	28.57	3.50	71.43
1984	25.07	Sep23 - Oct02	26.88	7	33.33	3.00	66.67
1983	31.37	Aug12 - Aug21	26.62	8	39.10	2.62	61.90
1982	31.01	Aug08 - Aug17	26.45	9	42.86	2.33	57.14
1981	24.75	Sep17 - Sep26	26.35	10	47.62	2.10	52.38
1980	27.46	Aug21 - Aug30	25.55	11	52.38	1.90	47.62
1979	26.88	Oct15 - Oct24	25.54	12	57.14	1.75	42.86
1978	25.55	Aug21 - Aug30	25.07	13	61.90	1.61	38.10
1977	22.36	Sep23 - Oct02	24.75	14	66.67	1.50	33.33
1976	27.405	Oct14 - Oct23	24.36	15	71.43	1.40	28.57
1975	26.62	Aug08 - Aug17	23.10	16	76.20	1.31	23.80
1974	25.54	Aug08 - Aug17	23.10	17	80.95	1.23	19.05
1973	26.45	Aug27 - Sep05	23.08	18	85.72	1.17	14.28
1972	23.08	Sep29 - Oct08	22.36	19	90.48	1.10	9.52
1970	26.35	Aug22 - Aug31	19.03	20	95.24	1.05	4.76

$\bar{x}$ = 25.79 mm | T_x = 2 Yrs | T_x = 20 Yrs

s = 2.91 mm | K_T = -0.164 | K_T = 1.866

C_v = 0.113 | x_T = 25.31 mm | x_T = 31.22 mm

Table 3.2 : Observed 10 day drought during growing period of T.Aman and frequency of occurrence at Mohipur.

Year	Maximum 10-day drought, x mm	Period	Drought values in descending order, mm	Rank m	Plotting position m/(N+1), %	Return period Year	Non-exceedance probability $P_m = 1 - m/(N+1)$, %
1990	31.80	Oct23 - Nov01	34.98	1	4.76	20.01	95.24
1989	33.00	Jul25 - Aug03	33.705	2	9.52	10.50	90.48
1988	31.80	Oct23 - Nov01	33.285	3	14.28	7.00	85.72
1987	30.975	Oct21 - Oct30	33.00	4	19.05	5.25	80.95
1986	33.705	Oct21 - Oct30	32.865	5	23.80	4.20	76.20
1985	32.465	Oct01 - Oct10	32.86	6	28.57	3.50	71.43
1984	32.465	Oct01 - Oct10	32.465	7	33.33	3.00	66.67
1983	29.26	Nov04 - Nov13	32.465	8	39.10	2.62	61.90
1982	32.86	Oct12 - Oct21	31.80	9	42.86	2.33	57.14
1981	31.68	Sep19 - Sep28	31.80	10	47.62	2.10	52.38
1980	22.155	Oct19 - Oct28	31.68	11	52.38	1.90	47.62
1979	34.98	Aug08 - Aug17	30.975	12	57.14	1.75	42.86
1978	33.285	Oct21 - Oct30	30.40	13	61.90	1.61	38.10
1977	29.26	Nov04 - Nov13	30.31	14	66.67	1.50	33.33
1976	32.865	Oct12 - Oct21	29.26	15	71.43	1.40	28.57
1975	29.26	Nov04 - Nov13	29.26	16	76.20	1.31	23.80
1974	30.40	Nov04 - Nov13	29.26	17	80.95	1.23	19.05
1973	30.31	Oct15 - Oct24	29.26	18	85.72	1.17	14.28
1972	29.26	Nov04 - Nov13	23.285	19	90.48	1.10	9.52
1970	23.285	Oct04 - Oct13	22.155	20	95.24	1.05	4.76

$\bar{x}$ = 30.75 mm $\quad$ T_x = 2 Yrs $\quad$ T_x = 20 Yrs

s = 3.20 mm $\quad$ K_T = -0.164 $\quad$ K_T = 1.866

C_v = 0.104 $\quad$ x_T = 30.22 mm $\quad$ x_T = 36.72 mm

Table 3.3 : Observed 10 day drought during growing period of T.Aman and frequency of occurrence at Rangpur.

Year	Maximum 10-day drought, x mm	Period	Drought values in descending order, mm	Rank m	Plotting position m/(N+1), %	Return period Year	Non-exceedance probability $P_m = 1-m/(N+1)$, %
1990	28.14	Oct19 - Oct28	41.14	1	4.76	20.01	95.24
1989	32.56	Jul25 - Jul31	39.38	2	9.52	10.50	90.48
1988	28.14	Oct19 - Oct28	38.39	3	14.28	7.00	85.72
1987	25.41	Oct23 - Nov01	32.56	4	19.05	5.25	80.95
1986	39.38	Aug04 - Aug13	29.19	5	23.80	4.20	76.20
1985	26.71	Sep29 - Oct08	29.19	6	28.57	3.50	71.43
1984	25.13	Sep24 - Oct03	28.94	7	33.33	3.00	66.67
1983	41.14	Aug09 - Aug18	28.86	8	39.10	2.62	61.90
1982	38.39	Aug08 - Aug17	28.82	9	42.86	2.33	57.14
1981	29.19	Oct13 - Oct22	28.665	10	47.62	2.10	52.38
1980	28.665	Oct09 - Oct22	28.14	11	52.38	1.90	47.62
1979	28.82	Sep16 - Sep25	28.14	12	57.14	1.75	42.86
1978	29.19	Oct13 - Oct22	28.14	13	61.90	1.61	38.10
1977	28.86	Aug01 - Aug10	27.20	14	66.67	1.50	33.33
1976	27.20	Aug28 - Sep06	26.71	15	71.43	1.40	28.57
1975	25.305	Oct20 - Oct29	25.41	16	76.20	1.31	23.80
1974	25.00	Aug08 - Aug17	25.305	17	80.95	1.23	19.05
1973	28.94	Jul15 - Jul24	25.13	18	85.72	1.17	14.28
1972	22.68	Oct20 - Oct29	25.00	19	90.48	1.10	9.52
1971	28.14	Oct19 - Oct28	22.68	20	95.24	1.05	4.76

$\bar{x}$ = 29.35 mm T_x = 2 Yrs T_x = 20 Yrs

s = 4.93 mm K_T = -0.164 K_T = 1.866

C_v = 0.168 x_T = 28.54 mm x_T = 38.55 mm

Table 3.4 : Observed 10 day drought during growing period of T.Aman and frequency of occurrence at Nawabganj.

Year	Maximum 10-day drought, x mm	Period	Drought values in descending order, mm	Rank m	Plotting position m/(N+1), %	Return period Year	Non-exceedance probability P_m=1-m/(N+1), %
1987	28.35	Oct10 - Oct19	44.11	1	4.76	20.01	95.24
1986	37.07	Aug05 - Aug14	37.40	2	9.52	10.50	90.48
1985	31.50	Oct01 - Oct10	37.32	3	14.28	7.00	85.72
1983	34.54	Aug07 - Aug16	37.07	4	19.05	5.25	80.95
1981	28.77	Oct11 - Oct20	34.54	5	23.80	4.20	76.20
1980	28.625	Oct23 - Nov01	34.21	6	28.57	3.50	71.43
1979	37.40	Aug03 - Aug12	32.78	7	33.33	3.00	66.67
1978	31.50	Oct01 - Oct10	31.92	8	39.10	2.62	61.90
1977	28.77	Oct11 - Oct20	31.92	9	42.86	2.33	57.14
1976	31.92	Oct09 - Oct18	31.50	10	47.62	2.10	52.38
1975	34.21	Aug03 - Aug12	31.50	11	52.38	1.90	47.62
1974	28.77	Oct11 - Oct20	31.50	12	57.14	1.75	42.86
1973	32.78	Sep14 - Sep23	31.29	13	61.90	1.61	38.10
1972	31.92	Oct09 - Oct18	30.25	14	66.67	1.50	33.33
1971	31.50	Oct01 - Oct10	28.77	15	71.43	1.40	28.57
1970	30.25	Sep18 - Sep27	28.77	16	76.20	1.31	23.80
1969	44.11	Sep20 - Sep29	28.77	17	80.95	1.23	19.05
1968	28.455	Oct15 - Oct24	28.625	18	85.72	1.17	14.28
1967	37.32	Aug09 - Aug18	28.455	19	90.48	1.10	9.52
1966	31.29	Oct17 - Oct26	28.35	20	95.24	1.05	4.76

$\bar{x}$ = 32.45 mm　　T_x = 2 Yrs　　T_x = 20 Yrs

s = 4.04 mm　　K_T = -0.164　　K_T = 1.866

C_v = 0.124　　x_T = 31.79 mm　　x_T = 40.00 mm

Table 3.5 : Observed 10 day drought during growing period of T.Aman and frequency of occurrence at Shibganj.

Year	Maximum 10-day drought, x mm	Period	Drought values in descending order, mm	Rank m	Plotting position m/(N+1), %	Return period Year	Non-exceedance probability $P_m = 1 - m/(N+1)$, %
1986	45.87	Aug10 - Aug19	54.42	1	4.76	20.01	95.24
1985	34.71	Aug10 - Aug19	52.92	2	9.52	10.50	90.48
1984	44.87	Sep26 - Oct05	51.12	3	14.28	7.00	85.72
1983	50.41	Oct26 - Nov04	50.42	4	19.05	5.25	80.95
1980	54.42	Sep28 - Oct07	50.41	5	23.80	4.20	76.20
1979	51.12	Oct22 - Oct31	47.96	6	28.57	3.50	71.43
1978	37.07	Aug10 - Aug19	46.725	7	33.33	3.00	66.67
1977	40.73	Aug29 - Sep07	45.87	8	39.10	2.62	61.90
1976	44.88	Aug28 - Sep06	44.88	9	42.86	2.33	57.14
1975	52.92	Oct22 - Oct31	44.87	10	47.62	2.10	52.38
1974	47.96	Aug07 - Aug16	43.08	11	52.38	1.90	47.62
1973	40.055	Oct15 - Oct24	42.84	12	57.14	1.75	42.86
1972	37.635	Sep24 - Oct03	42.68	13	61.90	1.61	38.10
1971	36.19	Sep13 - Sep22	40.73	14	66.67	1.50	33.33
1970	43.08	Aug29 - Sep07	40.055	15	71.43	1.40	28.57
1969	42.68	Aug27 - Sep05	37.635	16	76.20	1.31	23.80
1968	50.42	Oct22 - Oct31	37.07	17	80.95	1.23	19.05
1967	28.91	Oct23 - Nov01	36.19	18	85.72	1.17	14.28
1966	42.84	Oct14 - Oct23	34.71	19	90.48	1.10	9.52
1965	46.725	Oct02 - Oct11	28.91	20	95.24	1.05	4.76

$\bar{x}$ = 43.67 mm $\quad$ T_x = 2 Yrs $\quad$ T_x = 20 Yrs

s = 6.65 mm $\quad$ K_T = -0.164 $\quad$ K_T = 1.866

C_v = 0.152 $\quad$ x_T = 42.58 mm $\quad$ x_T = 56.08 mm

Table 3.6 : Observed 10 day drought during critical growing period of T.Amon and frequency of occurrence at Kaliganj.

Year	Maximum 10-day drought, x mm	Period	Drought values in descending order, mm	Rank m	Plotting position m/(N+1), %	Return period Year	Non-exceedance probability $P_m = 1 - m/(N+1)$, %
1990	23.10	Oct21 - Oct30	26.88	1	4.76	20.01	95.24
1989	23.10	Oct21 - Oct30	26.88	2	9.52	10.50	90.48
1988	23.10	Oct21 - Oct30	26.04	3	14.28	7.00	85.72
1987	19.03	Oct21 - Oct30	24.99	4	19.05	5.25	80.95
1986	19.845	Oct20 - Oct29	24.175	5	23.80	4.20	76.20
1985	22.35	Oct28 - Nov06	23.10	6	28.57	3.50	71.43
1984	22.35	Oct28 - Nov06	23.10	7	33.33	3.00	66.67
1983	26.04	Oct15 - Oct24	23.10	8	39.10	2.62	61.90
1982	20.815	Oct29 - Nov07	22.95	9	42.86	2.33	57.14
1981	24.175	Oct24 - Nov02	22.35	10	47.62	2.10	52.38
1980	21.85	Nov04 - Nov13	22.35	11	52.38	1.90	47.62
1979	26.88	Oct15 - Oct24	22.35	12	57.14	1.75	42.86
1978	18.48	Oct15 - Oct24	21.85	13	61.90	1.61	38.10
1977	20.79	Oct15 - Oct24	20.815	14	66.67	1.50	33.33
1976	26.88	Oct15 - Oct24	20.79	15	71.43	1.40	28.57
1975	19.53	Oct21 - Oct30	20.245	16	76.20	1.31	23.80
1974	22.35	Oct28 - Nov06	19.845	17	80.95	1.23	19.05
1973	24.99	Oct17 - Oct26	19.53	18	85.72	1.17	14.28
1972	20.245	Oct31 - Nov09	19.03	19	90.48	1.10	9.52
1970	22.95	Nov02 - Nov11	18.48	20	95.24	1.05	4.76

$\overline{x}$ = 22.44 mm	T_x = 2 Yrs	T_x = 20 Yrs
s = 2.47 mm	K_T = -0.164	K_T = 1.866
C_v = 0.110	x_T = 22.03 mm	x_T = 27.05 mm

Table 3.7 : Observed 10 day drought during critical growing period of T.Amon and frequency of occurrence at Mohipur.

Year	Maximum 10-day drought, x mm	Period	Drought values in descending order, mm	Rank m	Plotting position m/(N+1), %	Return period Year	Non-exceedance probability $P_m = 1 - m/(N+1)$, %
1990	31.80	Oct21 - Oct30	33.705	1	4.76	20.01	95.24
1989	31.29	Oct22 - Sct30	33.285	2	9.52	10.50	90.48
1988	31.80	Oct23 - Nov01	31.93	3	14.28	7.00	85.72
1987	30.975	Oct21 - Oct30	31.80	4	19.05	5.25	80.95
1986	33.705	Oct20 - Oct30	31.80	5	23.80	4.20	76.20
1985	29.26	Nov04 - Nov13	31.80	6	28.57	3.50	71.43
1984	29.26	Nov04 - Nov13	31.29	7	33.33	3.00	66.67
1983	29.26	Nov04 - Nov13	30.975	8	39.10	2.62	61.90
1982	31.93	Oct26 - Nov04	30.40	9	42.86	2.33	57.14
1981	22.155	Oct19 - Oct28	30.31	10	47.62	2.10	52.38
1980	22.155	Oct19 - Oct28	29.26	11	52.38	1.90	47.62
1979	31.80	Oct23 - Nov01	29.26	12	57.14	1.75	42.86
1978	33.285	Oct21 - Oct30	29.26	13	61.90	1.61	38.10
1977	29.26	Nov04 - Nov13	29.26	14	66.67	1.50	33.33
1976	28.64	Oct25 - Nov03	29.26	15	71.43	1.40	28.57
1975	29.26	Nov04 - Nov13	29.26	16	76.20	1.31	23.80
1974	30.40	Nov04 - Nov13	28.64	17	80.95	1.23	19.05
1973	30.31	Oct15 - Oct24	22.155	18	85.72	1.17	14.28
1972	29.26	Nov04 - Nov13	22.155	19	90.48	1.10	9.52
1970	22.155	Nov04 - Nov13	22.155	20	95.24	1.05	4.76

$\bar{x}$ = 29.40 mm	T_x = 2 Yrs	T_x = 20 Yrs
s = 3.42 mm	K_T = -0.164	K_T = 1.866
C_v = 0.116	x_T = 28.84 mm	x_T = 35.82 mm

Table 3.8 : Observed 10 day drought during critical growing period of T.Amon and frequency of occurrence at Rangpur.

Year	Maximum 10-day drought, x mm	Period	Drought values in descending order, mm	Rank m	Plotting position m/(N+1), %	Return period Year	Non-exceedance probability $P_n = 1 - m/(N+1)$, %
1990	28.14	Oct19 - Oct28	29.19	1	4.76	20.01	95.24
1989	28.14	Oct19 - Oct28	29.19	2	9.52	10.50	90.48
1988	28.14	Oct19 - Oct28	28.875	3	14.28	7.00	85.72
1987	25.41	Oct23 - Nov01	28.14	4	19.05	5.25	80.95
1986	28.875	Oct19 - Oct28	28.14	5	23.80	4.20	76.20
1985	25.305	Oct20 - Oct29	28.14	6	28.57	3.50	71.43
1984	23.835	Oct23 - Nov01	28.14	7	33.33	3.00	66.67
1983	25.60	Oct27 - Nov05	25.935	8	39.10	2.62	61.90
1982	21.475	Oct27 - Nov05	25.725	9	42.86	2.33	57.14
1981	29.19	Oct13 - Oct22	25.60	10	47.62	2.10	52.38
1980	24.79	Oct23 - Nov01	25.41	11	52.38	1.90	47.62
1979	24.79	Oct23 - Nov01	25.305	12	57.14	1.75	42.86
1978	29.19	Oct15 - Oct24	25.305	13	61.90	1.61	38.10
1977	21.315	Oct15 - Oct24	24.79	14	66.67	1.50	33.33
1976	25.725	Oct17 - Oct26	24.79	15	71.43	1.40	28.57
1975	25.305	Oct20 - Oct29	23.835	16	76.20	1.31	23.80
1974	22.205	Oct20 - Oct29	22.68	17	80.95	1.23	19.05
1973	25.935	Oct19 - Oct28	22.205	18	85.72	1.17	14.28
1972	22.68	Oct20 - Oct29	21.405	19	90.48	1.10	9.52
1971	28.14	Oct19 - Oct28	21.315	20	95.24	1.05	4.76

$\overline{X}$ = 25.71 mm	T_x = 2 Yrs	T_x = 20 Yrs
s = 2.54 mm	K_T = -0.164	K_T = 1.866
C_v = 0.100	x_T = 25.30 mm	x_T = 30.44 mm

Table 3.9 : Observed 10 day drought during critical growing period of T.Amon and frequency of occurrence at Nawabganj.

Year	Maximum 10-day drought, x mm	Period	Drought values in descending order, mm	Rank m	Plotting position m/(N+1), %	Return period Year	Non-exceedance probability P_m=1-m/(N+1), %
1987	27.09	Oct21 - Oct30	31.29	1	4.76	20.01	95.24
1986	28.455	Oct21 - Oct30	31.29	2	9.52	10.50	90.48
1985	31.29	Oct17 - Oct26	31.29	3	14.28	7.00	85.72
1983	25.725	Oct15 - Oct24	31.29	4	19.05	5.25	80.95
1981	27.72	Oct16 - Oct25	31.29	5	23.80	4.20	76.20
1980	28.625	Oct23 - Nov01	29.505	6	28.57	3.50	71.43
1979	29.505	Oct15 - Oct24	29.505	7	33.33	3.00	66.67
1978	31.29	Oct15 - Oct24	29.505	8	39.10	2.62	61.90
1977	28.455	Oct15 - Oct24	29.505	9	42.86	2.33	57.14
1976	29.505	Oct15 - Oct24	28.625	10	47.62	2.10	52.38
1975	31.29	Nov17 - Oct26	28.455	11	52.38	1.90	47.62
1974	25.23	Oct23 - Nov02	28.455	12	57.14	1.75	42.86
1973	28.455	Oct21 - Oct30	28.455	13	61.90	1.61	38.10
1972	29.505	Oct15 - Oct24	28.455	14	66.67	1.50	33.33
1971	31.29	Oct17 - Oct26	28.455	15	71.43	1.40	28.57
1970	28.455	Oct21 - Oct30	28.455	16	76.20	1.31	23.80
1969	29.505	Oct15 - Oct24	27.72	17	80.95	1.23	19.05
1968	28.455	Oct16 - Oct25	27.09	18	85.72	1.17	14.28
1967	28.455	Oct21 - Oct30	25.725	19	90.48	1.10	9.52
1966	31.29	Oct17 - Oct26	25.23	20	95.24	1.05	4.76

$\bar{x}$ = 28.98 mm T_x = 2 Yrs T_x = 20 Yrs

s = 1.77 mm K_T = -0.164 K_T = 1.866

C_v = 0.061 x_T = 28.69 mm x_T = 32.28 mm

Table 3.10 : Observed 10 day drought during critical growing period of T.Amon and frequency of occurrence at Shibganj.

Year	Maximum 10-day drought, x mm	Period	Drought values in descending order, mm	Rank m	Plotting position m/(N+1), %	Return period Year	Non-exceedance probability P_m=1-m/(N+1), %
1986	44.835	Oct17 - Oct28	52.92	1	4.76	20.01	95.24
1985	27.85	Oct27 - Nov05	52.92	2	9.52	10.50	90.48
1984	39.44	Oct17 - Oct26	51.12	3	14.28	7.00	85.72
1983	50.41	Oct26 - Nov04	50.42	4	19.05	5.25	80.95
1980	52.92	Oct22 - Oct31	50.41	5	23.80	4.20	76.20
1979	51.12	Oct22 - Oct31	44.835	6	28.57	3.50	71.43
1978	28.91	Oct23 - Nov01	43.365	7	33.33	3.00	66.67
1977	38.43	Oct22 - Oct31	41.055	8	39.10	2.62	61.90
1976	43.365	Oct21 - Oct30	40.055	9	42.86	2.33	57.14
1975	52.92	Oct22 - Oct31	39.44	10	47.62	2.10	52.38
1974	36.155	Nov27 - Nov05	38.955	11	52.38	1.90	47.62
1973	40.055	Oct15 - Oct24	38.685	12	57.14	1.75	42.86
1972	28.56	Oct20 - Oct29	38.43	13	61.90	1.61	38.10
1971	28.91	Oct23 - Nov01	37.71	14	66.67	1.50	33.33
1970	38.685	Oct25 - Nov03	36.155	15	71.43	1.40	28.57
1969	41.055	Oct15 - Oct24	28.91	16	76.20	1.31	23.80
1968	50.42	Oct22 - Oct31	28.91	17	80.95	1.23	19.05
1967	28.91	Oct23 - Nov01	28.91	18	85.72	1.17	14.28
1966	38.955	Oct15 - Oct24	28.56	19	90.48	1.10	9.52
1965	37.71	Oct24 - Nov02	27.85	20	95.24	1.05	4.76

$\overline{x}$ = 39.98 mm T_x = 2 Yrs T_x = 20 Yrs

s = 8.53 mm K_T = -0.164 K_T = 1.866

C_v = 0.213 x_T = 38.58 mm x_T = 55.87 mm

Table 3.11 : Annual number of consecutive days with rainfall ≥ 6.0 mm and < 6.0 mm at Kaliganj.

Year	Annual maximum no. of consecutive days with rainfall ≥ 6.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 6.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1990	5	5	77	60	1	4.76
1989	5	5	60	60	2	9.52
1988	6	5	61	60	3	14.28
1987	13	6	60	61	4	19.05
1986	10	6	94	62	5	23.80
1985	13	6	68	62	6	28.57
1984	10	6	71	66	7	33.33
1983	7	7	62	68	8	39.10
1982	8	7	69	69	9	42.86
1981	10	8	60	71	10	47.62
1980	9	8	66	74	11	52.38
1979	6	9	105	74	12	57.14
1978	6	9	105	77	13	61.90
1977	7	10	90	85	14	66.67
1976	10	10	110	90	15	71.43
1975	5	10	95	94	16	76.20
1974	11	10	74	95	17	80.95
1973	9	11	62	105	18	85.72
1972	6	13	74	105	19	90.48
1970	8	13	85	110	20	95.24

$\bar{x}$ = 8.20 days	$\bar{x}$ = 77.40 days
s = 2.52 days	s = 16.85 days
C_v = 0.308	C_v = 0.218
$\bar{x}$ + s = 10.72 days	$\bar{x}$ + s = 94.25 days
$\bar{x}$ - s = 5.68 days	$\bar{x}$ - s = 60.55 days

Table 3.12 : Annual number of consecutive days with rainfall ≥ 6.0 mm and < 6.0 mm at Mohipur.

Year	Annual maximum no. of consecutive days with rainfall ≥ 6.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 6.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1990	9	5	82	47	1	4.76
1989	14	6	83	53	2	9.52
1988	12	6	59	57	3	14.28
1987	14	6	47	59	4	19.05
1986	12	7	92	62	5	23.80
1985	9	7	63	63	6	28.57
1984	11	7	125	67	7	33.33
1983	12	7	70	70	8	39.10
1982	7	8	103	71	9	42.86
1981	7	9	71	71	10	47.62
1980	9	9	71	73	11	52.38
1979	6	9	80	79	12	57.14
1978	6	9	88	80	13	61.90
1977	7	9	92	82	14	66.67
1976	9	11	79	83	15	71.43
1975	5	12	73	88	16	76.20
1974	7	12	67	92	17	80.95
1973	9	12	57	92	18	85.72
1972	8	14	62	103	19	90.48
1970	6	14	53	125	20	95.24

$\bar{x}$ = 8.95 days
s = 2.72 days
C_v = 0.304
$\bar{x}$ + s = 11.67 days
$\bar{x}$ - s = 6.23 days

$\bar{x}$ = 75.85 days
s = 18.43 days
C_v = 0.243
$\bar{x}$ + s = 94.28 days
$\bar{x}$ - s = 57.42 days

Table 3.13 : Annual number of consecutive days with rainfall ≥ 6.0 mm and < 6.0 mm at Rangpur.

Year	Annual maximum no. of consecutive days with rainfall ≥ 6.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 6.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1990	4	4	77	48	1	4.76
1989	8	4	84	55	2	9.52
1988	7	4	55	59	3	14.28
1987	9	5	72	62	4	19.05
1986	7	5	94	66	5	23.80
1985	5	6	70	70	6	28.57
1984	7	6	85	70	7	33.33
1983	9	6	79	71	8	39.10
1982	7	7	103	72	9	42.86
1981	6	7	70	74	10	47.62
1980	4	7	71	77	11	52.38
1979	10	7	66	79	12	57.14
1978	6	7	103	84	13	61.90
1977	11	8	90	85	14	66.67
1976	6	9	85	85	15	71.43
1975	9	9	95	90	16	76.20
1974	7	9	74	94	17	80.95
1973	10	10	48	95	18	85.72
1972	5	10	62	103	19	90.48
1971	4	11	59	103	20	95.24

$\bar{x}$ = 7.05 days	$\bar{x}$ = 77.10 days
s = 2.11 days	s = 15.35 days
C_v = 0.300	C_v = 0.200
$\bar{x}$ + s = 9.16 days	$\bar{x}$ + s = 92.45 days
$\bar{x}$ - s = 4.94 days	$\bar{x}$ - s = 61.75 days

Table 3.14 : Annual number ofconsecutive days with rainfall ≥ 6.0 mm and < 6.0 mm at Nawabganj.

Year	Annual maximum no. of consecutive days with rainfall ≥ 6.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 6.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1987	6	3	72	34	1	4.76
1986	7	3	92	58	2	9.52
1985	5	4	74	68	3	14.28
1983	6	5	34	69	4	19.05
1981	6	5	69	71	5	23.80
1980	5	5	71	72	6	28.57
1979	7	5	109	74	7	33.33
1978	3	5	103	79	8	39.10
1977	8	5	97	81	9	42.86
1976	6	6	116	85	10	47.62
1975	3	6	134	87	11	52.38
1974	5	6	87	87	12	57.14
1973	6	6	58	92	13	61.90
1972	6	6	145	97	14	66.67
1971	10	6	68	103	15	71.43
1970	4	6	79	109	16	76.20
1969	5	7	81	116	17	80.95
1968	6	7	87	116	18	85.72
1967	5	8	85	134	19	90.48
1966	5	10	116	145	20	95.24

$\bar{x}$ = 5.70 days
s = 1.60 days
C_v = 0.280
$\bar{x}$ + s = 7.30 days
$\bar{x}$ - s = 4.10 days

$\bar{x}$ = 88.85 days
s = 26.30 days
C_v = 0.296
$\bar{x}$ + s = 115.15 days
$\bar{x}$ - s = 62.55 days

Table 3.15 : Annual number of consecutive days with rainfall ≥ 6.0 mm and < 6.0 mm at Shibganj.

Year	Annual maximum no. of consecutive days with rainfall ≥ 6.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 6.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1986	6	4	45	45	1	4.76
1985	5	4	75	48	2	9.52
1984	7	4	58	48	3	14.28
1983	7	4	62	55	4	19.05
1980	4	4	110	58	5	23.80
1979	6	5	62	60	6	28.57
1978	5	5	60	62	7	33.33
1977	4	5	55	62	8	39.10
1976	4	5	72	63	9	42.86
1975	5	5	78	67	10	47.62
1974	6	5	81	72	11	52.38
1973	5	6	48	75	12	57.14
1972	4	6	95	77	13	61.90
1971	7	6	91	78	14	66.67
1970	5	6	48	81	15	71.43
1969	7	7	77	82	16	76.20
1968	10	7	67	91	17	80.95
1967	4	7	63	95	18	85.72
1966	6	7	116	110	19	90.48
1965	5	10	82	116	20	95.24

$\bar{x}$ = 5.60 days	$\bar{x}$ = 72.25 days
s = 1.50 days	s = 19.65 days
C_v = 0.268	C_v = 0.272
$\bar{x}$ + s = 7.10 days	$\bar{x}$ + s = 91.90 days
$\bar{x}$ - s = 4.10 days	$\bar{x}$ - s = 52.60 days

Table 3.16 : Annual number of consecutive days with rainfall ≥ 3.0 mm and < 3.0 mm at Kaliganj.

Year	Annual maximum no. of consecutive days with rainfall ≥ 3.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 3.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1990	7	6	76	42	1	4.76
1989	7	6	60	53	2	9.52
1988	9	6	53	53	3	14.28
1987	13	7	60	60	4	19.05
1986	10	7	94	60	5	23.80
1985	13	8	68	60	6	28.57
1984	11	9	71	62	7	33.33
1983	9	9	62	65	8	39.10
1982	9	9	65	66	9	42.86
1981	10	9	60	66	10	47.62
1980	10	9	66	68	11	52.38
1979	13	10	66	68	12	57.14
1978	6	10	88	71	13	61.90
1977	8	10	90	74	14	66.67
1976	10	10	53	74	15	71.43
1975	6	11	95	76	16	76.20
1974	12	12	74	88	17	80.95
1973	9	13	42	90	18	85.72
1972	6	13	74	94	19	90.48
1970	9	13	68	95	20	95.24

$\overline{x}$ = 9.35 days	$\overline{x}$ = 69.25 days
s = 2.28 days	s = 14.09 days
C_v = 0.244	C_v = 0.203
$\overline{x}$ + s = 11.63 days	$\overline{x}$ + s = 83.34 days
$\overline{x}$ - s = 7.07 days	$\overline{x}$ - s = 55.16 days

Table 3.17 : Annual number of consecutive days with rainfall $\geq$ 3.0 mm and < 3.0 mm at Mohipur.

Year	Annual maximum no. of consecutive days with rainfall $\geq$ 3.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 3.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1990	9	6	82	47	1	4.76
1989	14	6	83	49	2	9.52
1988	13	7	59	52	3	14.28
1987	14	7	47	59	4	19.05
1986	14	7	92	59	5	23.80
1985	18	8	63	62	6	28.57
1984	11	8	108	63	7	33.33
1983	12	9	70	67	8	39.10
1982	9	9	103	70	9	42.86
1981	7	9	70	70	10	47.62
1980	9	9	71	70	11	52.38
1979	6	9	59	71	12	57.14
1978	7	11	70	73	13	61.90
1977	7	12	90	74	14	66.67
1976	9	12	74	82	15	71.43
1975	6	13	73	83	16	76.20
1974	8	14	67	90	17	80.95
1973	9	14	49	92	18	85.72
1972	8	14	62	103	19	90.48
1970	12	18	52	108	20	95.24

$\bar{x}$ = 10.10 days	$\bar{x}$ = 72.20 days
s = 3.26 days	s = 16.73 days
C_v = 0.322	C_v = 0.232
$\bar{x}$ + s = 13.36 days	$\bar{x}$ + s = 88.93 days
$\bar{x}$ - s = 6.84 days	$\bar{x}$ - s = 55.47 days

Table 3.18 : Annual number of consecutive days with rainfall ≥ 3.0 mm and < 3.0 mm at Rangpur.

Year	Annual maximum no. of consecutive days with rainfall ≥ 3.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 3.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1990	8	5	76	48	1	4.76
1989	10	5	80	53	2	9.52
1988	8	6	53	53	3	14.28
1987	15	7	72	58	4	19.05
1986	9	7	94	59	5	23.80
1985	10	8	70	62	6	28.57
1984	9	8	53	66	7	33.33
1983	16	8	74	70	8	39.10
1982	8	8	103	70	9	42.86
1981	8	9	70	70	10	47.62
1980	5	9	70	72	11	52.38
1979	13	9	66	74	12	57.14
1978	6	10	58	74	13	61.90
1977	13	10	90	76	14	66.67
1976	10	10	85	78	15	71.43
1975	9	10	78	80	16	76.20
1974	7	13	74	85	17	80.95
1973	10	13	48	90	18	85.72
1972	5	15	62	94	19	90.48
1971	7	16	59	103	20	95.24

$\bar{x}$ = 9.30 days
s = 3.01 days
C_v = 0.323
$\bar{x}$ + s = 12.31 days
$\bar{x}$ - s = 6.29 days

$\bar{x}$ = 71.75 days
s = 14.27 days
C_v = 0.200
$\bar{x}$ + s = 86.02 days
$\bar{x}$ - s = 57.47 days

Table 3.19 : Annual number of consecutive days with rainfall ≥ 3.0 mm and < 3.0 mm at Nawabganj.

Year	Annual maximum no. of consecutive days with rainfall ≥ 3.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 3.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1987	11	4	72	34	1	4.76
1986	7	5	92	55	2	9.52
1985	8	5	74	65	3	14.28
1983	6	5	34	69	4	19.05
1981	6	5	69	71	5	23.80
1980	5	5	71	72	6	28.57
1979	7	6	108	74	7	33.33
1978	6	6	103	75	8	39.10
1977	8	6	97	81	9	42.86
1976	6	6	110	83	10	47.62
1975	4	6	134	85	11	52.38
1974	7	6	87	87	12	57.14
1973	6	6	55	92	13	61.90
1972	6	7	145	97	14	66.67
1971	11	7	65	103	15	71.43
1970	5	7	75	108	16	76.20
1969	5	8	81	110	17	80.95
1968	6	8	85	116	18	85.72
1967	5	11	83	134	19	90.48
1966	5	11	116	145	20	95.24

$\bar{x}$ = 6.50 days
s = 1.85 days
C_v = 0.284
$\bar{x}$ + s = 8.35 days
$\bar{x}$ - s = 4.65 days

$\bar{x}$ = 87.80 days
s = 26.40 days
C_v = 0.300
$\bar{x}$ + s = 114.20 days
$\bar{x}$ - s = 61.40 days

Table 3.20 : Annual number of consecutive days with rainfall ≥ 3.0 mm and < 3.0 mm at Shibganj.

Year	Annual maximum no. of consecutive days with rainfall ≥ 3.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 3.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1986	7	4	45	45	1	4.76
1985	6	4	72	47	2	9.52
1984	8	4	58	48	3	14.28
1983	9	5	62	51	4	19.05
1980	4	5	71	54	5	23.80
1979	10	5	51	55	6	28.57
1978	5	5	70	58	7	33.33
1977	5	5	55	62	8	39.10
1976	4	6	72	62	9	42.86
1975	5	6	78	63	10	47.62
1974	6	7	81	67	11	52.38
1973	5	7	47	70	12	57.14
1972	4	7	62	71	13	61.90
1971	7	7	91	72	14	66.67
1970	7	7	48	72	15	71.43
1969	7	7	54	78	16	76.20
1968	10	8	67	81	17	80.95
1967	7	9	63	81	18	85.72
1966	7	10	116	91	19	90.48
1965	5	10	81	116	20	95.24

$\overline{x}$ = 6.40 days	$\overline{x}$ = 67.20 days
s = 1.85 days	s = 17.05 days
C_v = 0.289	C_v = 0.254
$\overline{x}$ + s = 8.25 days	$\overline{x}$ + s = 84.25 days
$\overline{x}$ - s = 4.55 days	$\overline{x}$ - s = 50.15 days

Table 3.21 : Annual number of consecutive days with rainfall ≥ 1.0 mm and < 1.0 mm at Kaliganj.

Year	Annual maximum no. of consecutive days with rainfall ≥ 1.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 1.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1990	9	6	75	34	1	4.76
1989	7	7	54	36	2	9.52
1988	11	7	53	42	3	14.28
1987	20	7	60	47	4	19.05
1986	10	8	74	50	5	23.80
1985	14	9	68	51	6	28.57
1984	11	9	53	53	7	33.33
1983	11	10	62	53	8	39.10
1982	9	10	51	54	9	42.86
1981	19	10	50	54	10	47.62
1980	10	11	66	54	11	52.38
1979	13	11	36	56	12	57.14
1978	7	11	58	58	13	61.90
1977	8	12	54	60	14	66.67
1976	10	13	47	62	15	71.43
1975	6	14	73	66	16	76.20
1974	12	15	54	68	17	80.95
1973	16	16	42	73	18	85.72
1972	7	19	34	74	19	90.48
1970	15	20	56	75	20	95.24

$\bar{x}$ = 11.25 days
s = 3.92 days
C_v = 0.348
$\bar{x} + s$ = 15.17 days
$\bar{x} - s$ = 7.33 days

$\bar{x}$ = 56.00 days
s = 11.53 days
C_v = 0.206
$\bar{x} + s$ = 67.53 days
$\bar{x} - s$ = 44.47 days

Table 3.22 : Annual number of consecutive days with rainfall ≥ 1.0 mm and < 1.0 mm at Mohipur.

Year	Annual maximum no. of consecutive days with rainfall ≥ 1.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 1.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1990	9	6	82	42	1	4.76
1989	14	7	83	47	2	9.52
1988	13	7	51	49	3	14.28
1987	15	9	47	51	4	19.05
1986	14	9	92	53	5	23.80
1985	18	9	63	58	6	28.57
1984	11	9	107	59	7	33.33
1983	14	10	70	61	8	39.10
1982	11	10	65	63	9	42.86
1981	7	10	70	65	10	47.62
1980	10	10	70	67	11	52.38
1979	6	11	59	70	12	57.14
1978	9	11	58	70	13	61.90
1977	7	12	53	70	14	66.67
1976	9	13	72	72	15	71.43
1975	9	14	72	72	16	76.20
1974	10	14	67	82	17	80.95
1973	10	14	42	83	18	85.72
1972	10	15	61	92	19	90.48
1970	12	18	49	107	20	95.24

$\bar{x}$ = 10.90 days
s = 3.02 days
C_v = 0.277
$\bar{x}$ + s = 13.92 days
$\bar{x}$ - s = 7.88 days

$\bar{x}$ = 66.65 days
s = 15.86 days
C_v = 0.238
$\bar{x}$ + s = 82.51 days
$\bar{x}$ - s = 50.79 days

Table 3.23 : Annual number of consecutive days with rainfall ≥ 1.0 mm and < 1.0 mm at Rangpur.

Year	Annual maximum no. of consecutive days with rainfall ≥ 1.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 1.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1990	10	6	76	44	1	4.76
1989	19	7	56	53	2	9.52
1988	13	7	53	53	3	14.28
1987	15	7	72	54	4	19.05
1986	9	8	94	55	5	23.80
1985	16	9	70	55	6	28.57
1984	11	9	53	56	7	33.33
1983	17	10	62	58	8	39.10
1982	11	10	60	60	9	42.86
1981	9	11	70	61	10	47.62
1980	7	11	70	62	11	52.38
1979	17	11	54	63	12	57.14
1978	7	13	58	70	13	61.90
1977	13	13	55	70	14	66.67
1976	10	15	81	70	15	71.43
1975	11	16	78	72	16	76.20
1974	7	16	63	76	17	80.95
1973	16	17	44	78	18	85.72
1972	6	17	61	81	19	90.48
1971	8	19	55	94	20	95.24

$\bar{x}$ = 11.60 days
s = 3.94 days
C_v = 0..339
$\bar{x}$ + s = 15.54 days
$\bar{x}$ - s = 7.66 days

$\bar{x}$ = 64.25 days
s = 12.00 days
C_v = 0.187
$\bar{x}$ + s = 76.25 days
$\bar{x}$ - s = 52.23 days

Table 3.24 : Annual number of consecutive days with rainfall ≥ 1.0 mm and < 1.0 mm at Nawabganj.

Year	Annual maximum no. of consecutive days with rainfall ≥ 1.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 1.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1987	11	4	72	34	1	4.76
1986	7	5	92	55	2	9.52
1985	13	5	74	65	3	14.28
1983	6	5	34	68	4	19.05
1981	11	5	68	71	5	23.80
1980	5	5	71	72	6	28.57
1979	7	6	108	74	7	33.33
1978	6	6	103	75	8	39.10
1977	8	6	97	81	9	42.86
1976	7	6	109	83	10	47.62
1975	4	6	134	85	11	52.38
1974	7	7	87	87	12	57.14
1973	6	7	55	92	13	61.90
1972	6	7	145	97	14	66.67
1971	12	7	65	103	15	71.43
1970	5	8	75	108	16	76.20
1969	5	11	81	109	17	80.95
1968	6	11	85	113	18	85.72
1967	5	12	83	134	19	90.48
1966	5	13	113	145	20	95.24

$\bar{x}$ = 7.10 days

s = 2.59 days

C_v = 0.364

$\bar{x}$ + s = 9.69 days

$\bar{x}$ - s = 4.51 days

$\bar{x}$ = 87.55 days

s = 26.23 days

C_v = 0.300

$\bar{x}$ + s = 113.78 days

$\bar{x}$ - s = 61.32 days

Table 3.25 : Annual number of consecutive days with rainfall ≥ 1.0 mm and < 1.0 mm at Shibganj.

Year	Annual maximum no. of consecutive days with rainfall ≥ 1.0 mm, x	Values arranged in ascending order	Annual maximum no. of consecutive days with rainfall < 1.0 mm, x	Values arranged in ascending order	Rank m	Plotting position m=(N+1), %
1986	7	5	46	45	1	4.76
1985	9	5	72	47	2	9.52
1984	12	6	53	48	3	14.28
1983	9	6	62	51	4	19.05
1980	8	7	70	54	5	23.80
1979	14	7	34	55	6	28.57
1978	6	7	63	58	7	33.33
1977	11	7	51	62	8	39.10
1976	7	7	48	62	9	42.86
1975	5	8	74	63	10	47.62
1974	6	8	66	64	11	52.38
1973	7	9	47	67	12	57.14
1972	5	9	62	70	13	61.90
1971	8	9	83	70	14	66.67
1970	7	10	48	71	15	71.43
1969	11	11	54	72	16	76.20
1968	10	11	67	72	17	80.95
1967	7	12	63	78	18	85.72
1966	9	13	64	82	19	90.48
1965	12	14	70	91	20	95.24

$\bar{x}$ = 8.55 days	$\bar{x}$ = 64.10 days
s = 2.58 days	s = 12.16 days
C_v = 0.302	C_v = 0.200
$\bar{x}$ + s = 11.13 days	$\bar{x}$ + s = 76.26 days
$\bar{x}$ - s = 5.97 days	$\bar{x}$ - s = 51.94 days

Table 3.26 : Class and frequency of consecutive rainfall days (rainfall ≥ 6.0 mm, 3.0 mm and 1.0 mm) at Kaliganj.

a) Rainfall ≥ 6.0 mm

Class days	frequency	Class mark × freq.
2.5 - 5.5	3	12
5.5 - 8.5	8	56
8.5 - 11.5	7	70
11.5 - 14.5	2	26
Σ	20	164

$\overline{X}$ = 164/20 = 8.2 days

b) Rainfall ≥ 3.0 mm

Class days	frequency	Class mark × freq.
3.5 - 6.5	3	15
6.5 - 9.5	8	64
9.5 - 12.5	6	66
12.5 - 15.5	3	42
Σ	20	187

$\overline{X}$ = 187/20 = 9.35 days

c) Rainfall ≥ 1.0 mm

Class days	frequency.	Class mark × freq.
5.5 - 8.5	5	35
8.5 - 11.5	8	80
11.5 - 14.5	3	39
14.5 - 17.5	2	32
17.5 - 20.5	2	38
Σ	20	224

$\overline{X}$ = 224/20 = 11.2 days

Table 3.27 : Class and frequency of consecutive rainfall days (rainfall ≥ 6.0 mm, 3.0 mm and 1.0 mm) at Mohipur.

a) Rainfall ≥ 6.0 mm

Class days	frequency	Class mark × freq.
3.5 - 6.5	4	20
6.5 - 9.5	10	80
9.5 - 12.5	4	44
12.5 - 15.5	2	28
Σ	20	172

$\overline{X}$ = 172/20 = 8.6 days

b) Rainfall ≥ 3.0 mm

Class days	frequency	Class mark × freq.
4.5 - 7.5	5	30
7.5 - 10.5	7	63
10.5 - 13.5	4	48
13.5 - 16.5	3	45
16.5 - 19.5	1	18
Σ	20	204

$\overline{X}$ = 204/20 = 10.2 days

c) Rainfall ≥ 1.0 mm

Class days	frequency	Class mark × freq.
3.5 - 6.5	1	5
6.5 - 9.5	6	48
9.5 - 12.5	7	77
12.5 - 15.5	5	70
15.5 - 18.5	1	17
Σ	20	217

$\overline{X}$ = 217/20 = 10.85 days

Table 3.28 : Class and frequency of consecutive rainfall days (rainfall ≥ 6.0 mm, 3.0 mm and 1.0 mm) at Rangpur.

a) Rainfall ≥ 6.0 mm

Class days	frequency	Class mark × freq.
3.5 - 5.5	5	22.5
5.5 - 7.5	8	52.0
7.5 - 9.5	4	34.0
9.5 - 11.5	3	31.5
Σ	20	140

$\overline{X}$ = 140/20 = 7.0 days

b) Rainfall ≥ 3.0 mm

Class days	frequency	Class mark × freq.
4.5 - 7.5	5	30
7.5 - 10.5	11	99
10.5 - 13.5	3	24
13.5 - 16.5	1	30
Σ	20	183

$\overline{X}$ = 183/20 = 9.15 days

c) Rainfall ≥ 1.0 mm

Class days	frequency.	Class mark × freq.
3.5 - 8.5	5	27.5
8.5 - 13.5	9	94.5
13.5 - 18.5	5	77.5
18.5 - 23.5	1	20.5
Σ	20	220

$\overline{X}$ = 220/20 = 11.0 days

Table 3.29 : Class and frequency of consecutive rainfall days (rainfall ≥ 6.0 mm, 3.0 mm and 1.0 mm) at Nawabganj.

a) Rainfall ≥ 6.0 mm

Class days	frequency	Class mark × freq.
2.5 - 4.5	3	10.5
4.5 - 6.5	13	71.5
6.5 - 8.5	3	22.5
8.5 - 10.5	1	9.5
Σ	20	114

$\overline{X}$ = 114/20 = 5.7 days

b) Rainfall ≥ 3.0 mm

Class days	frequency	Class mark × freq.
3.5 - 5.5	6	27
5.5 - 7.5	10	65
7.5 - 9.5	2	17
9.5 - 11.5	2	21
Σ	20	130

$\overline{X}$ = 130/20 = 6.5 days

c) Rainfall ≥ 1.0 mm

Class days	frequency.	Class mark × freq.
2.5 - 5.5	6	24
5.5 - 8.5	10	70
8.5 - 11.5	2	20
11.5 - 14.5	2	26
Σ	20	140

$\overline{X}$ = 140/20 = 7.0 days

Table 3.30 : Class and frequency of consecutive rainfall days (rainfall ≥ 6.0 mm, 3.0 mm and 1.0 mm) at Shibganj.

a) Rainfall ≥ 6.0 mm

Class days	frequency	Class mark × freq.
2.5 - 4.5	5	17.5
4.5 - 6.5	10	55.0
6.5 - 8.5	4	30.0
8.5 - 10.5	1	9.5
Σ	20	112

$\overline{X}$ = 112/20 = 5.6 days

b) Rainfall ≥ 3.0 mm

Class days	frequency	Class mark × freq.
1.5 - 4.5	3	9
4.5 - 7.5	13	78
7.5 - 10.5	4	36
Σ	20	123

$\overline{X}$ = 123/20 = 6.15 days

c) Rainfall ≥ 1.0 mm

Class days	frequency.	Class mark × freq.
3.5 - 6.5	4	20
6.5 - 9.5	10	80
9.5 - 12.5	4	44
12.5 - 15.5	2	28
Σ	20	172

$\overline{X}$ = 172/20 = 8.60 days

Table 3.31 : Monthly distribution of average dry-day sequences (rainfall < 6.0 mm) and frequency of dry-day sequences ≥ 25 days at Kaliganj.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	31	14	12	11	4	8	3	9	6	16	30	31
1989	31	18	31	30	8	6	9	11	3	20	29	31
1988	31	23	21	15	8	9	7	4	13	31	29	31
1987	31	22	16	22	16	6	4	17	4	15	29	31
1986	31	28	31	21	8	5	5	14	8	13	19	16
1985	31	15	26	20	7	4	5	7	7	7	30	31
1984	15	20	26	19	6	5	3	5	8	10	30	31
1983	31	22	20	27	6	4	8	10	5	8	30	26
1982	31	28	19	13	12	5	6	12	4	22	30	31
1981	24	17	30	16	5	7	8	4	9	20	30	19
1980	31	28	29	19	2	10	7	9	5	12	30	31
1979	31	28	31	15	9	14	9	7	9	12	27	29
1978	31	28	31	15	11	9	6	10	6	31	30	31
1977	31	28	31	7	6	7	6	11	6	9	17	27
1976	31	28	31	20	8	8	7	8	24	31	27	31
1975	31	28	31	13	6	6	3	9	7	14	30	31
1974	14	28	25	10	5	6	7	11	6	14	30	31
1973	22	27	21	21	11	3	11	5	10	16	30	31
1972	31	28	21	9	15	4	15	8	11	12	30	31
1970	31	27	21	20	11	9	8	10	8	19	30	31
Av.	28.55	24.25	25.20	17.15	8.20	6.75	6.85	9.05	7.95	16.60	28.35	29.10
Freq. ≥ 25 days	16	12	12	2	0	0	0	0	0	3	18	18

Table 3.32 : Monthly distribution of average dry-day sequences (rainfall < 6.0 mm) and frequency of dry-day sequences ≥ 25 days at Mohipur.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	31	12	12	8	5	8	4	3	2	21	30	31
1989	22	18	31	30	11	8	11	6	5	22	30	31
1988	31	23	31	15	11	7	6	6	11	31	28	31
1987	31	24	18	18	6	8	4	9	15	11	16	31
1986	31	28	31	13	9	6	12	19	6	20	30	17
1985	31	14	16	10	10	3	3	9	7	12	30	28
1984	15	20	25	9	6	7	3	7	30	31	30	31
1983	31	23	19	24	5	7	4	11	6	14	30	26
1982	31	28	31	13	12	4	5	18	6	22	20	31
1981	24	17	26	8	7	13	6	5	7	31	30	20
1980	31	28	21	18	3	10	6	7	3	10	30	31
1979	31	20	31	30	9	6	6	14	12	21	27	28
1978	31	28	28	13	12	4	9	10	10	31	27	31
1977	31	28	31	11	6	11	6	7	8	18	26	27
1976	31	22	31	20	5	10	13	9	16	20	27	31
1975	31	28	22	15	5	17	5	15	7	14	30	31
1974	16	28	23	7	8	6	8	5	7	16	30	31
1973	22	28	21	21	7	3	11	6	12	15	18	21
1972	31	14	25	10	14	4	9	6	10	11	30	31
1970	31	27	20	14	11	7	7	10	12	13	29	31
Av.	28.20	22.90	24.65	15.35	8.10	7.45	6.90	9.10	9.60	19.20	27.40	28.50
Freq. ≥ 25 days	15	9	11	2	0	0	0	0	1	4	17	17

Table 3.33 : Monthly distribution of average dry-day sequences (rainfall < 6.0 mm) and frequency of dry-day sequences ≥ 25 days at Rangpur.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	31	13	10	11	4	7	8	10	8	16	30	31
1989	31	18	31	30	10	7	10	6	5	23	30	31
1988	31	24	21	17	8	8	6	7	10	25	28	31
1987	31	23	15	23	13	5	2	6	4	11	30	31
1986	31	28	31	13	6	7	12	16	6	13	19	31
1985	31	21	27	18	8	5	3	6	5	13	30	27
1984	31	28	26	16	6	5	5	7	8	9	30	16
1983	31	28	20	13	6	7	11	17	7	9	30	26
1982	31	28	31	13	12	4	5	15	7	22	21	31
1981	23	17	24	15	6	17	8	5	8	31	30	21
1980	31	17	29	29	5	12	8	6	2	12	30	31
1979	31	20	31	15	14	13	11	7	11	19	28	30
1978	21	28	31	13	15	8	10	7	5	19	27	31
1977	31	28	31	7	4	4	6	11	8	23	25	27
1976	30	22	31	20	8	8	10	9	7	24	30	31
1975	31	28	31	13	6	7	4	17	7	17	30	31
1974	17	28	23	7	9	8	8	5	5	13	30	31
1973	22	27	23	27	9	5	19	6	4	9	11	21
1972	31	14	26	30	14	12	9	12	8	11	30	31
1971	31	27	27	6	5	6	8	6	6	22	28	31
Av.	29.45	23.35	25.95	16.80	8.40	7.75	8.20	9.05	6.60	17.05	27.35	28.55
Freq. ≥ 25 days	17	10	13	4	0	0	0	0	0	2	17	17

Table 3.34 : Monthly distribution of average dry-day sequences (rainfall < 6.0 mm) and frequency of dry-day sequences ≥ 25 days at Nawabganj.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1987	31	26	19	14	14	7	6	7	5	17	30	31
1986	31	28	31	11	5	10	10	16	9	13	30	17
1985	31	28	31	20	7	5	3	11	5	16	30	31
1983	31	28	31	31	4	16	15	9	8	9	25	31
1981	31	27	31	15	9	14	10	5	9	31	30	21
1980	31	18	31	26	3	10	7	8	4	11	30	31
1979	31	28	31	19	18	8	7	12	18	25	28	29
1978	31	28	31	13	7	6	5	11	6	31	30	31
1977	31	28	31	7	15	5	3	9	6	24	26	31
1976	31	28	31	26	7	9	14	4	19	31	30	31
1975	31	28	31	30	14	17	6	18	8	19	30	31
1974	31	28	28	12	9	10	10	14	6	21	30	31
1973	31	27	24	24	9	4	10	18	10	19	27	31
1972	31	28	31	30	25	5	13	5	16	29	30	31
1971	25	28	31	30	7	7	4	8	13	31	30	31
1970	20	28	31	16	16	9	8	7	11	22	25	31
1969	31	28	19	9	11	11	13	10	6	20	30	31
1968	31	28	18	21	11	4	5	14	9	26	30	31
1967	31	28	12	17	24	13	13	23	16	24	30	31
1966	31	28	31	26	19	13	10	6	13	13	22	31
Av.	30.15	27.30	27.70	19.85	11.70	9.15	8.60	10.75	9.85	21.60	28.65	29.70
Freq. ≥ 25 days	19	19	15	7	1	0	0	0	0	7	19	18

Table 3.35 : Monthly distribution of average dry-day sequences (rainfall < 6.0 mm) and frequency of dry-day sequences ≥ 25 days at Shibganj.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	31	14	31	15	10	8	11	10	7	13	21	16
1985	31	22	31	22	6	9	4	7	5	12	30	27
1984	16	28	26	27	7	6	6	12	10	15	30	17
1983	31	28	31	27	8	11	11	8	5	9	30	26
1980	28	28	31	20	5	11	6	3	7	10	30	31
1979	19	20	31	12	31	15	8	12	5	17	28	30
1978	31	28	12	15	7	9	11	9	12	26	27	31
1977	31	24	31	9	7	2	6	9	5	10	24	27
1976	31	21	23	26	7	6	16	9	6	16	30	31
1975	31	26	31	21	8	8	7	19	7	13	30	31
1974	31	28	23	13	9	9	2	11	7	12	30	31
1973	22	27	31	24	7	5	5	8	6	17	21	21
1972	31	28	31	24	22	8	7	6	9	22	30	31
1971	26	27	31	7	12	6	3	4	11	30	30	31
1970	20	19	23	13	9	7	5	11	10	11	17	31
1969	31	28	19	16	14	8	10	6	5	20	19	31
1968	23	28	16	18	13	11	8	5	14	22	29	31
1967	23	28	12	18	8	12	9	6	5	22	25	31
1966	31	28	31	26	15	9	6	4	8	27	21	31
1965	31	28	23	28	11	6	18	5	16	10	30	31
Av.	27.45	25.40	25.90	19.05	10.80	8.30	7.95	8.20	8.00	16.70	26.60	28.35
Freq. ≥ 25 days	14	14	12	5	1	0	0	0	0	3	14	17

Table 3.36 : Monthly distribution of average dry-day sequences (rainfall < 3.0 mm) and frequency of dry-day sequences ≥ 25 days at Kaliganj.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	31	14	12	11	2	7	2	9	5	14	30	31
1989	31	28	31	30	8	4	5	4	3	13	29	31
1988	31	22	21	15	8	8	4	4	13	25	24	31
1987	31	22	16	9	16	5	2	17	4	10	29	31
1986	31	28	31	21	8	5	5	14	5	13	19	16
1985	31	15	26	20	7	4	3	7	5	7	30	31
1984	15	19	26	14	5	5	3	5	8	10	30	26
1983	28	22	20	14	6	4	8	10	5	8	30	31
1982	31	28	19	13	12	3	6	6	4	22	20	19
1981	24	17	27	7	5	7	8	4	9	20	30	31
1980	31	28	29	19	2	10	6	9	4	11	30	29
1979	31	20	31	15	9	14	9	7	9	12	27	31
1978	31	28	29	15	11	6	6	10	5	27	27	27
1977	31	28	31	7	6	7	6	6	6	9	17	31
1976	31	22	21	20	6	8	7	8	24	27	27	31
1975	31	28	31	13	5	6	2	9	5	12	30	31
1974	14	28	23	8	5	6	7	11	6	14	30	21
1973	22	27	21	21	9	2	9	5	10	14	30	31
1972	31	28	20	9	9	15	4	15	8	12	30	31
1970	31	27	20	18	9	8	7	8	8	15	27	31
Av.	28.40	23.45	23.95	14.95	7.40	6.70	5.45	8.40	7.30	14.75	27.30	28.60
Freq. ≥ 25 days	16	11	10	1	0	0	0	0	0	3	16	17

Table 3.37 : Monthly distribution of average dry-day sequences (rainfall < 3.0 mm) and frequency of dry-day sequences ≥ 25 days at Mohipur.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	31	12	12	8	5	8	4	3	2	21	30	31
1989	22	18	31	30	11	8	11	6	5	22	30	31
1988	31	13	31	15	11	7	6	6	11	31	28	31
1987	31	24	18	18	5	8	4	9	11	11	16	31
1986	31	28	31	13	7	6	8	18	6	20	30	17
1985	31	14	16	10	10	3	3	9	7	11	30	28
1984	15	20	25	9	3	5	3	7	30	31	30	15
1983	31	23	19	24	4	7	4	11	6	14	30	26
1982	31	28	24	13	12	4	4	13	3	22	20	31
1981	16	17	26	8	6	9	6	5	7	31	30	20
1980	31	28	21	18	3	10	3	7	3	10	30	31
1979	31	20	31	20	9	6	6	14	12	21	27	28
1978	31	28	16	13	12	4	7	10	9	31	27	31
1977	31	28	31	11	6	8	3	7	8	18	26	27
1976	31	22	31	20	5	10	8	9	11	20	27	31
1975	31	26	22	13	5	8	5	14	7	14	30	31
1974	16	28	23	7	8	6	4	5	6	16	30	31
1973	22	27	21	21	6	3	10	6	9	15	18	21
1972	31	14	21	10	14	4	6	5	9	11	30	31
1970	31	27	19	13	9	6	5	7	9	10	27	31
Av.	27.80	22.25	23.75	14.70	7.55	6.50	5.50	8.55	8.55	19.00	27.30	27.70
Freq. ≥ 25 days	15	9	8	1	0	0	0	0	1	4	17	16

Table 3.38 : Monthly distribution of average dry-day sequences (rainfall < 3.0 mm) and frequency of dry-day sequences ≥ 25 days at Rangpur.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	31	13	10	7	4	6	4	9	5	15	30	31
1989	31	18	31	30	9	7	9	6	5	19	30	31
1988	31	15	21	17	8	7	4	7	10	25	28	31
1987	31	23	15	9	13	5	3	4	3	11	30	31
1986	31	28	31	12	6	6	11	10	6	13	19	16
1985	31	21	14	18	8	3	2	6	5	13	30	27
1984	31	20	26	14	4	5	5	7	8	9	30	16
1983	31	28	15	10	6	4	11	16	6	9	30	26
1982	31	28	31	13	13	4	3	12	6	22	21	31
1981	15	17	23	15	6	17	8	5	7	31	30	21
1980	31	17	21	16	5	10	7	6	3	12	30	31
1979	19	20	31	15	10	6	7	7	11	19	27	29
1978	31	17	24	13	15	8	7	7	5	19	27	31
1977	31	28	31	6	4	3	6	11	8	17	25	27
1976	31	22	31	20	8	8	8	9	6	23	30	31
1975	31	28	30	13	5	7	3	9	6	16	30	31
1974	17	28	23	6	8	6	8	5	5	12	30	31
1973	22	26	23	22	7	5	7	4	4	9	11	21
1972	31	14	22	18	14	12	9	12	8	11	30	31
1971	31	27	27	6	5	5	4	6	6	21	28	31
Av.	28.10	21.90	24.00	14.00	7.90	6.70	6.30	7.90	6.15	16.30	27.30	27.75
Freq. ≥ 25 days	15	8	9	1	0	0	0	0	0	2	17	16

Table 3.39 : Monthly distribution of average dry-day sequences (rainfall < 3.0 mm) and frequency of dry-day sequences ≥ 25 days at Nawabganj.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1987	31	24	19	14	14	7	4	7	5	17	30	31
1986	31	28	31	11	5	10	10	16	9	13	30	16
1985	31	28	31	20	7	5	3	11	5	16	30	31
1983	31	28	31	31	4	8	15	9	8	9	25	31
1981	31	27	31	15	9	14	10	5	9	31	30	21
1980	31	18	31	26	3	8	7	8	4	11	30	31
1979	31	28	31	19	18	8	4	12	18	25	24	29
1978	31	28	31	13	7	6	5	10	6	31	30	31
1977	31	28	31	7	15	5	3	8	6	24	26	31
1976	31	28	31	26	7	9	14	4	19	31	30	31
1975	31	28	31	30	14	17	6	18	7	19	30	31
1974	31	28	24	12	9	10	10	14	6	21	30	31
1973	31	27	24	24	9	4	10	18	10	19	27	31
1972	31	28	31	30	25	5	13	5	16	24	30	31
1971	21	28	31	30	7	7	4	8	13	31	30	31
1970	20	28	31	16	16	9	8	7	10	22	25	31
1969	31	28	19	9	11	11	13	10	6	20	30	31
1968	31	28	18	21	11	4	5	14	9	26	30	31
1967	31	28	12	17	24	13	13	23	16	24	30	31
1966	31	28	31	24	19	13	8	6	13	13	22	31
Av.	29.90	27.20	27.50	19.75	11.70	8.65	8.25	10.65	9.75	21.35	28.45	29.65
Freq. ≥ 25 days	18	18	14	6	1	0	0	0	0	6	18	18

Table 3.40 : Monthly distribution of average dry-day sequences (rainfall < 3.0 mm) and frequency of dry-day sequences ≥ 25 days at Shibganj.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	31	14	31	12	6	8	7	10	7	13	20	13
1985	31	22	31	19	6	5	3	5	5	12	30	27
1984	16	21	26	27	6	5	5	8	10	15	30	17
1983	31	28	31	15	7	11	11	8	3	9	30	24
1980	28	28	24	20	5	7	5	3	6	10	30	31
1979	19	11	31	12	17	9	8	12	5	10	28	30
1978	31	28	12	13	3	9	11	9	9	26	27	31
1977	31	24	31	9	6	2	5	5	5	10	24	27
1976	31	21	22	26	6	5	16	8	6	16	28	31
1975	31	26	31	21	8	8	5	19	7	13	30	31
1974	31	28	23	9	8	9	2	11	6	12	30	31
1973	22	27	24	24	7	5	5	7	5	17	21	21
1972	31	22	31	24	22	8	7	6	9	20	30	31
1971	26	27	31	7	7	6	2	4	11	30	30	31
1970	20	19	22	13	9	4	5	9	10	11	17	31
1969	17	28	19	16	14	5	10	4	5	20	18	31
1968	23	28	16	15	9	7	8	5	14	22	29	31
1967	23	28	12	18	8	12	5	6	5	22	24	31
1966	31	28	31	26	11	9	6	3	7	19	21	31
1965	31	28	22	16	11	6	18	4	6	10	30	31
Av.	26.75	24.30	25.05	17.60	8.80	7.00	7.20	7.30	7.05	15.85	26.35	28.10
Freq. ≥ 25 days	13	12	10	3	0	0	0	0	0	1	13	16

Table 3.41 : Monthly distribution of average dry-day sequences (rainfall < 1.0 mm) and frequency of dry-day sequences ≥ 25 days at Kaliganj.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	31	14	12	5	2	7	2	8	3	13	30	31
1989	31	18	31	30	8	4	3	3	3	13	29	24
1988	31	22	21	15	4	8	3	4	10	13	22	31
1987	31	22	15	9	12	3	2	17	1	10	29	31
1986	31	28	15	13	8	5	2	13	5	13	19	13
1985	31	12	26	20	6	4	3	7	3	7	30	31
1984	15	19	26	14	5	3	3	4	8	10	30	16
1983	28	22	15	13	6	4	8	9	3	8	30	26
1982	31	28	18	12	12	2	4	6	4	22	20	31
1981	24	17	26	7	5	7	7	4	6	20	30	19
1980	31	17	29	19	2	3	4	8	4	10	30	31
1979	31	20	22	15	8	7	3	7	8	12	27	28
1978	31	17	18	13	10	6	4	7	3	26	27	31
1977	31	23	31	4	6	4	6	6	5	9	17	27
1976	31	22	21	20	4	3	6	7	9	20	27	31
1975	22	28	31	13	5	6	2	7	4	12	30	31
1974	14	28	23	8	5	6	4	5	6	14	28	17
1973	12	21	21	21	7	2	9	5	5	14	17	21
1972	31	25	19	15	4	10	8	8	8	11	26	31
1970	31	27	20	15	8	6	5	7	7	15	26	31
Av.	27.45	21.50	22.10	14.05	6.35	5.00	4.40	7.10	5.25	13.60	26.25	26.60
Freq. ≥ 25 days	15	6	7	1	0	0	0	0	0	1	15	14

Table 3.42 : Monthly distribution of average dry-day sequences (rainfall < 1.0 mm) and frequency of dry-day sequences ≥ 25 days at Mohipur.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	31	12	12	8	5	8	4	3	2	21	30	31
1989	22	18	19	30	11	8	11	6	5	22	30	31
1988	31	13	31	15	11	7	6	6	11	17	28	31
1987	19	24	18	18	3	4	2	6	3	10	16	31
1986	31	28	31	13	7	6	4	17	5	20	30	16
1985	24	14	16	10	10	2	3	9	6	11	30	28
1984	15	19	25	7	2	2	3	7	30	31	30	15
1983	28	23	19	13	4	7	4	11	4	14	30	26
1982	31	28	24	13	12	4	3	12	3	22	20	31
1981	16	17	26	7	5	7	6	5	7	31	30	20
1980	31	17	20	12	2	10	3	4	2	10	30	31
1979	31	20	31	20	9	6	6	7	11	20	27	27
1978	21	28	11	13	12	4	7	8	8	31	27	31
1977	31	23	31	11	5	5	3	7	8	18	26	27
1976	30	21	31	20	5	9	8	8	4	20	27	31
1975	31	26	22	13	5	8	5	14	7	14	30	31
1974	16	28	23	7	7	5	4	4	6	16	30	31
1973	17	15	21	21	3	2	8	6	9	10	11	21
1972	31	14	21	10	14	4	6	5	6	9	30	31
1970	31	21	17	11	7	5	5	6	8	9	25	31
Av.	25.45	20.45	22.45	13.60	6.95	5.65	5.05	7.55	7.25	17.80	26.85	27.60
Freq. ≥ 25 days	11	5	7	1	0	0	0	0	1	3	17	16

Table 3.43 : Monthly distribution of average dry-day sequences (rainfall < 1.0 mm) and frequency of dry-day sequences ≥ 25 days at Rangpur.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	31	13	10	7	4	6	4	9	4	15	30	31
1989	22	18	19	30	7	7	9	6	3	16	30	24
1988	31	15	9	17	8	7	4	3	10	25	28	31
1987	31	23	15	8	12	5	3	3	3	11	30	31
1986	31	28	31	12	5	6	10	10	6	13	19	16
1985	31	21	14	18	6	3	2	5	5	13	30	27
1984	31	20	26	14	4	5	2	3	8	9	30	16
1983	28	28	15	10	6	3	4	14	5	8	30	26
1982	31	28	24	10	11	4	3	12	6	22	21	31
1981	15	17	23	15	6	17	6	3	6	31	30	21
1980	31	17	20	16	5	10	6	4	3	11	30	31
1979	19	11	31	15	10	6	7	4	11	19	27	29
1978	21	10	24	13	6	6	7	7	4	19	27	31
1977	31	24	31	6	4	3	6	9	8	17	25	27
1976	31	22	31	20	5	8	6	9	3	20	30	31
1975	31	27	24	13	5	7	3	8	6	17	30	31
1974	17	28	23	6	7	6	8	5	5	8	30	31
1973	18	26	23	21	6	2	7	4	4	9	11	21
1972	28	14	22	18	14	8	7	12	8	11	30	31
1971	22	27	27	4	5	5	4	6	6	16	24	31
Av.	26.55	20.85	22.10	13.65	6.80	6.20	5.40	6.80	5.70	15.50	27.10	27.40
Freq. ≥ 25 days	13	7	6	1	0	0	0	0	0	2	16	15

Table 3.44 : Monthly distribution of average dry-day sequences (rainfall < 1.0 mm) and frequency of dry-day sequences ≥ 25 days at Nawabganj.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1987	31	24	16	14	14	7	3	7	5	11	30	31
1986	31	28	31	11	5	10	6	16	9	13	30	16
1985	31	28	31	20	7	5	3	9	3	16	30	31
1983	31	27	31	31	4	8	15	9	5	9	25	31
1981	31	27	31	15	9	14	10	5	9	31	30	21
1980	31	18	31	26	3	8	7	8	4	11	30	31
1979	24	28	31	19	18	8	4	12	18	24	24	29
1978	31	28	31	13	7	6	5	10	6	31	30	31
1977	31	28	31	7	8	5	3	8	6	24	26	31
1976	31	28	31	20	7	9	14	4	19	31	30	31
1975	31	28	31	30	14	17	6	18	7	19	30	31
1974	31	28	28	12	9	10	10	14	6	21	30	31
1973	31	24	24	24	9	4	10	18	10	19	27	31
1972	31	28	31	30	24	5	13	5	16	24	30	31
1971	21	28	31	30	7	7	4	8	13	31	30	31
1970	20	28	31	16	16	8	8	7	10	22	21	31
1969	31	28	19	9	11	11	13	10	6	20	30	31
1968	31	28	18	21	11	4	5	14	9	26	30	31
1967	31	28	12	17	24	13	13	23	16	24	30	31
1966	31	28	31	24	19	13	8	6	13	13	22	31
Av.	29.55	27.05	27.45	19.45	11.30	8.60	8.00	10.55	9.50	21.00	28.40	29.65
Freq. ≥ 25 days	17	17	14	5	0	0	0	0	0	5	17	18

Table 3.45 : Monthly distribution of average dry-day sequences (rainfall < 1.0 mm) and frequency of dry-day sequences ≥ 25 days at Shibganj.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	31	14	31	12	5	8	6	10	6	13	20	13
1985	31	22	31	19	6	5	2	5	3	7	30	27
1984	16	20	26	27	6	5	5	8	10	10	30	17
1983	31	28	31	15	7	11	7	6	3	9	30	24
1980	28	28	24	20	5	6	4	3	6	10	30	31
1979	19	11	22	12	11	9	8	12	5	10	24	28
1978	31	28	11	13	3	2	3	9	5	26	27	31
1977	26	23	31	9	6	2	5	4	5	10	24	27
1976	31	21	22	26	6	4	12	6	6	16	28	31
1975	31	26	31	21	8	8	4	9	6	13	30	31
1974	16	28	23	9	8	9	2	11	6	12	30	31
1973	22	26	23	22	7	5	5	6	4	9	21	21
1972	31	22	31	24	22	8	7	6	7	20	30	31
1971	26	27	31	6	7	6	2	2	10	22	30	31
1970	20	19	22	13	9	4	5	9	7	11	17	31
1969	17	28	19	16	14	5	10	4	5	17	18	31
1968	23	28	16	15	9	7	8	5	14	16	29	31
1967	23	28	12	18	8	6	5	2	4	22	24	31
1966	31	28	25	26	9	9	6	2	6	10	21	31
1965	31	22	22	16	7	6	8	4	6	10	30	31
Av.	25.75	23.85	24.20	16.95	8.15	6.25	5.70	6.15	6.20	13.65	26.15	28.00
Freq. ≥ 25 days	12	11	9	3	0	0	0	0	0	1	12	16

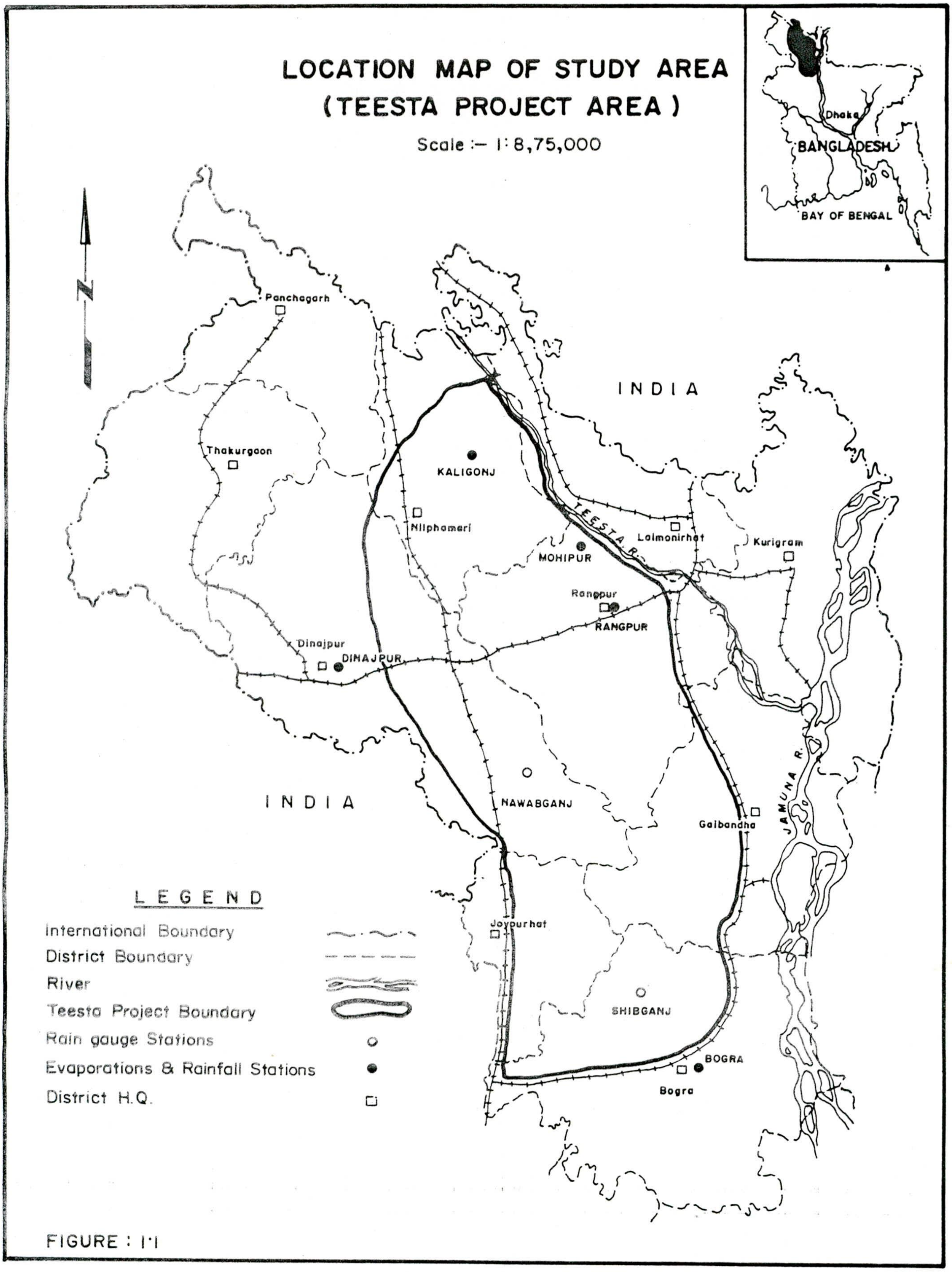
Table 4.1 : Summary of climatic drought analysis

Stations	Para-meters	Growing Period	Critical growing Period
Kaliganj	x mm	25.79	22.44
	s mm	2.91	2.47
	C_v	0.113	0.110
	Freq. eqn.	$x = 25.79 + 2.91 \times K_T$	$x = 22.44 + 2.47 \times K_T$
Mohipur	x mm	30.75	29.40
	s mm	3.20	3.42
	C_v	0.104	0.116
	Freq. eqn.	$x = 30.75 + 3.20 \times K_T$	$x = 29.40 + 3.42 \times K_T$
Rangpur	x mm	29.35	25.71
	s mm	4.93	2.54
	C_v	0.168	0.100
	Freq. eqn.	$x = 29.35 + 4.93 \times K_T$	$x = 25.71 + 2.54 \times K_T$
Nawabganj	x mm	32.45	28.98
	s mm	4.04	1.77
	C_v	0.124	0.061
	Freq. eqn.	$x = 32.45 + 4.04 \times K_T$	$x = 28.98 + 1.77 \times K_T$
Shibganj	x mm	43.67	39.98
	s mm	6.65	8.53
	C_v	0.152	0.213
	Freq. eqn.	$x = 43.67 + 6.65 \times K_T$	$x = 39.98 + 8.53 \times K_T$

Table 4.2 Summery of dry-day sequences analysis

Stations	para-meters	rainfall ≥			rainfall <		
		6.0 mm	3.0 mm	1.0 mm	6.0 mm	3.0 mm	1.0 mm
Kaliganj	x days	8.20	9.35	11.25	77.40	69.25	56.00
	s days	2.52	2.28	3.92	16.85	14.09	11.53
	C_v	0.308	0.244	0.348	0.218	0.203	0.206
Mohipur	x days	8.95	10.10	10.90	75.85	72.20	66.65
	s days	2.72	3.26	3.02	18.43	16.73	15.86
	C_v	0.304	0.322	0.277	0.243	0.232	0.238
Rangpur	x days	7.05	9.20	11.60	77.10	71.75	64.25
	s days	2.11	2.84	3.94	15.35	14.27	12.00
	C_v	0.300	0.308	0.339	0.200	0.200	0.187
Nawabganj	x days	5.70	6.50	7.10	88.85	87.80	87.55
	s days	1.60	1.85	2.59	26.30	26.40	26.23
	C_v	0.280	0.284	0.364	0.296	0.300	0.300
Shibganj	x days	5.60	6.40	8.55	72.25	67.20	64.10
	s days	1.50	1.85	2.58	19.65	17.05	12.16
	C_v	0.268	0.289	0.302	0.272	0.254	0.200

FIGURES


LOCATION MAP OF STUDY AREA
(TEESTA PROJECT AREA)
Scale :- 1: 8,75,000
Dhaka
BANGLADESH
BAY OF BENGAL
N
Panchagarh
Thakurgaon
KALIGONJ
Nilphamari
INDIA
TEESTA R.
Lalmonirhat
Kurigram
MOHIPUR
Rangpur
RANGPUR
Dinajpur
DINAJPUR
INDIA
NAWABGANJ
Gaibandha
JAMUNA R.
Joypurhat
SHIBGANJ
BOGRA
Bogra
LEGEND
International Boundary
District Boundary
River
Teesta Project Boundary
Rain gauge Stations
Evaporations & Rainfall Stations
District H.Q.
FIGURE : 1·1

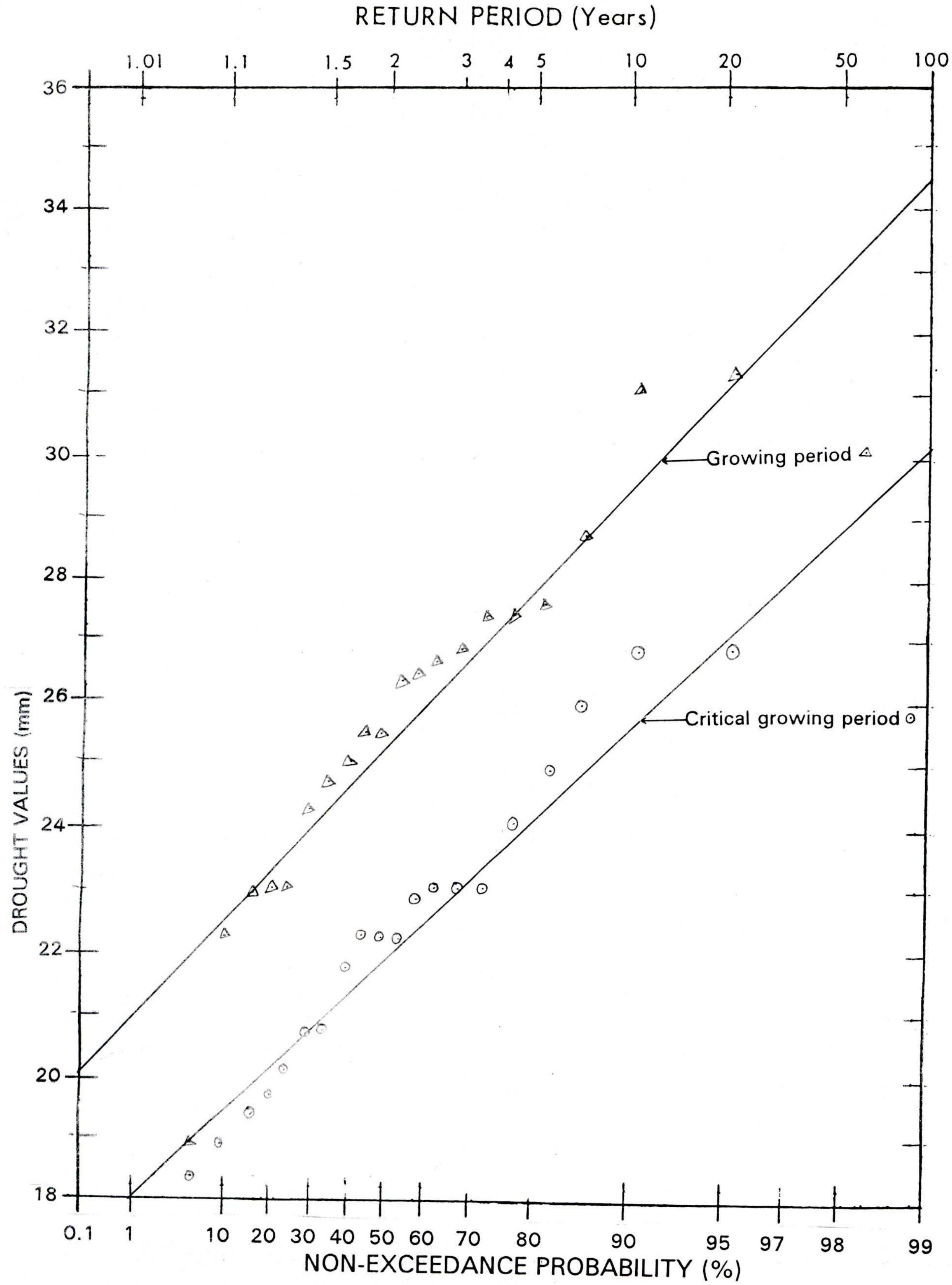


Figure 3.1 : Gumbel plot of drought values during growing and critical growing period of T.Aman at Kaliganj (1970, 1972-90).

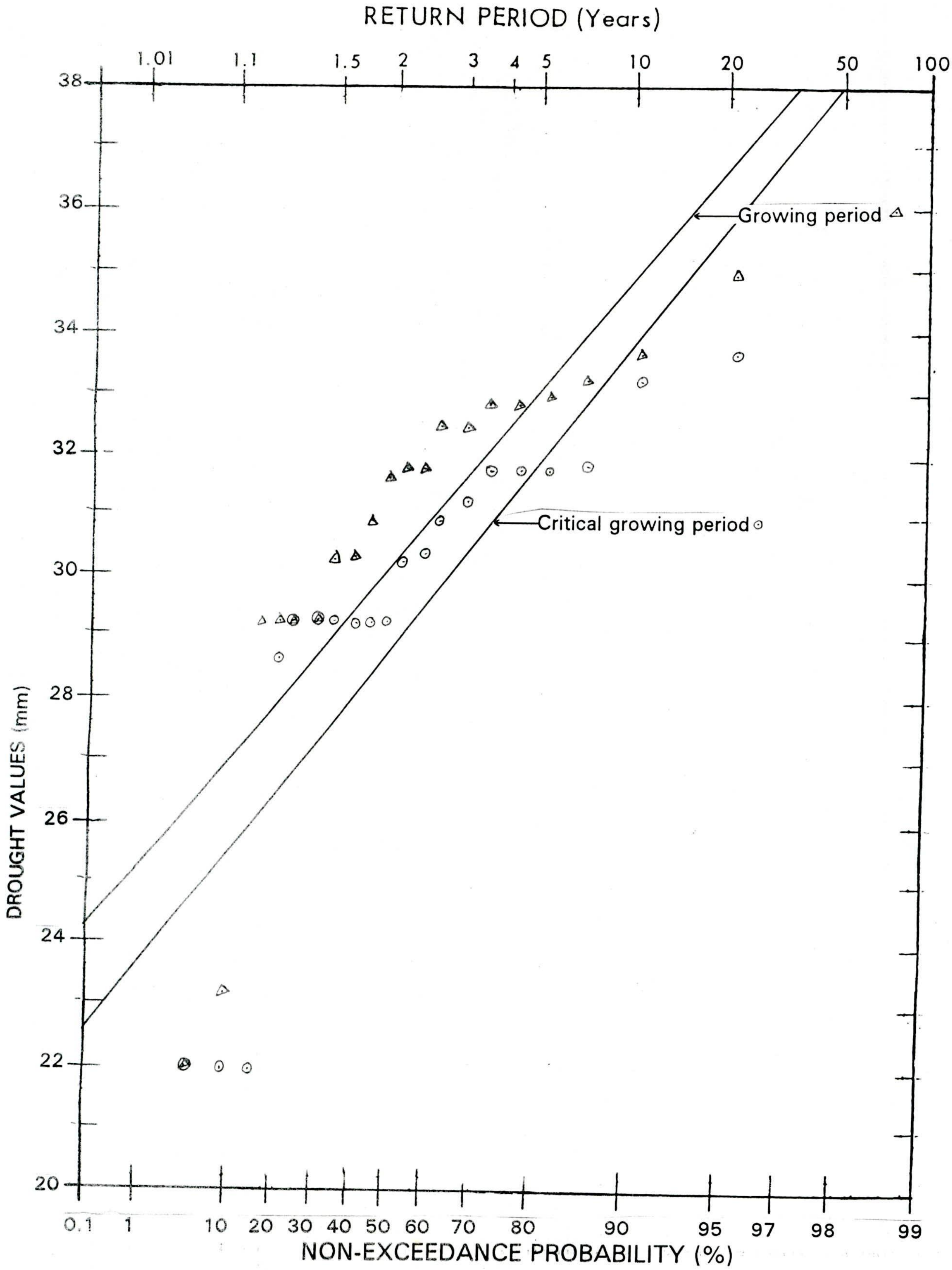


Figure 3.2 : Gumbel plot of drought values during growing and critical growing period of T.Aman at Mohipur(1970, 1972-90).

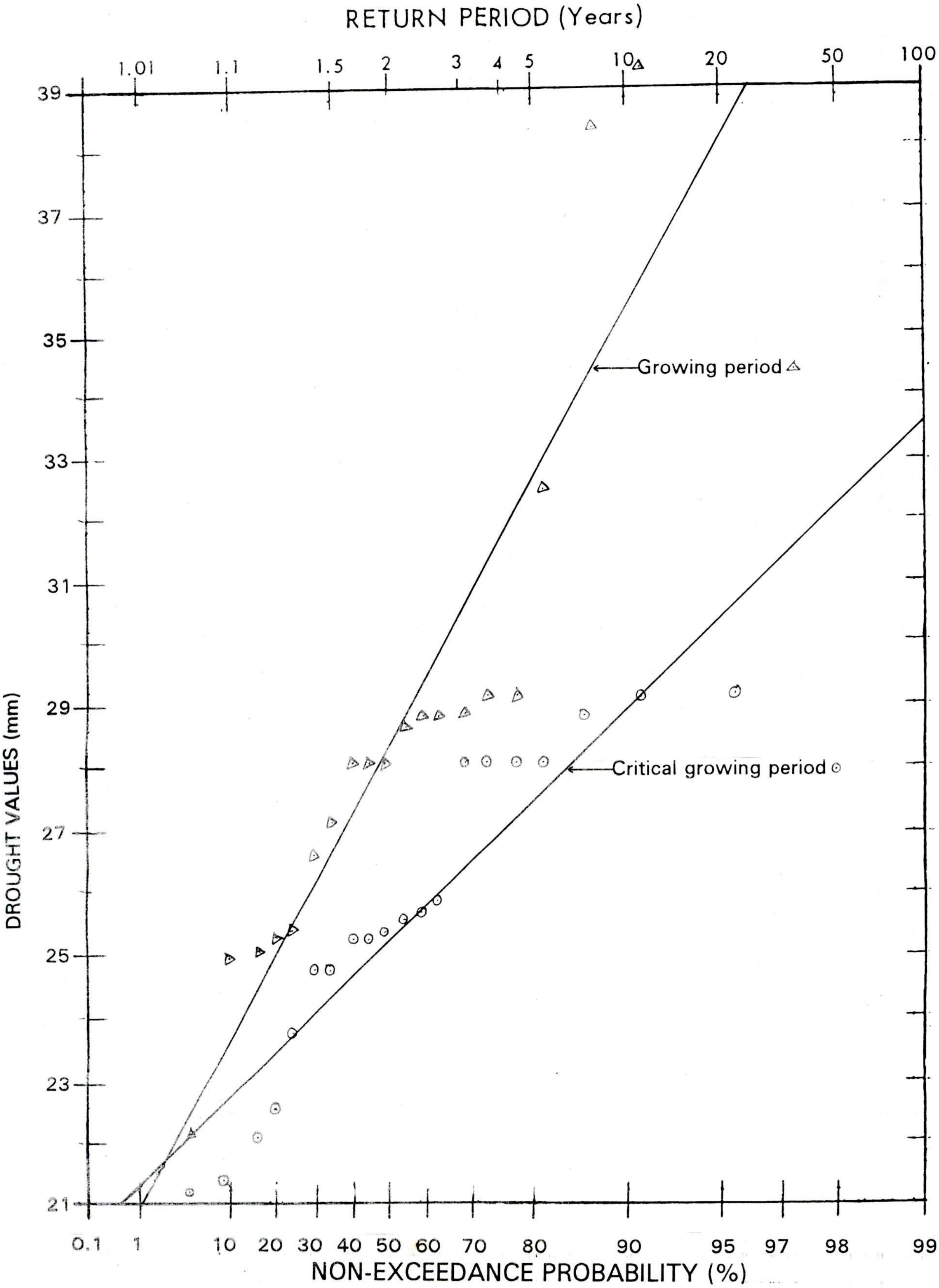


Figure 3.3 : Gumbel plot of drought values during growing and critical growing period of T.Aman at Rangpur (1971-90).

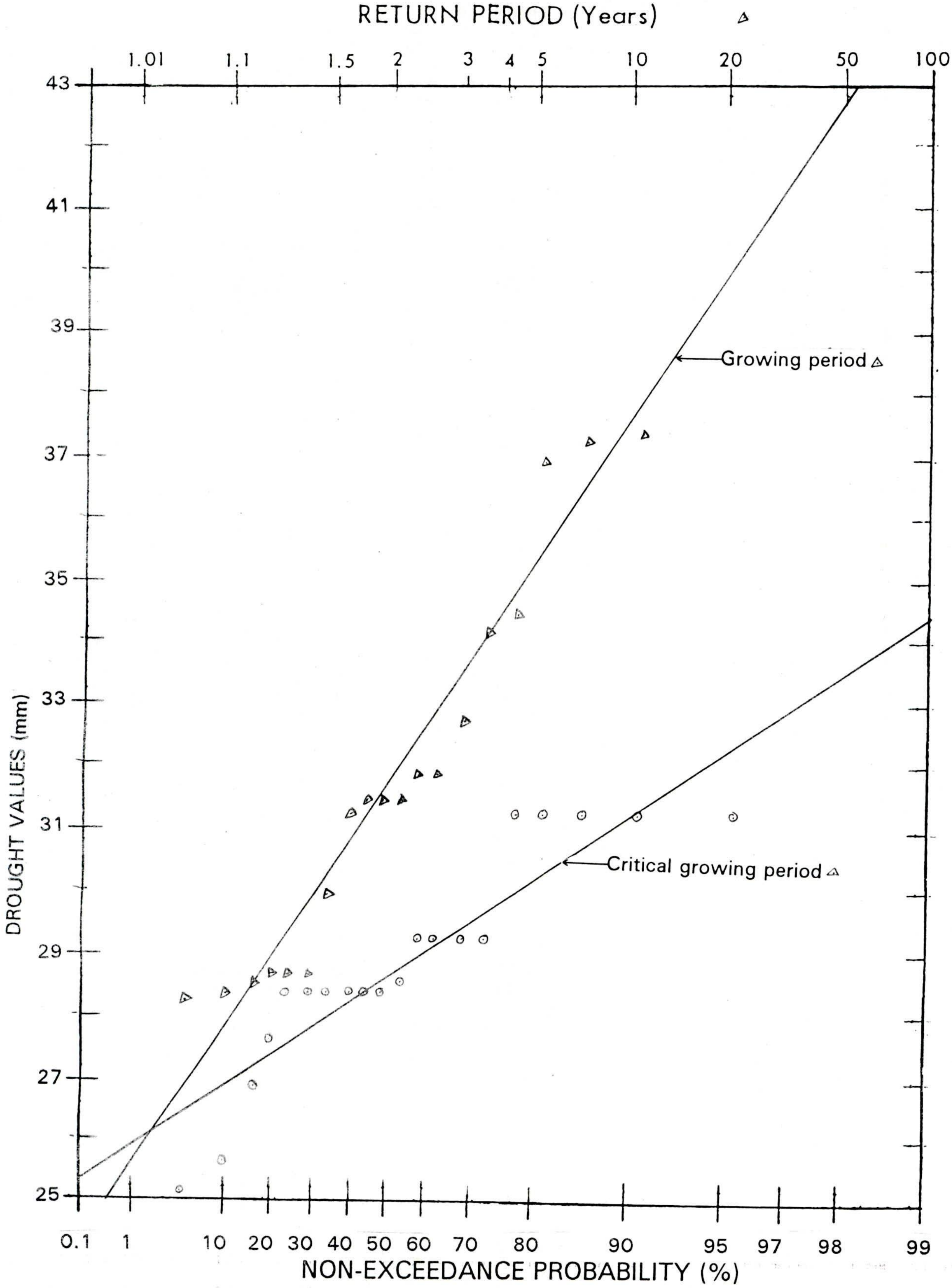


Figure 3.4 : Gumbel plot of drought values during growing and critical growing period of T.Aman at Nawabganj (1966-81, 1983, 1985-87).

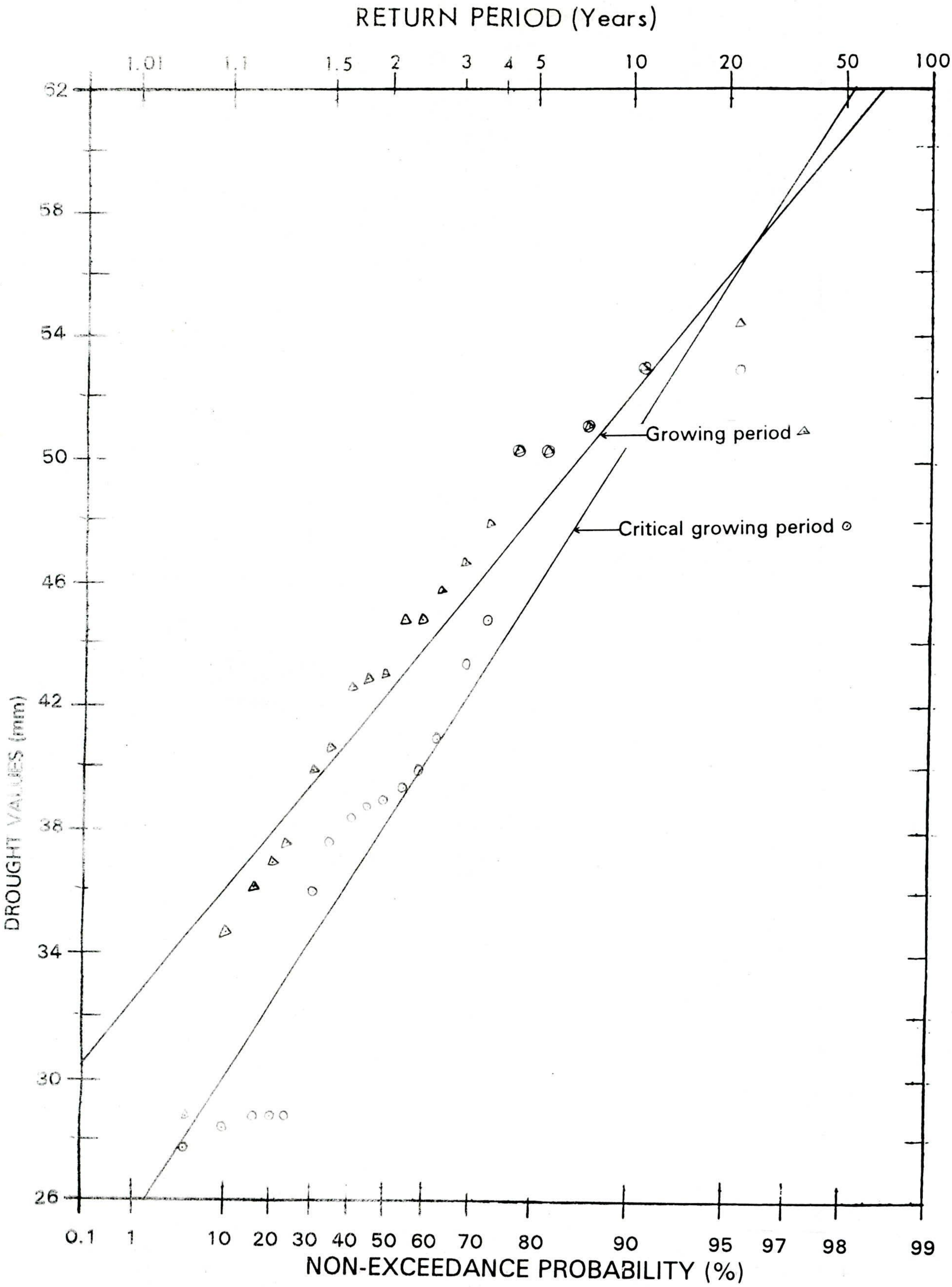


Figure 3.5 : Gumbel plot of drought values during growing and critical growing period of T.Aman at Shibganj (1965-80, 1983-86).

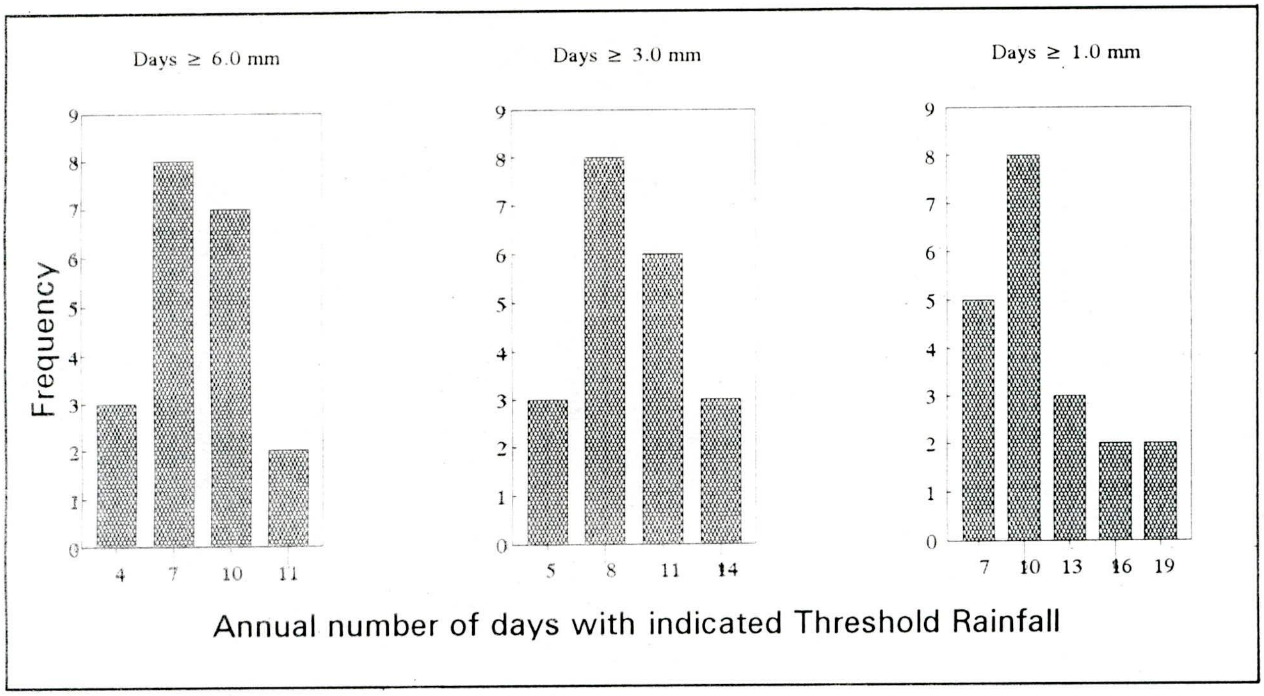


Figure 3.6 : Distribution of annual number of days with rainfall ≥ 6.0 mm, ≥ 3.0 mm and ≥ 1.0 mm at Kaliganj (1970, 1972-90).

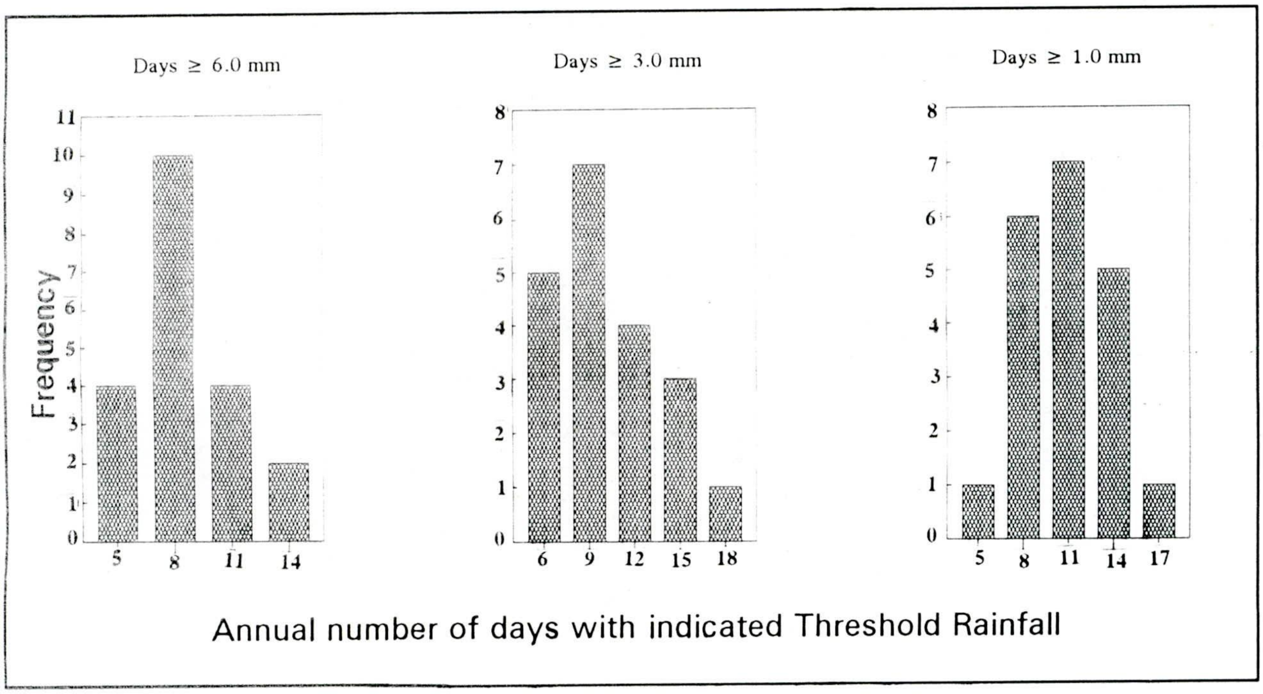


Figure 3.7 : Distribution of annual number of days with rainfall ≥ 6.0 mm, ≥ 3.0 mm and ≥ 1.0 mm at Mohipur (1970, 1972-90).

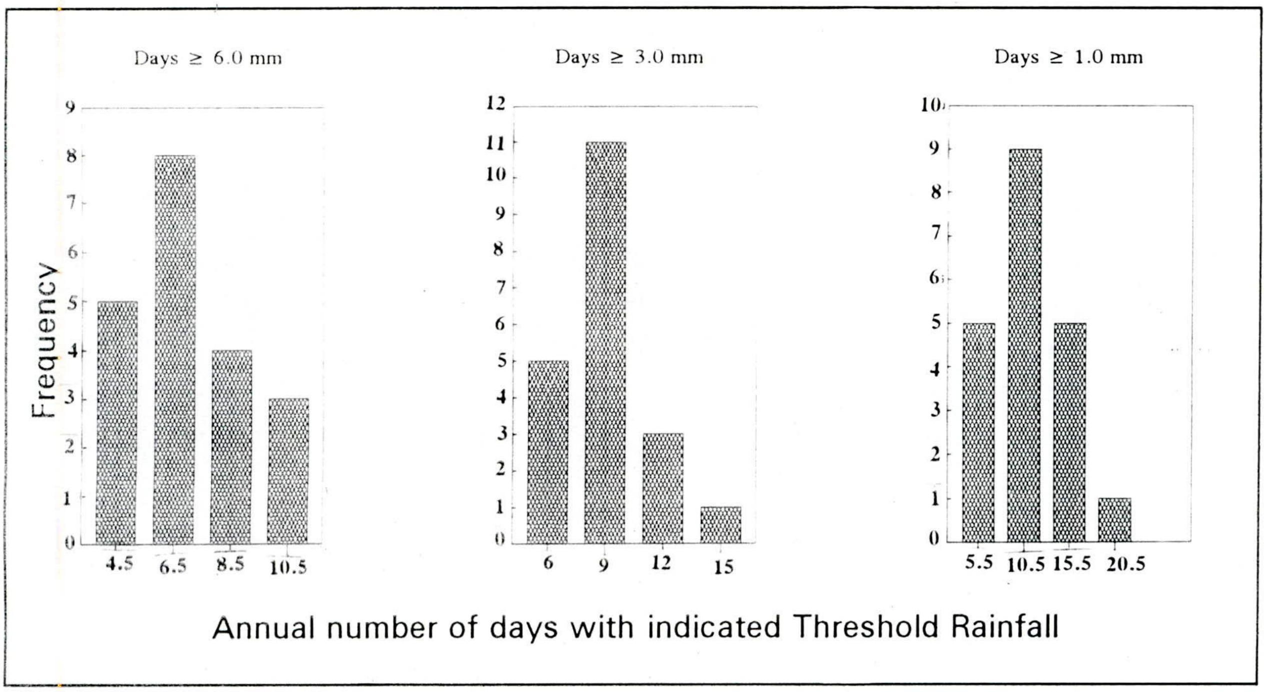


Figure 3.8 : Distribution of annual number of days with rainfall ≥ 6.0 mm, ≥ 3.0 mm and ≥ 1.0 mm at Rangpur (1971-90).

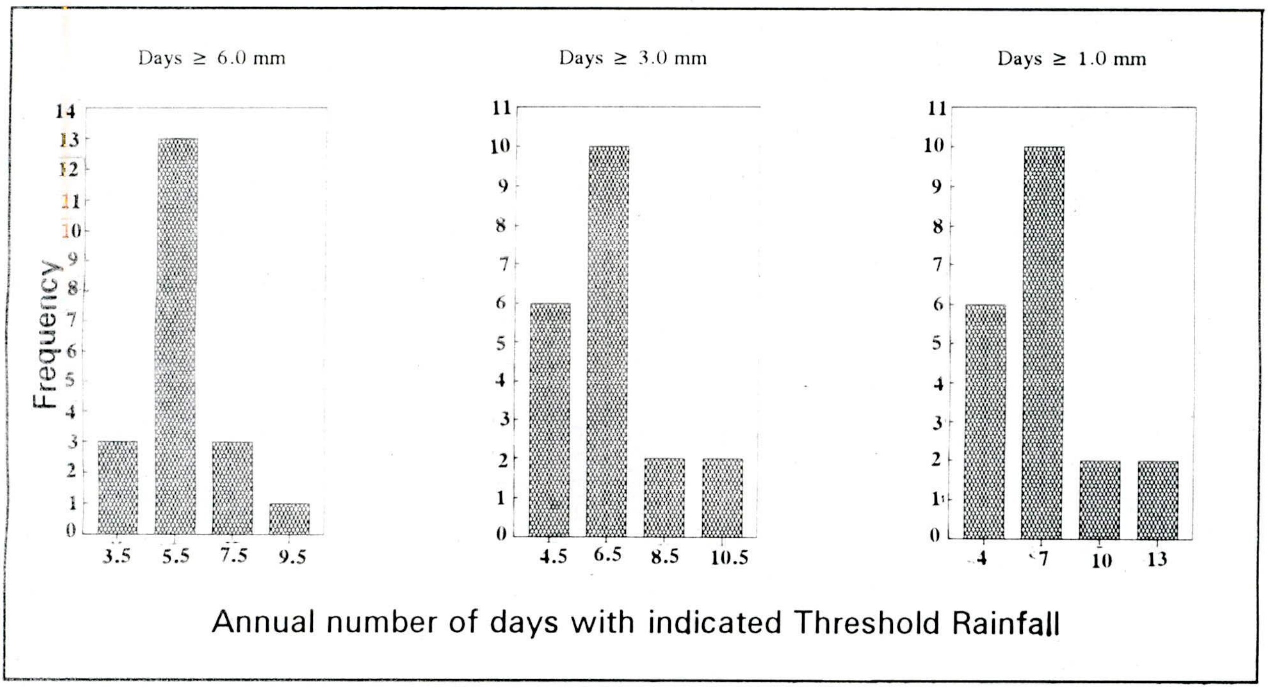


Figure 3.9 : Distribution of annual number of days with rainfall ≥ 6.0 mm, ≥ 3.0 mm and ≥ 1.0 mm at Nawabganj (1966-81, 1983, 1985-87).

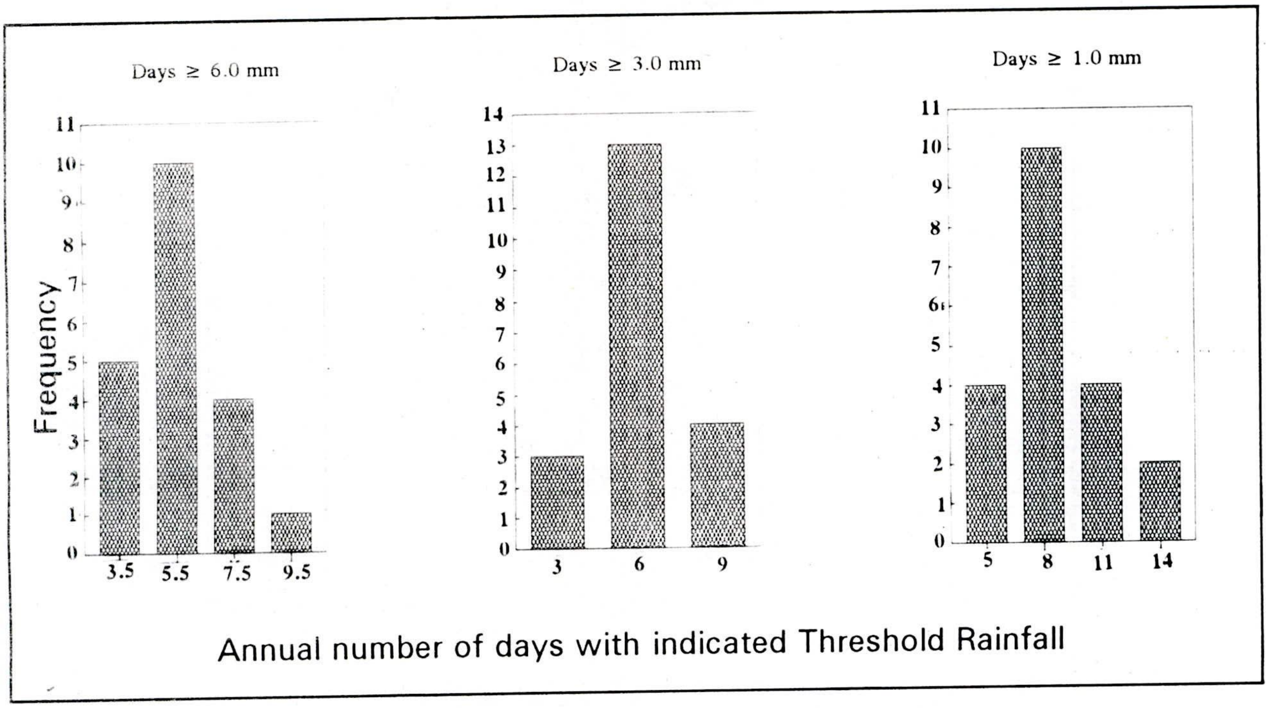


Figure 3.10 : Distribution of annual number of days with rainfall ≥ 6.0 mm, ≥ 3.0 mm and ≥ 1.0 mm at Shibganj (1965-80, 1983-86).

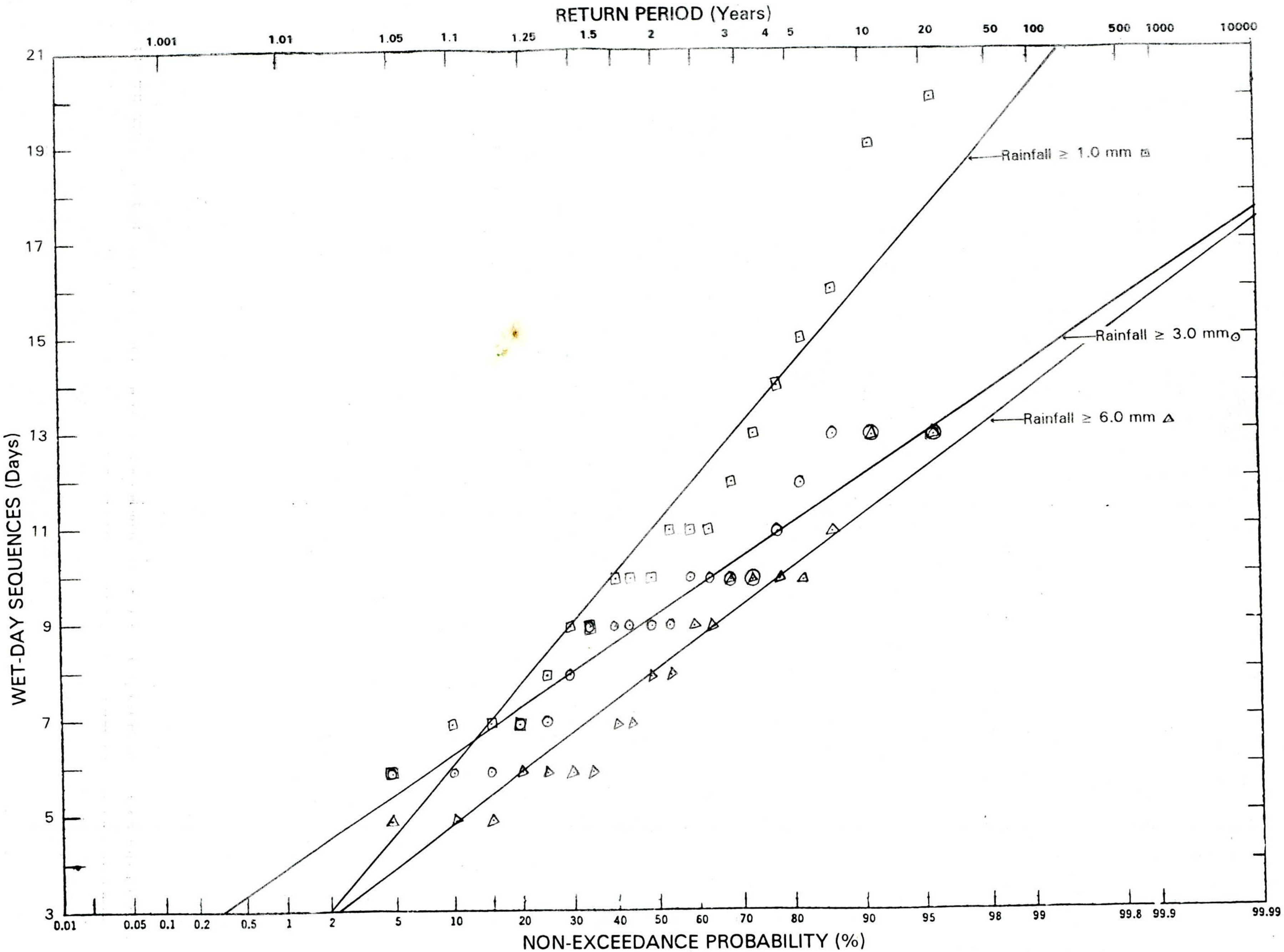


Figure 3.11 : Normal plots of annual number of days with indicated amounts of rainfall at Kaliganj (1970, 1972-90).

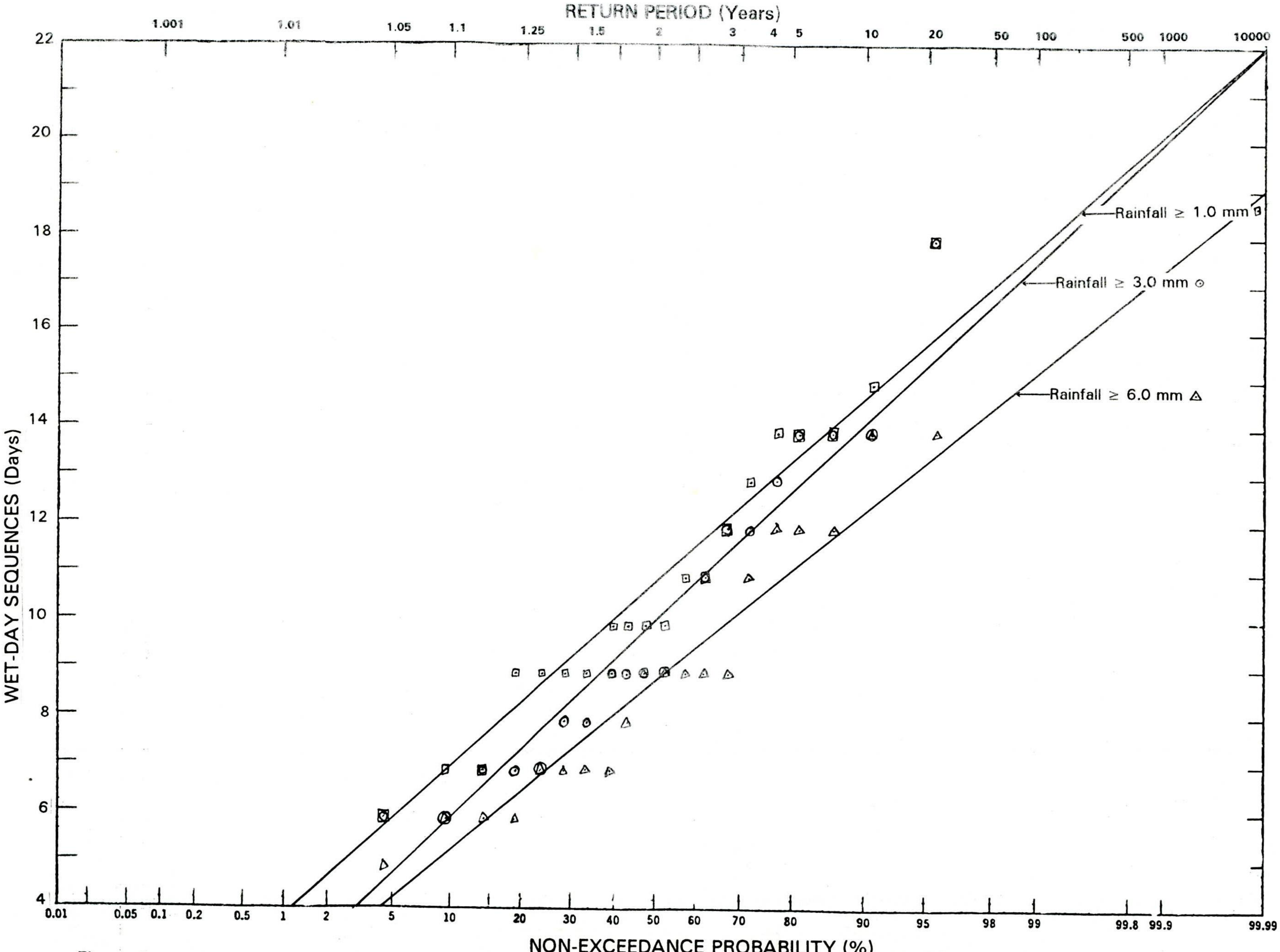


Figure 3.12 : Normal plots of annual number of days with indicated amounts of rainfall at Mohipur (1970, 1972-90).

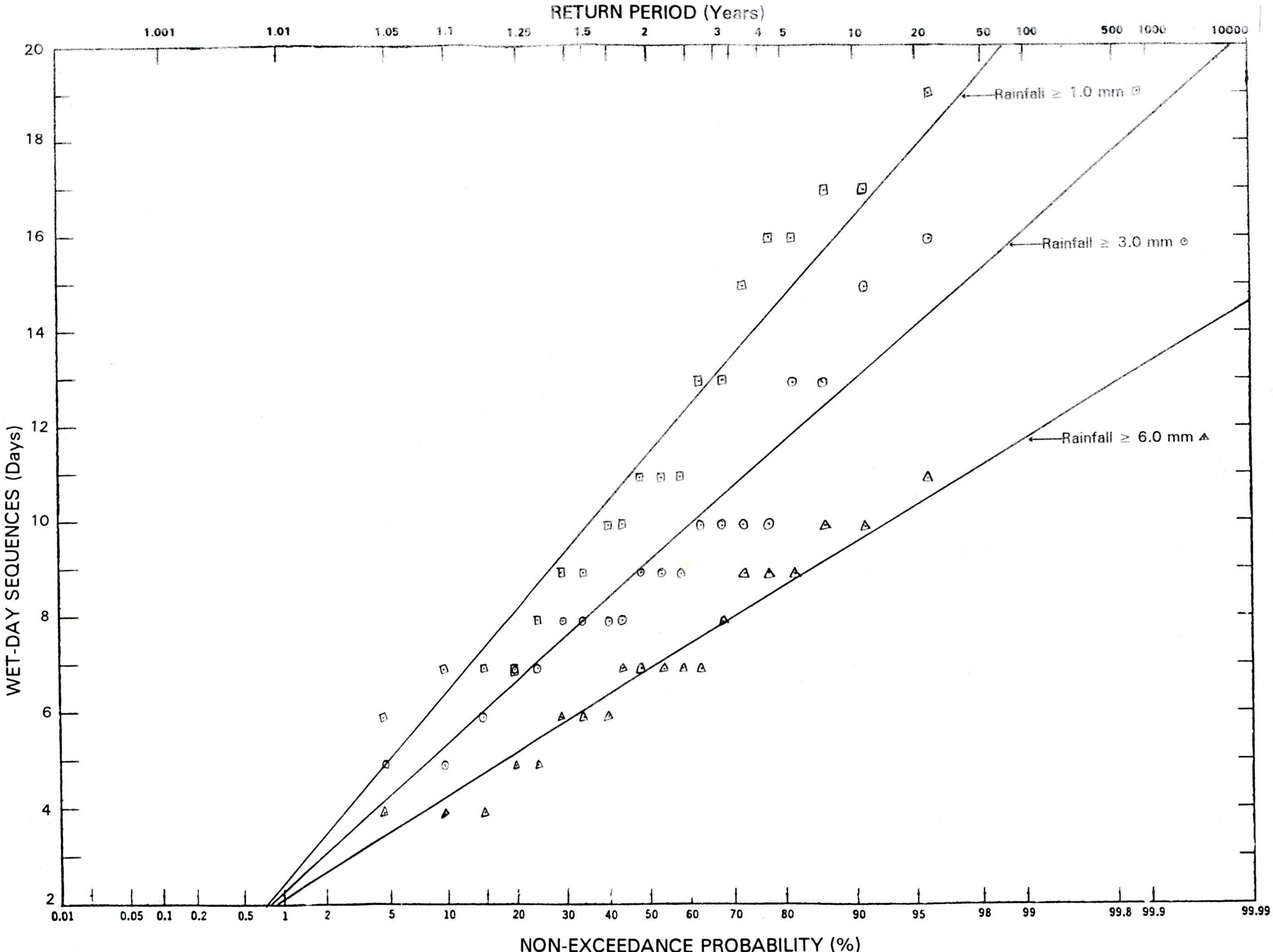


Figure 3.13 : Normal plots of annual number of days with indicated amounts of rainfall at Rangpur (1971-90).

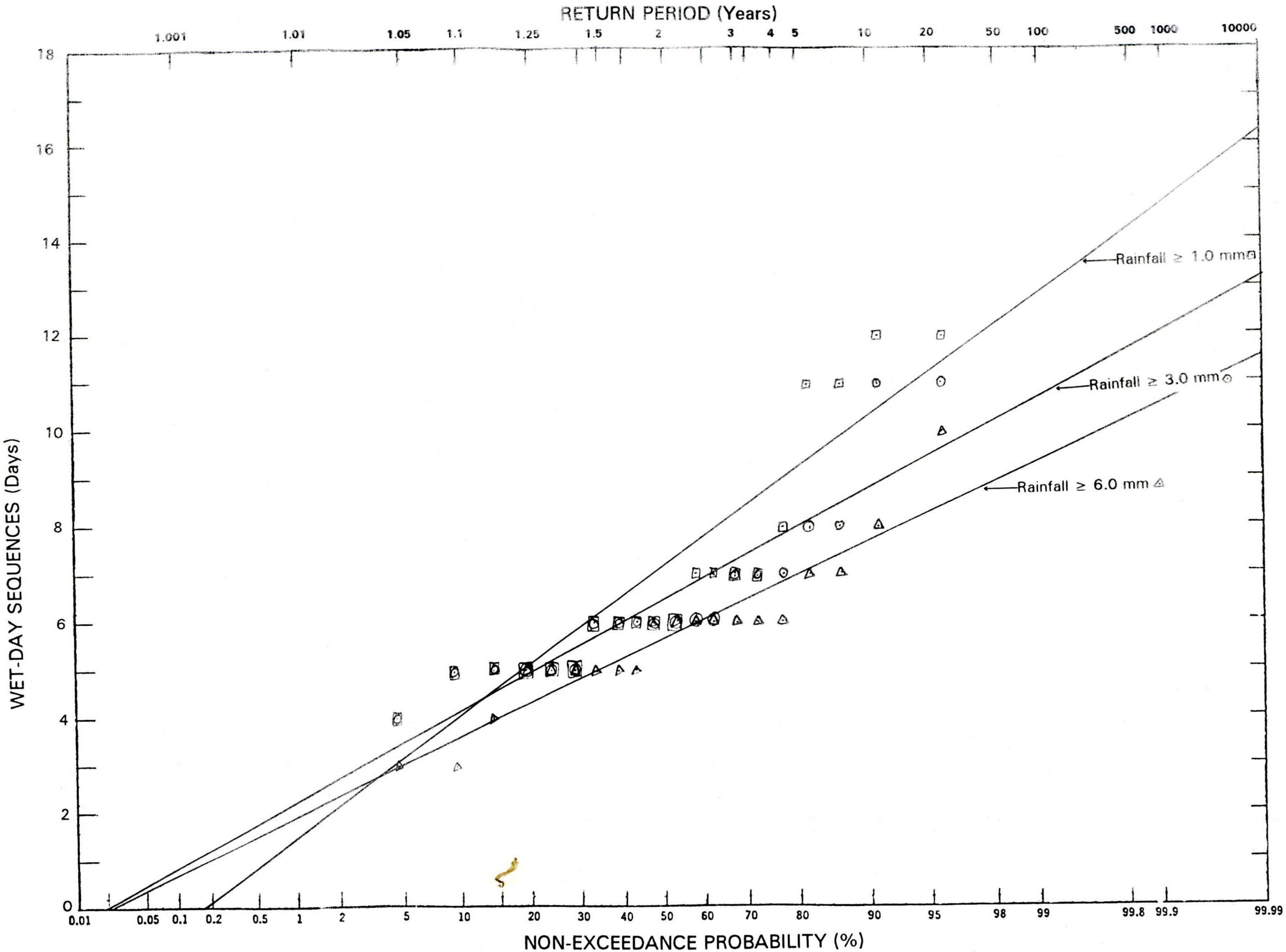


Figure 3.14 : Normal plots of annual number of days with indicated amounts of rainfall at Nawabganj (1966-81, 1983, 1985-87).

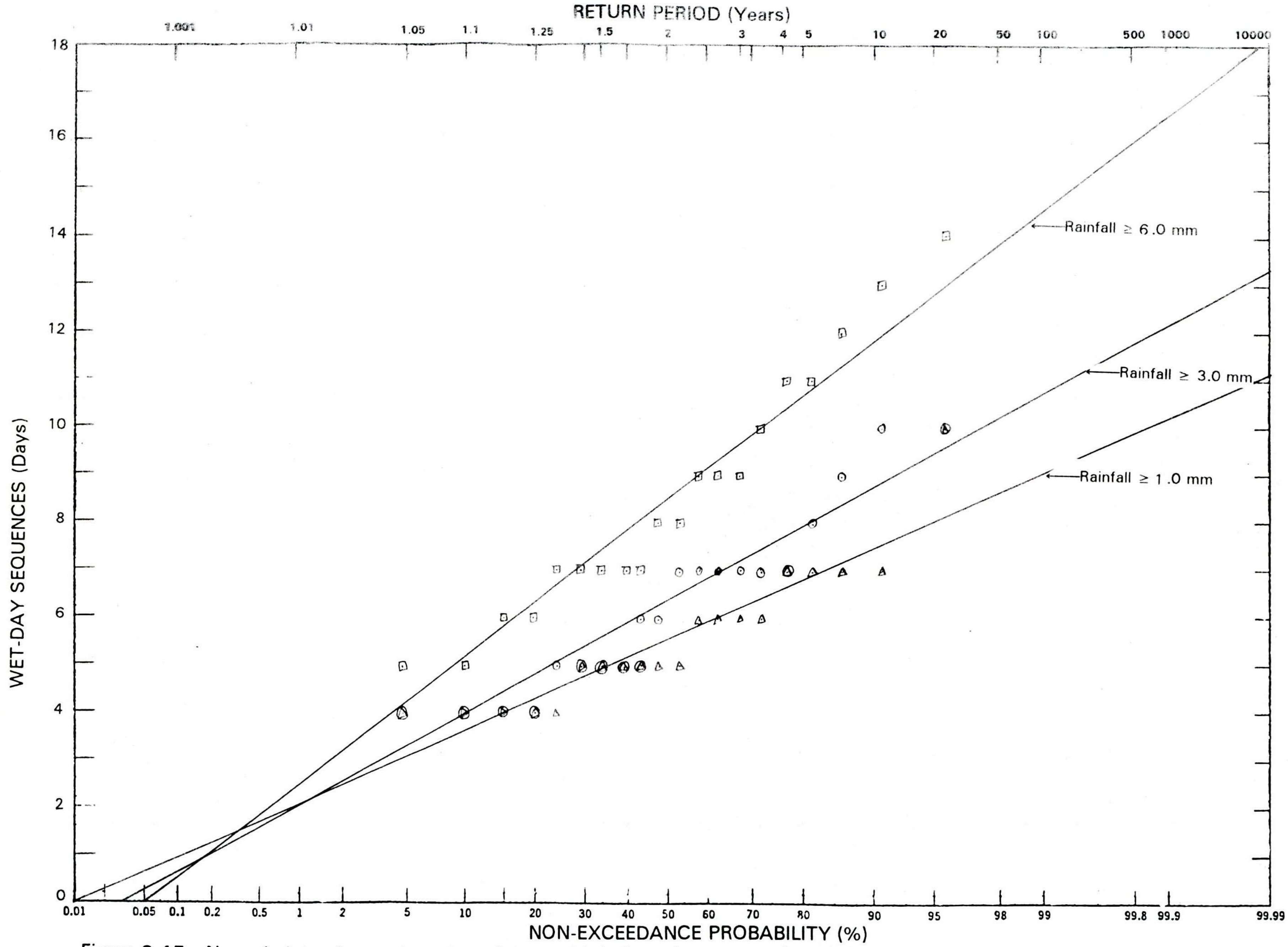


Figure 3.15 : Normal plots of annual number of days with indicated amounts of rainfall at Shibganj (1965-80, 1983-86).

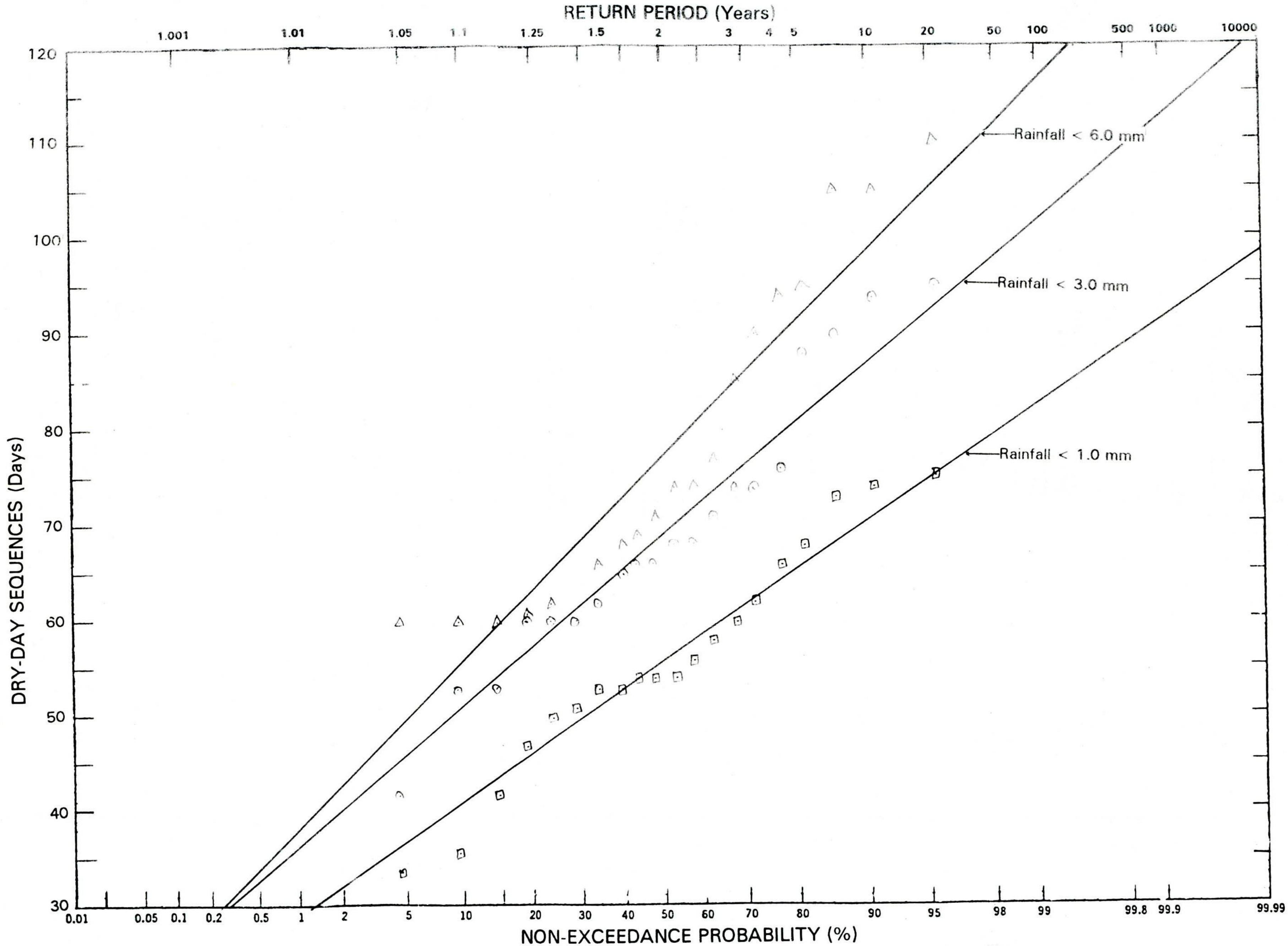


Figure 3.16 : Normal plots of annual number of days with indicated amounts of rainfall at Kaliganj (1970, 1972-90).

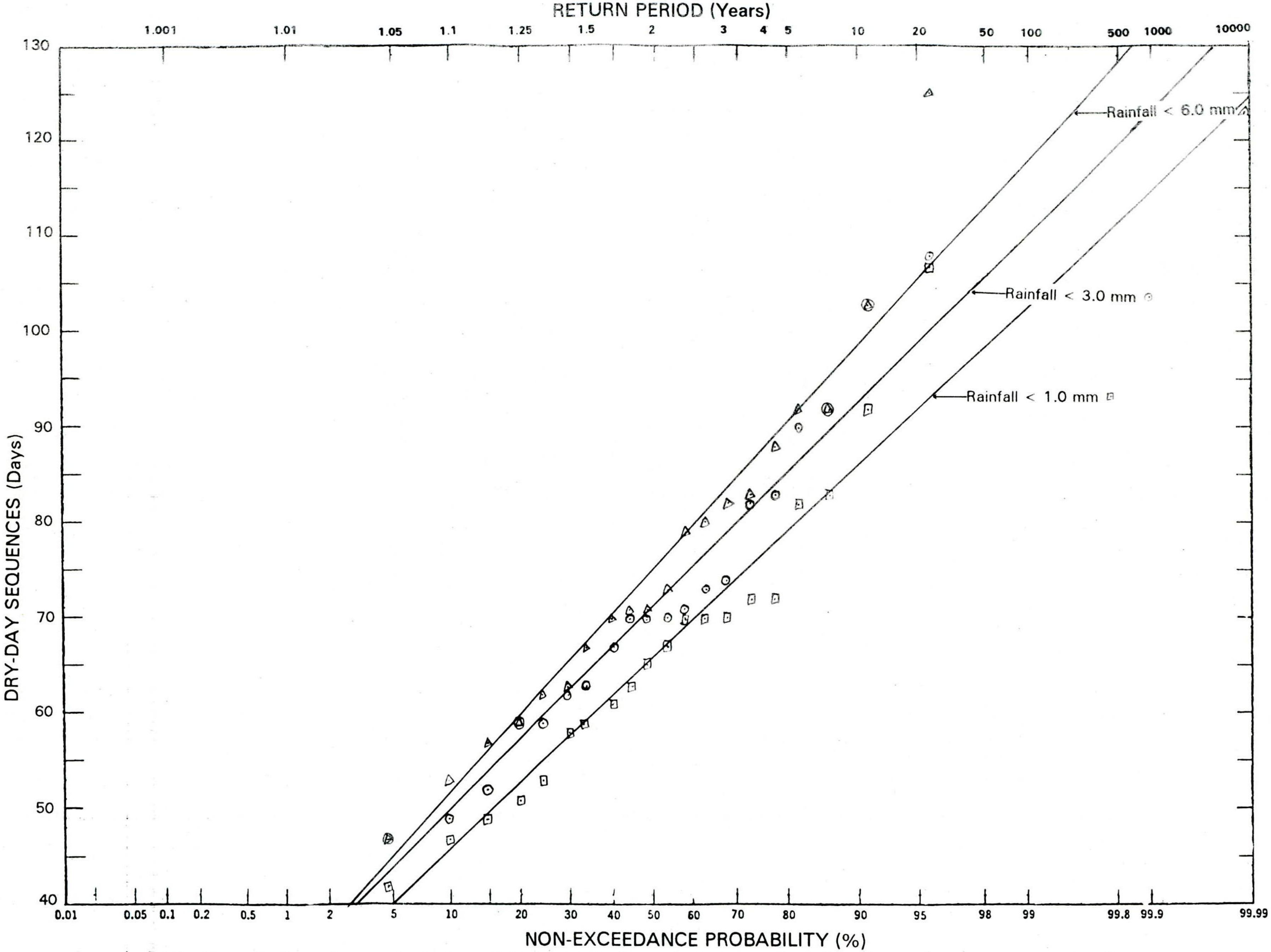


Figure 3.17 : Normal plots of annual number of days with indicated amounts of rainfall at Mohipur (1970, 1972-90).

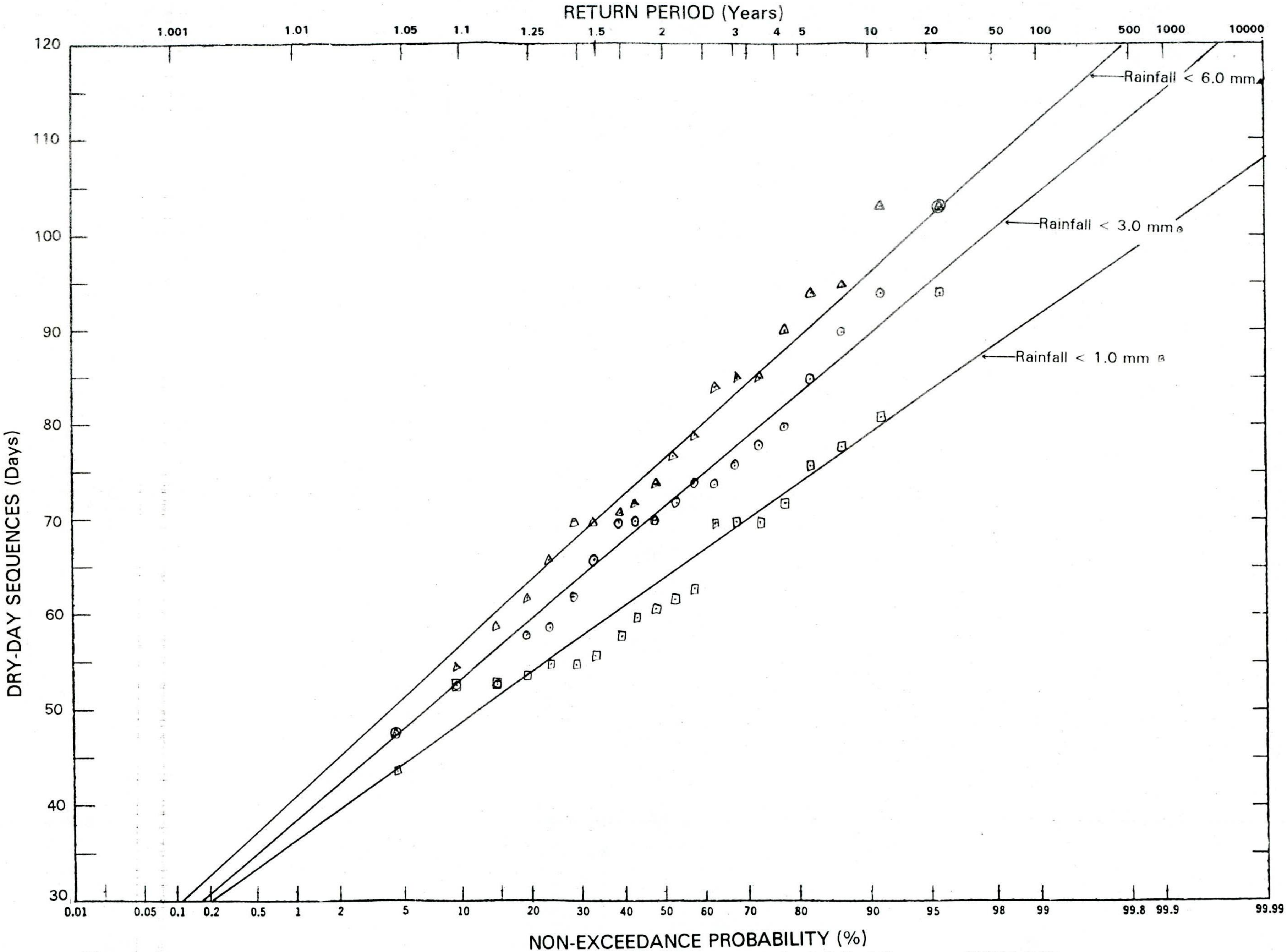


Figure 3.18 : Normal plots of annual number of days with indicated amounts of rainfall at Rangpur (1971-90).

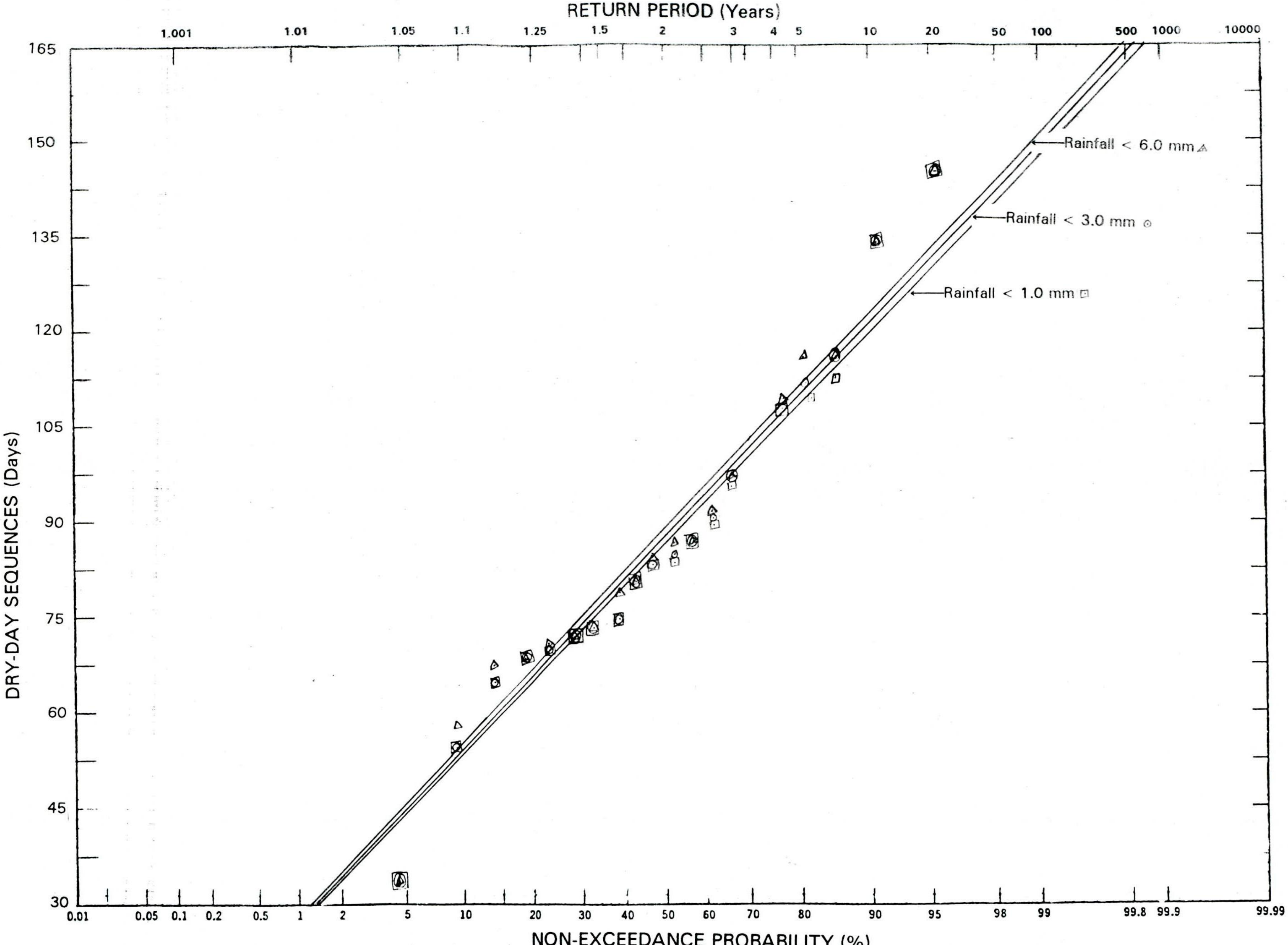


Figure 3.19 : Normal plots of annual number of days with indicated amounts of rainfall at Nawabganj (1966-81, 1983, 1985-87).

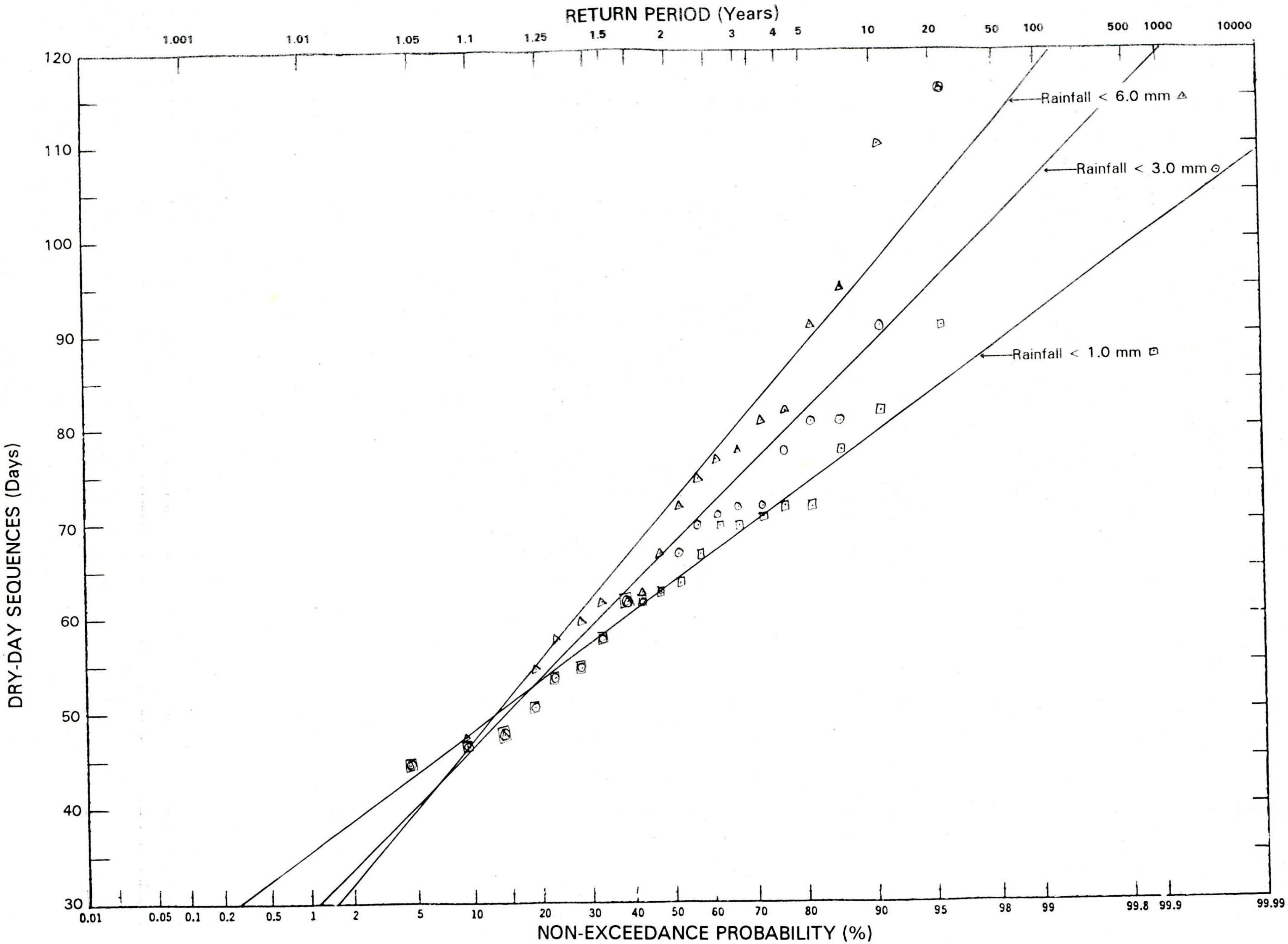


Figure 3.20 : Normal plots of annual number of days with indicated amounts of rainfall at Shibganj (1965-80, 1983-86).

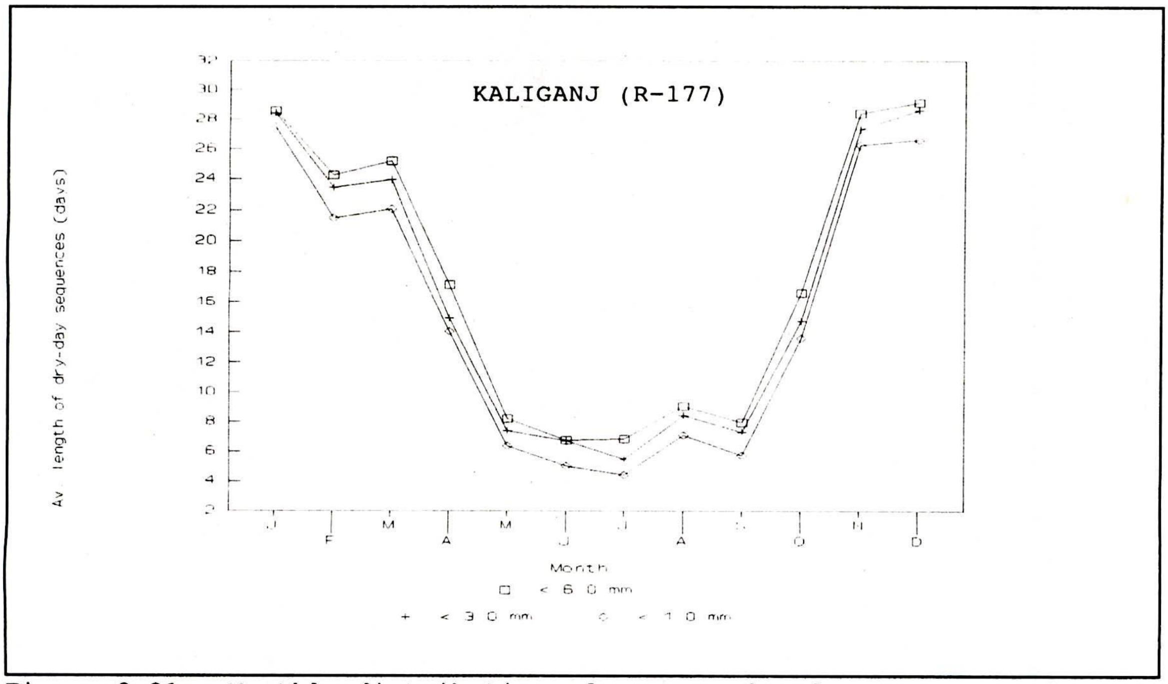


Figure 3.21 : Monthly distribution of average dry-day sequences at Kaliganj (1970, 1972-90).

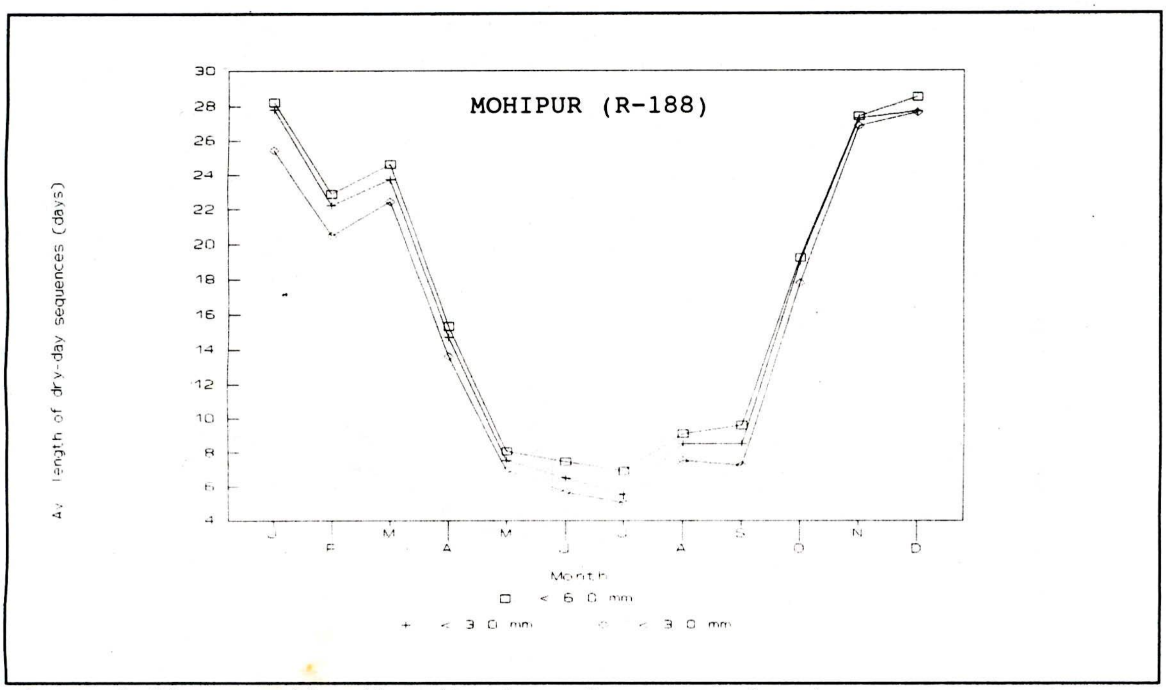


Figure 3.22 : Monthly distribution of average dry-day sequences at Mohipur (1970, 1972-90).

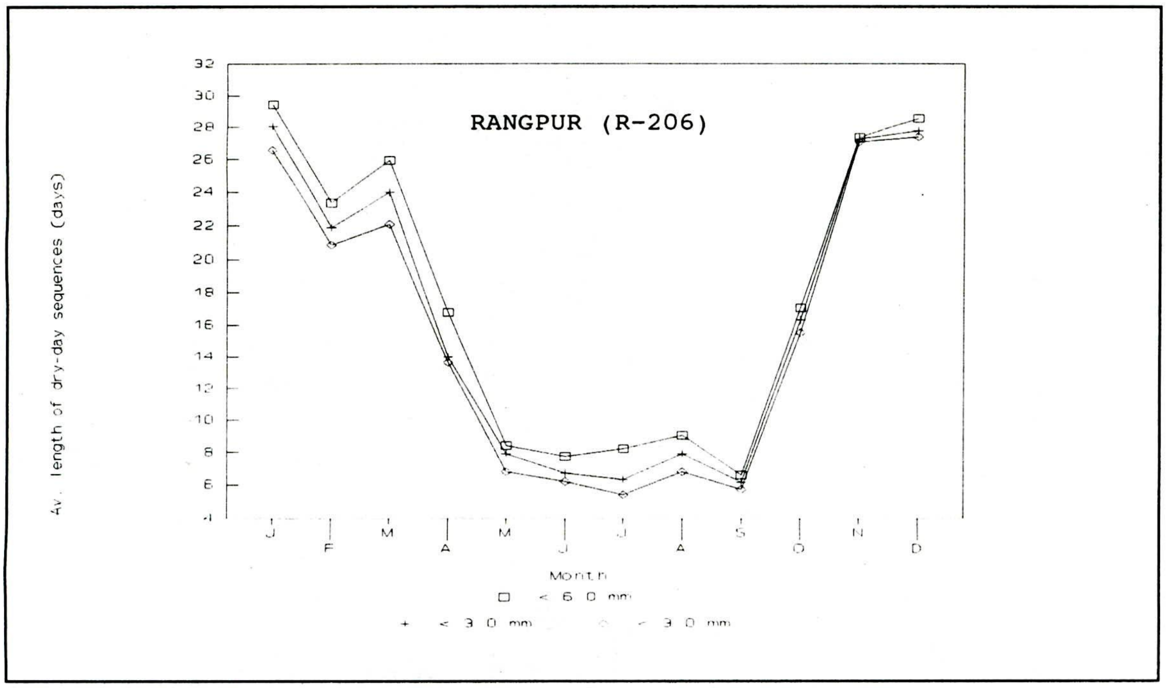


Figure 3.23 : Monthly distribution of average dry-day sequences at Rangpur (1971-90).

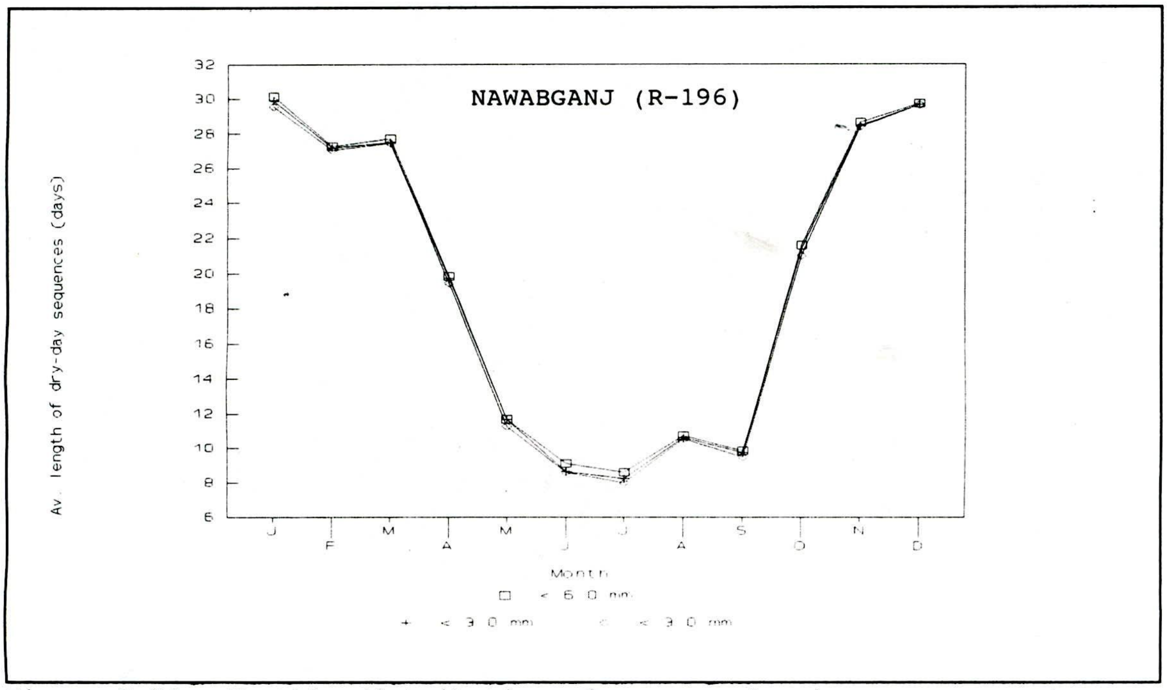


Figure 3.24 : Monthly distribution of average dry-day sequences at Nawabganj (1966-81, 1983, 1985-87).

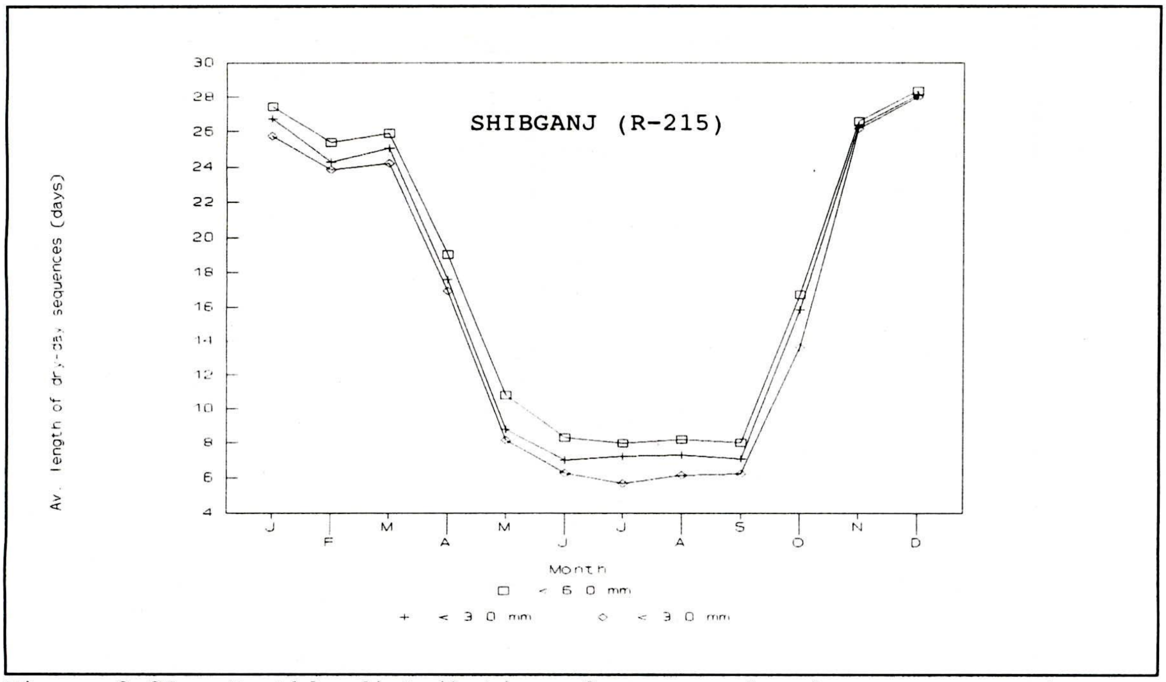


Figure 3.25 : Monthly distribution of average dry-day sequences at Shibganj (1965-80, 1983-86).

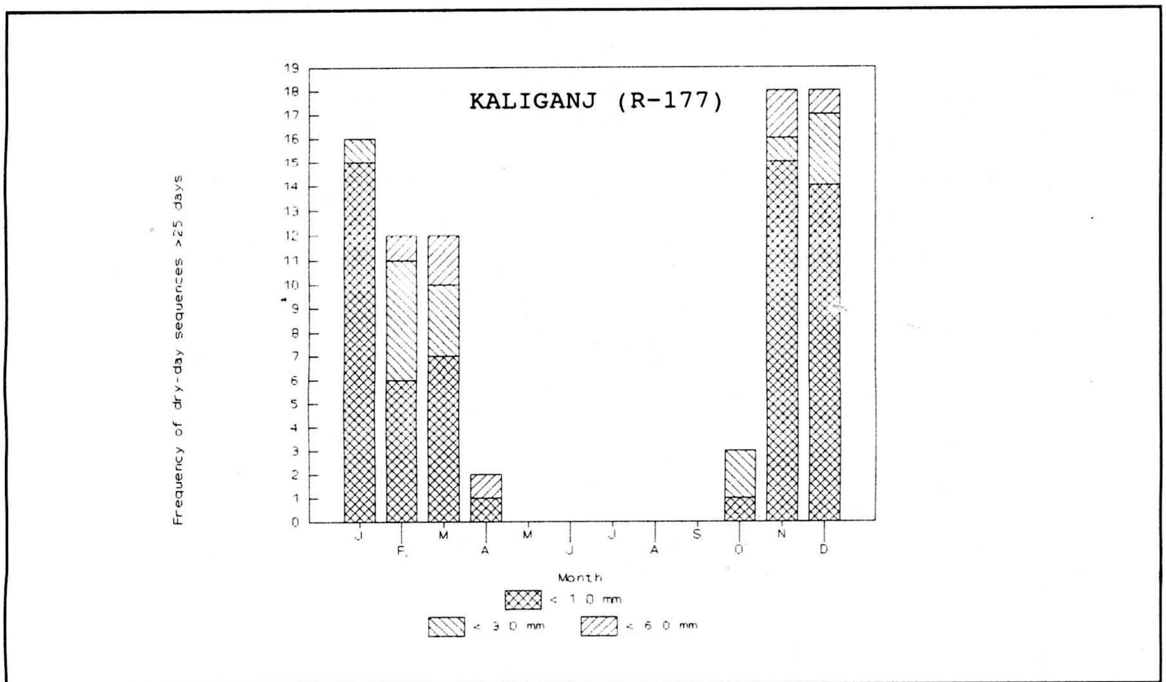


Figure 3.26 : Monthly distribution of dry-day sequences at Kaliganj (1970, 1972-90).

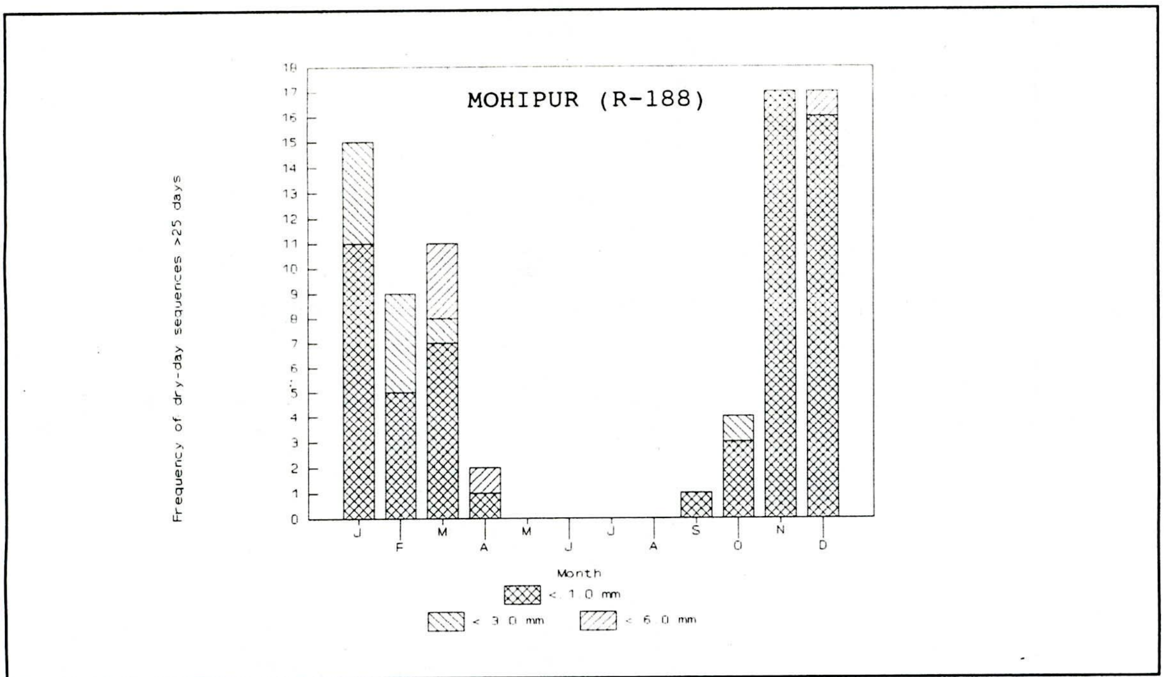


Figure 3.27 : Monthly distribution of dry-day sequences at Mohipur (1970, 1972-90).

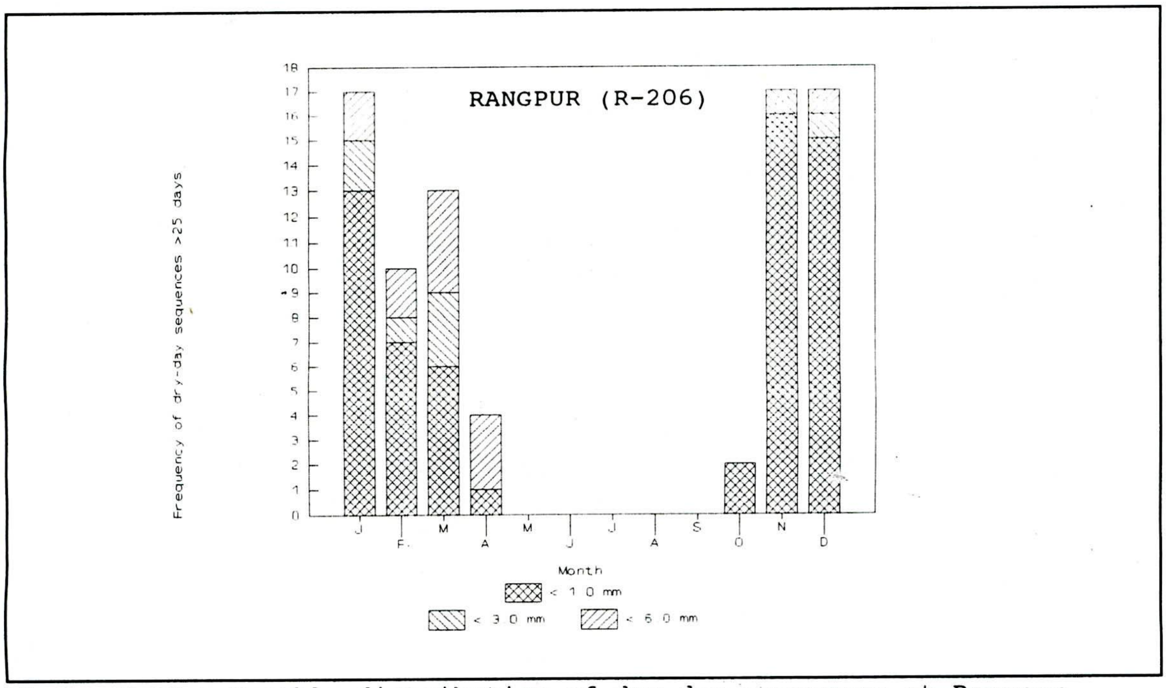


Figure 3.28 : Monthly distribution of dry-day sequences at Rangpur (1971-90).

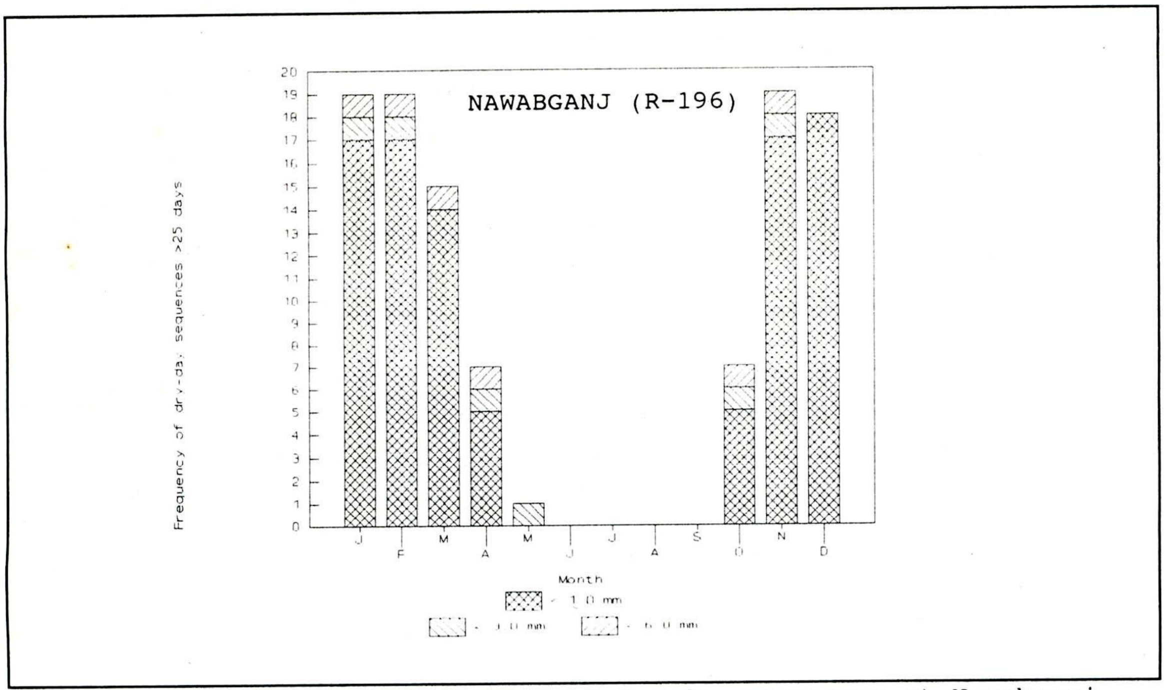


Figure 3.29 : Monthly distribution of dry-day sequences at Nawabganj (1966-81, 1983, 1985-87).

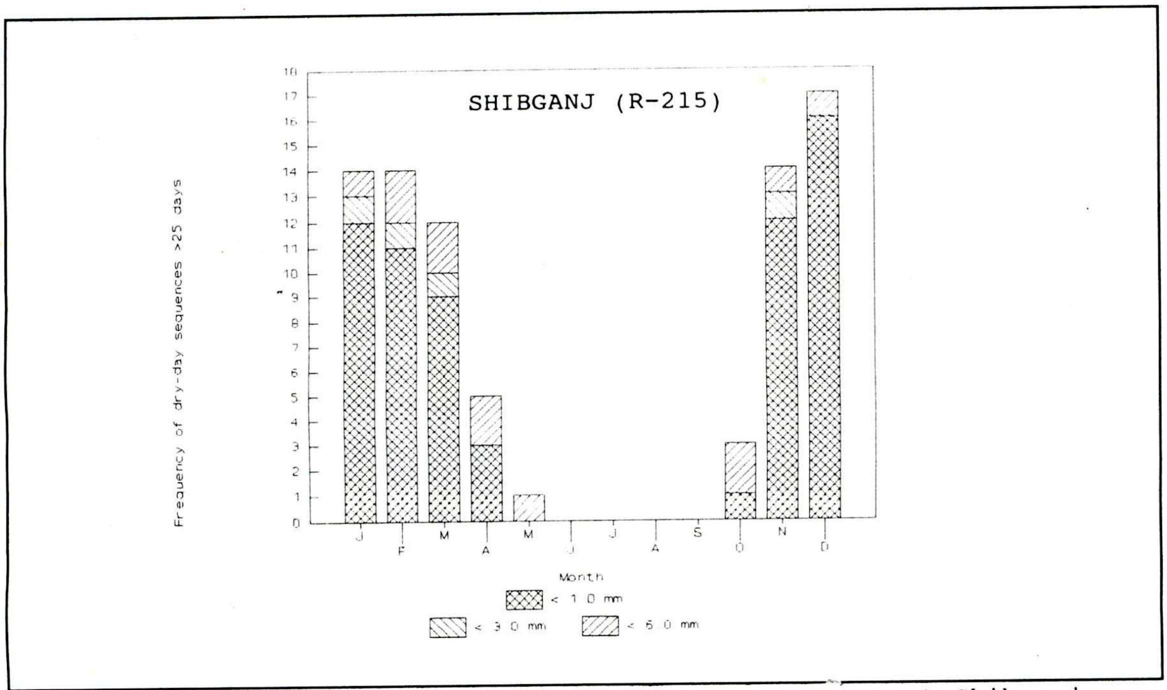


Figure 3.30 : Monthly distribution of dry-day sequences at Shibganj (1965-80, 1983-86).