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Rainfall Characterization for Crop Planning of Bokaro District in Jharkhand

Yellagandula Mani*, Ramesh Kumar, Pragyan Kumari and A. Wadood
Department of Agrometeorology and Environmental Science,
Birsa Agricultural University, Ranchi, (Jharkhand), India.

(Corresponding author: Yellagandula Mani)*
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ABSTRACT: Indian agriculture is heavily dependent on monsoons. About 61% of farmers in India rely on rain-fed agriculture (NRAA, 2019). The knowledge of rainfall distribution provided a road map for optimal crop planning and water resources management. Present study has been undertaken to determine the expected amount of rainfall of Bokaro district at different probability levels (90%, 75% and 50%) using Incomplete Gamma Probability distribution in Weather Cock model. Rainfall data of 30 years (1989-2018) has been collected from Directorate of Economics and Statistics, Govt. of Jharkhand to estimate annual, seasonal and monthly rainfall probabilities of Bokaro district. The analysis of 30 years rainfall data revealed that the annual average rainfall of Bokaro is 1063.2 mm. The average annual predicted rainfall at 90%, 75% and 50% probability levels are 717.2 mm, 859.4 mm and 1038.5mm respectively. 33 SMW has the record of receiving highest amount of rainfall at all the three probability levels. At 75% of assured probability level monsoon may receive 319.4 mm of rainfall and post monsoon period may receive 11.8 mm of rainfall. So, rice is best suitable crop in medium and lowlands during kharif and pulses like black gram, green gram, soybean, horse gram, oil seeds like sesame, mustard etc can be taken up during rabi season. Sweet potato is also added in crop plan because it is under cultivation by most of farmers.

Keywords: Rainfall probability, SMW, Incomplete gamma probability, Assured rainfall and Crop Planning.

INTRODUCTION

Around 58% of cultivated area is under rain-fed condition which contributes to 40% of food production in country (Prasad *et al*., 2015). Rain-fed 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). Rainfall trend, distribution and variation are important in determining crop yield, lower standard deviation values indicate less rainfall variation and higher CV specify irregularity in rainfall distribution (Rani *et al.*, 2020). 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). Lowest amount of rainfall at different probability levels is computed by fitting gamma distribution probability model on weekly basis. The single probability distribution was not adequate to represent the entire data set (Alam *et al.*, 2018). Probability and frequency analysis of rainfall data enables us to determine the expected rainfall (Bhakar *et al*., 2008). Probability analysis of rainfall is needed to know the rainfall behaviour for water resources management and optimal crop planning (Sachan, 2016). 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*., 2016). Weekly, seasonal and monthly predicted amount of rainfall will help farmers in deciding the cropping system and carryout different agricultural operations like time of sowing in kharif and rabi crops are also decided according to the availability of water (Pattanayak, 2019). Hence, present study has been undertaken to suggest the cropping pattern for Bokaro district of Jharkhand considering the rainfall amount at different probability levels using incomplete gamma probability distribution.

MATERIALS AND METHODS

A. Study Area

The study was conducted in 9 blocks (Chas, Chandankiyari, Jaridih, Kasmar, Peterwar, Gumia, Bermo, Nawadih and Chandrapura) of Bokaro district in Jharkhand for estimating the expected amount of rainfall at different probability levels. The district is located under latitude from 23°26" to 23°57″N and longitude from 85°34″ to 86° 26″E. Its elevation ranges from 200-546 m above mean sea level and receives average rainfall of 1063.2mm with maximum and minimum temperature of 46° and 4° respectively.

B. Rainfall Probability

The probability analysis of rainfall helps to determine the expected amount of rainfall at different levels (90%,

75%, 50%). Thirty years of rainfall data has been collected from Directorate of Economics and Statistics, Govt. of Jharkhand to determine the weekly, monthly and seasonal rainfall probability. It is estimated using WEATHER COCK software, which is developed by CRIDA, Hyderabad for weather data analysis.

Some attention is needed to be given before going for weather data analysis by using Weather Cock software which is as follows.

1. NEVER rename the Weather Cock folder.
2. All Data files should be either created in Notepad or as. csv file (comma separated values) of excel.
3. Kindly examine the data file structure in the SAMPLE DATA folder for any analysis before creating the new data file.
4. While analysing data with. csv file if any error occurs then open the. csv file in Notepad and delete all the last commas in every data line.
5. Data for everyday Date structure- mm/dd/yyyy.
6. The possible errors in data are like 12.8.0 or 12.8 or 12.8. instead of 12.8. Data may be typed as a nonnumeric symbol (space, _, +).

C. Analysis of annual and weekly rainfall probability

Annual and Weekly rainfall probabilities have been calculated through the module named as "Incomplete Gamma Probabilities.exe". Block wise weekly rainfall data has been used as an input to obtain the annual and weekly probability of rainfall at a level of 90%, 75%, and 50%. The amount of rainfall at three probability level has been computed for each standard week by fitting Incomplete Gamma Distribution model.

RESULT AND DISCUSSION

A. Mean annual and weekly rainfall probability

The expected amount of annual rainfall for the district at 90%, 75% and 50% are 717.2 mm, 859.4 mm and 1038.5 mm respectively (Table 1). The rainfall amount is expected to be less than 5 mm in the weeks before the onset of monsoon at 75% probability level. After the onset of monsoon, i.e. from 24 SMW till 40 SMW the rainfall amount is very high. The district may receive a fair amount of rainfall during 25 to 38 SMWs at 75% probability. Highest rainfall has been estimated in 33 SMW at all the probability levels. The amount of rainfall again decreases gradually after 40 SMW (during cessation of monsoon) and water stress condition prevails during that period for rabi season crops. Similar results have also been reported in southern part of Bihar (Kumari *et al.,* 2000) and in semi-arid Indore region of Madhya Pradesh (Tomar, 2006).

Table 1: Annual and weekly rainfall probability of Bokaro district.

Week	Probability levels (%)			Mean
	90%	75%	50%	
1	0.2	0.8	2.8	1.3
2	0.2	0.7	2.1	1.0
3	0.4	0.8	1.5	0.9
4	0.6	0.8	1.1	0.8
5	0.7	0.9	1.1	0.9
6	0.0	0.3	0.0	0.1
7	0.0	0.0	0.4	0.1
8	0.0	0.0	0.4	0.1
9	0.2	0.6	1.8	0.9
10	0.5	0.8	1.2	0.8
11	0.5	0.8	1.2	0.8
12	0.5	0.7	0.9	0.7
13	0.5	0.8	1.2	0.8
14	0.1	0.6	1.7	0.8
15	0.3	0.7	1.5	0.8
16	0.2	0.7	1.7	0.9
17	0.2	0.6	1.7	0.8
18	0.4	1.3	3.8	1.8
19	0.4	1.3	3.7	1.8
20	0.3	1.6	6.1	2.7
21	0.4	2.1	7.5	3.3
22	0.4	2.5	11.4	4.8
23	0.4	2.6	11.4	4.8
24	1.5	5.2	15.2	7.3
25	4.3	13.5	35.9	17.9
26	8.3	19.2	40.8	22.8
27	7.0	19.4	47.3	24.6
28	10.6	22.9	46.2	26.6
29	8.6	22.1	50.7	27.1
30	12.2	27.5	57.2	32.3
31	22.1	37.4	61.7	40.4
32	9.8	22.5	47.6	26.6
33	23.0	39.1	64.9	42.3
34	13.4	27.2	52.4	31.0

35	11.3	22.2	41.5	25.0
36	3.6	12.5	35.6	17.2
37	3.5	10.2	25.5	13.1
38	4.4	12.4	30.5	15.8
39	0.6	3.5	15.2	6.4
40	0.8	3.6	12.6	5.7
41	0.3	2.1	8.7	3.7
42	0.2	1.5	7.1	2.9
43	0.1	0.8	4.2	1.7
44	0.3	0.8	1.9	1.0
45	0.3	0.7	1.5	0.8
46	0.5	0.7	0.9	0.7
47	0.5	0.7	0.9	0.7
48	0.8	0.9	1.0	0.9
49	0.7	0.9	1.1	0.9
50	0.2	0.6	1.5	0.8
51	0.4	0.8	1.5	0.9
52	0.2	0.6	1.8	0.9
Annual	**717.2**	**859.4**	**1038.5**	**871.7**

B. Mean seasonal rainfall probability

The Indian weather system has been categorised into four seasons: Winter (49-52 SMW and 1-8 SMW), Summer (9-22 SMW), South West monsoon (23-39 SMW) and North East monsoon (40-48 SMW). At 75% probability the district may receive 7.2 mm of rainfall in winter season, 15.1 mm in summer season, 319.4 mm during monsoon and 11.8 mm of rainfall during post monsoon period (Table 2). This amount of rainfall provides 17 weeks or 120 days of growing period during monsoon season (24-40 SMW).

C. Mean monthly rainfall probability

Monthly rainfall probability for Bokaro has been estimated at three different probability levels, i.e. 90%, 75% and 50%. The assured rainfall probability of more concern for producing crops is 75%. Highest amount of rainfall is expected in the month of July (129.3 mm) at 75% probability (Table 3). Three months namely June, July and August receive maximum amount of rainfall. Six months period of November to April may receive negligible amount of rainfall.

Table 2: Mean seasonal rainfall probability of Bokaro district.

Week	Probability levels (%)			Mean
	90%	75%	50%	
Winter	3.6	7.2	15.3	8.7
Summer	4.9	15.1	45.4	21.7
SW Monsoon	144.6	319.4	679.6	381.2
NE Monsoon	3.8	11.8	38.8	18.1

Table 3: **Mean monthly rainfall probability of Bokaro district.**

Week	Probability levels (%)			Mean
	90%	75%	50%	
January	2.1	4	8.6	4.9
February	0.2	0.9	2.6	1.2
March	2	3.1	4.5	3.1
April	1.2	3.9	10.4	5.1
May	1.5	7.5	28.7	12.6
June	14.5	40.5	103.3	52.8
July	60.5	129.3	263.1	151
August	57.5	111	206.4	124.9
September	12.1	38.6	106.8	52.5
October	1.7	8.8	34.5	15
November	2.1	3	4.3	3.1
December	1.5	2.9	5.9	3.5

At 75% probability level negligible amount of rainfall is predicted to be received by the district during the winter months. So, it has been revealed that the rabi crops are always grown under moisture stress condition. The soil condition remains dry due to unavailability of required amount of rainfall which is detrimental for seed germination and crop growth. So, it is quite necessary to conserve and store excess of rainwater in harvesting structures to utilise it efficiently during water stress condition and provide pre-sowing irrigation whenever necessary. The early varieties can be grown if pre sowing irrigation facility is provided.

D. Crop planning

The crop plans were prepared for three land situations *i.e.* upland, medium land and lowlands on which cropping are entirely different.

Upland: Maize, Soybean, Groundnut, Urd bean (black gram), Moong (green gram), Pigeon pea, Mustard are the main crops recommended for uplands either as sole crops or intercrops in different combinations. Vegetable and tuber crops like Cauliflower, Cabbage, Tomato, Brinjal and Sweet potato are also included. As inter cropping is more economical and beneficial, following combinations of established intercropping were recommended with an advice to complete sowing of crops on uplands by the end of June. Recommended intercropping under ordinary weather conditions were (i) maize + black gram (ii) maize + pigeon pea (iii) maize + moong (iv) Pigeon pea + okra.

Medium lands: usually short duration rice varieties should be preferred because of less amount of predicted rainfall during monsoon. Varieties like Lalat, Sahabhagi, Shatabdi Swarna, MTU-1010, Jaya, Rajshree, Sambha mansoori etc. of 110-125 days duration are suitable for Bokaro region. The direct seeded rice is mainly sown after the first shower of monsoon, i.e. 24-25 SMW for better seed germination. The dry seed beds are prepared for nursery rising in 26-27 SMW so that rice can be transplanted during 31-33 SMW.

No crops are advised to take up after 47-48 SMW as there is very little chance of getting rainfall in medium and uplands.

Lowlands: as lowlands store moisture for a little more time than medium and uplands due to water stagnation. The transplanted rice varieties like Swarna, MTU-1010, Jaya, Rajshree, Sambha mansoori and hybrid rice varieties like Hybrid 6444, PAC 801, KRH2, PHB-71 are best suitable for cultivation.

CONCLUSION

Rainfall probability analysis through Incomplete Gamma distribution model predicts the amount of rainfall of the district at different probability levels, i.e. 90%, 75% and 50%. Assured rain on weekly basis at 50% probability was closer to normal rain in all blocks. Weekly, seasonal and monthly predicted amount of rainfall will help the farmers in carrying out different agricultural operations in the field and deciding the cropping system for the same area. Time of sowing of kharif and rabi crops are also decided according to the availability of water. Rabi crops are mainly sown during winter season when rainwater availability is very less and so they take up the water from residual soil moisture. Rainwater need to be stored in water harvesting structures for efficient utilisation during water stress condition in critical stages of crop growth. In uplands pulses can be grown during kharif season and vegetables in rabi season and intercropping of major crops have been found suitable than sole cropping. In normal weather condition Maize, Pigeonpea, Moong (green gram), Urd (black gram), Ground nut, Soybean and Finger millets have been found most suitable crops for uplands are in all blocks. Rice can be cultivated in kharif season in medium and lowlands followed by pulses in rabi season.

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