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A REVIEW

Rainfall probability analysis for contingent crop planning in Keonjhar (Odisha)

M. RAY

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ABSTRACT : Rainfall is the most important but variable climatic parameter in suitable crop planning especially in the regions of rainfed agriculture. Rainfall data of 36 years (1980-2015) of Keonjhar district were analysed whose annual average rainfall is 892.53 mm, with 52 numbers of rainy days, to find out the weekly, monthly and seasonal probability. Out of this 105.37, 661.65 and 125.51 mm is received in pre-monsoon (January-May), monsoon (June-September) and post monsoon (October-December) season, respectively. Probability for receiving more than 100 mm of rainfall can be expected only at 25 per cent probability level and that too in four weeks which is leading to the interpretation that rainfed rice production is a challenging task in this region. It has been found that at 75 per cent assured probability level rainfall of more than 250 mms can be expected only in July and August months and this rainfall is hardly sufficient for meeting the water requirement in upland situations. However at 50 per cent probability which is equivalent to average condition, cultivation of rice is possible under well water management conditions or else some non- rice crops can be taken as an alternative. On seasonal basis rainfall at assured probability level of 75 per cent is not sufficient as the quantity is 465.4 mm rainfall in monsoon season.

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Probability analysis, Rainfed agriculture, Crop planning, Keonjhar

Author for correspondence :
M. RAY
Regional Research and Technology Transfer Station (O.U.A.T.), KEONJHAR (ODISHA) INDIA
Email : monikarayouat@gmail.com

Rainfall is one of the most important natural input resources to crop production and its occurrence and distribution is erratic, temporal and spatial variations in nature. Of all the climatic factors, rainfall is of the greatest concern to population in rainfed agriculture. Around 60 per cent of the Indian agriculture is rain-dependent, distress-prone and vulnerable to climate. The rainfed agro-ecology is characterized as vulnerable for agricultural operations which revolve around moisture availability due to rainfall pattern, amount, intensity and its uses for crop production (Deka and Nath, 2000). Detailed knowledge of rainfall pattern helps in planning the cultivation of crops, their varieties, adoption of cultural operations, designing of different storage structures (Ray *et al*., 1987) and harvesting of excess rain water of any region (Sinhababu 1977; Budhar *et al*., 1987 and Kar, 2002) to meet out irrigation requirement during drought period.

The distribution pattern of rainfall rather than the total rainfall during the entire period of time is more important for studying the pattern of rainfall occurrence. Fisher (1924) studied the influence of rainfall on the yield of wheat in Rothamasted. He showed that it is the distribution of rainfall during a season rather than its total amount which influence the crop yield. Bhargava *et al.* (1974) also showed that for a number of crops the

distribution of rainfall over the season has a great influence on the yield. Analysis of the rainfall data strongly depends on its distribution pattern. Analysis of rainfall and determination of annual maximum daily rainfall would enhance the management of water resources applications as well as the effective utilization of water resources (Subudhi, 2007). Frequency analysis of rainfall is an important tool for solving various water management problems and is used to assess the extent of crop failure due to deficiency or excess of rainfall (Kumar, 1999). Probability and frequency analysis of rainfall data enables us to determine the expected rainfall at various chances (Bhakar *et al*., 2008). Probability analysis can be used for prediction of occurrence of future events from available records of rainfall with the help of statistical methods (Kumar and Kumar, 1989). Therefore, probability analysis of rainfall is necessary for solving various water management problems and to access the crop failure due to deficit or excess rainfall. Scientific prediction of rains and crop planning done analytically may prove a significant tool in the hands of farmers for better economic returns (Bhakar *et al.,* 2008). Generally, the cropping pattern is suggested considering the rainfall probabilities at different levels (Mahale and Dhane, 2003). Probability and frequency analysis of rainfall data enables us to determine the expected rainfall at various chances. Studies on rainfall probability in India have also been carried out earlier by many workers (Victor *et al.,* 1991 and Panigrahi, 1998). Rainfall at 80 per cent probability can be safely taken as assured rainfall, while 50 per cent chance can be considered as the maximum limit for taking any risk (Bhakar *et al.,* 2008).

The weekly distribution of rainfall and its probability is helpful in crop planning by identifying the period of drought, normal and excess rainfall (Ray *et al.,* 1980). In most of studies the workers have suggested the cropping pattern considering the rainfall amount at different probability levels (Hundal and Kaur, 2002; Ahmed *et al.,* 2009 and Ravindrababu *et al.,* 2010). Kulandaivelu (1984) analysed the daily precipitation data of Coimbatore for a period of 70 years for weekly totals by fitting incomplete Gamma distribution model. The data indicate the likely commencement of rains, period of drought length of growing season and end of growing season. Based on the assured rainfall at (50%) probability level, suitable cropping system was suggested for Coimbatore. Duan *et al*. (1995) suggested that for modelling daily rainfall amounts, the weibull and to a lesser extent the exponential distribution is suitable.

The study place, Keonjhar has an area of 8240 km², and lies between 21 ^{0}1' N and 22 ^{0}10' N latitude and 85°11' E to 86°22' E longitude with an altitude of 480 m above mean sea level. The amount of rainfall and number of rainy days in a week at Keonjhar, Odisha from historic daily rainfall records (1980-2015) collected from India Meteorological Department (IMD), Pune are calculated using probabilistic approach. Probability analysis is carried out to estimate the expected amount of rainfall at various probability levels of (50 - 90%) at Keonjhar station using Weibull's plotting position method (Murthy, 1998).

The weekly rainfall data have been analysed at different levels of probability by using Weibull's method. In this method, the weekly rainfall was arranged in descending order of magnitude. The highest one assigned rank 1; next magnitude was given rank 2 and so on. The probability 'P' of the week having rainfall exceeding or equaling normal value was calculated by using Weibull's formula (Eq.1) :

$$P = \frac{m}{n+1}$$

where,

P = probability of occurrence m = rank number;

and n = number of years of data used

Rainfall at various probability levels (25, 50, 75 and 90 %) for weekly, monthly, seasonal and annual basis has been worked out and are presented in Table 1 and 2.

Thirty six years (1980-2015) of daily point rainfall data was analysed and the average annual rainfall of Keonjhar is worked out to be 892.53 mm, with 52 numbers of rainy days. The maximum rainfall of 1859.9 mm occurred in the year 2011 and the minimum quantum 455.3 mm of rainfall was received during the year 1980. The average monthly rainfall of the place for the months of March, April, May, June, July, August, September and October is 23.05, 28.01, 38.60, 128.06, 179.99, 191.48, 162.12 and 96.2 mm, respectively (Table 1). The maximum average rainfall is received during the month of August to a tune of 191.48 mm and the minimum average rainfall is received during the month of December to a tune of 4.13 mm.

It was analysed that when the monthly statistics was put to probability analysis the rainfall quantity came down drastically at 90 per cent. 90 per cent probability means that we can expect this rainfall quantity in 9 out of 10

years. However, the assured probability level of 75 per cent which is considered as assured rainfall in 3 out of 4 years. On annual basis, at 50 probability annual rainfall quantity is 741.1 mm and at 25 per cent probability, annual rainfall quantity is 796.7 mm. Moreover, August happens to be wettest month with rainfall quantity of 83.1, 138.9, 187.7, 243.8 mm at 90, 75, 50 and 25 per cent probability level and its quantity is more than July month. It leads to

Table 1 : Monthly and seasonal expected rainfall amount (mm) at different probability levels at Keonjhar (Odisha)

Months	Probability levels			
	90%	75%	50%	25%
January	0	0	0	7.3
February	0	0	0	12.8
March	0	0	10	30
April	0	6.3	26.3	45.6
May	0.8	10	30.6	48.4
June	47.7	66.7	114.9	167.2
July	67.3	100.8	148.4	271.6
August	83.1	138.9	187.7	243.8
September	47.7	67.4	157.2	212.1
October	11.6	37.5	73.1	141.8
November	0	0	12	26.8
December	0	0	0	4.6
Seasons				
Pre-monsoon (Jan.-May)	43.8	55.3	98.6	144.4
Monsoon (Jun.-Sept.)	391.2	465.4	595	793.3
Post-monsoon (Oct.-Dec.)	20.2	55.8	117	159

Table 2: Weekly rainfall at Keonjhar station at different probability levels in a year

Standard met week (SMW)	Probability levels			
	90%	75%	50%	25%
23 (4th to 10 June)	0	3.4	15	42
24 (11th to 17 th June)	0	9.6	28.1	80.2
25 (18th to 24th June)	0	3.8	23.1	45.4
26 (25th to 1st July)	0	3.3	16.7	41.5
27 (2nd to 8th July)	0	9.3	20.9	50.8
28(9th to 15th July)	3	6.4	23	59.4
29(16th to 22nd July)	0	8.4	27.8	61.2
30(23rd to 29th July)	0.6	16.6	36.6	71.5
31(30th to 5th August	1	11.8	36.8	70
32(6th to12th August)	0	8.8	34.2	91.6
33(13th to19th August	1.2	14.2	32.2	53.5
34(20th to 26th August	0	8.7	18.4	73.6
35(27th to 2nd September)	1	6.6	29.8	65.4
36(3rd to 9th September)	0.8	10	22.8	59
37(10th to 16th September)	0.6	8.2	25.7	48.9
38(17th to 23rd September)	1.8	9	33.8	62.6
39(24th to 30th September)	0	0.8	20	43.5
40(1st to 7th October)	0	0.2	13.8	49.4
41(8th to 14th October)	0	0	9.5	46.4
42(15th to 21st October)	0	0	2.6	21.4
42(22nd to 28th October)	0	0	1.2	12.4

conclusion that there is need of more preparedness on part of the farmers to go for water management practices (conservation and harvesting) in the months of July and August. Moreover, there is water conservation scope in the month of August which can later be utilized for rice crop at reproductive phase in the month of October. Rainfall quantity is very less in the month of October and at 50 per cent probability, the expected rainfall is 73.1 mm only.

Similarly seasonal basis analysis has been carried out at different probability levels. At 50 per cent probability, there is expected rainfall of 595 mm in monsoon season while at 75 per cent probability level assured rainfall of 465.4 mm which is not sufficient for meeting the water requirement of long duration rice variety and even medium duration rice variety. As here lies risk in rainfed rice production therefore, diversified land use with low duty non-paddy crops is the best option in this condition. The major thrust should be on rain water management through *in situ* conservation and water harvesting through on-farm reservoirs/ capturing runoff from local catchments/ flash flood water from local streams to recycle at the time of need.

However, it is the distribution of rainfall on weekly basis which is very important and rainfall quantity expected at 75 per cent probability is less than 15 mm in almost all the weeks during south west monsoon period which adds uncertainty factor in rainfed rice production. Standard week number 30 is receiving highest rainfall quantity of 16.6 mm which satisfies the minimum water requirement of percolation and ET losses for rice crop. However at 50 per cent probability which means on every alternate year basis, there is definite rainfall receipt of more than 20 mm per week during the period between 23 and 39 standard weeks and this period is in between 4 June and 30 September (Table 2).

As there is definite rainfall receipt of more than 20 mm per week during the period between 23 and 39 standard weeks not only rice but some efficient and promising non-rice crops (like maize, cowpea, arhar, blackgram, rice bean, ragi, groundnut, sesame, castor, pumpkin, sweet potato, elephant foot yam, yam, tapioca, yambean, arrowroot and colocassia) and cropping systems matching the length of growing seasoncan be taken up. During the month of May at 50 per cent probability there is 30.6mm of rainfall which can be utilised to perform off season ploughing of inversion type to conserve moisture, reduce pest and weed problem and to facilitate early sowing. In monsoon season rain water can be stored to be utilized as life saving irrigation. Agricultural strategies, farming operations need to be based on this type of analysis and advisories should be planned accordingly.

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