



**STUDIES IN CROP WEATHER
OF
RICE CROP IN KARNAL DISTRICT**

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**THE ECONOMIC & STATISTICAL ORGANISATION, PLANNING DEPARTMENT,
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The Haryana Government does not hold itself responsible for any opinions expressed or conclusions reached by the writers in this report:

PREFACE

The Economic and Statistical Organisation, Haryana has attempted to compile this Brochure on 'Crop Weather Studies of Rice Crop' in Karnal district. It contains useful time series data regarding area, production and yield extending over a period of half a century. The estimates of area and production are based on the State Season and Crop Reports issued by the Directorate of Land Records.

It is hoped that the publication will be found useful by the persons and organisations interested in long term Crop Weather Studies.

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CONTENTS

<i>Preface</i>	<i>Page</i>
CHAPTER — 1 GEO-PHYSIOGRAPHY OF KARNAL DISTRICT	
1.1 Location	.. 1
1.2 Area	.. 1
1.3 Physical Features	.. 1
1.4 Rivers and Streams	.. 2
1.5 Climate	.. 2
1.6 Rainfall	.. 2
CHAPTER — II AGRO-ECONOMIC PROFILE OF KARNAL DISTRICT	
2.1 Introduction	.. 5
2.2 Size of Holding	.. 5
2.3 Land Utilization	.. 6
2.4 Cropping System	.. 6
2.5 Main Crops	.. 7
2.6 Cropping Pattern	.. 7
2.7 Irrigation	.. 7
CHAPTER — III EXPLANATORY NOTES	9
CHAPTER — IV APPENDICES	
4.1 Area, Yield, Production & percentage of Irrigated Area to Total Area under Rice 1906-07 to 1970-71 in Karnal District.	.. 14
4.2 (a) Monthly Rainfall Data for Karnal Station 1913 to 1971.	.. 16
(b) Monthly Rainy Days for Karnal Station 1913-1971.	.. 20
4.3 Average Monthly Temperature Data for Karnal District 1949-50 to 1970-71.	.. 22
4.4 Frequency Distribution of Monthly Rainfall at Karnal Station according to the amount of Rainfall (1922-1971)	.. 23
4.5 Mean, Standard Deviation, Co-efficient of Variability, Range, Deciles, Quartiles & Semi-Inter Quartile Range of Monthly Data of Karnal Station (1922 to 1971).	.. 24
4.6 Frequency Distribution of Monthly Rainfall Data together with the value of Mean, Standard Deviation and Co-efficient of Variability for Karnal Station 1922-1971 (January-December)	.. 26

4.7 Occurrence of Flood and Drought in Karnal District during Different Months (1922—1971)	.. 32
4.8 Consumption of Fertilizers in Karnal District (1960-61 to 1970-71)	.. 36
4.9 Agricultural Machinery & Implements in Karnal District	.. 37
4.10 Sowing, Harvesting and Peak Marketing Seasons of Principal Crops in Karnal District.	.. 38
4.11 Land Utilization	.. 39
4.12 Cropping Pattern	.. 41
4.13 Relative Contribution of Area and Yield to increase in Production of Rice in Karnal District (1951-52 to 1970-71)	.. 43

1. Rainfall Pattern of Karnal District (1922—1971).
2. Range, Lower Quartile, Upper Quartile and Median for Monthly Rainfall Data for Karnal Station from 1922—1971.

1. Calendar of Rice Cultivation Practices in Karnal District.

CHAPTER 1

GEO-PHYSIOGRAPHY OF KARNAL DISTRICT

Location

1.1 The Karnal District, with its headquarters at Karnal, inherits its location from Karnal, half brother of the Pandwas. The district lies along the eastern boundary of Haryana, between $29^{\circ} 09' 50''$ and $30^{\circ} 15' 15''$ north latitude and $76^{\circ} 10' 10''$ & $77^{\circ} 17' 05''$ east longitude. Districts of Saharanpur, Muzaffarnagar and Meerut of Uttar Pradesh face it across the river Jamuna which forms its eastern boundary. Further, it is bounded by Ambala District in the north, Patiala and Sangrur districts of Punjab on the west and Rohtak District on the south. The city of Karnal is situated on the G.T. Road and is nearly 120 km north of Delhi.

Area

1.2 Next to Hissar district, Karnal is the 2nd biggest district of Haryana State. According to the Surveyor General of India it stretches over an area of 7932 sq. Kilometres which forms 18% of the total area of the State. The district comprises of five (5) tehsils, namely, Thanesar, Panipat, Kaithal and Guhla. There are 1,421 inhabited villages (1961 Census) covered by 15 Community Development Blocks.

Physical Features

1.3 By and large, the district is a flat alluvial plain having a transition from north to south by the water shed separating the drainage of the J. river from that of the Ghaggar. The east of the water shed which consists of river tract of Jamuna is known as 'Khadar'. It is a low lying tract of new alluvium and marks western limit of Jamuna waters. The soil is fertile and water being close to the surface, renders the sinking of wells easy. The tract is threatened with recurring floods. The altitude of the plain gradually decreases from north to south at about 44 cms. to a Kilometre.

In upland plain of 8 to 17 Km. which lies to the west of the water shed is called 'Bangar'. It stretches parallel to 'Khadar' in Thanesar, Panipat and Guhla tehsils. The area is well irrigated by canals, tube wells and shallow wells. To the west of 'Bangar' in Karnal and Kaithal Tehsils, a high table land called the 'Nardak' is situated where the water table is deep and land is covered with various grasses and 'Dhak' trees. These trees have been removed now during the land reclamation operations. Both the 'Bangar' and the 'Nardak' tracts are composed of old alluvium. 'Bangar' tract of I. Tehsil which lies west of the 'Nardak' resembles the uplands of Rohtak and The country west of 'Bangar' consisting of western parts of Thanesar and Panipat tehsils is known as the 'Naili' of Chhachhra tract. A number of stream bed torrents traverse on it. The 'Bet' along the Markanda stream is relatively a low lying flood plain in which clay is the prevalent soil. A lot of land has been reclaimed here. The low lying area along the Saraswati stream suffers from poor drainage during rainy season.

The mean elevation of Karnal above the sea level is about 252 metres, of Thanesar 252 metres, of Panipat 235 metres, of Kaithal 235 metres and of Guhla 238 metres.

Rivers and Streams

1.4 The river Jamuna flows on the eastern boundary of the district for a length of 78 Km. from the village Ramgarh to the village Rakhsera. The Jamuna has been drifting eastward and some scholars are of the opinion that it was once flowing in the present course of Saraswati.

The 'Bhuri Nadi' runs along the western margin of the 'Khadar' tract and causes considerable damage during monsoons both to the villages on its banks and the 'Kharif' crops but the silt it deposits, helps in the 'Rabi' sowings.

The 'Ghaggar' flows in the north of the district. Two other streams, namely, Markanda and Saraswati flow towards the west of the district and join into the Ghaggar river. All the three streams originate from the lower Shiwalik Hills.

The 'Markanda' enters the Karnal district near the Domli village and passes by Shahbad. After flowing in the south-westerly direction for about 48 Kms., it joins the Saraswati. It is seasonal and quite a nuisance causing flood havocs during monsoons. The lands on its banks are fairly fertile.

The 'Saraswati Nadi' along with several small tributaries, drains a large part of Thanesar tehsil and causes floods in the rainy season in the low-lying 'Naili' tract. It joins the Ghaggar soon after crossing the boundary of the district.

Besides, there is a number of other streams flowing in the north-west of the district, namely, the Rahkshi Nadi, the Chautang Nadi, the Omla Nadi, the Patiala Nadi, the Nai Nadi and the Ganda Nala. Consequent upon the low lying banks, Karnal district suffers heavily from inundation during the rainy season.

Climate

1.5 Like plains of the Punjab, the climate of the Karnal district is of extreme nature i.e. quite hot in summer and sufficiently cold in winter. The temperature begins to rise towards the close of March and keeps on rising till the mercury touches 114° towards the middle of June. Hot winds blow and the sun blazes hot especially between 1 PM. and 4 PM. The rainy season sets in by the first week of July and continues till about the end of September. The atmosphere becomes sultry and humidity is more marked, because of the swamps which make it malarial. From early October, the weather takes a turn to fine and a mild cold sets in by the end of October. November and December are pleasant and normally free from rain though light frost is also experienced from mid December. January and February are the months of biting cold and also experience mild rains. Towards the beginning of March the spring season sets in with the return of pleasant weather. There is a large variation in temperature between the different seasons.

Rainfall

1.6 Bulk of the rainfall (82.27%) is confined to the months of July to

September. The average annual rainfall of the district for the last 50 years *i.e.* 1922 to 1971 has been measured at 735.82 millimetres. Generally, the monsoons start towards the end of June. July and August are the months of heaviest rainfall. The variation in the monthly rainfall over a number of years can be well appreciated from Appendix 4.2.

The erratic character and unevenly distribution of rainfall is pretty evident. The rainfall during the past 50 years has varied from 354.08 mm. to 1200.65 mm. Further the variation of rainfall during the same months in different years is also significant. For instance, normally, the month of November receives very scanty rainfall but during the year 1959 the rainfall recorded during the month was as high as 32.00 mms. A similar position in respect of other months can also be observed from the Appendix under discussion.

The precipitation, as given in the following Table, is the highest during the monsoon season which alone accounts for 82.27 per cent of the annual rainfall during the period 1922 to 1971. The winter rains are generally received in the months of January and February. Of the period under study, the highest rainfall has been during the year 1935 being 1200.65 mms.

**Average Rainfall at the Karnal Station for the period
1922 to 1971**

Month	Rainfall (mms.)	Season	Total rainfall (mms.)	Percentage to total rainfall	Total number of rainy days
1	2	3	4	5	6
June	61.13	Monsoon Season	605.33	82.27	3
July	203.23				9
August	217.16				9
September	123.81				4
October	20.27	Post Monsoon season	34.96	4.75	1
November	3.22				1
December	11.47				2
January	30.95	Cold Season	60.38	8.21	1
February	29.43				1
March	15.33	Hot Season	35.15	4.77	1
April	10.17				1
May	9.65				1
Total	735.82		735.82	100.00	33

The average annual rainfall of 735.82 mms. during the period under discussion, was received in 33 rainy days. The concentration of rainy days is the highest in the monsoon season. During the hot season, the post monsoon season and the cold season there had been rainfall of 35.15, 34.96 and 60.38 milimetres, respectively.

Precipitation and number of rainy days may be sufficient to meet the requirements for crop production provided the rains are well distributed. In actual condition, the sowing season of crops may remain without any rain or the absence of precipitation during the growth period may also affect the maturity of the crops. Heavy rains during the monsoon season may create havoc by devastating the standing 'Kharif' crops and also resulting in the loss of human life and the cattle head.

CHAPTER II

AGRO-ECONOMIC PROFILE OF DISTRICT KARNAL

Introduction

2.1 Though in the past, sugar, wine & spirits, hand-loom textiles, woolen yarn, agricultural implements, engineering, foundaries, cycle and sewing machine parts, conduit pipes, steel fabrication, rice shellers and oil extraction etc. industries have developed yet the general economy of the district is predominantly an agricultural one. In 1971, the District population was about 19.75 lakh of which nearly 83% was rural. The proportion of total working population dependent on agriculture was 67.38% according to the 1971 census.

Size of Holding

2.2 The holdings are generally small but with the increase in irrigational facilities, coupled with the knowledge and consciousness about the new technology, farmers are trying to raise two to three crops in a year. In the water-logged and swampy areas caused by heavy rains and floods, a changed cropping pattern is being adopted to suit the conditions. Instead of usual growing of cotton, maize and bajra, they have switched over to more and more of rice and sugarcane cultivation during Kharif season.

Percentage of sample households engaged in cultivation classified by size of land cultivated in district Karnal *vis a vis* the Haryana State based on 20% sample (1961 census) are given below in the Table.

Sample Households Engaged in Cultivation in Karnal District
(Classified by size of land cultivated).

Size of Holding (Acres)	KARNAL		HARYANA	
	No.	Percentage	No.	Percentage
Less than 5	3390	13.47	21211	16
5—10	7382	29.32	33965	26
10—15	6317	25.09	29224	22
15—30	5864	23.29	32004	25
30 Acres and above	2223	8.83	14337	11
Total*	25176	100.00	130741	100

*Excludes the number of unspecified holdings.

Source :—Census of India 1961 (Part III, Vol. III).

As regards the size of holdings, the preponderance in this district is of smaller farmers compared to the general size of holdings in Haryana as a whole. It is pretty evident from the above table that bulk of the land in the district (68%) is held in sizes less than 15 Acres whereas the large holdings do influence the economic conditions and the attitude of the farmers also considerably. Economically, a larger holding means a larger income even if the return per hectare on the average is low.

Land Utilization

2.3 Since the inception of planning era in 1950-51, the land utilization pattern of the district has undergone a significant change (Appendix 4.11). Out of 803 thousand hectares of total area according to village papers, eleven thousand hectares were covered by forests, 97 thousand hectares were classified as area not available for cultivation, 38 thousand hectares as other uncultivated land excluding fallow land and 11 thousand hectares as current fallows during the year 1970-71. The net area sown was 646 thousand hectares and area sown more than once was 298 thousand hectares, thus making the total cropped area to 944 thousand hectares.

Cropping System

2.4 Three systems of cropping are prevalent in the District of Karnal, namely, 'Dofasli harsala, Dofasli dosala and Ekfasli harsala'.

The 'Dofasli harsala' means two harvests in a period of twelve months. It usually takes the form of sowing maize in Kharif followed by gram or fodder in Rabi, or wheat followed by Kharif crop (Paddy/Bajra, etc). If the Kharif crop is cotton, it is usual to sow 'Señji' or 'Metha' for fodder in the standing crop of cotton for the Rabi. This system of cropping is in vogue in the areas having irrigation facilities. On Well/Tube-Well irrigated lands near the towns normally as many as three crops of vegetables and fodders are raised in a year.

The 'Dofasli dosala' system consists in sowing of Rabi followed by Kharif and then leaving the land fallow for a year to recoup the nutrients of soil. This system is followed on lands irrigated by seasonal canals and also on firmer 'Barani' areas but is not popular since it frequently gets upset on account of erratic character of rainfall in the region.

'Ekfasli harsala' indicates a single crop in a year. This system is practised on Barani lands. In swampy land where nothing but rice can be grown, the fields are left fallow for the Rabi or sometimes Barley is put in as a fodder crop. If the soil is purely sandy, the crop grown is Gram but in case good soil lies under sand, 'Gochani' (Mixture of wheat and Gram) is grown year after year.

Like other districts of the State, growing of mixed crops like "Gochani and Bejhar" (Barley and Gram) is quite familiar in 'Barani' areas. Mixed crops are sown so as to stand against the vagaries of uncertain weather. If the rains favour, Wheat comes up better but should the rains be scanty, then at least

Gram may be expected to bear some yield. 'Sarson' seed is sometimes sprinkled in the wheat fields, and its crop is removed early for fodder and wheat is allowed to grow in full strength. Melons are also sown with cotton and removed before Cotton plants shade the ground. Mixed fodder of Jowar and Gowara is also raised.

Again it is a common practice to grow pulses which are of short duration alongwith cereals, e.g., maize and mash; bajra and moong; barley and masoor, etc.

Main Crops

2.5 Like whole of the Haryana State, there are two main harvests 'Rabi' (Hari) and 'Kharif' (Sawni) in the district. The Rabi, also known as spring harvest, consists of wheat, gram, barley, oilseeds (rape and mustard, etc.), potatoes and fodder crops (barseem, senji, etc.). They are sown mostly during October-November and are harvested from mid-March to mid-May. The Kharif or autumn crops comprise of rice, maize, Jowar, Bajra, pulses (Moong, Mash, etc.), Cotton, Groundnut and Sugarcane. They are sown in March to August and are reaped from early September to late December. Sugarcane and cotton are sown a little earlier and there are some crops which come in—between the principal harvests. For instance, Toria matures late in December and is classed as 'Zaid Kharif'. Similarly Tobacco and Melons are harvested late in June and are classed as 'Zaid Rabi'.

Cropping Pattern

2.6 The cropping pattern in the Karnal district is heavily biased in favour of food-grains which accounted for 80.2% of the total cropped area during the year 1970-71 (Appendix 4.12). Next to wheat, rice is the most important crop covering about 19% of the cropped area, followed by gram, maize and bajra which occupied 8.8%, 5.6% and 4.2% respectively. Among the commercial crops, sugarcane had the largest area (3.9%) of the gross cropped area followed by oilseeds (2.4%) and cotton (1.5%).

Except for Rajound and barring a few areas of Kaithal, rice is cultivated extensively all over the district. Further, of late, water logging and swamps from which the district suffers have also helped in the increase of area of the said crops. Paddy cultivation has increased tremendously (nearly 300% in 1970-71 over 1950-51). Thus, the district has earned the name of "Rice Bowl" of the State. Not only in quantity but the region is also very famous for its quality rice (BASMATI) which fetches more remunerative prices and perhaps this is one of the reasons why the adoption of improved varieties of rice is slow with the cultivators of this area as compared to the other rice producing regions of India. Again on account of good taste and popularity, it also helps in securing higher prices to the growers. Nearly 62% of the State output of paddy is contributed by this region alone.

Irrigation

2.7 The rainfall in the district is not at all adequate for crop husbandry, since it is not only erratic in character but very much unevenly distributed. This inadequacy of rainfall coupled with meagre supply of water by canals and awakening of the agriculturists about the benefits of HYV seeds and use of fertilizers for higher outputs has encouraged them to exploit the sub-soil water. As

a result of which minor irrigation has made a tremendous progress. The number of tubewells and pumping sets has increased from 12,852 in 1966-67 to *42,193 in 1970-71.

Wells and Tubewells are the chief source of irrigation in the district which alone command more than 64% of the irrigated area. Canals come next in importance (35.5%). The proportion of net irrigated area to net area sown was 70.4% during the year under review. Of the total irrigated area of about 668 thousand hectares during 1970-71, 538 thousand hectares were under food-grains. The irrigated area under rice was 173 thousand hectares which formed nearly 97% of the total area under the crop.

2.8 The operation of Intensive Agricultural District Programme, commonly called the Package Programme is a most significant feature of district Karnal. This programme was launched in Rabi 1966-67 soon after the Haryana State came into existence. In 1967-68 all the villages spread over 15 C.D. blocks were covered under the I.A.D.P. The College of Agriculture at Kaul and the National Dairy Research Institute, the Ground Water Testing Laboratory and a wing of the Indian Agricultural Research Institute are located at the District Headquarters.

*Table No. 4.6 of Haryana State Statistical Abstract, 1971-72.

CHAPTER III

EXPLANATORY NOTES

Data regarding area, yield and production in respect of rice crop and percentage of irrigated area to total cropped area under rice in the Karnal district for the years 1906-07 to 1970-71 have been presented in Appendix 4.1. The data have been taken from the relevant Season and Crop Reports of Punjab and Haryana States. The estimates of production of rice for 1952-53 and subsequent years are based on the results of random sample crop cutting experiments whereas the estimates for the year 1951-52 and the preceding years are based on an eye estimation and are, therefore, not strictly comparable to those for the subsequent years.

Appendix 4.2 shows the average monthly rainfall data for the Karnal station from 1913 to 1971. The normal dates of starting and closing of monsoon rains in the district are 15th June and 15th September, respectively.

Figures of average monthly temperature for the years 1949 to 1970 have been set out in Appendix 4.3

Appendix 4.4 describes the frequency distribution of monthly rainfall of Karnal according to the amount of rainfall for the 50 years' period ending 1971. This frequency distribution has been depicted by a graph at the end of this report (Graph I). Probabilities of variation in rainfall can be calculated from this graph, taking 50 years equal to 100% probability.

If a particular rainfall range occurred in say "fi" years, probability of such rainfall will be $\frac{fi \times 100}{50}$ per cent. For example, reading from the graph the probability of 25.1 mm to 50 mm rainfall in June is $\frac{8 \times 100}{50} = 16\%$.

Appendix 4.6 indicates mean, standard deviation and co-efficient of variability of rainfall of Karnal station from 1922 to 1971 for each month. This appendix also gives Deciles, Median and Semi-Inter-Quartile Range. Range, Lower Quartile, Upper Quartile and Median for monthly rainfall data have been shown in Graph II. Dependability of rainfall can be taken as inversely proportional to co-efficient of variability. It will be seen from the appendix that the Co-efficient of Variability is above 100% for the months of February to April, June, October and December. It is less than 100% for the months of January, May and September and just above 55% for July and August months. But the co-efficient of variability of the annual rainfall is only 28.3%. This shows that though the annual rainfall is fairly stable, its distribution over different months varies considerably.

High values of Co-efficient of Variability are no doubt due to large variations in the monthly rainfall over years, but are also due to the fact that arithmetic mean and standard deviation are much affected by the few extreme

values. This fact is clearly brought out by the rainfall data of October. Co-efficient of Variability for October is as high as 243%, mainly due to high rainfall in only two years out of the 50 years. Excluding the highest rainfall value, the Co-efficient of Variability comes down to 128 % and excluding further the next two highest rainfall values it comes down to 111 %. Mean rainfall also comes down to 12 mm from 20 mm if the extreme two values are excluded. Hence it was thought that pattern of monthly rainfall might be studied better by taking Median as average and Semi Inter-Quartile Range as a measure of dispersion. Deciles are also calculated for finer analysis of the range. Analysis of the rainfall data for each month is as under : —

JANUARY

During the 50 years' period under discussion, though the rainfall varied from 0 mm. to 113 mm, Median rainfall was only 21.3 mm and Semi-Inter-Quartile Range was 26.3 mm. Reading from the Deciles, it may be pointed out that in one out of 10 years the rainfall may practically be nil. In 4 out of the 10 years, the rainfall may be around 2 cm. In another 3 years in the decade, rainfall may be moderate *i.e.* between 2 cm. and 8 cm. In the remaining two years of the decade, it may be relatively higher *i.e.* above 8 cm.

FEBRUARY

Though rainfall varied from 0 mm to 144 mm during the period under reference, Median rainfall came to 19.1 mm and Semi-Inter Quartile Range was 17.0 mm. Observing the Deciles, it may be experienced that in one out of the 10 years rainfall may practically be nil. In 3 out of the 10 years, there may be rainfall up to 1 cm. In another 5 years of the decade, rainfall may be moderate *i.e.* ranging between 1 cm and 5 cm, whereas in the remaining two years of the decade, it may relatively be higher *i.e.* above 5 cm.

MARCH

During the half-century period under review, though rainfall varied from 0 mm to 62.5 mm., Median rainfall was only 7.0 mm and Semi-Inter-Quartile Range was 11.6 mm. While going through Deciles, it has been observed that in 1 out of 10 years there may not be any rainfall at all. In another 3 years of the decade, rainfall may be up to 1 Cm. and in another 5 years, rainfall may be moderate *i.e.* ranging between 1 cm. and 5 cm. In the remaining one year in the decade, it may be relatively higher *i.e.* above 5 cm.

APRIL

The Median rainfall was only 23 mm and Semi-Inter-Quartile Range was only 7.7 mm, though the rainfall varied from 0 mm to 55.9 mm during the period 1922 to 1971. Reading from Deciles, it may be pointed out that in 3 out of 10 years the rainfall may practically be nil. In 4 out of 10 years, the rainfall may be very low *i.e.* about one centimetre. In another 3 years, it may be moderate *i.e.* from 1 cm. to 3 cm and only in one year it may relatively be higher *i.e.* above 3 cm.

MAY

During the 50 years' period under consideration, the rainfall varied

from 0 mm to 52.1 mm but the Median rainfall came to 5.6 mm only and Semi-Inter-Quartile Range was 7.6 mm. While going through the Deciles, it has been observed that in two of 10 years, the rainfall may practically be nil. In another 4 years it was around 1 cm. In another 3 years it may be moderate ranging between 1cm and 2.1 cm. Only in one year it may be relatively higher i.e. above 2 cm.

JUNE

Though rainfall varied from 0 mm to 373.9 mm, Median rainfall was only 34.5mm. and Semi-Inter-Quartile Range was 34.3 during the period under discussion. No doubt monsoons break in the last week of this month, yet one in 10 years may be without any rain showing late outbreak of the monsoons. In 3 out of 10 years, rainfall may be low i.e. between 1 cm and 3 cm. In another 4 years out of 10 years, rainfall may be moderate i.e. from 3 cm to 8cm. And in the remaining 3 years it may be relatively higher i.e. above 8 cm. showing a good start of the monsoons.

JULY

During the period of 1922 to 1971, rainfall varied from 26.5 mm to 548.5 mm. Median rainfall was 175 mm and Semi-Inter-Quartile Range was only 84.8 mm. Only in two out of the 10 years, rainfall may be very high exceeding 30 cm. In one out of the 10 years, rainfall may be comparatively low i.e. less than 3 cm. In another 4 years, rainfall may be moderate, i.e. between 8 cm. and 20 cm. In the remaining 3 years out of the 10 years, rainfall may be somewhat higher being between 20 cm. and 30 cm.

AUGUST

Median rainfall was 195.3 mm and Semi-Inter-Quartile Range was only 84.8 mm though the rainfall varied from 29.5 mm to 562.1 mm during the period under review. While observing the Deciles, it has been noticed that in 2 out of the 10 years, rainfall may be 2 cm. to 10 cm. In another 6 years out of the 10 years, it may be moderate i.e. between 10 and 30 cm. and only in 2 years it may be relatively higher exceeding 30 cm.

SEPTEMBER

During the half-century period under discussion, rainfall varied from 0 mm to 543 mm. Median rainfall was only 88.5 mm and Semi-Inter-Quartile Range was 69.8 mm. Though rainfall range is very wide, it will be seen from the Deciles that, only in two out of 10 years, the rainfall may be excessive i.e. more than 32 cm. and on the other hand one out of the 10 years may practically be without any rainfall. Out of the remaining 7 years of the decade, four years may have lower rainfall of 1cm. to 8cm. Two years may have moderate rainfall of 8 to 18 cm. and the remaining one year may have relatively higher rainfall of 18 to 32 cm.

OCTOBER

During the 50 years' period under reference, rainfall varied from 0 mm. to 262 mm. and the Median rainfall was very low i.e. only 1.8 mm. and Semi-Inter-Quartile Range was 7.5 mm. Though rainfall range was wide (26 cm.) it will be noticed from the Deciles that in 9 out of the 10 years,

rainfall may not exceed 4 cm. Out of these 9 years, there may not be any rainfall at Karnal in the month of October for 5 years, in 2 years it may receive rainfall less than 1 cm. and only in the remaining two years it may receive rainfall worth the name i.e. 1 to 4 cm. In one year (out of the 10 years) of excessive rainfall also, probability of rainfall exceeding 14 cm. is very small.

NOVEMBER

Though rainfall varied from 0 mm. to 35.3 mm, the Median rainfall was 0 mm. and Semi-Inter-Quartile Range was 0.6 mm. during the period under reference. Reading from Deciles it may be pointed out that in 6 out of the 10 years there may practically be no rainfall; in 2 years there may be light rainfall around 0.15 cm., in one year the rainfall may be around 1 cm. and only in the remaining one year it may be more than 3 cm.

DECEMBER

During the 50 years' period under review, though the rainfall varied from 0 mm. to 66.7 mm. Median rainfall was only 2 mm and Semi-Inter-Quartile Range was 8.3 mm. It will be observed from the Deciles that in 4 out of 10 years there may practically be no rain and in 2 years rainfall may be around 1 cm. In another 2 years the rainfall may be moderate i.e. between 1 cm and 2 cm. Only in the remaining 2 years it may comparatively be more/exceeding 2 cm.

Appendix 4.6 shows the frequency distribution of rainfall data for the Karnal station from 1922 to 1971 for the various months. Arithmetic mean, Standard deviation and Co-efficient of Variability (Std. deviation $\times$ 100/Arithmetic mean) calculated from frequency distributions as well as from discrete series have also been indicated in this appendix

Appendix 4.7 indicates the years of drought and flood in the Karnal district from 1922 to 1971 based on monthly and annual rainfall data. For the various months, rainfall less than or equal to the half of the normal rainfall has been taken as drought and that more than or equal to the double of the normal rainfall is taken as flood. For annual rainfall if the deviation from the normal is negative and more than the mean deviation but less than twice the mean deviation it is taken as moderate drought but if it is more than or equal to twice the mean deviation it is taken as severe drought. On the other hand, if the deviation is positive and more than or equal to twice the mean deviation it is taken as flood. As rainfall spacing from month to month varies considerably, only drought or flood in succession for 3 or 4 months may really be taken as of significance.

In addition to establishing relationship of area and production of rice crop with rainfall, a few appendices (4.8 to 4.12) giving data pertaining to consumption of fertilizers, agricultural implements and machinery, sowing, harvesting peak and marketing seasons of principal crops, land utilization and cropping pattern of Karnal District have also been given at the end of the report for the general information of the reader.

The relative contribution of area and yield to increase production in the Karnal District during the period 1951-1952 to 1970-71 has been analysed and comes to 31.1 per cent and 68.9 per cent, respectively (Appendix 4.13).

A chart showing the calendar of rice cultivation practices in the Karnal District has also been added at the end of this report.

CHAPTER IV

APPENDICES

Appendix 4.1

Area, Yield, Production and Percentage of Irrigated Area to Total area under Rice in the Karnal district—1906-07 to 1970-71.

Year	Area (Hectares)	Yield per Hectare (kgs.)	Production (M. Tonnes)	Percentage of Irrigated Area under Rice to Total Area under Rice
1	2	3	4	5
1906-07	28943	632	18294	23.2
1907-08	32634	142	4621	20.3
1908-09	23687	260	6153	22.5
1909-10	26614	422	11240	15.3
1910-11	19082	N.A	N.A	13.9
1911-12	3142	525	1649	62.8
1912-13	27479	482	13232	19.9
1913-14	2382	N.A	N.A	22.2
1914-15	28661	567	16255	20.8
1915-16	20261	N.A	N.A	29.8
1916-17	25409	N.A	N.A	15.6
1917-18	25409	717	18224	22.3
1918-19	15568	246	3830	31.0
1919-20	26953	359	9681	29.9
1920-21	27374	330	9042	27.8
1921-22	26432	657	17376	25.7
1922-23	21508	699	15037	28.7
1923-24	22135	702	15545	21.7
1924-25	18176	324	5893	23.4
1925-26	20756	534	11074	21.2
1926-27	24455	461	11278	25.2
1927-28	21552	519	11176	32.7
1928-29	19612	394	7722	40.9
1929-30	18460	264	4870	49.7
1930-31	21901	501	10973	39.7
1931-32	17862	637	11379	46.7
1932-33	22925	563	12903	30.1
1933-34	26851	507	13614	24.9
1934-35	30923	506	15646	24.8

1	2	3	4	5
1935-36	38686	536	20726	21.9
1936-37	32506	588	19101	26.3
1937-38	29232	587	17170	30.5
1938-39	24006	491	11786	30.0
1939-40	28170	188	5283	40.3
1940-41	26646	644	17170	45.1
1941-42	13207	1716	22657	48.6
1942-43	24030	271	6502	36.7
1943-44	28456	568	16154	43.1
1944-45	19727	1221	24079	57.1
1945-46	22365	681	15240	48.7
1946-47	27486	595	16358	46.1
1947-48	17300	1186	20523	36.0
1948-49	19272	754	14528	44.5
1949-50	23134	804	18593	52.2
1950-51	39658	769	30480	51.0
1951-52	32779	1333	43688	58.0
1952-53	37231	1337	49784	58.7
1953-54	41277	1575	65024	62.7
1954-55	38040	1496	56896	66.0
1955-56	41682	1243	51816	61.2
1956-57	57060	1264	72136	63.1
1957-58	60297	1736	104648	73.8
1958-59	68391	1649	112776	69.8
1959-60	77699	1739	135128	73.4
1960-61	93072	668	158300	74.2
1961-62	102324	627	183803	72.5
1962-63	105000	1771	185928	73.3
1963-64	95527	528	124974	77.9
1964-65	119000	1588	188976	68.9
1965-66	127000	1252	159544	80.3
1966-67	125702	1214	153000	83.3
1967-68	138362	1431	198000	87.7
1968-69	145187	1163	169000	91.0
1969-70	154650	1570	243000	94.8
1970-71	178569	1930	346000	96.9

N.A. = Not Available

APPENDIX
Monthly Rainfall Data

Year	January	February	March	April	May	June
1	2	3	4	5	6	7
1913	3.81	44.45	46.99	2.54	46.99	114.30
1914	—	20.32	2.54	33.02	46.99	44.45
1915	59.18	67.06	25.40	2.54	29.21	5.08
1916	1.27	8.38	—	2.03	22.86	77.22
1917	6.35	9.65	2.79	24.64	19.30	89.15
1918	10.67	—	8.38	11.94	—	59.94
1919	70.36	2.79	9.40	1.27	7.62	6.60
1920	8.38	12.70	7.87	—	10.16	108.46
1921	40.39	1.27	0.25	3.05	—	20.32
1922	18.03	13.46	—	2.79	1.78	209.80
1923	10.92	61.72	1.27	—	22.61	—
1924	76.71	6.86	1.52	—	5.59	17.53
1925	33.27	—	—	8.64	15.75	373.89
1926	7.62	19.05	55.63	14.73	19.05	21.59
1927	—	84.33	19.30	40.64	11.94	5.33
1928	57.66	50.80	—	2.03	8.13	23.88
1929	47.50	—	—	20.07	2.54	2.54
1930	42.42	6.86	—	3.05	0.76	85.09
1931	—	44.20	19.30	2.54	5.59	—
1932	—	4.06	52.07	4.83	1.02	24.64
1933	2.29	28.45	25.40	6.10	52.07	146.56
1934	27.94	8.13	43.94	1.52	3.05	21.84
1935	101.85	39.12	14.48	39.62	—	—
1936	2.03	22.10	4.83	—	19.81	302.01
1937	0.51	109.98	2.49	42.16	3.56	34.54
1938	80.01	19.81	1.27	6.35	2.54	19.56
1939	2.03	58.17	11.43	—	—	143.00
1940	21.34	72.90	22.61	19.81	5.33	29.97

4.2 (a)

For the Karnal Station 1913-1971

(In Millimetres)

July	August	September	October	November	December	Total
8	9	10	11	12	13	14
120.65	231.14	58.42	—	—	17.78	687.07
335.28	161.29	254.00	20.32	—	—	918.21
147.32	118.11	305.82	29.21	—	—	788.93
264.67	222.25	261.37	33.78	—	—	893.83
205.49	199.64	192.54	137.67	—	14.22	901.43
40.64	223.01	—	—	1.52	—	356.10
229.36	281.94	65.53	—	—	20.07	694.94
209.80	34.04	6.10	7.11	—	—	404.62
153.67	174.50	164.85	57.40	—	—	615.70
231.14	229.36	67.31	5.84	—	30.23	809.74
340.11	304.80	26.67	14.73	—	52.58	835.41
137.41	195.33	439.42	48.77	—	13.97	943.11
433.58	134.62	—	0.51	23.62	—	1,023.88
221.74	229.11	54.36	—	4.06	—	646.94
246.89	109.73	70.87	85.85	—	39.12	714.00
155.19	149.35	51.31	—	35.31	11.43	545.09
136.65	92.20	0.51	1.78	—	50.29	354.08
252.22	55.63	37.08	—	—	—	483.11
193.80	302.77	174.24	1.78	—	—	744.22
250.70	181.61	264.67	—	—	48.26	831.86
214.88	162.81	321.82	28.08	—	2.03	983.49
438.40	280.92	32.00	—	—	6.60	864.34
338.84	368.55	264.67	14.22	2.54	16.76	1,200.65
213.11	173.99	114.81	—	—	38.61	891.30
153.67	31.50	255.78	—	—	25.65	659.64
91.95	137.16	6.60	9.40	1.27	—	375.92
99.82	29.46	44.70	—	—	—	388.61
161.29	78.49	7.87	—	—	1.02	420.63

1	2	3	4	5	6	7
1941	65.79	13.97	2.54	—	18.03	136.65
1942	57.66	90.93	4.57	17.27	10.92	76.71
1943	42.67	7.62	7.11	14.22	—	72.64
1944	28.96	83.82	18.29	55.88	—	65.79
1945	53.85	—	1.52	11.68	4.32	41.66
1946	—	21.84	6.35	29.21	20.83	132.08
1947	44.45	6.86	3.81	—	8.38	6.35
1948	28.19	144.02	36.32	—	—	29.21
1949	—	31.24	2.79	—	7.62	12.45
1950	38.86	13.97	26.42	3.30	—	16.26
1951	19.05	—	34.54	9.65	28.70	8.13
1952	17.53	19.56	24.64	—	8.64	42.42
1953	46.99	4.06	—	24.64	0.76	131.05
1954	34.29	139.19	24.89	—	13.72	97.28
1955	92.46	11.94	4.06	26.42	8.64	47.75
1956	17.27	2.79	59.18	1.27	4.57	130.81
1957	79.90	—	44.90	23.70	—	11.20
1958	15.50	—	7.60	—	12.40	2.10
1959	28.40	19.80	23.70	—	7.00	55.00
1960	46.90	—	20.60	2.20	—	54.00
1961	113.00	29.80	—	11.00	2.70	6.80
1962	13.00	30.60	15.00	—	—	—
1963	22.00	15.00	7.00	4.00	7.00	77.00
1964	13.00	—	—	—	13.00	45.00
1965	3.20	36.00	4.00	52.00	25.00	—
1966	RNR	22.00	0.20	—	19.50	58.60
1967	—	0.20	67.60	0.20	14.90	6.40
1968	12.80	36.30	28.30	—	—	47.20
1969	6.00	25.50	22.60	—	17.80	21.30
1970	68.70	14.60	12.00	—	20.40	100.20
1971	4.80	—	1.50	7.10	36.50	62.60

RNR == Register Not Received
 — = Nil
 N.A. = Not Available

8	9	10	11	12	13	14
86.36	177.29	45.47	—	—	6.35	552.45
438.66	236.22	101.85	—	—	16.51	1,051.30
200.66	146.05	94.23	—	—	—	585.20
227.08	105.92	102.87	6.35	—	0.51	695.47
88.39	207.77	330.20	3.30	—	—	742.69
105.66	113.79	14.99	25.91	1.52	6.86	479.04
27.18	95.76	543.31	—	—	0.76	736.86
207.77	410.46	11.43	—	—	—	867.40
404.62	72.90	134.11	—	—	—	665.73
382.52	150.88	183.13	—	—	—	815.34
86.11	119.89	89.92	—	19.81	—	415.80
243.59	486.16	—	—	—	2.03	844.57
321.82	93.22	89.92	6.10	—	6.60	725.17
175.51	134.37	165.35	33.27	—	—	817.87
73.91	211.07	251.71	233.68	—	—	961.64
147.32	476.76	38.86	262.38	9.65	—	1,150.86
123.60	251.60	146.40	88.40	7.90	38.70	816.30
149.10	41.70	319.50	41.20	—	25.80	614.90
103.90	285.10	166.00	8.00	32.00	—	607.90
101.70	120.00	18.00	9.50	—	11.00	383.90
53.80	249.20	R	33.30	—	10.00	509.60
202.60	246.60	386.00	—	13.00	25.00	931.80
98.50	334.00	169.00	—	9.00	2.00	744.50
454.60	270.00	160.00	—	—	15.40	970.70
175.00	203.00	1.00	18.20	—	R	517.40
125.60	431.70	38.80	8.00	—	—	704.40
209.70	562.10	439.00	30.90	1.10	66.70	967.90
548.50	296.20	2.00	15.70	—	3.00	990.00
110.40	218.90	143.80	—	—	—	566.30
26.50	480.50	88.50	—	—	—	811.40
149.50	381.50	80.70	3.10	—	—	727.30

Appendix 4.2(b)

Monthly Rainy days for the Karnal Station 1913-1971

RAINY DAYS													
Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1913	1	3	4	1	3	6	7	7	1	0	0	2	35
1914	0	4	1	2	3	3	12	7	5	1	0	0	38
1915	4	3	2	1	1	1	7	5	5	1	0	0	30
1916	0	1	0	0	1	3	10	8	10	2	0	0	35
1917	1	2	0	2	4	6	14	10	15	3	0	1	58
1918	1	0	1	2	0	4	3	6	0	0	0	0	17
1919	4	1	2	0	1	1	9	10	2	0	0	3	33
1920	2	2	1	0	2	7	9	2	2	1	0	0	28
1921	2	0	0	1	0	2	9	10	7	7	0	0	38
1922	2	2	0	0	0	5	12	8	5	1	0	4	39
1923	2	5	0	0	3	0	12	11	3	3	0	3	42
1924	3	1	0	0	1	1	5	8	11	3	0	1	34
1925	2	0	0	1	4	8	15	6	0	0	2	0	38
1926	2	1	2	1	3	2	9	12	3	0	1	0	36
1927	0	8	3	1	2	1	9	7	2	3	0	2	38
1928	5	5	0	0	1	3	8	9	2	0	2	2	37
1929	4	0	0	2	1	0	9	7	0	0	0	4	27
1930	2	1	0	1	0	6	13	5	2	0	0	0	30
1931	0	5	2	1	0	0	11	6	8	0	0	0	33
1932	0	0	4	1	0	2	11	9	7	0	0	2	36
1933	0	2	2	0	4	6	12	9	10	2	0	0	47
1934	4	1	1	0	0	3	10	10	2	0	0	1	32
1935	3	2	2	3	0	0	11	10	4	1	1	2	39
1936	0	4	1	0	3	10	9	6	5	0	0	4	42
1937	0	6	0	3	1	4	11	4	4	0	0	2	35
1938	5	2	0	1	1	2	8	5	1	1	0	0	26
1939	0	5	2	0	0	8	7	3	5	0	0	0	30

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1940	3	6	3	2	1	3	12	9	2	0	0	0	41
1941	4	1	1	0	1	6	5	7	2	0	0	2	29
1942	3	4	1	1	1	3	15	15	6	0	0	3	52
1943	4	1	1	2	0	2	14	8	4	0	0	0	36
1944	2	4	3	3	0	6	9	6	2	1	0	0	35
1945	5	0	0	2	2	1	9	7	10	1	0	0	37
1946	0	2	1	2	3	7	8	9	2	2	0	1	37
1947	3	1	0	0	1	1	2	9	12	0	0	0	29
1948	4	4	4	0	0	2	8	13	1	0	0	0	36
1949	0	5	1	0	1	2	12	2	5	0	0	8	36
1950	5	3	5	1	0	2	10	8	8	0	0	0	42
1951	2	0	2	1	1	2	5	6	4	0	0	0	23
1952	3	2	2	0	1	4	12	14	0	0	0	0	38
1953	4	1	0	1	0	7	9	8	4	1	0	1	36
1954	3	6	2	0	2	3	8	5	9	2	0	0	40
1955	7	1	1	1	2	3	6	7	9	5	0	0	42
1956	3	1	3	0	1	7	8	14	2	5	1	0	45
1957	8	0	5	1	0	1	9	10	9	3	1	3	50
1958	0	0	1	0	1	0	9	7	9	2	0	1	30
1959	1	2	1	0	1	3	6	12	7	1	2	0	36
1960	2	0	2	0	0	2	10	13	2	2	0	1	34
1961	4	4	0	1	1	1	9	11	0	3	0	2	36
1962	2	3	2	0	0	0	6	5	6	0	2	2	28
1963	1	2	1	1	1	5	5	8	4	0	2	0	30
1964	1	0	0	0	1	2	19	5	3	0	0	1	32
1965	0	2	1	3	2	0	6	7	0	3	0	0	24
1966	*RNR	1	0	0	2	6	6	12	2	1	0	0	30
1967	0	0	2	0	1	1	7	16	3	1	1	3	35
1968	1	2	2	—	—	3	12	9	—	1	—	—	30
1969	—	1	1	—	1	1	4	10	6	—	—	—	24
1970	4	1	1	—	2	6	2	13	6	0	0	0	35
1971	1	0	0	1	4	6	8	19	6	1	0	0	46

*RNR=Register Not Received

1032
Hew
2.3.82

BAPTIST CHURCH OF AMERICA

APPENDIX 4.3

Latitude 29° 42''

Longitude 76° 59'

Height above Mean Sea Level. 252 Metres

Average Monthly Temperature (F°) Data for Karnal Station 1949—1970

Year	Jan.	Feb.	March	April	May	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2	3	4	5	6	7	8	9	10	11	12	13
1949	N.A.	N.A.	N.A.	83.8	91.1	91.1	84.8	85.7	85.5	76.8	64.3	56.9
1950	58.8	57.7	66.9	79.1	91.3	91.5	84.9	82.3	81.2	75.2	65.6	56.3
1951	55.6	60.6	70.6	77.3	88.2	98.9	88.9	85.7	84.1	82.1	68.5	60.1
1952	59.2	64.3	70.0	83.9	90.5	95.0	85.7	84.7	85.2	77.5	65.9	58.3
1953	55.4	64.6	76.3	84.8	90.9	92.1	85.5	84.8	83.5	76.5	66.3	61.8
1954	54.7	61.9	69.6	82.7	91.7	95.2	86.7	86.2	83.2	73.1	65.2	58.3
1955	56.5	61.5	74.1	77.9	85.4	96.0	87.6	83.3	82.3	75.9	68.1	59.9
1956	56.9	62.5	71.7	85.0	94.3	90.5	84.9	85.0	86.9	76.0	66.5	60.1
1957	13.3	14.7	19.4	25.2	30.2	35.2	30.3	28.7	26.8	24.2	19.4	14.9
1958	14.9	16.0	22.2	28.9	31.5	33.8	30.0	28.3	28.1	24.6	20.7	15.2
1959	RNR	14.7	30.3	35.3	39.3	41.1	35.7	33.2	33.3	32.2	26.5	23.8
1960	5.4	18.7	20.2	26.3	31.9	32.7	28.1	27.1	27.5	35.1	19.9	17.1
1961	RNR	15.1	21.9	25.7	R	R	R	R	R	29.3	24.5	17.7
1962	11.9	16.4	20.4	22.6	30.7	32.8	31.8	31.6	27.7	22.2	18.3	13.8
1963	12.2	18.2	21.2	28.9	30.3	33.0	31.1	29.3	27.9	24.9	19.9	14.5
1964	11.2	15.5	22.7	24.7	33.2	RNR	29.1	27.5	22.4	17.3	18.3	13.7
1965*	14.1	out	—	—	—	of	—	—	—	order	—	—
1966	RNR	RNR	20.8	27.4	30.7	32.5	31.3	28.3	28.1	25.0	19.0	13.9
1967	12.5	17.5	19.9	25.9	30.7	33.9	29.9	28.5	28.1	24.2	18.7	24.7
1968	12.8	14.4	20.7	26.2	30.6	31.7	28.8	28.8	29.0	23.5	17.5	X
1969	13.5	16.2	22.9	27.5	30.0	34.0	30.0	29.3	27.5	25.4	20.1	14.7
1970	13.5	15.4	20.3	28.0	—	31.2	NA	NA	NA	NA	NA	NA

Note :—Since recording of temperature at Karnal Station was started in 1949 by the Indian Meteorological Department, the relevant figures for the preceding years are not available.

NA = Not available.

RNR = Register not received.

R = Rejected.

X = Incomplete.

* = Out of order.

APPENDIX 4.4**Frequency Distribution of Monthly Rainfall at Karnal Station****According to Amount of Rainfall—1922-1971.**

Rainfall (mms.)	Number of years											
	January	February	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0.0	7	9	8	18	10	5	—	—	3	23	37	21
0.1-25.0	19	22	31	25	37	17	—	—	8	18	11	19
25.1-50.0	13	9	7	5	2	8	2	3	8	5	2	7
50.1-75.0	5	4	4	2	1	6	2	2	4	—	—	3
75.1-100.0	4	3	—	—	—	4	6	4	5	2	—	—
100.1-125.0	2	1	—	—	—	1	5	5	3	—	—	—
125.1-150.0	—	2	—	—	—	6	6	5	3	—	—	—
150.1-200.0	—	—	—	—	—	—	6	6	6	—	—	—
200.1-250.0	—	—	—	—	—	1	11	9	—	1	—	—
250.1-300.0	—	—	—	—	—	—	2	5	4	1	—	—
300.1-350.0	—	—	—	—	—	1	3	3	3	—	—	—
350.1-on-wards	—	—	—	—	—	1	7	8	3	—	—	—

APPENDIX

Mean, Standard Deviation, Co-efficient of Variability. Total Range, Deciles, Quartiles & Semi-Inter-

Probability Level	Partition Values. Co-efficient of Variability etc.	January	February	March	April	May
1	2	3	4	5	6	7
	Mean	30.9	29.4	15.3	10.2	9.6
	Standard Deviation	29.5	34.8	16.6	14.5	9.5
	Co-efficient of Variability	95.3	118.4	108.2	142.5	98.4
0%	Lowest Rainfall occurred in the month	0.0	0.0	0.0	0.0	0.0
10%	1st Decile	0.0	0.0	0.0	0.0	0.0
20%	2nd Decile	2.0	2.0	1.3	0.0	0.0
25%	Lower Quartile (Q ¹)	4.4	3.0	1.5	0.0	1.0
30%	3rd Decile	7.6	6.9	2.3	0.0	2.5
40%	4th Decile	15.5	13.5	4.0	1.3	4.3
50%	Median (on 5th Decile)	21.3	19.1	7.0	2.8	5.6
60%	6th Decile	28.9	22.0	14.5	6.1	8.4
70%	7th Decile	42.7	30.6	20.6	11.0	12.4
75%	Upper Quartile (Q ³)	46.9	37.0	24.6	15.4	16.3
80%	8th Decile	53.8	44.2	25.4	19.8	18.0
90%	9th Decile	76.7	83.9	43.9	29.3	20.8
100%	Highest Rainfall occurred in the month	113.0	144.0	67.6	55.9	52.1
	Semi-Inter-Quartile Range: $\frac{1}{2} (Q_3 - Q_1)$	21.3	17.0	11.6	7.7	7.6

4.5

Quartile Range for Monthly Rainfall Data for Karnal Station—1922 to 1971

(In Milimetres)

June	July	August	September	October	November	December
8	9	10	11	12	13	14
61.1	203.2	217.2	123.8	20.2	3.2	13.5
64.5	121.0	126.9	121.9	49.1	2.6	15.2
105.5	59.6	58.5	99.1	242.8	82.0	113.4
0.0	26.5	29.5	0.0	0.0	0.0	0.0
0.0	86.1	72.9	1.0	0.0	0.0	0.0
6.4	99.8	105.9	15.0	0.0	0.0	0.0
10.4	105.2	118.4	30.7	0.0	0.0	0.0
16.3	123.6	134.4	38.9	0.0	0.0	0.0
21.8	149.1	150.9	51.3	0.0	0.0	0.0
34.5	175.0	195.3	88.5	1.8	0.0	2.0
47.7	207.8	229.1	102.9	6.1	0.0	6.6
65.8	227.1	251.6	160.0	9.5	0.0	11.4
79.0	274.8	287.9	170.3	15.0	1.1	16.6
97.3	282.2	302.8	183.1	18.2	1.5	25.0
136.6	404.6	410.5	319.5	41.2	9.7	38.7
373.9	584.5	562.1	543.3	262.4	35.3	66.7
34.3	84.8	84.8	64.8	7.5	0.6	8.3

Appendix No. 4.6

Frequency Distribution of Monthly Rainfall Data together with the Values of Mean, Standard Deviation and Co-efficient of Variability for Karnal Station—1922 to 1971.

1. JANUARY

Class Interval (In m.m.)	Frequency (of years)	Mean, Standard Deviation & Co-efficient of Variability		
			for Continuous series	for Discrete series
0.0-5.0	13			
5.0-10.0	2			
0.0-10.0	15			
10.0-20.0	9	Mean,	31.60	30.95
20.0-30.0	6	Standard Deviation	28.70	29.52
30.0-40.0	3	Co-efficient of Variability	90.82%	95.29%
40.0-50.0	6			
50.0-60.0	3			
60.0-70.0	2			
70.0-80.0	2			
80.0-90.0	1			
90.0-100.0	1			
100.0-110.0	1			
110.0-120.0	1			
Total	50			

2. FEBRUARY

Class Interval (In m.m.)	Frequency (of years)	Mean, Standard Deviation & Co-efficient of Variability		
			for Continuous series	for Discrete series
0.0-5.0	13			
5.0-10.0	5			
0.0-10.0	18			
10.0-15.0	6	Mean	30.20	29.43
15.0-20.0	4	Standard Deviation	34.20	34.84
20.0-30.0	6	Co-efficient of Variability	113.25%	118.38%
30.0-40.0	5			
40.0-50.0	1			
50.0-60.0	2			
60.0-70.0	1			
70.0-80.0	1			
80.0-90.0	2			
90.0-100.0	2			
100.0-150.0	2			
Total	50			

3. MARCH

Class Interval (In m.m.)	Frequency (of years)	Mean, Standard Deviation & Co-efficient of Variability		
			for Continuous series	for Discrete series
0.0-5.0	23			
5.0-10.0	4			
0.0-10.0	27			
10.0-20.0	7	Mean,	16.60	15.30
20.0-30.0	8	Standard Deviation	16.30	16.59
30.0-40.0	2	Co-efficient of Variability	98.19%	108.22%
40.0-50.0	2			
50.0-60.0	3			
60.0-70.0	1			
Total	50			

4. APRIL

Class Interval (In m.m.)	Frequency (of years)	Mean, Standard Deviation & Co-efficient of Variability		
			for Continuous series	for Discrete series
0.0-5.0	29			
5.0-10.0	5			
0.0-10.0	34			
10.0-20.0	6	Mean	11.40	10.18
20.0-30.0	5	Standard Deviation	15.20	14.51
30.0-40.0	1	Co-efficient of Variability	134.21%	142.53%
40.0-50.0	2			
50.0-60.0	2			
Total	50			

5. MAY

Class Interval (In m.m.)	Frequency (of years)	Mean, Standard Deviation & Co-efficient of variability		
			for Continuous series	for Discrete series
0.0-5.0	22			
5.0-10.0	10			
0.0-10.0	32			
10.0-20.0	11	Mean	10.80	9.65
20.0-30.0	5	Standard Deviation	9.70	9.50
30.0-40.0	1	Co-efficient of Variability	89.81 %	98.45 %
40.0-50.0	0			
50.0-60.0	1			
Total	50			

6. JUNE

Class Interval (In m.m.)	Frequency (of years)	Mean, Standard Deviation & Co-efficient of Variability		
			for Continuous series	for Discrete series
0.0-10.0	12			
10.0-20.0	5			
20.0-30.0	7			
30.0-40.0	1	Mean	66.00	61.13
40.0-50.0	5	Standard Deviation	63.50	64.47
0.0-50.0	30	Co-efficient of Variability	96.21 %	105.46 %
50.0-75.0	6			
75.0-100.0	4			
50.0-100.0	10			
100.0-150.0	7			
150.0-200.0	0			
200.0-250.0	1			
250.0-300.0	0			
300.0-350.0	1			
350.0-400.0	1			
Total	50			

7. JULY

Class Interval (In m.m.)	Frequency (of years)	Mean, Standard Deviation & Co-efficient of Variability		
			for Continuous series	for Discrete series
0.0—50.0	2			
50.0—100.0	8			
100.0—150.0	11	Mean	203.00	203.23
150.0—200.0	6	Standard Deviation	121.30	121.05
200.0—250.0	11	Co-efficient of Variability	59.61 %	59.56 %
250.0—300.0	2			
300.0—350.0	3			
350.0—400.0	1			
400.0—450.0	4			
450.0—500.0	1			
500.0—550.0	1			
Total	50			

8. AUGUST

Class Interval (In m.m.)	Frequency (of years)	Mean, Standard Deviation & Co-efficient of Variability		
			for Continuous series	for Discrete series
0.0—50.0	3			
50.0—100.0	6			
100.0—150.0	10			
150.0—200.0	6	Mean	216.00	217.16
200.0—250.0	9	Standard Deviation	129.50	126.97
250.0—300.0	5	Co-efficient of Variability	59.95 %	58.47 %
300.0—350.0	3			
350.0—400.0	2			
400.0—450.0	2			
450.0—500.0	3			
500.0—550.0	0			
550.0—600.0	1			
Total	50			

9. SEPTEMBER

Class Interval (In m.m.)	Frequency (of years)	Mean, Standard Deviation & Co-efficient of Variability		
			for Continuous series	for Discrete series
0.0—25.0	11			
25.0—50.0	8			
0.0—50.0	19			
50.0—75.0	4	Mean	124.00	123.80
75.0—100.0	5	Standard Deviation	122.50	121.87
50.0—100.0	9	Co-efficient of Variability	98.97%	99.08%
100.0—125.0	3			
125.0—150.0	3			
100.0—150.0	6			
150.0—175.0	5			
175.0—200.0	1			
150.0—200.0	6			
200.0—250.0	0			
250.0—300.0	4			
300.0—350.0	3			
350.0—400.0	1			
400.0—450.0	1			
450.0—500.0	0			
500.0—550.0	1			
Total	50			

10. OCTOBER

Class Interval (In m.m.)	Frequency (of years)	Mean, Standard Deviation & Co-efficient of Variability		
			for Continuous series	for Discrete series
0.0—1.0	24			
1.0—5.0	4			
5.0—10.0	9			
00—10.0	37	Mean	21.60	20.21
10.0—20.0	4	Standard Deviation	49.90	49.07
20.0—30.0	2	Co-efficient of Variability	231.02%	242.80%
30.0—40.0	2			
40.0—50.0	1			
50.0—60.0	0			
60.0—70.0	0			
70.0—80.0	0			
80.0—90.0	2			
90.0—100.0	0			
100.0—200.0	0			
200.0—250.0	1			
250.0—300.0	1			
Total	50			

11. NOVEMBER

Class Interval (In m.m.)	Frequency (of years)	Mean, Standard Deviation & Co-efficient of Variability		
			for Continuous series	for Discrete series
0.0—1.0	37			
1.0—5.0	5			
5.0—10.0	3	Mean	7.00	3.22
0.0—10.0	45	Standard Deviation	6.60	2.64
10.0—20.0	2	Co-efficient of Variability	94.29%	81.99%
20.0—30.0	1			
30.0—40.0	2			
Total	50			

12. DECEMBER

Class Interval (In m.m.)	Frequency (of years)	Mean, Standard Deviation & Co-efficient of Variability		
			for Continuous series	for Discrete series
0.0—1.0	23			
1.0—5.0	5			
5.0—10.0	5	Mean	13.80	13.47
0.0—10.0	33	Standard Deviation	15.30	15.25
10.0—15.0	3	Co-efficient of Variability	110.87%	113.41%
15.0—20.0	3			
10.0—20.0	6			
20.0—30.0	3			
30.0—40.0	4			
40.0—50.0	1			
50.0—60.0	2			
60.0—70.0	1			
Total	50			

APPENDIX

Occurrence of Flood & Drought at Karnal Station

Month/ Calendar Year	January	February	March	April	May	June
1	2	3	4	5	6	7
$\bar{X}$	30.947	29.432	15.331	10.172	9.645	61.128
$\bar{X}/2$	15.474	14.71	7.6	5.0	4.8	30.5
$2\bar{X}$	61.8	58.8	30.6	20.3	19.3	122.3
1922	D	D2	—	D	D	F
1923	D	F	D	—	—	—
1924	F	D	D	—	D	D
1925	F	—	—	D2	D2	F
1926	D	D2	F	—	—	D
1927	—	F	F	F	D	D
1928	F	—	—	D	D	D
1929	F	—	—	—	D	D
1930	F	D	—	D	D	—
1931	—	—	F	D	D	—
1932	—	D	F	D	D	D
1933	D	D2	—	D	F	D
1934	—	D	F	D	D	D
1935	F	F	D2	—	—	F
1936	D	D2	D2	—	—	F
1937	D	F	D	D2	D	D
1938	F	D2	D	D2	D	D
1939	D	F	D2	—	—	F
1940	—	F	—	—	D	D
1941	F	D	D	—	—	F
1942	F	F	D	—	D	—
1943	F	D	D	—	—	—

4.7

In Different Months 1922-71

July	August	September	October	November	December	Annual
8	9	10	11	12	13	14
203.231	217.160	123.815	20.207	3.216	11.469	735.7
102.6	108.5	111.9	10.1	1.6	5.78	169.2
406.4	434.3	247.6	40.4	6.4	22.9	338.4
—	—	D2	D2	—	F	—
—	—	D	—	—	F	—
—	—	F	F	—	—	—
F	—	—	D	F	—	—
—	—	D	F	F	—	—
—	—	—	D	F	F	—
—	D2	D	F	F	—	D
—	D	D	—	F	F	—
—	—	D	D	—	—	—
—	—	—	—	—	—	—
—	—	F	D	—	F	—
—	—	F	—	—	D	—
F	F	D	—	—	D	F
—	D	—	—	—	—	—
—	D	—	D2	D	F	—
D	D	D	—	—	F	D2
D	D	D	—	—	—	D2
D	D	D	D	D	..	—
—	—	D	—	—	D	—
D	—	D	—	—	D	—
F	—	—	—	—	—	—
—	—	—	—	—	—	—

1	2	3	4	5	6	7
1944	—	F	F	F	—	—
1945	F	—	D	—	D	D2
1946	—	D2	D	F	—	F
1947	F	D	D	—	D	D
1948	—	F	F	—	—	D
1949	—	—	D	—	D	D
1950	—	D	F	D	—	D
1951	D2	—	—	—	—	D
1952	D	D2	—	F	D	D2
1953	—	D	—	—	D	D
1954	—	F	D	F	D2	—
1955	F	D	F	D	D	D2
1956	D	D	F	—	D	—
1957	F	—	F	—	—	D
1958	D	—	D	—	D	D
1959	—	D2	D	D	D	—
1960	—	—	—	—	—	—
1961	F	—	—	—	D	D
1962	D	—	—	D	—	—
1963	D2	D	D	—	D	—
1964	D	—	—	F	D	D2
1965	D	—	D	—	—	D2
1966	—	D2	D	D	—	—
1967	—	D	F	—	D	D
1968	D	—	—	—	—	D2
1969	D	—	—	—	—	D
1970	F	D	D2	—	F	—
1971	D	—	D	D2	F	—
X-Arithmetic Mean F-Flood	S-Mean Deviation about D2-Moderate Drought			Arithmetic Mean		D-Drought

8	9	10	11	12	13	14
—	—	—	D	—	D	—
D	—	F	D2	—	—	—
D	—	D	D	D	D	—
D	D2	F	F	—	D	—
—	F	—	—	—	—	—
—	D	—	—	—	—	—
—	—	—	—	—	—	—
D	—	—	—	F	—	—
—	F	F	—	—	—	—
—	D2	—	—	—	D	—
—	—	—	D2	—	—	—
D	—	D	F	—	—	—
—	F	D	F	F	F	—
—	—	.	F	—	F	—
—	D	F	F	—	—	—
D	—	—	F	F	—	—
D	—	D	D2	—	—	D2
D	—	—	D2	—	F	—
—	—	D	F	F	D	—
D	F	—	—	F	F	—
F	—	—	—	—	—	—
—	—	D	—	—	—	—
—	—	D	—	—	—	—
—	F	D	D2	D	D	—
—	—	D	—	—	—	—
D2	F	—	—	—	—	—
D	F	—	—	—	—	—
—	F	—	D	—	—	—

APPENDIX 4.8**Consumption of Different Fertilizers in Karnal District**

(In M. Tons)

Type of Fertilizer	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71	1971-72
1	2	3	4	5	6	7	8
1 Urea	4	737	3477	15987	28028	42404	55433
2 Calcium Ammonium Nitrate (CAN)	11287	12851	23792	25944	20448	24182	23243
3 Ammonium Sulphate (A.S)	5481	2438	6039	4174	3286	1417	400
4 Super Phosphate (S/P)	1345	791	1137	521	669	1117	1374
5 Di-Ammonium Phosphate (DAP)	—	271	1061	6224	5082	4572	2782
6 Ammonium Phosphate (A/P)	—	—	354	96	110	191	140
7 Muriate Potash (M/P)	38	167	432	979	759	1016	622
8 Nitro Phosphate (N/P)	—	—	39	2	1	—	—
9 Suphala	—	—	—	1	1	15	7
10 NPK Mixture	—	—	—	—	225	2181	5201
11 Ammonium Chloride	—	—	—	—	—	441	237
12 Urea, Ammonium Phosphate (28:28:0)	—	—	—	—	—	990	744
TOTAL	18155	17255	36330	53928	58599	78526	90183
Total Nutrients							
N	3355	4128	10604	16661	19742	27304	32619
P₂O₅	215	256	789	2966	2488	3128	2932
K₂O	25	100	258	586	815	978	1062

Source :— Haryana Co-operative Supplies & Marketing Federation Ltd., Chandigarh.

APPENDIX 4.9

Agricultural Machinery and Implements in Karnal District

(Number)

Item	1966	1961	1956	1951
1. Ploughs				
(a) Wooden	100411	101,788	87,939	1,00,557
(b) Iron	42883	24,865	2,101	1,336
2. Carts	65037	45,685	36,642	32,580
3. Sugarcane Crushers				
(a) Worked by power	248	142	31	48
(b) Worked by bullocks	1835	4,069	2068	1636
4. Oil engines with pumps for irrigation purposes.	1762	508	553	154
5. Electric pumps for irrigation purposes.	5350	811	290	21
6. Perisan wheels or Rahats	16190	15,529	14,084	187
7. Tractors	1164	632	298	98
8. Ghanis				
(a) Five Kg. and more	59	135	171	93
(b) Less than five Kg.	19	30	18	12

Note:—Data pertaining to the Quinquennial live stock census for the year ending 1971, is not available.

Source:— District Statistical Abstract, Karnal.

APPENDIX 4.10

**Sowing, Harvesting and Peak Marketing Seasons of Principal
Crops in Karnal District.**

Crop (1)	Sowing (2)	Harvesting (3)	Peak Marketing Season (4)
Rice (Pady)	July to Mid August	Mid October to November	November
Jowar	From last week of June to Mid July	From last week of September to end of October	November—December
Bajra	From last week of June to Mid July	From last week of October to beginning of November	November—December
Maize	July	October	November—December
Sugarcane	From mid February to end of March	From 4th week of October to Mid of March	December—February
Cotton	April—May	October—December	November—January
Wheat	From end of September to Mid October	From 2nd week of April to 1st week of May	May—June
Gram	1st week of September to October	From 3rd week of March to 1st week of April	May—June
Barley	October—December	Fourth week of March to 1st week of April	May—June

APPENDIX 4.11

LAND UTILIZATION IN KARNAL DISTRICT—1901-71

(Quinquennial Average Figures).

(In 000' Hectares)

Classification of Area	1901-02 (1898-99 to 1902-03)	1911-12 (1908-09 to 1912-13)	1921-22 [@] (1918-19 to 1922-23)	1931-32 (1928-29 to 1932-33)	1941-42 (1938-39 to 1942-43)	1951-52 (1948-49 to 1952-53)	1961-62 (1958-59 to 1962-63)	**1970-71
1	2	3	4	5	6	7	8	9
I Total Geographical Area according to village papers.	815	810	815	817	817	809	799	803
II Forests.	0.59	0.40	0.34	0.31	—	0.79	4.70	11
III Land not available for cultivation.	116	113	111	111	108	105	94	97
(a) Land put to non-agricultural uses.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	37	45
(b) Barren and unculturable lands.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	57	52
IV Other un-cultivable land.	241	242	241	255	252	229	106	38
(a) Culturable waste other than fallows.	241	242	241	255	252	229	67	13
(b) Permanent pastures & other grazing lands.—	—	—	—	—	—	N.A.	37	23
(c) Land under miscellaneous tree crops and groves not included under net area sown.	—	—	—	—	—	N.A.	2	2
V Fallow land.	171	54	129	69	99	75	30	11
(a) Fallow land other than current fallows.	—	—	—	—	—	—	—	—
(b) Current fallows.	171	54	129	69	99	75	30	11

	1	2	3	4	5	6	7	8	9
VI Net area sown		287	401	333	382	359	400	564	479
VII Area sown more than once.		40	60	41	83	74	74	225	159
III Total Cropped Area	327		461	374	465	433	474	789	638

Note :—(i) Figures may not tally with the total because of rounding off.

(ii) 3 years' average : figures for 1901-02 & 1902-03 are not available.

(iii) " 3 years' average : figures for 1921-22 & 1922-23 are not available.

(iv) 4 years' average : figures for 1928-29 are not available.

(v) ** Data pertains to the year 1970-71 only.

Source :—(i) Director of land records.

(ii) District Census Hand Book Karnal District.

APPENDIX 4.12

AREA UNDER PRINCIPAL CROPS IN KARNAL DISTRICT—1901 to 1971

(Quinquennial Average Figures)

(In Hectares)

Classification of Crops	1901* (1898-99 to 1902-03)	1911 (1908-09 to 1912-13)	1921 (1918-19 to 1922-23)	1931 ^a (1928-29 to 1932-33)	1941 (1938-39 to 1942-43)	1951 (1948-49 to 1952-53)	1961 (1958-59 to 1962-63)	1970-71*
1	2	3	4	5	6	7	8	9
I. Basic Food Crops								
Rice	28479	22966	27061	24340	26653	34995	102505	178569
Wheat	97763	115122	100417	111643	102404	117115	209853	356985
Total Cereals	N.A.	224253	236586	N.A.	N.A.	233767	409071	659780
Total Pulses	N.A.	125195	95118	N.A.	N.A.	134103	224203	96803
Total Food- grains	254202	349448	331704	344303	315872	367870	633274	756583
Fruit & Vegetables	1477	2116	3003	3489	3480	4418	5695	9401
II. Other Food Crops								
Sugarcane	10326	10813	12864	1177	8683	14704	31672	36611
Condiments & Spices	1162	1265	1138	2128	4292	4314	4266	6216
Other Food Crops	1467	156	155	240	560	114	223	8
Total Food Crops	268634	363798	348864	351337	332887	391420	675130	808819
III. Non-food Crops								
Groundnut	—	—	—	—	—	84	10	475
Total Oilseeds	14063	22291	17882	14924	10812	17653	17861	22864
Cotton	17460	27586	20735	26207	26229	10451	20121	13846
Total Fibres	18349	28533	21640	27346	27231	11140	20811	14284

1	2	3	4	5	6	7	8	9
Tobacco	815	695	864	957	1069	422	219	97
Dyes & Tanning Material	1383	49	38	2	3	2	—	—
Drugs & Narcotics (Other than tea & tobacco)	395	71	—	—	—	—	—	—
Fodder Crops	22276	43843	47217	61009	60661	53191	74575	96797
Other Non-food crops	1017	468	49	74	182	374	—	671
Total Non-food crops	58298	95950	87690	104312	99958	82666	113476	135188
Total Cropped Area	326932	459748	436554	456549	432485	474266	788606	944007

Source :— 1. District Census Hand Book Karnal Distt.
2. Annual season & crop report.

ote :— *3 years' average : Figures for 1900—01 and 1902—03 are not available.

**4 years' average : Figures for 1928—29 are not available.

**Pertains to 1970—71 year only.

APPENDIX 4.13

Relative Contribution of Area and Yield to increase in Production of Rice in Karnal District, 1951-52 to 1970-71.

The figures of Area, Production and Yield per hectare of rice (Paddy) in Karnal district from 1906-07 to 1970-71 have been projected in Appendix 4.1. With the dawn of independence a large number of measures for increasing the production of food-grains have been undertaken. These measures consisted of land reclamation, improvement of irrigation facilities, introduction of improved varieties of seed, distribution of chemical fertilizers, etc. As a result of the implementation of various agricultural development programmes, production of rice in Karnal district increased from 44 thousand tonnes in 1951-52 to 346 thousand tonnes in 1970-71. During the same period area under rice crop rose from 33 thousand hectares to 179 thousand hectares and correspondingly yield increased from 1333 Kilogram to 1930 Kg. per hectare. In other words, production, area and yield of rice in 1970-71 were 7.9, 5.4 and 1.5 times that of 1951-52.

In view of the year to year fluctuations in area, yield and production, comparison of the first and the last year of the time series may not truly reflect the long term changes and the relative contribution of area and yield to the change in production. A further analysis of the data is, therefore, necessary to get a correct idea of the relative contribution of area and yield to the increase in production over a period of time. This can be done by taking the following relationship:—

$$P = A \times Y \quad (I)$$

P = Production of rice in tonnes

A = Area under rice in hectares

Y = Yield rate in kilograms per hectare

Taking logarithm of both sides of equation (I)

$$\log P = \log A + \log Y \quad (2)$$

The change of production from year to year thus can be related to the change in area and yield rate for the same years by taking first differences. Thus from equation (2) we get

$$\Delta \log P_t = \Delta \log A_t + \Delta \log Y_t \quad (3)$$

Putting

$$X_1 = \Delta \log P_t$$

$$X_2 = \Delta \log A_t$$

$$X_3 = \Delta \log Y_t$$

We can write equation (3) as

$$X_1 = X_2 + X_3 \quad (4)$$

Now considering X_1 as independent variable and X_2 and X_3 as dependent variables we can find the linear regression by least square method, of the form.

$$X_2 = a_{21} + b_{21} x_1 \quad (5)$$

$$X_3 = a_{31} + b_{31} x_1 \quad (6)$$

From equation (4) we get

$$\frac{dx_2}{dx_1} + \frac{dx_3}{dx_1} = 1 \quad (7)$$

and from equations (5) and (6) respectively.

$$\frac{dx_2}{dx_1} = b_{21} \quad \& \quad \frac{dx_3}{dx_1} = b_{31}$$

and hence by relation (7)

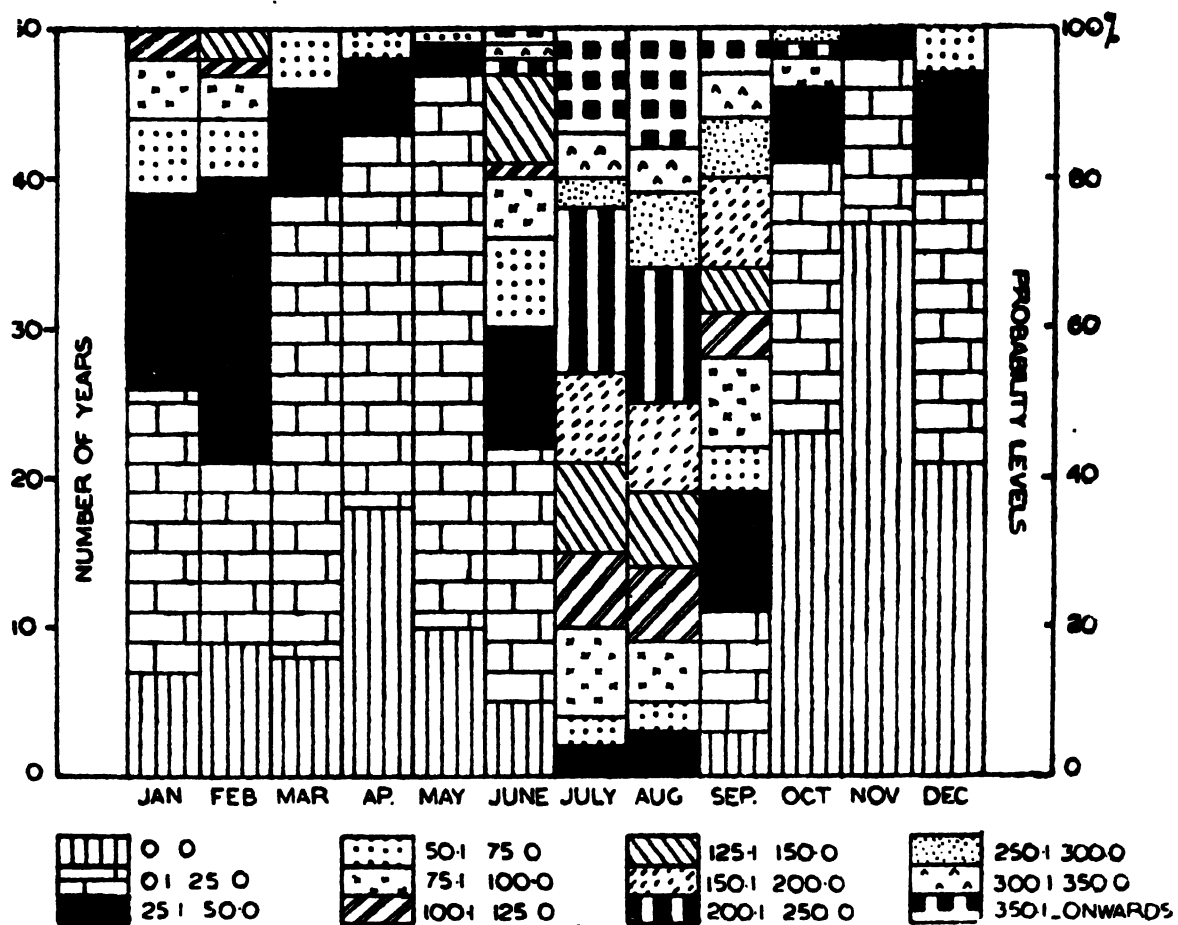
$$b_{21} + b_{31} = 1$$

Thus the sum of b_{21} and b_{31} exactly equals one and b_{21} and b_{31} are the co-efficients of variable x_1 respectively in the simple regression equation of x_2 on x_1 & of x_3 on x_1

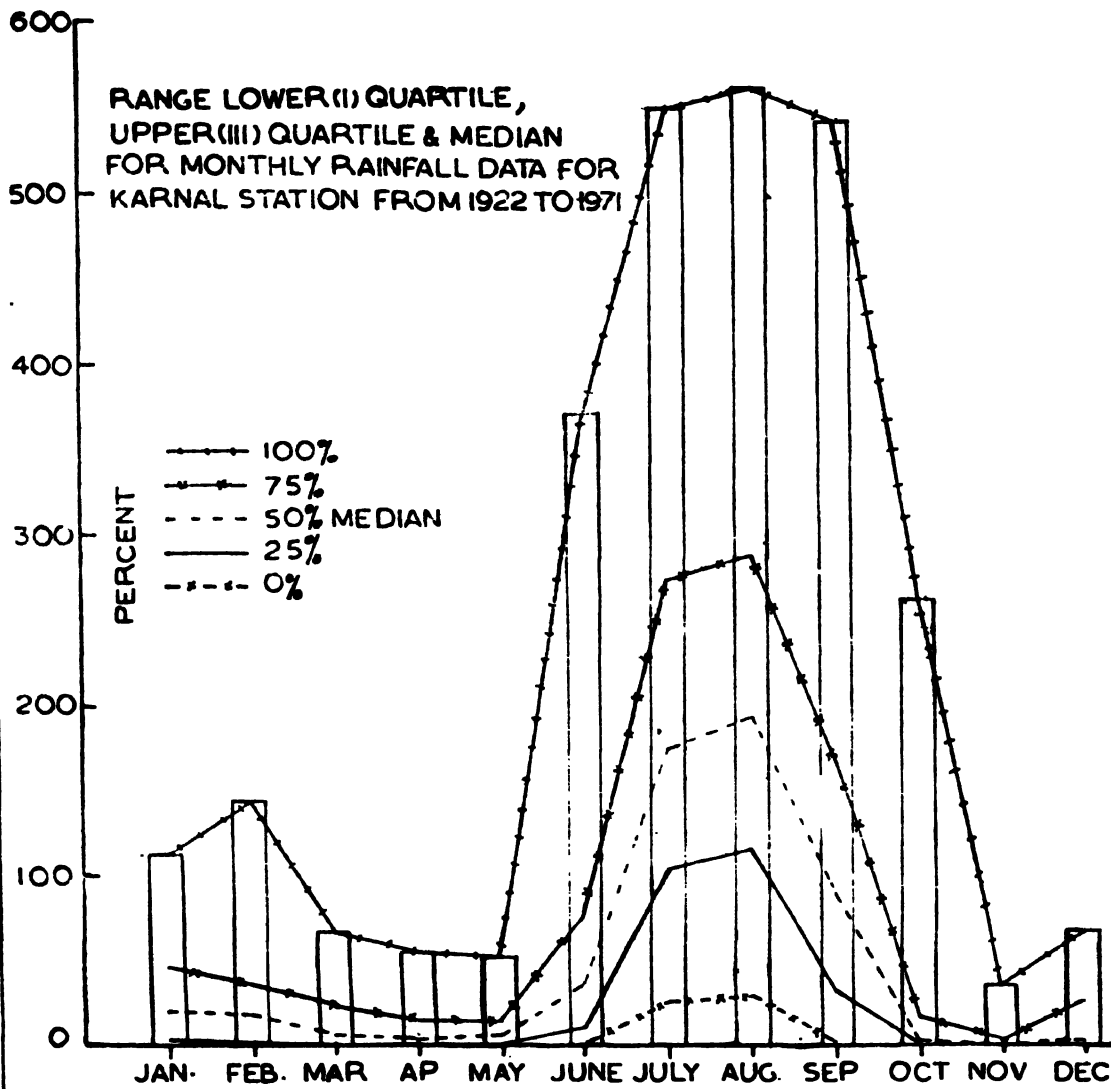
Co-efficient b_{21} measures the change in x_2 associated with a unit change in x_1 and coefficient b_{31} measures the change in x_3 associating with a unit change in x_1 . As the data are expressed as first differences of logarithms, unit change involved here is a one per cent change from the preceding year. This one per cent change is the exact sum of the changes in the two determining variables. Hence the co-efficients b_{21} and b_{31} represent the proportion of the total that each comprises.

An analysis of the data on the above lines shows that in Karnal District, during the period 1951-52 to 1970-71 contribution of area to year to year increase in production was only 31.1% and that of yield 68.9 per cent.

RAINFALL PATTERN AT KARNAL STATION FROM 1922 TO 1971



GRAPH NO. II



CALENDER OF RICE CULTIVATION PRACTICES IN KARNAL DISTRICT

