Agricultural Planning through Prediction of Rainfall Characteristics for Bilaspur Region of Chhattisgarh Plain in India

B. L. Sinha, Assistant Professor (Soil and Water Engineering), BRSM College of Agricultural Engineering and Technology& Research Station, Indira Gandhi Krishi Vishva Vidylay, Chhattisgarh, India
Jitendra Bairwa, M. Tech. Student, College of Agricultural Engineering, Jawahar Lal Nehru Krishi Vishva Vidylay ,Jabalpur (M.P.), India
Ravishankar Sahu, M. Tech. Student, Department of Agricultural Engineering and Technology, Indira Gandhi Krishi Vishva Vidylay, Raipur, Chhattisgarh, India
Likeshwari Chandrakar, M. Tech. Student, Department of Agricultural Engineering and Technology, Indira Gandhi Krishi Vishva Vidylay, Raipur, Chhattisgarh, India

ABSTRACT

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 soil and water conservation structures. In rain-fed agriculture, the total amount of rainfall as well as its distribution affects the plant growth. In view of this, an attempt has been made to evaluate rainfall distribution patterns i.e. weekly, seasonal and annual rainfall, based on 12 years (2001-2012) data of Bilaspur, Chhattisgarh in the year of 2014 at BRSM College of Agricultural Engineering and Technology, Indira Gandhi Krishi Vishva Vidylay, Mungeli, Chhattisgarh. The analysis showed that amongst various weeks of monsoon season, the 26th week received highest rainfall amount equal to 362.8 mm. However, average rainfall as 102.7 mm was found to be highest for 26th week. From the monthly rainfall analysis, it was found that maximum value of average monthly rainfall (340.4 mm) and minimum value (2.2 mm) were recorded in the months of July and December, respectively amounting to 28.26 % and 0.18 % of the average annual rainfall with CV of 50 % and 251 %, respectively. The annual average rainfall was computed as 1204.6 mm.

INTRODUCTION

The amount and distribution of rainfall holds the key of the success for agriculture production. Weekly, monthly and seasonal rainfall data are very useful for planning agricultural operations. 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 soil and water conservation structures. The amount and distribution of rainfall holds the key of the success for agriculture production. Weekly, monthly and seasonal rainfall data are very useful for planning agricultural operations. Due to variation in rainfall distribution it is imperative to determine the probability of rainfall recurrence. Probability and frequency analysis of rainfall data enable us to determine the expected rainfall at various per cent chances. Probability analysis is the most reliable method to predict occurrence of future rainfall events based on past behavior of rainfall. Rainfall analysis is of great important for developing and modifying the crop management practices for sustainable production system.

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 receives 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, 2006). More than 80 % of the average annual rainfall of Bilaspur 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. Subudhi (2010) analyzed the rainfall data for twenty six years (1975-2000) at Tikabali ,Orissa and found that the average annual rainfall was 1424.4 mm and amounting 72% of annual rainfall was received from June to September. Sharma and Dubey (2013) 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/ hydraulic/structural failure of these structures causing loss of valuable time, labour and money. Keeping this in view, an effort was made in the present investigation to interpret daily, weekly, monthly, seasonal and annual rainfall of 12 years (2001-2012) data of Bilaspur, Chhattisgarh in simple and meaningful form to make it more useful.

MATERIALS AND METHODS

Bilaspur district is located in the eastern part of Chhattisgarh. It is situated within latitude 21° 47' to 23° 8' N and longitude 81° 14' to 83° 15' E. The total area of Bilaspur is approximately 6377 km^2 recently and is shown Fig1.

Physiographically, the district is being divided into new Bilaspur, Korba and Janjgir Chanpa. The new Bilaspur district is hilly towards North and plane in South. Secondly, the northern part of Bilaspur is quite cold and hot as we move towards Southern part. Major rivers which surrounds Bilaspur district are Agaar, Maniyaar and Arpa. Total population of Bilaspur district is 16, 948, 83 out of which 8, 59, 027 is male and 8, 35, 856 is female. Out of the total population, 79 % people live in village area and density of the population is 266 persons / km^2. In the Bilaspur region there are wide variations in the climate. Bilaspur 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 TCB College of Agriculture and Research station, Bilaspur and are presented in Fig. 2.

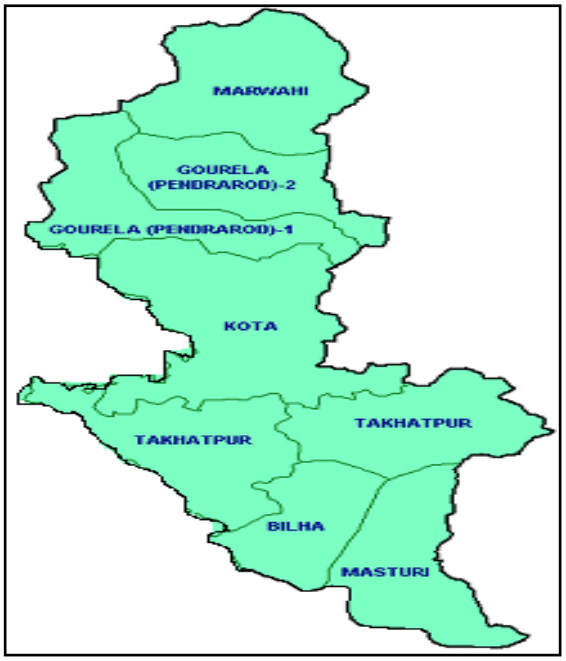

Fig. 1: District and block boundary of Bilaspur district

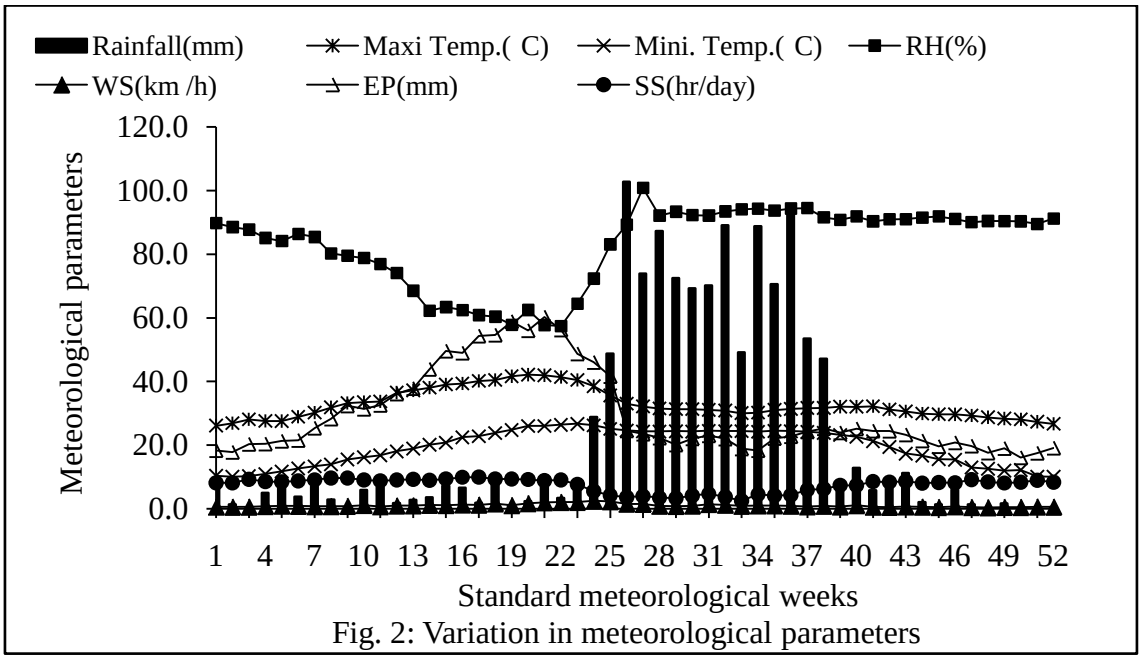

Fig. 2: Variation in meteorological parameters

The daily rainfall data of the study area was collected from Meteorological Department of TCB College of Agriculture and Research station, Bilaspur. This was a 24 hours rainfall data measured with the help of non-recording and recording type rain gauge installed in nearby area. The daily rainfall data pertains to a period of past 12 years, *viz.* 2001 – 2012. Weekly rainfall data, monthly, seasonally and annually were obtained by summing up the daily rainfall values as per recommendation of IMD.

ANALYSIS OF RAINFALL DATA

Daily, weekly, monthly, seasonally and annual rainfall data of past 12 years of Bilaspur were used probability 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 analysis 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 programme 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:

1. Weekly rainfall analysis

The analysis of weekly rainfall data of 12 years (2001-2012) reveals that there was marked variation among the rainfall in Standard Meteorological Weeks (SMW) of the different years. SMW 24rd 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 42nd SMW.

Table 1: Variation in rainfall for monsoon weeks

SMW	Avg. rainfall (mm)	Percentage of annual rainfall	Max. rainfall (mm)	Min. rainfall (mm)	SD	CV (%)	Skewness
24	28.8	2.4	129.8	0	37.4	129.9	2.0
25	48.6	4.0	148.2	0	43.1	88.7	1.0
26	102.7	8.5	362.8	3.2	109.0	106.2	1.4
27	73.7	6.1	226.8	9	60.6	82.2	1.6
28	87.2	7.2	183	7.6	61.2	70.3	0.4
29	72.4	6.0	193.2	13	60.0	82.9	1.2
30	69.1	5.7	218	0	69.0	99.9	1.1
31	70.1	5.8	290.4	0	85.4	121.9	2.0
32	88.9	7.4	226.5	8.4	64.5	72.5	0.9
33	49.1	4.1	115.8	9.6	31.3	63.8	0.9
34	88.7	7.4	244.2	36.4	66.4	74.9	1.4
35	70.5	5.9	269.4	0	84.8	120.3	1.5
36	93.8	7.8	218.8	11.2	69.2	73.8	0.6
37	53.3	4.4	128	4.8	37.2	69.8	0.9
38	47.1	3.9	133.2	0	50.2	106.7	0.6
39	7.1	0.6	30.9	0	11.2	157.1	1.7
40	12.8	1.1	51	0	16.0	125.2	1.4

It is clear from the data that the highest average rainfall of 102.7 mm was observed in the 26th SMW which was 8.5 % of the average annual rainfall, while the lowest value (0.0 mm) was recorded in 50th week shown in Table 1. The variation in maximum weekly rainfall is observed in the range of 0.0 mm to 362.8 mm, whereas, minimum rainfall varied between 0.0 mm and 36.4 mm (Table 4.1). The average weekly rainfall was found to be highest of 102.7 mm in 26th SMW while the lowest was 0.0 mm in 50th SMW. The variation in standard deviation (SD) was ranged from 0.0 to 109.0, whereas, coefficient of variation (CV) varied in between 63.8 % and 346.4 %, respectively (Fig3). 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. Skewness found to be varied between 0.4 and 3.5 and shown in Fig 3.

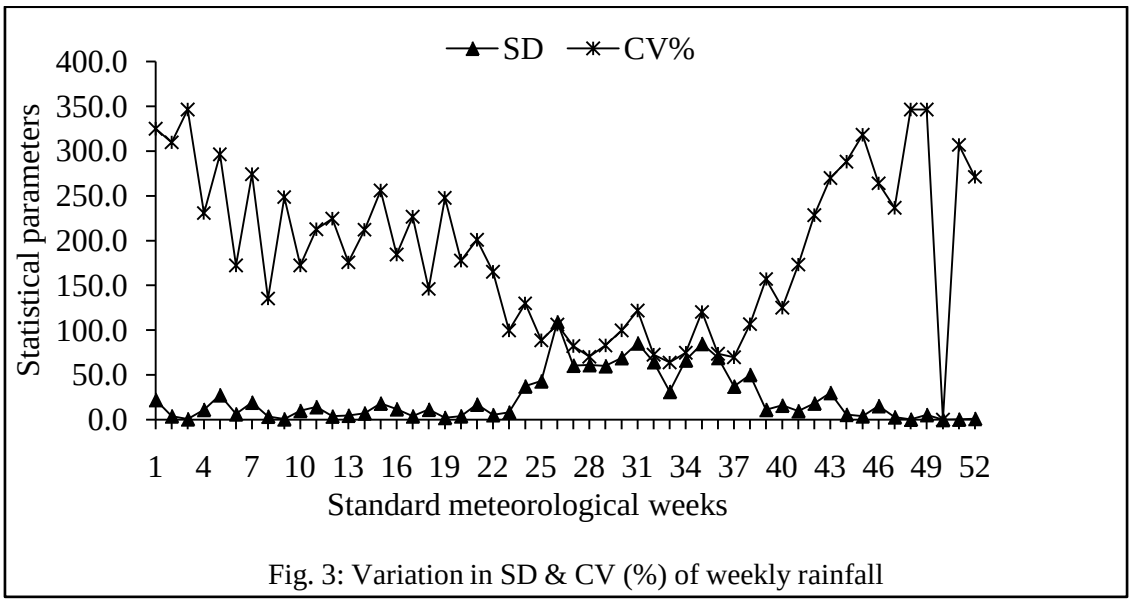

Fig. 3: Variation in SD & CV (%) of weekly rainfall

2. Monthly rainfall analysis*:*
Monthly rainfall analysis (Table 2 and Fig 4) clearly depicts this region receives more than 90 percent of annual rainfall during the month of May to October.

July is the wettest month with an average of 340.4 mm followed by August of 330.1 mm. It is also very much clear that the chances of heavy rainfall during May to October are assured as they have lowest drought month. It is also found from the analysis of 12 years data that the maximum value of average monthly rainfall (340.4 mm) and minimum value (2.2 mm) were recorded in the months of July and December, respectively amounting to 28.3 % and 0.2 % of the average annual rainfall with coefficient of variation of 49.7 % and 251.4%, respectively and shown in Fig 4. High value of standard deviation of 169.1 in the month of July and minimum value of standard deviation of 5.4 in the month of December indicates its dependability. The variation in minimum monthly rainfall was observed in the range of 0.0 to 201.6 mm. Further from the analysis, it is also observed that the value of coefficient of variation, and skewness were found to be lowest of 30.2 % and 0.1, respectively in the month of August and September.

Table 2: Monthly, seasonally and yearly rainfall statistics at Bilaspur

Month	Avg. rainfall (mm)	Percentage of annual rainfall	Max. rainfall (mm)	Min. rainfall (mm)	SD	CV (%)	Skewness
Jan	22.2	1.8	118.8	0	40.5	182.8	1.9
Feb	14.0	1.2	77.4	0	22.3	159.0	2.5
Mar	17.1	1.4	48.6	0	16.3	95.5	1.1
Apr	18.8	1.6	111.4	0	30.6	162.3	2.9
May	22.4	1.9	67	0	19.8	88.3	1.0
Jun	173.2	14.4	387.4	13.2	113.8	65.7	0.5
Jul	340.4	28.3	616.2	63	169.1	49.7	0.3
Aug	330.1	27.4	535.9	201.6	99.8	30.2	0.9
Sep	216.6	18.0	388.2	52.8	119.0	54.9	0.1
Oct	37.2	3.1	125.7	4.6	35.0	94.2	1.6
Nov	10.5	0.9	53.8	0	16.4	156.9	2.0
Dec	2.2	0.2	19	0	5.4	251.4	3.2
Cropping season							
Zaid	231.6	19.2	429.2	45.8	111.7	48.3	0.2
Kharif	924.2	76.7	1309.0	635.6	182.0	19.7	0.5
Rabi	48.8	4.1	133.0	0.0	41.7	85.4	0.8
Annually							
Yearly	1204.6	100	1596.4	884.6	233.1	19.3	0.2

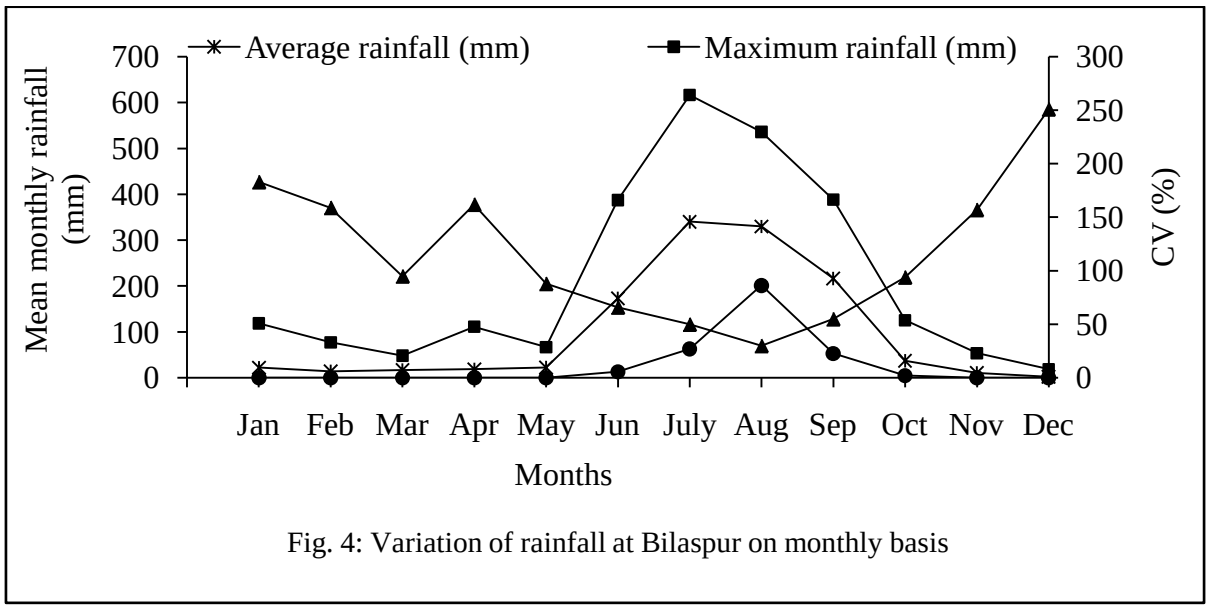

Fig. 4: Variation of rainfall at Bilaspur on monthly basis

3. Seasonal Rainfall analysis*:*

3.1 Cropping season

The rainfall data of cropping season was analyzed and presented in Table 2 and Fig 5 which depicts the variations of the quantitative measures (maximum, minimum, mean, standard deviation, and coefficient of variation, skewness and percentage deviation) of the season. The mean *kharif* (Jul-October), rainfall of 924.2 mm accounts for 76.7 % of annual rainfall with coefficient of variation of 19.7 % and standard deviation of 182.0 mm indicating its dependability.

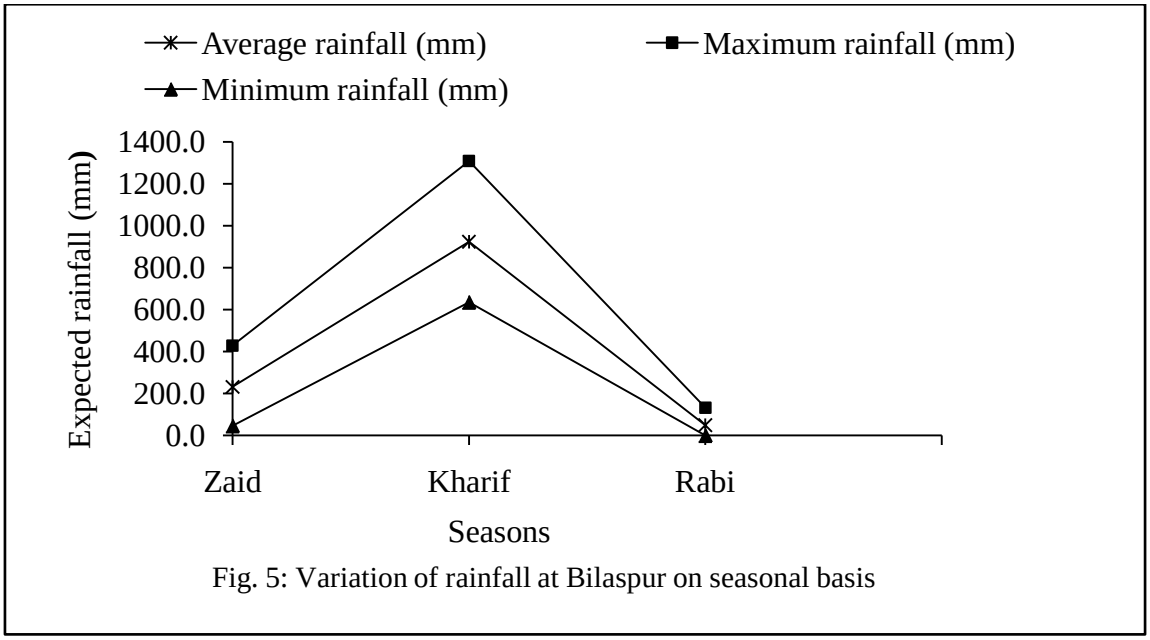

Fig. 5: Variation of rainfall at Bilaspur on seasonal basis

3.2 Annually rainfall analysis*:*

The analysis of rainfall data of Bilaspur region on annual basis showed a significant variation in the range of 884.6 mm to 1596.4 mm with an average value of 1204.6 mm. Hence, the annual rainfall showed high standard deviation and coefficient of variation. Standard deviation and coefficient of variation and skewness were 233.1 mm, 19.3 % and 0.2, respectively (Table 2). The highest annual rainfall is 1596.4 mm observed in the year 2012, whereas, it is found lowest of 884.6 mm in the year 2009. About 42

% of the total years received highest rains than that of the average annual rainfall and 58 % of the total years received lesser rains than that of the average annual rainfall.

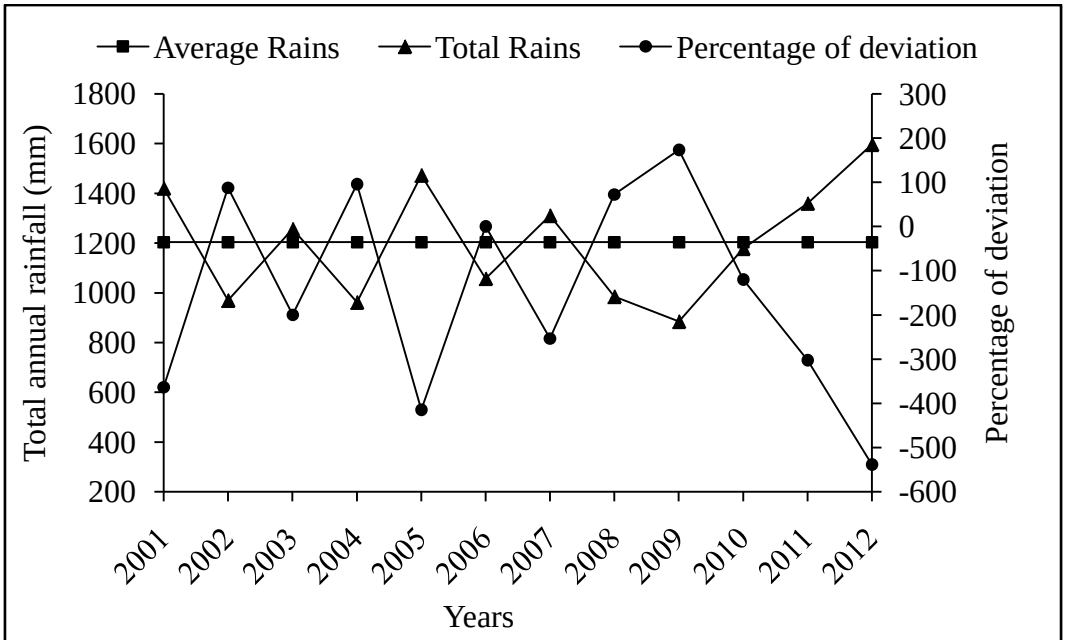

Fig. 6: Years-wise total annual rainfall distribution and percent deviation

CONCLUSION

On the basis of rainfall analysis of rainfall data of Bilaspur, it can be inferred that conclusion:

The highest value of average rainfall of 102.7 mm was observed in the 26th SMW which was 8.5 % of the average annual rainfall, while the lowest value (0.0 mm) was recorded in 50th SMW. July is the wettest month with an average rainfall of 340.4 mm followed by August of 330.1 mm while December is the driest month with an average rainfall of 2.2 mm. On the basis of crop (*Kharif*) seasons received the highest rainfall 1309 mm and contributing 76.7% of the total average annual rainfall. The annual rainfall varies from 884.6 to 1596.4 mm with an average value of 1204.6 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 Bilaspur region.

REFERENCES

[1] Anonymous (2006). Annual Report of ALL India Coordinate Research Project on Ground Water Utilization, Indira Gandhi Agricultural University, Raipur (C.G.).

[2] Appa Rao, G. 1986. Drought climatology, Jal Vigyan Samiksha, Publication of High Level Technical Committee on Hydrology, National Institute of Hydrology, Roorkee.

[3] Dhingre, S., Shahi, N.C. and Khan, A.A. 2004. Predicting precipitation characteristics of Srinagar region of Kashmir valley, journal of water management, 12 (2): 71-74.

[4] Sharma, K.K. and S.K.Dubey 2013.Prabability analysis of rainfall for planning water harvesting and irrigation in semi arid region of Uttar Pradesh. Indian journal of soil conservation, 41 (1): 14-19.

[5] Subudhi, CR 2010. Rainfall analysis at tikabali block of kandhamal district, Orissa. http://www.ag.ohio-state.edu/~beef/library/water.html

[6] 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.