Asian Jr. of Microbiol. Biotech. Env. Sc. Vol. 24, No. (4) : 2022 : 728-734

ISSN-0972-3005

DOI No.: http://doi.org/10.53550/AJMBES.2022.v24i04.018

STUDY OF RAINFALL DISTRIBUTION PATTERN AND ITS VARIABILITY IN BIDAR REGION, KARNATAKA, INDIA

VISHWANATH*, G.V. VENKATARAMANA AND N. PRABHAKARAN

Department of Studies in Environmental Science, University of Mysore, Mysore 570 005, Karnataka, India

(Received 16 July, 2022; Accepted 7 September, 2022)

***Key words** : Rainfall, Rainy days, Seasonal rainfall and crop planning*

Abstract–A case study has been done to study the rainfall distribution pattern and its variability for the selection of crops and cropping pattern of Bidar region, Karnataka with a predominant pigeon pea and sugarcane cropping systems. The study revealed that the overall mean annual rainfall of Aurad was 846 mm, which was distributed as 673.7 mm, 101.6 mm, 60.2 mm and 10.7 mm in monsoon, post monsoon, summer and winter respectively. The average annual rainfall of Bhalki was 874.7 mm with average rainy days of 51 days. The mean annual rainfall of Humnabad is 797 mm with 27 per cent variability spread over 50 mean rainy days. The analysis of rainfall data indicate that the average annual rainfall for the Basavakalyan was 759 mm spread over with a mean rainy days of 49.9 days. The mean annual rainfall for Bidar is 937.3 mm with coefficient of variation of 22.2 per cent indicated that the annual rainfall was more or less stable over the years. Within the rainy season, August was the highest rainfall contributing month (21.3 per cent) followed by July (19.9 per cent). Rainfall during monsoon season and its variability govern the cropping system of Bidar. There is an ample scope for rain water harvesting from July to September which can be utilized as crop saving irrigation as well as per sowing irrigation for succeeding r*abi* crops which are generally sown on residual soil moisture.

INTRODUCTION

Rainfall, being considered as the prime input for agriculture has its own erratic behavior in terms of amount and distribution. For better crop planning, a detailed study on rainfall behaviour is vital. Agriculture will be adversely affected by an increase or decreased amount of rainfall and shifting of time of rainfall. The annual and seasonal rainfall received and its variability directly influences the success or failure of crops through its beneficial or adverse effect on growth and yield. Therefore, the study of variability of annual and seasonal rainfall is essential in selection of suitable crops and to take appropriate mitigating measures based on rainfall characteristics.

Barman *et al.* (2012) studied the seasonal analysis of rainfall data to meet the water demand of different cropping systems. Bemal *et al.* (2012) calculated the long term trend for two different regions like Ambala and Karnal by utilizing the rainfall data for the period from 1977 to 2008. Maragatham (2012) studied and presented the secular changes in the annual rainfall of 1476 rain gauge stations for the period of 100 years from 1901–2000 in India, by various test to detect the best suitable trend for the rainfall time series. Subash *et al*. (2012) analyzed the variability and trend of annual and monthly monsoon rainfall for the different districts of Bihar. Rainfall analysis for crop planning was carried out in different regions of the country as reported by Mandal *et al.* (2013), Sunit Das *et al*. (2015), Shonam Sharma and Prasoon Kumar (2017), Meshram *et al.* (2018), Panda A and Sahu N (2019) and Deoli V and Rana (2019). In this context, a similar attempt was made to analyze the rainfall variability in month, season and annual wise for Bidar region of Karnataka.

MATERIALS AND METHODS

Study area

The Bidar comprises of five talukas (sub-districts) *viz.,* Aurad, Bhalki, Humnabad, Basavakalyan and Bidar. The rainfall analysis was carried out for all talukas. The area selected for the study purpose is presented in Fig. 1.

Data used

For the proposed study, the rainfall data of 34 years (1986-2020) was collected from District Statistical Office, Bidar.

Analysis of data

The rainfall data for the period from 1986 to 2020 was statistically analyzed and the results were presented under different heads for mean, standard deviation (mm) and coefficient of variance (%) of annual and seasonal rainfall and the per cent of different seasonal rainfall vis-à-vis annual rainfall. The highest and lowest rainfall (mm) recorded in annual and in different seasons was also analyzed.

RESULTS AND DISCUSSION

Annual rainfall

The overall mean total annual rainfall of Aurad region for the past thirty four years was 846.0 mm spread over 49 rainy days. The lowest and highest rainfall and rainy days recorded was 453.5 and 1337.7 and 30 and 69 respectively. The standard deviation and coefficient of variation for annual rainfall was 243 mm and 28.7 per cent where as for annual rainy days it was 9.2 days and 18.6 per cent respectively (Table 1). The overall mean annual rainfall of Bhalki for the past thirty four years was 874.7 mm with a standard deviation (SD) of 200 mm and coefficient of variation (CV) 22.8 per cent. The maximum annual rainfall of 1362.3 mm and the lowest rainfall of 538 mm were recorded. The overall mean rainy days was 51 days (range: 35 to 74) with a standard deviation (SD) of 8.5 mm and coefficient of variance (CV) 16.5 per cent (Table 1). The mean annual rainfall of Humanabad was 797.0 mm spread over 50 rainy days.

The overall mean total annual rainfall of Basavakalyan region for the past thirty four years was found to be 759.1 mm with a CV of 23.6 per cent spread over 50 rainy days. This revealed that the rainfall was more or less stable over the years. The annual rainfall ranged from 392.3 to 1122.5 mm. The standard deviation and coefficient of variation for annual rainy days was 7.8 days and 15.6 per cent respectively with mean of 49.9 mm. The highest and lowest annual rainy days recorded was 33 and 62 respectively (Table 1).

The overall mean annual rainfall of Bidar for the past thirty four years was 937.3 mm (range: 562.1 to 1347.6 mm) with a standard deviation (SD) of 208.6 mm and coefficient of variance (CV) 22.2 per cent. The overall mean rainy days comes to be 53 days (range: 38 to 69) with a standard deviation (SD) of 7.7 mm and coefficient of variance (CV) 14.4 per cent.

Seasonal rainfall

The average seasonal rainfall along with rainy days and its variability during the seasons winter **(**January – February), summer (March- May), Monsoon (June - September) and Post monsoon **(**October – December) are presented in Table 2. South west (SW) monsoon season for the Aurad region contributes 79.6 per cent of mean annual rainfall. Rainfall during this period varied between 386.4 mm to 1129.5 mm with mean value of 673.7 mm. Mean number of rainy days during SW monsoon season was 37 days. Total amount of rainfall received during north east (NE) monsoon was 12.0 per cent of the mean annual rainfall. The mean rainfall during this period was 101.6 mm. Pre monsoon season contributed 7.1 per cent (60.2 mm) of the mean annual rainfall. The winter rainfall contributed 1.2 per cent (10.7 mm) to the mean annual rainfall.

In Bhalki region the South west (SW) monsoon season contributes 76.9 per cent of mean annual rainfall. Rainfall during this period varied between 420.7 mm to 1074.1 mm with mean value of 671.9 mm. Total amount of rainfall received during north east (NE) monsoon was 13.8 per cent of the mean annual rainfall. The mean rainfall during this period

Table 1. Characteristics of annual rainfall (mm) and rainy days

Region	Rainfall (mm)					Rainy day				
	Lowest	Highest	Mean	SD	CV (%)	Lowest	Highest	Mean	SD	CV (%)
Aurad	453.5	1337.7	846.0	243	28.7	30	69	49.4	9.2	18.6
Bhalki	538.0	1362.3	874.7	200	22.8	35	74	51.3	8.5	16.5
Humnabad	454.3	1176.7	797.0	216	27	33	66	50.7	8.7	17
Basavakalyan	392.3	1122.5	759.1	179.3	23.6	33	62	49.9	7.8	15.6
Bidar	562.1	1347.6	937.3	208.6	22.2	38	69	53.3	7.7	14.4

was 121.4 mm. Pre monsoon season contributed 7.8 per cent (68.7 mm) of the mean annual rainfall. The winter rainfall contributed 1.5 per cent (12.8 mm) to the mean annual rainfall. Mean number of rainy days during SW monsoon season was 39 days (Table 2).

In Humnabad region the highest rainfall received during monsoon season was 594.7 mm followed by post monsoon season (111.3 mm) and the lowest by winter season (103 mm). The per cent contribution of seasonal rainfall to the total annual rainfall was 74.6, 13.9, 9.8 and 1.7 by monsoon, post monsoon, summer and winter seasons respectively with the lowest CV during monsoon (31%), followed by post monsoon (63%) and summer (71%) seasons. As Humnabad region is highly benefited through southwest monsoon rainfall, the CV of the mean monthly rainfall during monsoon season is the lowest. The average rainfall during monsoon season (594.7mm) with its highest contribution of 74.6 per cent to the total annual rainfall revealed that during the season, a major part of rainfall amount is generally lost through runoff which can be stored through water harvesting structures such as farm ponds and lakes and used during the winter season for growing *rabi* crops. Also it can be utilized as life saving irrigation particularly in years of low rainfall. During post monsoon season, which contributes to 13.9 per cent of the total annual rainfall, an average amount of 111.3 mm rainfall could satisfy the cultivation of less water requiring crops such as pulses (Chickpea), sunflower, safflower crops. About 9.8 per cent of total annual rainfall received during summer season would be helpful for land preparation particularly for summer ploughing operation during the season.

The highest rainfall was received during monsoon season (999.7 mm) followed by post monsoon (270.9 mm) and summer (202.6 mm), where as the lowest by winter (56.2 mm) season in the Basavakalyan region. South west (SW) monsoon season contributes 74.6 per cent of mean annual rainfall. Rainfall during this period varied between 358.8 mm to 999.7 mm with the mean value of 566.9 mm. Mean number of rainy days during SW monsoon season was 36 days. Total amount of rainfall received during north east monsoon was 14.6 per cent of the mean annual rainfall. The mean rainfall during this period was 110.7 mm. Pre monsoon season contributed 9.3 per cent (70.2 mm)

Table 2. Characteristics of seasonal rainfall (mm) and rainy days

Seasons	Regions	Rainfall (mm)					% of	Rainy day				
		Lowest	Highest	Mean	SD	CV(%)	annual rainfall	Lowest	Highest	Mean	SD	CV (%)
Winter	Aurad	0.0	75.8	10.7	18.1	169.1	1.2	0	4	0.8	1.1	137
	Bhalki	0.0	98.5	12.8	21.3	166	1.5	0	4	0.8	1.2	150
	Humnabad	0.0	103.0	13.7	25.2	183	1.7	0	4	0.9	1.1	122
	Basavakalyan	0.0	56.2	11.3	16.4	145	1.5	0	4	0.9	1.1	122
	Bidar	0.0	70.4	15.4	23.4	151.9	1.6	0	5	1.0	1.2	120
Summer	Aurad	3.0	198.5	60.2	46.9	77.9	7.1	1	12	4.8	2.8	58
	Bhalki	0.0	255.0	68.7	51.5	74	7.8	0	11	5.2	2.4	46
	Humnabad	2.0	244.4	77.5	55.6	71	9.8	0	13	6.1	3.3	54
	Basavakalyan	0.0	202.6	70.2	48.7	69.3	9.3	0	13	5.5	3.1	56
	Bidar	5.8	297.4	78.7	56.1	71.2	8.4	1	13	6.7	2.5	37
Monsoon	Aurad	386.4	1129.5	673.7	218.5	32.4	79.6	25	64	37.6	8.1	21
	Bhalki	420.7	1074.1	671.9	177.0	26	76.9	23	54	39.2	7.9	20
	Humnabad	280.8	1012.3	594.7	186.0	31	74.6	25	57	37.1	7.6	20
	Basavakalyan	325.8	999.7	566.9	175.9	31.0	74.6	24	59	36.5	7.9	21
	Bidar	427.7	1254.3	707.3	209.6	29.6	75.5	27	53	38.9	6.1	15
Post monsoon	Aurad	3.2	279.2	101.6	66.0	64.9	12.0	1	13	6.2	2.9	46
	Bhalki	2.8	268.7	121.4	87.9	72	13.8	1	14	6.2	3.3	53
	Humnabad	17.4	249.4	111.3	70.2	63	13.9	2	14	6.8	3.3	48
	Basavakalyan	5.3	270.9	110.7	77.0	69.5	14.6	1	15	6.9	3.7	53
	Bidar	7.0	353.0	136.1	102.4	75.2	14.5	1	15	6.9	3.9	56

Annual : January – December **Winter :** January – February **Summer :** March- May
Monsoon : June - September **Post monsoon/north east monsoon:** October - December
SD : Standard Deviation CV : Coefficient of variation

of the mean annual rainfall. The winter rainfall contributed 1.5 per cent (11.3 mm) to the mean annual rainfall. The lowest CV was during monsoon (31.0%).

The South west monsoon season contributes 75.5 per cent of total mean annual rainfall with coefficient of variance of 29.6 per cent and standard deviation of 209.6 mm indicating its dependability in the Bidar region. Rainfall during this period varied between 427.7 to 1254.3 mm with mean value of 707.3 mm. Mean number of rainy days during SW monsoon season was 38 days (range: 27 to 53 days). For post monsoon season the mean rainfall is 136.1 mm (range: 7 to 353 mm) and contributes 14.5 per cent to the total annual rainfall with coefficient of variance of 75.2 per cent and standard deviation of 102.4 mm. The mean rainy days during this period was 6 days (range: 1 to 15). Summer rainfall also contributes substantial amount of 78.7 mm and contributes 8.4 per cent of the total mean annual rainfall. The winter rainfall contributes 1.6 per cent (mean - 15.4 mm) to the mean annual rainfall. The mean rainy days are less in winter (1 day) as compared to summer (6.7 days) and so also the highest rainy days recorded (Table 2).

Monthly rainfall

Rainfall quantum and distribution in the Aurad region during different months was shown in Fig. 1. It is evident that monthly rainfall had unimodal peak. August month receives maximum mean rainfall of 212.3 mm distributed in 11 mean rainy days followed by July (188.5 mm) in 10 rainy days. Monthly rainfall during November to May remained lowest in the range of 2.7 to 33.3 mm. The highest rainfall of 498.5 mm was reported in the

Table 3. Characteristics of monthly rainfall (mm) and rainy day of Aurad

Month	Rainfall					% of	Rainy days				
	Lowest (mm)	Highest (mm)	Mean (mm)	SD (mm)	CV (%)	annual RF	Lowest (mm)	Highest (mm)	Mean (mm)	SD (day/s)	CV (%)
January	0	75.8	8	16.2	202	0.9	0	2	0.6	0.7	116
February	0	29.4	2.7	5.9	218	0.4	0	3	0.4	0.6	150
March	0	67.8	12.0	21.2	176	1.5	0	4	0.8	1.1	137
April	0	50.0	15.0	13.2	88	1.7	0	4	1.6	1.2	75
May	0	198.5	33.3	46.2	138	3.9	0	12	2.5	2.6	104
June	20.4	285.3	122.8	65.7	53	14.5	2	15	7.8	2.9	37
July	40.5	492.1	188.5	105.1	55	22.3	3	18	10.5	3.4	32
August	45.7	498.5	212.3	115.6	54	25.0	4	20	11.2	3.7	33
September	12.0	427.0	150.3	105.6	70	17.8	2	19	8.4	4.4	52
October	0	225.8	76.8	61.7	80	9.0	0	10	4.5	2.8	62
November	0	161.0	18.6	33.9	182	2.2	0	6	1.3	1.4	107
December	0	34.8	6.3	13.6	215	0.8	0	4	0.5	0.9	180

Table 4. Characteristics of monthly rainfall (mm) and rainy day of Bhalki

Month	Rainfall					% of	Rainy days				
	Lowest (mm)	Highest (mm)	Mean (mm)	SD (mm)	CV (%)	annual RF	Lowest (mm)	Highest (mm)	Mean (mm)	SD (day/s)	CV (%)
January	0	98.5	8.6	20.1	233	0.9	0	3	0.5	0.8	160
February	0	35.6	4.3	8.7	202	0.5	0	3	0.4	0.7	175
March	0	99.6	12	23.2	193	1.4	0	4	0.9	1.4	155
April	0	112	23.8	26.0	109	2.8	0	5	2	1.5	75
May	0	255	32.9	46.5	141	3.7	0	11	2.3	2.2	95
June	8.5	297.4	118	76.6	64	13.5	1	14	8	2.7	33
July	31	540.6	169	103.3	61	19.4	5	19	10.2	3.4	33
August	54.4	446.3	211.6	112.0	52	24.2	5	21	11.6	3.9	33
September	17.3	337.6	173.4	100.9	58	19.8	3	18	9.5	4.0	42
October	0	260.4	96	86.6	90	10.9	0	9	4.3	2.9	67
November	0	105.8	20.3	30.1	148	2.3	0	8	1.5	2.0	133
December	0	44.1	5	10.6	212	0.6	0	3	0.5	0.8	160

August month followed by July 492.1 mm. The highest coefficient of variation is noticed during the start of the year i.e. from January to May and November – December. The lowest coefficient of variation is confined to monsoon season indicate the dependability and reliability of rainfall during monsoon season (Table 3).

For Bhalki region August month receives

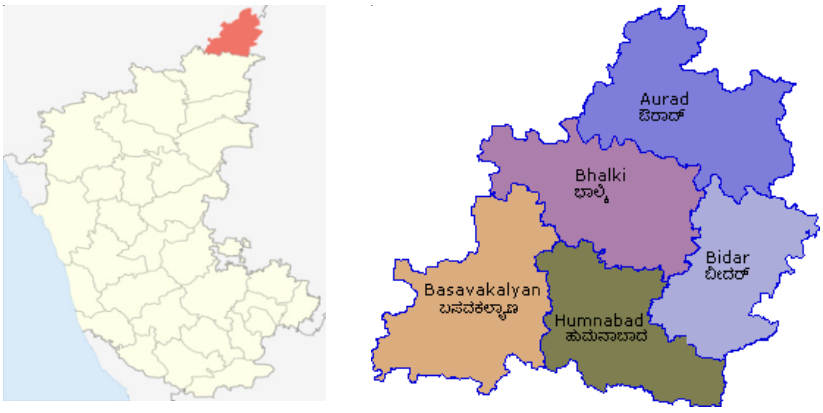

Fig. 1. Political map of Bidar district depicting different talukas

Table 5. Characteristics of monthly rainfall (mm) and rainy day of Humnabad

Month	Rainfall					% of	Rainy days				
	Lowest (mm)	Highest (mm)	Mean (mm)	SD (mm)	CV (%)	annual RF	Lowest (mm)	Highest (mm)	Mean (mm)	SD (mm)	CV (%)
January	0	103	8.3	20	240	1	0	2	0.5	0.7	140
February	0	88	5.5	16.1	292	0.7	0	3	0.5	0.9	180
March	0	103.2	14.1	24.3	172	1.8	0	5	0.9	1.2	133
April	0	79.9	22.5	19.0	84	2.8	0	5	2	1.6	80
May	0	219.3	41	49.0	119	5.2	0	13	3.3	2.8	84
June	28	295.6	113.4	63.0	55	14.2	4	15	7.6	2.5	32
July	24.2	262	145.3	88.8	61	18.2	3	17	9.5	4.1	43
August	52	405.8	172.7	87.7	50	21.7	2	18	10.3	3.7	35
September	24.2	451.5	163.3	100.9	61	20.5	4	18	9.8	4.3	43
October	1.2	235.6	83.8	64.6	77	10.5	0	11	4.8	3.1	64
November	0	139.1	23.3	33.8	145	2.9	0	6	1.5	1.5	100
December	0	23.2	4.2	7.3	173	0.5	0	3	0.5	0.8	160

Table 6. Characteristics of monthly rainfall (mm) and rainy day of Basavakalyan

Month	Rainfall					% of	Rainy days				
	Lowest (mm)	Highest (mm)	Mean (mm)	SD (mm)	CV (%)	annual RF	Lowest (mm)	Highest (mm)	Mean (mm)	SD (day/s)	CV (%)
January	0	32.4	6.2	12.2	196	0.8	0	2	0.5	0.7	140
February	0	19.8	5.2	10.8	207	0.6	0	4	0.4	0.8	200
March	0	92.6	15.5	25.2	162	2.0	0	4	1.1	1.4	127
April	0	63.8	22.1	20.2	91	2.9	0	5	2.1	1.7	80
May	0	200.8	32.7	43.4	132	4.4	0	11	2.5	2.4	96
June	26.0	198.8	101.9	46.5	45	13.5	3	11	7.5	2.3	30
July	32.0	439.6	144.5	98.7	68	19.0	3	16	9.1	3.3	36
August	22.1	353.9	158.1	89.5	56	20.9	3	19	10.4	3.9	37
September	22.0	432.5	162.6	97.9	60	21.5	3	19	9.7	4.1	42
October	0	236.4	83.3	70.4	84	10.9	0	12	4.9	3.3	67
November	0	172.2	22.5	34.4	152	2.9	0	7	1.8	1.8	100
December	0	29.6	5.0	9.0	180	0.6	0	2	0.5	0.7	140

maximum mean rainfall of 211.6 mm distributed in 11 mean rainy days followed by September (173.4 mm) in 9 rainy days. Monthly rainfall during November to May remained lowest in the range of 5.1 to 32.9 mm. The highest rainfall of 540.6 mm reported in the July month. It is also observed that there is higher dependability of rainfall from the months of June to September (CV less than 65%) (Table 4).

From Table 5, it could be observed that rainfall in Humanabad region increases from April month onwards, attains a peak during August and then falls down reaching the lowest value of 4.2 mm during December month. Mean monthly rainfall is highest in August (172.7 mm) with its contribution of 21.7 per cent to the total annual rainfall. It is observed that there is higher dependability of rainfall from the month of June to October (CV < 78 %). Hence, a successful cultivation of pigeon pea based cropping system under rainfed condition with medium or long duration varieties is possible during that period.

For Basavakalyan region September month receives maximum mean rainfall of 162.6 mm distributed in 9 mean rainy days followed by August (158.1 mm) in 10 rainy days. Monthly rainfall during November to May remained lowest in the range of 5.0 to 32.7 mm. The highest rainfall of 439.6 mm was reported in the July month (Table 6).

It is evident that Bidar region monthly rainfall had unimodal peak. August month receives maximum mean rainfall of 199.4 mm with coefficient of variance of 48.6 percent and standard deviation of 97.1 mm, distributed in 11 mean rainy days followed by July (186.6 mm) in 10 rainy days and so also it contributes highest (21.3) per cent of the annual rainfall. The CV was highest in February month indicating more variability in rainfall. Monthly rainfall during November to May remained lowest in the range of 5.2 to 37.8 mm. The highest rainfall of 439.8 mm was reported in the August month (Table 7).

CONCLUSION

Based on the above analysis, the following recommendations for the region could be made to increase the crop production per unit area under rainfed conditions. About 79.6 per cent of the total average annual rainfall coincides with the monsoon season and is received during a short time span of two to three months between June to September due to south-west monsoon in less number of rainy days. During summer season as the rainfall receipt is too low for crop cultivation, it is recommended to go for land preparation, especially summer ploughing and make the soil fit for cultivation during the succeeding year. Or else, less water requiring short duration crops such as millets, forage crops etc. can be grown with supplement irrigation practices. During *kharif* season, arable short duration crops like pulses, sunflower, millets, maize can be grown. In uplands and in the embankments of water harvesting structures, cultivation of vegetables like cucumber and fruit crops like water melon can be done after the cessation of northeast monsoon rains for effective utilization of land and other resources. Since the winter rainfall is uncertain and erratic, residual moisture and lowland area can be utilized for

Table 7. Characteristics of monthly rainfall (mm) and rainy day of Bidar

Month	Rainfall					% of	Rainy days				
	Lowest (mm)	Highest (mm)	Mean (mm)	SD (mm)	CV (%)	annual RF	Lowest (mm)	Highest (mm)	Mean (mm)	SD (day/s)	CV (%)
January	0	66.6	9.8	18.4	187.7	1	0	3	0.6	0.8	133
February	0	66.8	5.6	13.2	235.7	0.6	0	3	0.5	0.7	140
March	0	83.5	15.9	23.3	146.5	1.6	0	4	1.2	1.3	108
April	0	78.3	25.1	21.5	85.6	2.6	0	5	2.5	1.5	60
May	0	295.4	37.8	57.6	152.3	4.1	0	13	3.0	2.4	80
June	30.6	310.5	137.7	70.4	51.1	14.7	3	16	8.0	2.8	35
July	56.2	349.6	186.6	114.4	61.3	19.9	5	19	10.7	3.2	29
August	35.3	439.8	199.4	97.1	48.6	21.3	5	18	11.2	3.3	29
September	13.9	322.8	183.8	105.3	57.2	19.6	1	18	9.0	3.9	43
October	0	298.2	97.4	87.8	90.1	10.4	0	11	4.8	3.3	68
November	0	225.6	33.6	55.1	163.9	3.6	0	8	1.6	2.1	131
December	0	27.2	5.2	8.1	155.7	0.6	0	3	0.5	0.8	160

growing a second crop under rainfed conditions. Wheat may be grown only with assured irrigation during *rabi* season. With normal onset of rainfall, sowing of main crop like redgram + Jowar or sole sunflower in shallow soils and redgram + blackgram in medium and deep soils can be taken up. In the event of mid season drought, mulching will be help in reducing soil evaporation and conserving moisture in top layers of the soil. In the event of terminal drought, receding soil moisture conditions, crop requires supplementary irrigation. The major portion of monsoon rainfall is generally lost through runoff which can be stored through the construction of suitable water harvesting structures as on-farm reservoirs which be utilized for giving crop saving irrigation for *rabi* crops.

REFERENCES

Barman, D., Saha, A.R., Kundu, D.K. and Mahapatra, B.S. 2012. Rainfall characteristics analysis for jute based cropping system at Barrackpore, West Bengal, India. *J. Agric. Phys.* 12(1) : 23 28.

Bemal, S., Singh, D. and Singh, S. 2012. Rainfall variability analysis over eastern agroclimatic zone of Haryana. *J. Agrometeorol.* 14(1) : 8890.

Deoli, V. and Rana, S. 2019. Seasonal Trend Analysis in Rainfall and Temperature for Udaipur District of Rajasthan. *Current World Environ.* 14(2) : 312-319.

Mandal, K.G., Padhi, J., Kumar, A., Sahoo. D.K., Majhi, P., Ghosh, S., Mohanty, R.K. and Roychaudhuri, M. 2013. Analyzing rainfall events and soil characteristics for water resources management in a canal irrigated area. *J. Water Resources and Ocean Sci.* 2(1) : 18.

Maragatham, S.R. 2012. Trend analysis of rainfall data a comparative study of existing methods. *Int. J. Phys. Math Sci.* 2(1) : 1318.

Meshram, S.G., Gautam, R. and Kahya, E. 2018. Drought analysis in the Tons River Basin, India during 1969-2008. *Theor. Appl. Climatol.* 132 : 939–951.

Panda, A. and Sahu, N. 2019. Trend analysis of seasonal rainfall and temperature pattern in Kalahandi, Bolangir and Koraput districts of Odisha, India. *Atmos. Sci. Lett.* 20 : e932.

Sharma, S. and Kumar, P. 2017. Long Term Spatiotemporal Variability in Rainfall Trends over the State of Jharkhand, India. *Climate.* 5-18.

Subash, N., Singh, S.S. and Priya, N. 2012. Rainfall variability and its impact on change of cropping systems in Bihar. *Indian J. Soil Conserv.* 40(1) : 3340.

Sunit, D., Tomar, C.S., Saha, D., Shaw, S.O. and Singh, C. 2015. Trends in Rainfall Patterns over North-East India during 1961-2010. *Inter. J. Earth Atmo. Sci.* 2(2): 37-48.