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**Research Article**

# Rainfall Characteristics Analysis for Jute based Cropping System at Barrackpore, West Bengal, India

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**ABSTRACT**

Knowledge about onset of monsoon, amount of rainfall and its distribution are prerequisite to adopt any cropping system model at a particular region especially for rainfed crops. Therefore, seasonal analysis of rainfall data was done in this study to meet the water demand of different cropping systems. The probability analysis of the rainfall data revealed that the onset of monsoon is on 23rd week which is extended between 4th to 10th June in meteorological standard week. The probability distribution of seasonal rainfall indicated that the occurrence of 80% rainfall in kharif, *zaid* and rabi season are 751.8, 419.4 and 22.2 mm respectively, whereas 1193.4 mm is the annual rainfall. It was forecast that the occurrence of rainy days (>2.5 mm rainfall per day) is 69 days per annum. Water balance was calculated for jute growing period. The design of water harvesting structure was also formulated for in-situ jute retting.

**Key words:** Rainfall analysis, Cropping system, Water balance, Jute retting

## Introduction

Rainfall and temperature of a region determine the sowing time and other agricultural activities there especially for rainfed farming system. Rainfall also determines the potential of any region in terms of crops to be produced, farming system to be adopted , the nature and sequence of farming operations to be followed and to achieve higher agricultural productivity as well (Singh and Dhillon, 1994). In rainfed agriculture, the total amount of rainfall as well as its distribution affects the plant growth (Sharma *et al.*, 1979; Sharda and Bhushan, 1985; Ram Suresh *et al.*, 1992).

Jute is one of the important remunerative crops in widely adaptive cropping systems in West Bengal. But sowing time, length of growing period and retting of jute are highly rainfall and temperature dependant. Therefore, prediction of rainfall and temperature is necessary for timely agricultural operations. Probability analysis is the most reliable method to predict occurrence of rainfall events based on past behavior of rainfall (Kumar and Kumar, 1989). Rainfall analysis is of great importance for developing and modifying the crop management practices for sustainable production system, particularly in jute based cropping systems.

The amount of rainfall received by hot moist subhumid region of West Bengal is adequate for rainfed farming in *kharif* season. But, timely harvesting of jute and its retting requires precise prediction of onset of monsoon and construction of appropriate water harvesting-cum-jute retting structures. The present study was undertaken to analyze the distribution of rainfall characteristics for better planning of jute based cropping systems.

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## Material and Methods

Meteorological observatory of Central Research Institute for Jute & Allied Fibres (CRIJAF), Barrackpore is situated at 22°45’16.53" North latitude and 88°25’19.25" East longitude and 9.69 m above mean sea level. Decadal average annual rainfall in this region is 1383.2 mm (ranges between 1057.6 mm and 1751.2 mm), 85.7% of which precipitated during the months of June to October (monsoon). Mean maximum and minimum temperatures are 31.2°C and 20.5°C, respectively. However, average monthly maximum air temperature is 35.4°C and minimum 24.7°C during May identified as the hottest month followed by April. Similarly January is the coolest month experiencing minimum air temperature 10.5°C and maximum 24.5°C followed by December. The climate is subtropical and humid.

Historical rainfall data for the period from 2001-2010 collected from the meteorological observatory at CRIJAF, Barrackpore was converted to weekly, monthly and seasonal rainfall by simple mathematical means. Three agricultural seasons, viz. *zaid*/summer (1 April-15 July), *kharif* (16 July-15 November) and *rabi* (16 November-31 March) were identified according to existing jute based cropping systems in this region. The total rainfall of the corresponding time period of the months of the respective seasons was summed up for its probability analysis. Daily rainfall of the respective year was summed up to calculate yearly total rainfall and average was calculated by dividing the yearly total by the total number of years. Rainy day was considered as rainfall of a particular day if exceeded 2.5 mm.

The date of onset of effective monsoon was defined as the date of commencement of a 7-day spell satisfying the following criteria (Verma and Sharma, 1989; Sharma *et al.* 1979; Sahoo, 1993): (i) first day’s rain in 7-day spell is not less than average daily evapo-transpiration (ET), (ii) at least four out of seven days are rainy days with not less than 2.5 mm rain each day, and (iii) total rain during the 7-day spell is not less than (5ET+10) mm.

The mean date and standard deviation of onset of effective monsoon was calculated as follows:

$$D_m = \Sigma (X_i/n) \quad \ldots(1)$$

$$\sigma = \sqrt{[\{X_i - (\Sigma (X_i/n)\}^2 /n]} \quad \ldots(2)$$

where, $D_m$ is mean date of effective monsoon; $X_i$ is date of onset of effective monsoon in $i^{th}$ year, (i=1, 2… n); n is total number of years for which rainfall data is being analyzed; σ is standard deviation of date of onset of effective monsoon from its mean date.

The probability analysis was carried out using Weibull’s method (Chow, 1964), which is

$$P= [m/(n+1)]*100 \quad \ldots(3)$$

where, P is the plotting position in percent chance; m is the rank number when the data are arranged in descending order and n is total number of years. Jena and Senapati (1981) found that Weibull’s equation gave better linear relationship between the rainfall and plotting positions than the other equations.

## Results and Discussion

### *Annual and Seasonal Rainfall*

Scrutiny of rainfall data showed that average annual rainfall during the last decade (2001-2010) was 1383.12 mm (ranges between 1057.6 mm in 2009 and 1751.2 mm in 2007) and 60.8% of which occurred during *kharif* season (July 16 to November 15), 36.2% in *zaid* season (April 1 to July 15) and 2.9% in *rabi* (November 16 to March 31) season (Table 1). Coefficient of variation in seasonal rainfall was 19.1% for *kharif* season, 25.1% for *zaid* and 79.1% for rabi season. Therefore, cultivation in the rabi season required assured irrigation. However, *kharif* and *zaid* season cultivation may be carried out under rainfed condition depending upon the water requirement of crops to be cultivated. The amount of rainfall 501.7 mm during the *zaid* season is sufficient for jute cultivation and its retting if proper water harvesting technology is adopted. Marked variation of annual rainfall was observed during the last decade. However, trend analysis

**Table 1.** Annual and seasonal variability of rainfall (mm) and rainy days (Number) at Barrackpore

| Year | *Zaid* | | *Kharif* | | *Rabi* | | Annual | |
|---|---|---|---|---|---|---|---|---|
| | Rainfall | Rainyday | Rainfall | Rainyday | Rainfall | Rainyday | Rainfall | Rainyday |
| 2001 | 635.2 | 37.0 | 772.6 | 55.0 | 38.8 | 5.0 | 1446.6 | 97 |
| 2002 | 684.4 | 34.0 | 838.9 | 47.0 | 22.2 | 2.0 | 1545.5 | 83 |
| 2003 | 419.4 | 26.0 | 1089.2 | 60.0 | 29.1 | 4.0 | 1537.7 | 90 |
| 2004 | 578.3 | 31.0 | 870.9 | 56.0 | 5.9 | 2.0 | 1455.1 | 89 |
| 2005 | 407.1 | 20.0 | 729.6 | 48.0 | 103.2 | 8.0 | 1239.9 | 76 |
| 2006 | 479.3 | 33.0 | 910.3 | 47.0 | 0.0 | 0.0 | 1389.6 | 80 |
| 2007 | 586.8 | 29.0 | 1099.9 | 42.0 | 64.5 | 4.0 | 1751.2 | 75 |
| 2008 | 511.8 | 34.0 | 751.8 | 45.0 | 70.2 | 7.0 | 1333.8 | 86 |
| 2009 | 254.9 | 23.0 | 775.0 | 41.0 | 27.7 | 4.0 | 1057.6 | 68 |
| 2010 | 460.2 | 25.0 | 579.3 | 36.0 | 35.3 | 4.0 | 1074.8 | 65 |
| Mean | 501.7 | 29.2 | 841.8 | 47.7 | 39.7 | 4.0 | 1383.2 | 80.9 |
| SD | 126.2 | 5.5 | 160.6 | 7.4 | 31.4 | 2.4 | 215.8 | 10.1 |
| CV (%) | 25.1 | 19.0 | 19.1 | 15.6 | 79.1 | 58.9 | 15.6 | 12.5 |

Rainyday = >2.5 mm rainfall in a day

of annual rainfall during 2001 to 2010 revealed that annual rainfall decreased over the past decade at the rate of 40.9 mm per annum (Figure 1).

### *Annual and Seasonal Rainy Day*

The number of rainy days (>2.5 mm rainfall in a day) varied from 65 to 97 in a year but average was 80.9 in number (Table 1) with 15.6% coefficient of variation (CV). The occurrence of rainy days in the *kharif* season was 59% followed by *zaid* season 36.1% and then *rabi* season 4.9%. Among the three seasons, the lowest CV for occurrence of rainy day was found in *kharif* season (15.6%), followed by *zaid* (19.0%) but it was found maximum in *rabi* season (58.9%). The lower value of CV depicted more consistent occurrence of rainfall and rainy days annually and for *kharif* and *zaid* season crops whereas higher value of CV inferred that agriculture in *rabi* season can still be practiced by depending on residual soil moisture or assured irrigation due to uncertain rainfall.

### *Monthly Rainfall and Rainy Day*

Monthly rainfall distribution followed the bell shaped curve (Figure 2). The concentration of rainfall was more during the month of June to October which is 85.7% of annual rainfall.

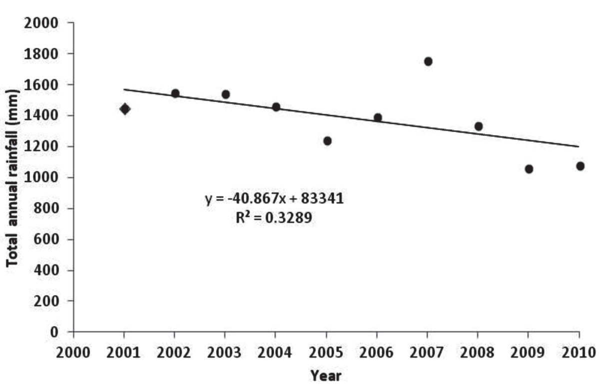



**Fig. 1.** Trend of annual rainfall during 2001-2010 at Barrackpore

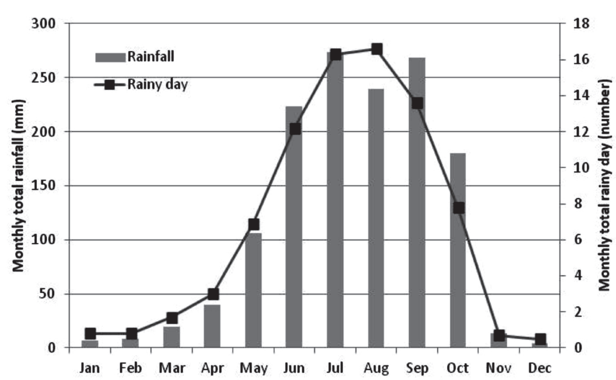



**Fig. 2.** Monthly distribution of rainfall and rainy day at Barrackpore

However, maximum total rainfall of 273.5 mm was recorded in the month of July and the minimum of 3.8 mm in December. High rainfall period synchronizes with *kharif* season which leads to cultivation of high water demanding crops like paddy in this region. It also indicates to harvest excess water during this period and to recycle the harvested water in the off-season cultivation for better water management. The *in situ* harvesting of water may be used for retting of jute as its harvesting time varies from last week of June to first week of July.

The relationship between rainfall and rainy days was similar for weekly, monthly and seasonal basis data. The correlation between monthly rainfall and rainy day is expressed by regression equation (y = 17.257x - 1.0748, where y is monthly rainfall and x is number of rainy days) which can explain more than 95% of the variability ($R^2$ = 0.9562). Similar findings were reported by Barman *et al*. (2011), Chakraborty and Mandal (2008), and Dabral (1996).

### *Weekly Rainfall*

The plotting of weekly rainfall and evaporation indicates the surplus and deficit estimates of moisture for cultivation. Weekly rainfall, evaporation and mean temperature were plotted in the Figure 3, to identify water balance scenario for choosing crops to be cultivated and their water management practices. Average weekly rainfall was maximum (58.63 mm) in 39th week followed by 38th week (58.14 mm). From the Figure 3, it was evident that standard week numbers 23rd to 43rd were the monsoon weeks when greater concentration of rainfall was identified. During this period, the total amount of rainfall was 738.2 mm which was more than the evaporative demand, 428.9 mm at Barrackpore region. Therefore, the surplus rain water of 309.3 mm is needed to be managed in soil profile or by harvesting on soil surface so that this surplus water can be used during the deficit period. Except the monsoon period, rest of the time in a year water deficit was obvious in the magnitude of 471.8 mm.

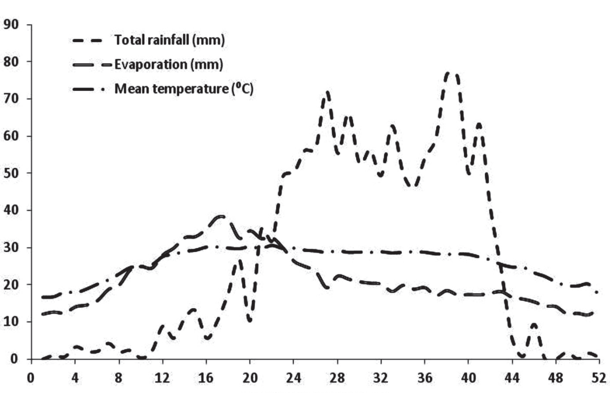


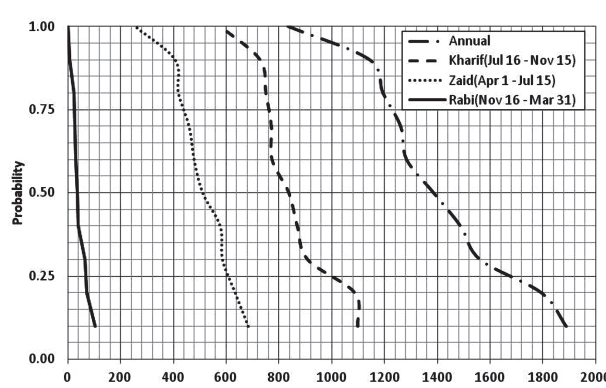

**Fig. 3.** Weekly distribution of rainfall, evaporation and mean temperature at Barrackpore

### *Onset of Effective Monsoon*

The knowledge of mean date of arrival of monsoon is very useful for planning timely *kharif* operations to take maximum advantage of monsoon rain**.** The probability analysis showed that the onset of monsoon on 23rd standard meteorological week which is extended between 4th to 10th June at more than 95% probability level. India Meteorological Department, Pune predicted that June 10 is the probable date of onset of monsoon which is well matched with this analysis.

### *Probability of Rainfall and Rainy Days*

The rainfall data for the past decade (2001-2010) were analyzed and its annual and season wise (*kharif*, *zaid* and *rabi*) probability of occurrence was predicted by using the equation (iii) (Figure 4). This prediction helps to optimize choice of crops, sowing date and irrigation scheduling for different crops cultivated in this




**Fig, 4.** Probability of occurrence of annual and seasonal rainfall at Barrackpore region. The probability of occurrence of rainfall at 80% confidence level was 1193.4 mm per annum, 751.8 mm in *kharif* season, 419.4 mm in *zaid* season and 22.2 mm in *rabi* season. In the *zaid* season, rainfall also occurred during April and May due to low pressure formed in the Pacific Ocean during this period.

The number of rainy day (>2.5 mm rainfall in a day) indicates the distribution of rainfall over a period. The probability of occurrence of rainy days at 80% confidence level was 69 days per annum, 42 days in *kharif*, 25 days in *zaid* and 2 days in *rabi* season (Figure 5).

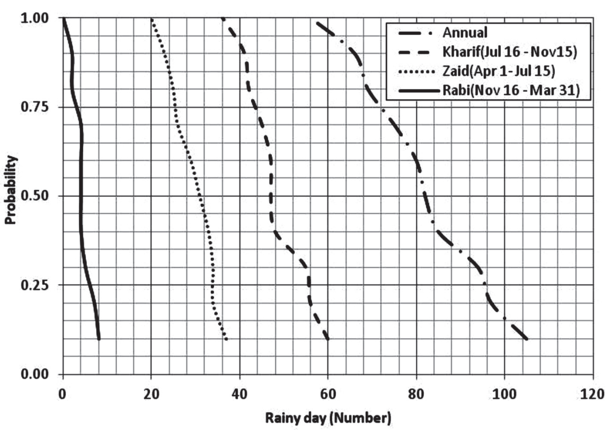



**Fig. 5.** Probability of occurrence of annual and seasonal rainy day at Barrackpore

### *Water Budget for Jute*

Jute requires about 418 mm water for its growth and development during its life cycle. In addition, 77 mm water is required for land preparation in respect of better germination of seed. However, during the period of land preparation and jute seed sowing (13$^{th}$, 14$^{th}$ and 15$^{th}$ standard meteorological week), rainfall in this area was erratic and inconsistent in the last decade (Figure 6). It was calculated that the average rainfall during 10$^{th}$ to 15$^{th}$ week (5$^{th}$ March to 15$^{th}$ April) was 41 mm in the last decade (Figure 3). Therefore, the deficit of water during the land preparation and sowing was 36 mm and the magnitude of which would increase mainly by two phenomena viz. evaporation loss from the soil surface and percolation loss in the soil profile depending upon their various governing factors.

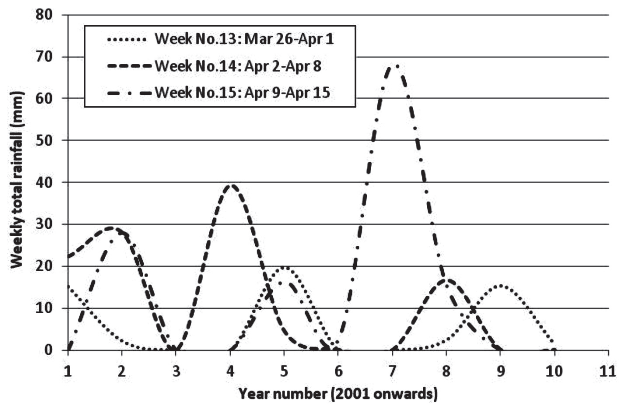



**Fig. 6.** Weekly rainfall distribution at sowing time of jute during 2001 - 2010 at Barrackpore

This depicted that the requirement of pre-sowing irrigation for jute crop to supplement rain water for better germination and crop growth. Indeed, the requirement of irrigation water would increase because rainfall in the month of March-April showed a decreasing trend during the last decade (Figure 7).

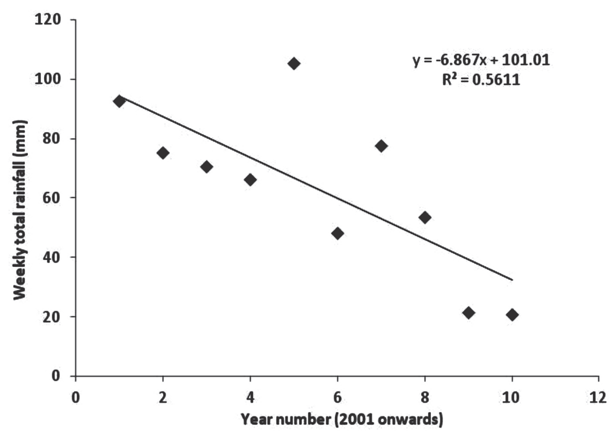



**Fig. 7.** Weekly rainfall trend in March-April during 2001 - 2010 at Barrackpore

### *Jute Retting and Water Management*

It has been established that the jute biomass of one hectare requires 421 cubic meter of water for their retting and fibre extraction. This water demand can be fulfilled by rainwater because jute harvesting time is well coincided with the early period of monsoon in the Barrackpore region. In-situ rainwater harvesting for jute retting can be started on 23$^{rd}$ week and extended unto 29$^{th}$ week during which possibility of rainwater harvesting was 406 mm without considering the evaporation and percolation loss (Figure 5). Therefore, for one hectare land, 4060 cubic meter of water can be harvested. If loss of rainwater through potential evaporation of 1680 cu m from one hectare land is considered in addition to the percolation loss in silt clay soil in this region, sufficient amount of rain water can still be harvested for retting of jute in-situ. However, the dimension of pond for 421 cu m water harvesting is 30 m in length and 15 m of width for surface with 15 m of length and 7.5 m of width at bottom and 1.5 m depth.

## Conclusions

The knowledge of probable time of arrival of monsoon, which is 23rd week (extended between 4th to 10th June) for Barrackpore region will be helpful for planning *kharif* operations to take maximum advantage of monsoon rain. The probability of 419.4 mm rainfall during *kharif* season at 80% confidence level depicted the requirement of suitable water harvesting structure for jute retting. Similarly, probable (80% confidence level) rainfall of 751.8 mm in *kharif* indicated cultivation of high water demanding crops like paddy in this season. In *kharif* season, rainfall is adequate for rice cultivation; however, irrigation is required for *rabi* and *zaid* season crops particularly for land preparation and sowing of jute crop. This prediction helps to optimize choice of crops and irrigation scheduling for different crops cultivated in this region.

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