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Evaluation of Rainfall Distribution Pattern for Agricultural Planning in Raipur Region of Chhattisgarh Plain

B. L. Sinha

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Abstract Rainfall is the major determinant of agriculture production, especially in rainfed areas. Since the contribution of rainfed agriculture is almost half to the national kitty and about 68% sown area is still dependent on rainfall it is imperative that the prediction of rainfall pattern should be accurate and reliable. So it would be prudent to go for localized predictions. In view of this, an attempt has been made to evaluate rainfall distribution patterns i.e. weekly, seasonal and annual rainfall based on 40 years (1971–2010) data of Raipur, Chhattisgarh. The analysis showed that amongst various weeks of monsoon season, the 26th week received highest rainfall amount equal to 557.2 mm. However, average rainfall as 89.79 mm was found to be highest for 33rd week. From the monthly rainfall analysis, it was found that maximum value of average monthly rainfall (715.50 mm) and minimum value (39.00 mm) were recorded in the months of July and February respectively amounting to 27.47% and 1.126% of the average annual rainfall with CV of 43.38% and 88.92% respectively. Amongst seasonal rainfall distribution, the monsoon season received highest average rainfall i.e. 1024.26 mm.

Keywords Rainfall, Distribution pattern, Agricultural planting.

B. L. Sinha
Assistant Professor (Soil and Water Engineering),
College of Agricultural Engineering &
Technology and Research Station,
Indira Gandhi Krishi Vishva Vidylay,
Pandariya Road, Mungeli,
Chhattisgarh 495334, India
e-mail : blsinha_cg11@rediffmail.com

Introduction

Rainwater is the single most important potential source of moisture for agricultural farming system. Rainfall determines the potential of any region in terms of crops to be produced, farming system to be adopted, the nature and sequence of farming operation to be followed and to achieve higher agricultural productivity as well. In rainfed agriculture, the total amount of rainfed as well as its distribution affects the plant growth. Rainfall is a randomly distributed hydrological event. It varies with space and time. The knowledge of total rainfall and its distribution pattern round the year of a place is very important for better crop planning, determining irrigation and drainage requirement of crops, design and construction of hydrological structures. Solanki and Singh [1], Sharma and Dubey [2], Shriwastav and Shriwastav [3] have

Table 1. Rainfall characteristic at Raipur during 1971–2010.

SMW	Avg rainfall	Percentage of annual rainfall	Max rainfall	Min rainfall	SD	CV (%)	Skewness
23	16.84	1.43	174.50	0.00	30.24	179.62	3.89
24	45.73	3.88	277.20	0.00	62.52	136.73	2.31
25	58.86	5.00	322.90	0.00	61.21	103.99	2.31
26	75.29	6.39	557.20	4.20	91.60	121.66	3.91
27	66.96	5.69	231.40	0.00	59.71	89.17	1.61
28	82.56	7.01	334.00	4.80	67.22	81.41	1.75
29	69.78	5.93	227.60	10.20	49.56	71.02	1.28
30	72.96	6.19	277.80	0.00	67.76	92.88	1.47
31	76.40	6.49	284.20	2.00	66.93	87.61	1.55
32	77.30	6.56	240.10	7.00	58.10	75.17	1.23
33	89.79	7.62	303.80	4.60	73.21	81.54	1.17
34	52.45	4.45	147.60	0.00	37.72	71.91	0.62
35	66.14	5.62	262.80	0.80	57.33	86.69	1.51
36	52.10	4.42	129.60	0.00	39.09	75.03	0.52
37	57.00	4.84	359.00	1.60	75.09	131.73	2.64
38	34.83	2.96	238.80	0.00	54.52	156.51	2.15
39	25.76	2.19	77.40	0.00	25.69	99.76	0.66

suggested the use of daily, weekly, monthly, seasonal and annual rainfall distribution for crop planning.

The state of Chhattisgarh is dominated by tribal and backwards. Rice is the main crop of the state. The productivity is very low (1.34 t/ha) as compared to the national average (1.88 t/ha). The state received fairly high amount of rainfall 1200 to 1600 mm annually. But the shortage of water at critical growth stages is often experienced due to uneven distribution of rainfall resulting in frequent terminal droughts in wide spread areas leading to large scale migration of farm labours and farmers to other potential areas Anonymous [4]. More than 80% of the average annual rainfall of Raipur occurs during South West monsoon. Due to uneven distribution of rainfall and absence of suitable *in-situ* rainwater harvesting practices, the district is affected by water scarcity during *rabi* and summer seasons every year. However, analysis of rainfall data for computation of expected rainfall for the desired frequency and consequent excess rainfall is required for the safe design of any structure. Sharma and Dubey [2] carried out the study for analyzing the rainfall under changing climatic scenario for better planning of farm practices in semiarid region of Uttar Pradesh. Construction of SWC structures across the drainage line is an important activity in any design of any of these structures requires quantification of peak runoff rate for the design return period. The experiences from projects in Raipur reveal that improper design of structures without considering the expected maximum daily rainfall and consequent peak runoff for the design return period often lead to hydrological/hyfraulic/structural failure of these structures causing loss of valuable time, labor and money. Keeping this in view, an effort was made in the present investigation to interpret daily, weekly, monthly seasonal and annual rainfall of 40 years (1971–2010) data of Raipur, Chhattisgarh in simple and meaningful form to make it more useful.

Materials and Methods

Raipur district covers an area of 13083 km^2 and lies between North latitudes 19^{o}46´ and 21^{o}50´ and East longitudes 81^{o}25´ to 83^o 16´. Physiolographically, the district is divided into three unit's viz. Chhattisgarh plain, eastern and south eastern undulating and hilly tract and southern hilly range. The land use pattern indicates that 42% of the area is occupied by the agricultural land. The district has a tropical climatic condition. The entire district falls under Mahanadi Basin- main tributaries being Seonath, Jok and Tel. In the Rainpur region there are wide variations in the climate. Raipur has a tropical wet and dry climate, temperatures remain moderate throughout the year, except from March to June, which can be extremely hot. The winter commences from November and last till the end of February. The summer season beings from March and continues till the second week of June. Monsoon season commences from middle of June and remains till the end of the September. The information about normal values of climatic parameters was taken from Meteorological Department of College of Agriculture, IGKVV, Raipur and are presented in Figure 1.

Analysis of rainfall data

Daily, weekly, monthly, seasonally and annual rainfall data of past 40 years of Raipur were used probability

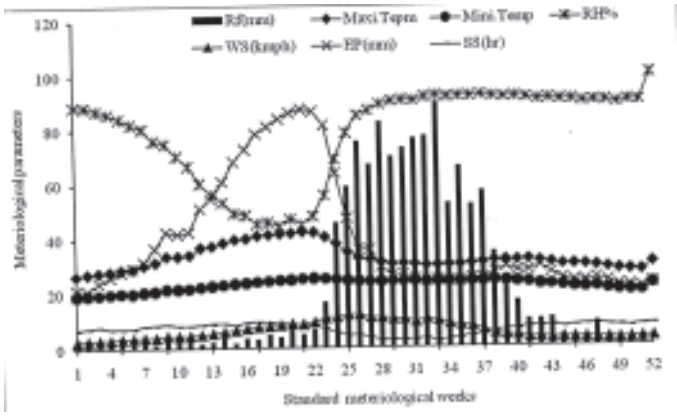

Fig. 1. Variation in meteriological parameters.

analyses of these data were made to fit in appropriate probability distribution in order to draw inference on probable future behavior of such events. An alanysis of rainfall characteristics involved determination of statistical parameters such as maximum, minimum, mean, standard deviation, coefficient of variation, skewness and percentage deviation of weekly, monthly, seasonal and annual value of rainfall were also computed by using computer programe in MS excel. The maximum and minimum value of rainfall was determined on accounting the highest and lowest rainfall in the respective week, month, season and year.

Results and Discussion

Analysis of rainfall characteristics

The characteristic of the rainfall of the region was evaluated on the basis of quantitative measures such as maximum, minimum, mean, standard deviation, and coefficient of variation, skewness and percentage deviation of weekly, monthly, seasonal and annual value of rainfall. The results of quantitative measures are discussed as under.

Weekly rainfall analysis

The analysis of weekly rainfall data of 40 years (1971–2010) reveals that there was marked variation among the rainfall in standard meteorological weeks (SMW) of the different years. SMW 23rd to 39th were found as monsoon weeks in which period greater concentration of higher rainfall was found. It can be clearly observed from the weekly rainfall distribution that 90% of rainfall occurs during 23rd to 39th SMW. It is clear from the data that the highest rainfall of 557.2 mm was observed in the 26th SMW in 2007. The variation in maximum weekly rainfall is observed in the range of 13.6 mm to 557.2 mm, whereas, minimum rainfall varied between 0.0 mm and 10.20 mm (Table 1). The average weekly rainfall was found to be highest of 89.79 mm in 33rd SMW while the lowest was 16.84 mm in 23rd SMW. The variation in standard deviation (SD) was ranged from 3.58 to 91.59, whereas coefficient of variation (CV) varied in between 71.09% and 470.16% respectively. Higher value of standard deviation and lower value of coefficient of variation indicates dependability. This also shows the uniform and consistent rainfall pattern during the weeks. Skwness found to be varied between 5.85 and 50.52. This analysis shows there is wide variations in quantitative measures which indicates that the rainfall received in region are highly erratic.

Monthly rainfall analysis

Monthly rainfall analysis (Table 2) clearly depicts this region receives more than 90% of annual rainfall dur-

Table 2. Monthly, seasonally and yerly rainfall characteristics during 1971–2010.

Month	Avg rainfall	Percentage of annual rainfall	Max rainfall	Min rainfall	SD	CV (%)	Skewness
Jan	13.84	1.18	104.40	0.00	21.56	155.77	2.50
Feb	13.27	1.13	39.40	0.00	11.80	88.92	0.40
Mar	13.81	1.17	51.20	0.00	15.25	110.45	1.09
Apr	14.07	1.19	64.00	0.00	14.93	106.13	1.52
May	24.26	2.06	87.40	0.00	22.95	94.59	1.40
Jun	187.70	15.94	713.40	41.30	130.05	75.04	2.04
Jul	323.59	27.48	715.50	71.80	140.39	43.39	0.47
Aug	327.11	27.77	553.40	141.50	114.28	34.94	0.09
Sep	185.87	15.78	605.60	25.60	117.18	63.04	1.64
Oct	48.57	4.12	154.26	0.00	44.58	91.79	0.96
Nov	19.16	1.63	228.10	0.00	41.53	216.77	3.76
Dec	6.56	0.56	72.60	0.00	15.03	229.24	3.33
Climatic season							
Summer	52.14	4.43	159.00	11.40	38.46	73.77	1.32
Monsoon	1024.26	86.97	1531.60	610.20	242.00	23.63	0.27
Post monsoon	62.20	5.28	166.20	0.00	48.94	78.68	0.62
Winter	33.74	2.87	135.40	0.00	31.05	92.04	1.28
Cropping season							
zaid	278.47	23.64	1073.80	77.50	218.59	78.50	2.14
kharif	885.13	75.15	1389.60	473.10	244.16	27.58	0.32
rabi	47.30	4.02	192.20	0.90	40.68	86.00	1.51
Yearly	1177.78	–	1651.20	709.10	266.21	22.60	-0.04

ing the month of May to October. August is the wettest month with an average of 327.11 mm followed by July of 323.59 mm. It is also found from the analysis of 40 years data that the maximum value of average monthly rainfall (715.50 mm) and minimum value (39.40 mm) were recorded in the months of July and February respectively amounting to 27.48% and 1.13% of the average annual rainfall with coefficient of variation of 43.39% and 88.92% respectively. High value of standard deviation of 140.39 in the month of July indicates its dependability. The variation in minimum monthly rainfall was observed in the range of 0.0 to 141.5 mm. Further from the analysis, it is also observed that the value of coefficient of variation skewness were found to be lowest of 34.93% and 0.09 respectively in the month of August which indicates less variation in rainfall distribution of the region and has a consistent and uniform rainfall pattern. December is the driest month with a meagre rainfall of 6.56 mm. It is due to receiving of lowest amount of rainfall throughout the year and contributes 0.56% to the annual rainfall which is also a negligible amount. It is also having the highest value of coefficient of variation of 229.24%, which shows the erratic pattern of rainfall of the region.

Seasonal rainfall analysis

Climatic seasonal. It is evident from the analysis that the Raipur region receives 86.96%, 5.28%, 4.42% and 2.86% of average annual rainfall during the monsoon (June–September), post monsoon (October–November), winter (December–February) and summer (March–May) season, respectively (Table 2). The maximum rainfall for season monsoon, post monsoon, winter and summer are 1531.60, 166.20, 135.40 and 159.00 mm respectively. The highest average rainfall equal to 1024.26 mm was observed in the monsoon season of the region while the lowest of 33.74 mm was in the winter season. A major part of it generally lost through runoff, which can be stored through *in-situ* or *ex-situ* water harvesting structures and used

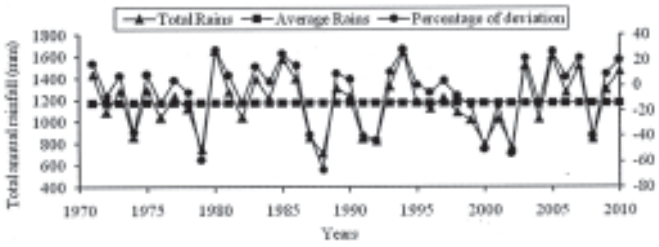

Fig. 2. Years-wise total annual rain distribution and percent rain deviation.

during *kharif/rabi/*summer season for growing crops. It can also be utilized as life saving irrigation particularly in dry period of one or two weeks in rainy season also adversely affect standing *kharif* crop in the region. The minimum value of rainfall of the region varied between 0.0 to 610.20 mm. The coefficient of variations, standard deviation and skewness of the monsoon season were 23.62%, 242.0%, and 0.27% respectively which indicates its dependability. The lower value of coefficient of variation depicted consistent occurrence of rainfall in monsoon season.

Cropping season. The mean *kharif* (Jul–October), rainfall of 885.13 mm accounts for 75.15% of annual rainfall with coefficient of variation of 27.58% and standard deviation of 244.16 mm indicating its dependability (Table 2). A major part of rainfall in this season generally lost through runoff, which can be stored through *in-situ* or *ex-situ* water harvesting structures and used during *kharif/rabi/ziad* season for growing crops. It can also be utilized as life saving irrigation particularly in dry period of one or two weeks in rainy season also adversely affect standing *kharif* crops in the region. The mean summer (March-June) rainfall of 278.47 mm accounts for 23.64% of annual rainfall with coefficient of variation of 78.50% and standard deviation of 218.59 mm whereas mean winter (November–February) rainfall of 47.30 mm accounts for 4.02% of annual rainfall with coefficient of variation of 86.00% and standard deviation of 40.68 mm. The maximum and minimum amounts of rainfall in *kharif* season were 1389.60 and 473.10 mm respectively. The lower value of coefficient of variation depicted consistent occurrence of rainfall in *kharif* season.

Annual rainfall analysis

The analysis of rainfall data of Raipur region on annual basis showed a significant variation in the range of 709.1 to 1577.7 mm with an average value of 1177.78 mm. Hence, the annual rainfall showed high standard deviation and coefficient of variation. Standard deviation and coefficient of variation and skewness were 266.21 mm, 22.60% and -0.04 respectively. The highest annual rainfall was observed in the year 1985, whereas it was found lowest in the year 1988. About 55% of the total years received highest rains than that of the average annual rainfall and 45% of the total years received lesser rains than that of the average annual rainfall. It is evident from the figure that percentage deviation over mean annual rainfall (1177.783 mm) ranged in between (-) 66.02% and (+) 28.10% at rained region of Raipur during period under investigation as shown in Figure 2. Although the annual rainfall over forty years (1971-2010) was in no particular trend, however, last three years of annual average showed the decreasing trend.

Conclusion

On the basis of rainfall analysis of rainfall data of Bilaspur, the following conclusion may be drawn : Weekly rainfall varies in the range from 0.00 mm to 557.2 mm with highest rainfall 327.103 mm received in

the month August contributing to about 27.77% to the average annual rainfall and the lowest values of rainfall 6.55 mm received in the month December contributing the 0.556% to the total annual rainfall. This extends great possibility to collect and utilize huge surplus surface runoff in the water storage bodies and recycling the same for qualitative and quantitative production of different crop in this region. The seasonal rainfall varied 1531.6 mm highest in monsoon season contributing to about 86.96% to the average annual rainfall, the lowest value of rainfall received in winter season which is 135.4 mm contributing to about 33.74% to the average annual rainfall. On the basis of crop season *kharif* season received the highest rainfall 1389.6 mm and contributing 75.12% of the total average annual rainfall. The annual rainfall varies from 709.1 to 1577.7 mm with an average value of 1177.783 mm.

Hence the valuable information obtained from the analysis of rainfall in present study can be used for crop planning, designing of soil and water conservation structure in the Raipur region.

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