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Analysis of the probability of rainfall in the Fingeshwar Tehsil of the Gariyaband District for crop planning

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ABSTRACT

Rainfall probability analysis improves predictions of the minimum assured rainfall to aid crop planning. An attempt has been made to look into the patterns of rainfall distribution, including weekly, seasonal, and annual rainfall, using data collected from the Fingeshwar tehsil of the Gariyaband district, Chhattisgarh, over a ten-year period (2011-2020). Using the Weibull plotting position function, expected weekly, monthly, seasonal, and yearly rainfall values were calculated for various probability levels. Based on a 10-year yearly average, the data revealed that 1074.4 mm of rain were actually seen, following an average of 52.2 rainy days. A rainfall amount with a 75% probability level predicts 862.9 mm annually. The largest amount of weekly rainfall, 49 mm, was predicted to fall in the 35th week, followed by 32.1 mm in the 25th standard week and the least amount, 0.0 mm, in the 20-22nd, 29, 37, 40-42nd SMW. This prediction was made at a 75% chance level, same like the one before. According to a study of monthly rainfall at 70, 75, and 80% probability levels, the three crucial wet months are July, August, and September, with probabilities of getting a monthly rainfall between 0 and 50 mm. At a 70% probability level, the seasonal rainfall report projects 833 mm for the *Kharif* season. Thus, it can conclude that the kharif season's activities could start between the 22nd and the 23rd standard week and farmers can properly produce paddy crops in highland areas followed by any rabi crop in rabi season.

Introduction

One of the main climatic elements that directly influences the water balance of the soil is rainfall. The crop planning and crop calendar for a particular agroclimatic zone are influenced by the quantity, timing, and spatial variability of the rainfall that falls on the soil surface. The start and end of the rainy season are clearly associated with the agricultural calendar, which in turn directly affects agricultural productivity. It is essential to comprehend the pattern based on past data in order to be able to predict the future. The probability of rainfall and its occurrence has been studied by a number of researchers. For a number of locations in India, rainfall data have been subjected to frequency analysis. Raju *et al.* (2021) studied the weekly probability analysis of rainfall using statistical methods to forecast the lowest assured rainfall that aids in crop planning and management in Anakapalle, it gives the length of the growth season taking a 50% chance of rain into account. In spite of the amount of rainfall expected, a study of the coefficient of variation of weekly rainfall showed that reliable rainfall would occur during the time period. Sinha *et al.* (2018) investigated the rainfall probability for crop planning in the Raipur region of Chhattisgarh state and discovered that despite the need for more irrigation for Kharif crops, there is at least a 70% chance that there will be enough rainfall to support the growth of high-value fruit crops. Based on data collected over a 13-

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year period (2000–2012) at Shivri, Lucknow, Uttar Pradesh, S. Singh *et al.* (2016) attempted to assess the distribution of rainfall and forcast the rainfall using plotting-position formula. Baweja (2011) found that Solan, Himachal Pradesh, India's constant rainfall period spanned from the 24th to the 37th standard meteorological week based on an analysis of 38 years of rainfall data. In the Orissa area of Kandhmal, Subudhi *et al.* (2012) did a study on the probability analysis of rainfall for crop planning. They discovered that there is a 75% chance that there will be enough rain to water crops.He demonstrated that the season's rainfall distribution, not its total amount, has an impact on agricultural productivity. Krishnamurthy *et al*. (2009) reveals that the intensity and frequency of extreme events have typically decreased in the north and centre of the Indian Subcontinent, while they've surged in the coastal regions of the peninsula and the immediate area west of Bangladesh.This shows that understanding the overall quantity of rainfall that falls in a particular year and how it is distributed is ultimately necessary for effective crop planning, estimating the irrigation and drainage needs of crops, and devising and constructing buildings for soil and water conservation. A probability and frequency analysis of rainfall data can be used to estimate the projected rainfall at various percent chances. It is the most reliable method of predicting the probability of possible rainfall data since it is based on the behaviour of rainfall in the past. When analysing rainfall data, several probability distributions are typically employed to calculate the predicted rainfall for a certain frequency. This demonstrates the value of using local rainfall data to study the localised pattern of rainfall. As a result, information from the region was collected to conduct a 10-year rainfall probability study for the Fingeshwar tehsil in the Chhattisgarh district of Gariyaband.

Material and Methods

The Fingeshwar Tehsil in the Gariyaband district of Chhattisgarh, which is located at 20°57'56"N latitude and 81°53'19"E longitude, provided the daily rainfall data for the previous 10 years (2011-2020) Anonymous, (2019) Rainfall patterns are looked at and analysed on a weekly, monthly, seasonal, and annual level. The entire year is classified into the three seasons of summer, kharif, and rabi in order to assess the seasonal tendency. The Standard Week Nos. 17 to 19 (from 23 April to 13 May) are regarded to be the Summer (Zaid) Season, the Nos. 20 to 44 (from 14 May to 4 November) are considered to be the Kharif (Monsoon) Season, and the Nos. 45 to 16 (from 5 November to 22 April) are considered to be the Rabi Season (Winter). The daily totals for each of the 12 months have been combined in the case of rainfall, starting at the start and finish of each month. To anticipate the behaviour that these occurrences are likely to display in the future, the data were changed to match an appropriate probability distribution. Using the Weibull graphing function, the probability of rainfall at various levels and the amount of precipitation were computed and predicted. The following formula can be used to calculate the normal probability density function from the mean and standard deviation:

$$\boldsymbol{P = \frac{m}{n+1}} \text{.........} \ \mathbf{(1)}$$

Where,
P = Probability
m = Rank
n = Number of years

The predicted rainfall levels were estimated using this equation for various probabilities of exceedance. Additionally, a second-degree power equation was fitted to predict rainfall at different probability levels, and probability (P%) was displayed in relation to weekly, monthly, seasonal, and annual time intervals using a semi-log scale.

Results and Discussion

Rainfall trend

Annual rainfall

The 10-year trends in average rainfall and number of rainy days are displayed in Figure 1. Based on an analysis of the yearly rainfall pattern from 2011 to 2020, the lowest amount of rain, 445 mm, was recorded in 2015, the result of 44 rainy days. This was closely followed by 2014, which had 48 rainy days and a total of 687 mm of average rainfall. 65 wet days contributed to the 1417.2 mm average annual rainfall in 2013. 1074.4 mm of rain have been recorded over the past ten years, with an average of 52.2 rainy days. The results show that rainfall in this region fluctuates substantially from year to year. While preparing for the region's future development and management, it is crucial to take this variability into account (Sinha, 2019).

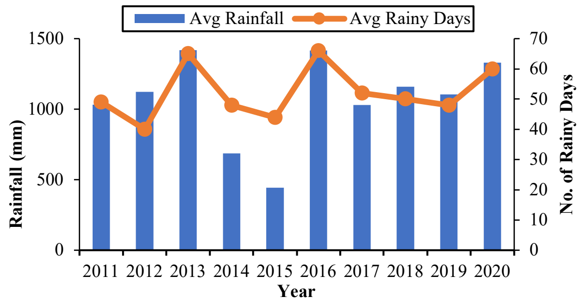

Figure 1: Annual rainfall and rainy days variability at Fingeshwar

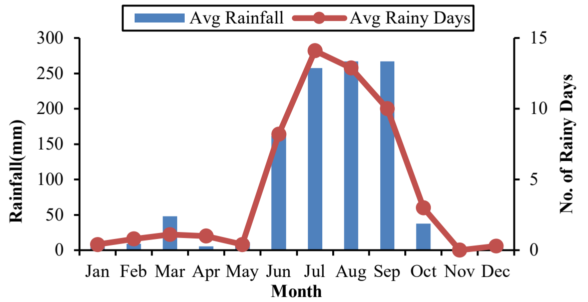

Figure 2: Average monthly rainfall (mm) and rainy days for 10 years

Mean monthly rainfall

The average monthly rainfall for the preceding ten years is depicted in Figure 2 together with the number of rainy days. It demonstrates that pre-monsoon rains beginning in May cause the majority of the region's annual rainfall to fall in the months of June, July, August, and September. The average monthly total of rainy days showed the same trends. According to the rainfall pattern, the number of rainy days each month in May, June, July, August, and September was 0.4, 8.2, 14.1, 12.9, and 10, respectively. As a result, May, June, July, August, and September experienced average monthly rainfalls of 0.4, 8.2, 257.38, 267.02, and 267.08 mm, respectively. With an average rainfall of 1074.4 mm and average number of wet days of 52.2 days over the last ten years. The end of the monsoon season can start in October. On the other hand, there are signs that it rained during the winter, although in very little amounts and mostly just during the months of December through February. The average annual rainfall of 1074.4 mm during the previous 10 years has been observed to fall between May and October with the monsoon months of June, July, August, and September contributing for 93% of this total amount. From this finding, it may be inferred that while there is sufficient rainfall throughout the Kharif season, less irrigation is required during the Rabi season due to a lack of precipitation. This finding is supported by the fact that this area, which receives less rainfall during the Rabi season than other area in India, has a lower incidence of drought than most others. Tomar, (2006)

Mean weekly rainfall

The pattern of rainfall during the last 10 years is illustrated in Figure 3. The monsoon rains, with the exception of pre-monsoon rains, often fall between the 19th and 22nd standard weeks, occasionally between the 25th and 29th standard weeks (18th June to 22th July) rainfall begins. Between the 38th and 40th standard weeks, the monsoon departs (17th Sept to 7th Oct.). According to the 10-year average, the rainy time of the year falls between the 26th and 37th standard weeks (25 June to 16 September). The biggest chance of receiving the weekly average rainfall is during this time period.

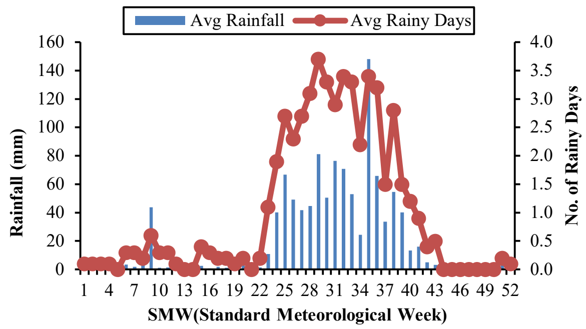

Figure 3: Average weekly rainfall for 10 years

Rainfall Probability Estimation

Weekly rainfall probability estimation

Table 1 illustrates the results of the analysis of rainfall data from the previous 10 years together with a weekly chance of occurrence. The choice of crop, timing of sowing, irrigation strategy, and efficient use of rainwater for optimal output can all be assisted by this forecast. We focused on calculating the probability of weekly rainfall for the monsoon season weeks (the 22nd to the 40th), which are shown in Table 1. The predicted values of rainfall show that the value of rainfall declines as the probability level for a certain week rises. According to variety of studies, (Sinha *et al.* (2018), Singh *et al.,* (2016)) a minimum guaranteed number should be used for crop planning and should be the projected amount of rainfall with a 75% possibility of exceeding it. Figure 4 illustrates the anticipated rainfall amounts for a 70 to 90 percent probability level. The probability of 70% is at the top of the graph, with the curve with greater probabilities coming next, showing that the probability of 90% got the least amount of rainfall. The maximum rainfall, 39 mm, was recorded in the 35th week, followed by 32.1 mm in the 25th standard week, both at a 75 percent probability level. The weeks 20-22, 29, 37 and 40-42 saw the lowest rainfall, of 0.0 mm. Similar to this, the greatest observed rainfall values for 70, 80, and 90 percent probabilities were 51.6 mm (35th week), 29.2 mm (38th week), and 25.6 mm (38th week), while the lowest observed rainfall values were 0 mm (20-22, 29, 37 and 40-42 standard week). The graphical trend between the 26th, 28th, 30th to 31st, 33rd to 35th, and 38th standard weeks shows five peaks. This suggests that there is a higher chance of rainfall between the 26th and 38th standard weeks, while at other periods irrigation can be provided as needed utilising the available irrigation sources.

Monthly rainfall probability estimation

The monthly rainfall changes at various probabilities are displayed in Table 2 and Figure 5. The three major rainy months are predicted to be July, August, and September, with probabilities of monthly precipitation ranging from 210 to 260 mm at 70, 75, and 80% probability levels.

As a result, measures for harvesting surface runoff can be considered during this time in order to effectively use captured rainfall during the next dry period. Tomar (2006) advised that rain with a 70% probability of occurring is safe to presume to be guaranteed rain, while risk-taking should be limited to 50%. In the months of July, August, and September, it was expected to rain between 210 and 270 mm, with a 70% chance of doing so. With the expected rainfall from the table taken into

Table 1: Prediction of rainfall at different probability level (mm) on basis of SMW (Standard Meteorological Week)

SMW	Probability Level									
	90%	80%	75%	70%	60%	50%	40%	30%	20%	10%
22	0.0	0.0	0.0	0.0	1.7	7.1	13.7	22.2	34.3	54.8
23	0.0	0.8	2.8	5.0	9.8	15.6	22.6	31.7	44.4	66.3
24	0.0	6.2	11.3	16.7	28.8	43.1	60.6	83.2	115.0	169.4
25	8.3	19.7	25.9	32.6	47.4	65.0	86.6	114.3	153.4	220.2
26	27.3	34.3	38.2	42.4	51.6	62.6	76.0	93.3	117.6	159.3
27	6.1	12.8	16.5	20.5	29.3	39.7	52.4	68.9	92.0	131.6
28	29.5	37.7	42.2	47.0	57.6	70.3	85.7	105.7	133.8	181.8
29	4.1	24.4	35.5	47.3	73.8	105.2	143.6	193.0	262.8	382.0
30	23.0	31.5	36.1	41.1	52.2	65.3	81.3	102.0	131.2	181.1
31	9.5	26.9	36.4	46.6	69.4	96.3	129.2	171.7	231.5	333.9
32	5.9	13.4	17.5	21.8	31.6	43.2	57.3	75.6	101.3	145.2
33	30.7	38.5	42.8	47.4	57.6	69.7	84.5	103.6	130.5	176.5
34	29.1	34.9	38.1	41.5	49.1	58.1	69.1	83.3	103.3	137.6
35	20.8	34.2	41.6	49.5	67.1	87.9	113.4	146.2	192.5	271.6
36	6.6	21.5	29.7	38.4	58.0	81.1	109.4	145.9	197.3	285.3
37	6.8	13.4	17.0	20.9	29.5	39.8	52.3	68.4	91.2	130.1
38	8.7	24.5	33.2	42.4	63.1	87.6	117.6	156.2	210.7	303.7
39	0.8	3.1	4.4	5.8	8.9	12.6	17.1	22.9	31.0	45.0
40	0.8	4.9	7.2	9.6	14.9	21.3	29.1	39.1	53.2	77.3

Table 2: Prediction of monthly rainfall (mm) at different probability level

Month	Probability Level									
	90%	80%	75%	70%	60%	50%	40%	30%	20%	10%
Jan	0.0	0.0	0.0	0.0	0.0	0.5	1.2	2.0	3.2	5.2
Feb	0.0	0.0	0.0	0.0	0.0	2.1	5.6	10.1	16.5	27.5
Mar	0.0	0.0	0.0	0.0	2.1	5.1	8.8	13.5	20.2	31.6
Apr	0.0	0.0	0.0	0.0	2.9	6.7	11.4	17.4	25.9	40.5
May	0.0	0.0	0.0	0.3	6.6	14.0	23.1	34.8	51.3	79.6
Jun	117.5	118.8	119.5	120.2	121.9	123.8	126.2	129.3	133.7	141.2
Jul	208.3	237.9	254.2	271.6	310.5	356.4	412.6	485.1	587.3	762.0
Aug	222.1	245.6	258.5	272.2	303.0	339.4	384.0	441.4	522.3	660.7
Sep	194.7	211.3	220.5	230.2	252.0	277.9	309.4	350.1	407.5	505.6
Oct	16.5	25.2	30.0	35.2	46.7	60.2	76.9	98.3	128.5	180.1
Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dec	12.5	14.9	16.2	17.6	20.8	24.5	29.0	34.9	43.1	57.2

consideration, it can be seen that the three rainy months of July, August, and September are likely to contribute, with a 70, 21 and 17% of the annual rainfall, respectively. As a result, this accounts for 70% of total annual rainfall. Because the majority of the rice plant's water-dependent stages take place between July and September, Singh *et al.,* (2016) transplantation should be carefully timed.

Cropping season rainfall probability estimation

Table 3 and Figure 6 show the crop season probabilities. Both the rainfall trend and the data's seasonal analysis imply that rainfall value falls as probability rises. Planning agricultural operations around the seasonal cycle is thought to be safer at a 70% probability level. Barman *et. al* (2016) At a 70% Probability level, the seasonal rainfall projection for the kharif season predicts 1237.24 mm of rain annually, more than the other two seasons combined. Using this strategy, it is possible to plan harvests throughout the Kharif season and repurpose irrigation during drought spells to protect crops throughout critical growth stages. The 4.84 mm rainfall predicted for Rabi, which has a 70% chance of occurring, demonstrates the need for a solid irrigation infrastructure for other crops in addition to pulses, such as wheat and oilseeds.

Table 3: Prediction of seasonal rainfall (mm) at different probability level.

Season	Probability Level									
	90%	80%	75%	70%	60%	50%	40%	30%	20%	10%
Zaid	0.0	0.0	0.0	0.0	2.4	7.7	14.3	22.7	34.7	55.0
Kharif	1155.7	1193.9	1214.9	1237.2	1287.3	1346.4	1418.8	1512.2	1643.8	1868.7
Rabi	0.0	0.0	1.8	4.8	11.7	19.9	29.8	42.7	60.8	91.8

Annual rainfall probability estimation

To estimate the relative frequency of occurrence of a particular amount of annual rainfall with adequate accuracy and to visualise the probability distribution of annual rainfall. It is evident from Figure 7 that the value of rainfall decreases as the probability level rises. At 90, 80, 75, 70, 60, 40, 30, 20, and 10% chance levels, the values of rainfall projected to occur are 1877.64, 1668.86, 1546.74, 1460.09, 1392.88, 1337.9, 1291.53 and 1270.75 mm. IMD defines a place or area as drought-affected if its seasonal or annual total rainfall is less than 75% of the average (Appa Rao, 1986; Sinha B.L., 2019). Hence, based on the yearly rainfall over the previous ten years, the four years of 2011, 2012, 2015, 2016, and 2017 were hit by drought.

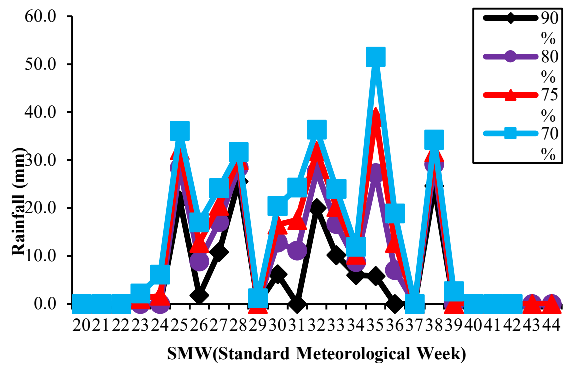

Figure 4: Predicted weekly rainfall at different probability level of monsoon week (*Kharif*)

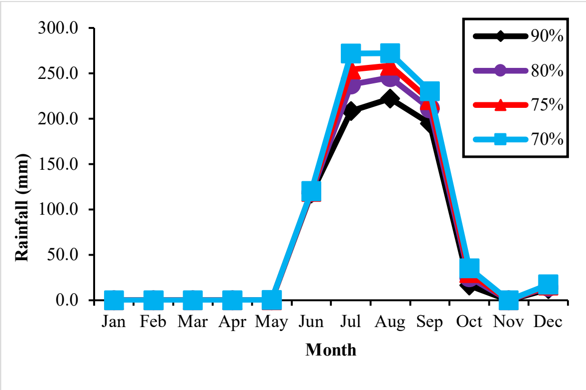

Figure 5: Predicted monthly rainfall at different probability level

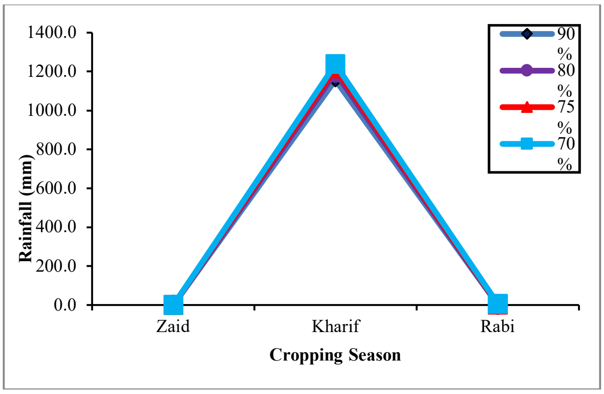

Figure 6: Estimation of rainfall at different probability level on the basis of cropping season

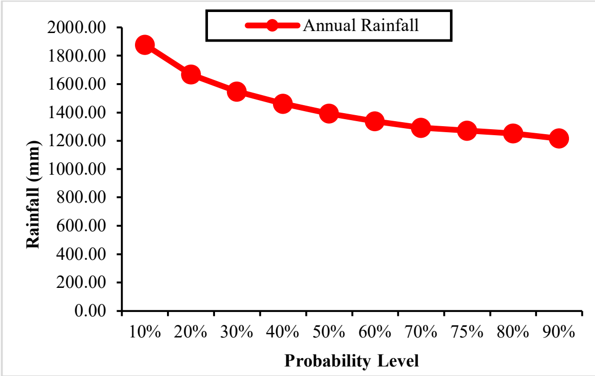

Figure 7: Annual expected rainfall at different probability level.

Conclusion

Possessing exact and consistent rainfall pattern information is useful for managing and executing irrigation techniques during drought spells. Knowledge of successive days of return periods is a crucial parameter of safe, sound, and effective economic planning, as well as in the design of various structural and non-structural measures for small and medium hydraulic structures such as culverts, bridges, check dams, and ponds. It has been observed that the June, July, August, and September got more than 100 mm, thus farmers in these places can produce paddy crops in highland areas followed by any rabi crop in rabi season. At a 50% probability level, the annual rainfall in Fingeshwar Tahsil of the Gariyaband district is 1005.9 mm. It is reasonable to conclude that the kharif season's activities could start between the 22nd and the 23rd standard week and additional runoff should be collected and can be used in post-monsoon crops in this area. It also becomes imperative to offer farmers with high yielding crop types as well as those that use less water and mature earlier.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Anonymous, (2019). *District Survey Report, Gariyaband (Chhattisgarh)*. Directorate of Geology & Mining, Mineral Resource Department, Government of Chhattisgarh

AppaRao, G. (1986). *Drought Climatology*. Jal Vigyan Samiksha, National Institute of Hydrology, Roorkee.

Barman, D., Shaha, A. R., Kundu, D. K., & Mahapatra, B. S. (2012). Rainfall Characteristics Analysis for Jute-Based Cropping System at Barrackpore, West Bengal, India. *Journal of Agricultural Physics*, *12*(1), 23–28.

Baweja, & Kaur, P. (2011). Rainfall Variability and Probability for Crop Planning in Solan, Himachal Pradesh. *Journal of Farm Sciences*, *1*(1), 75–88.

Dhingre, S., Shahi, N. C., & Khan, A. A. (2004). Predicting Precipitation Characteristics of Srinagar Region of Kashmir Valley. *Journal of Water Management*, *12*(2), 71–74.

Krishnamurthy, Chandra, K., Lall, U., Kwon, & Hyun-Han. (2003). Changing Frequency and Intensity of Rainfall Extremes Over India from 1951 to 2003. *Journal of Climate*, *22*, 4737–4746.

Rizvi, R. H., Singh, R., Tewari, R. S., Dadhwal, R. K., K., S., & Solanki, K. R. (2001). Probability Analysis of Annual Maximum Daily Rainfall for Bundelkhand Region of Uttar Pradesh. *Indian Journal of Soil Conservation*, *29*(3), 259–262.

Singh, A. K., Singh, Y., Mishra, V. K., Arora, S., Verma, C., Verma, N., Verma, H., & Srivastav, A. K. (2016). Probability analysis of rainfall at Shivri for crop planning. *Journal of Soil and Water Conservation in India*, 306–312. https://doi.org/10.5958/2455-7145.2016.00021.7

Sinha, B.L. (2019). Analysis of Rainfall Data for Drought Investigation at Mungeli of Chhattisgarh Plain. *International Journal of Current Microbiology and Applied Sciences*. https://doi.org/10.20546/ijcmas.2019.803.269

Sinha, B. L., & Pradhan, M. K. (2018). Rainfall Probability Analysis for Crop Planning in Raipur Region of CG Plain. *Journal of Pharmacognosy & Phytochemistry*, *7*(5), 2207–2211.

Tomar, A. S. (2006). Rainfall Analysis for Ensuring Soil Moisture Availability at Dryland Area of Semi-Arid Indore Region of Madhya Pradesh. *Indian Journal of Soil Conservation.*, *5*(1), 1–5.