Int.J.Curr.Microbiol.App.Sci (2021) *10*(03): 1026-1036

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 10 Number 02 (2021)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2021.1003.130

Estimate of the Variation Rainfall with Respect to Normal, Surplus and Drought Months in Etawah District of U.P.

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Keywords

Water supply, Agriculture, Hydropower generation

Article Info

Accepted:
10 February 2021
Available Online:
10 March 2021

A B S T R A C T

The percentage of normal, surplus and drought months are 27.78%, 16.67%, and 62.78% respectively. The percentage of drought, surplus and normal years are 13.33%, 13.34% and 73.33% respectively according to Standard Deviation (sd). The analysis also revealed erratic distribution of precipitation during Rabi season thereby preventing the farmers to go for Rabi crops. Therefore, the irrigation must be assured for sowing Rabi crops. The monthly maximum rainfall at different probability level was calculated by Gumbel's Distribution method. From the drought analysis it was observed that study area is drought prone at two stages; firstly, at the beginning of the season which can cause delay in transplantation and secondly, at the beginning of the grain ripening stage, which can drastically reduce the crop yield. The annual daily maximum rainfall received at any time ranged between 975.2 mm (maximum) to zero (minimum) indicating a very large range of fluctuation during the period of study.

Introduction

Drought is an extended period where water availability falls below the statistical requirements for a region. It is not a purely physical phenomenon, but rather interplays between natural water availability and human demands for water supply. There are two main

kinds of drought definitions: conceptual and operational. Conceptually, it can be defined as "a protracted period of deficient precipitation resulting in extensive damage to crops, resulting in loss of yield" (National Drought Mitigation Center, 2006).

The defining of drought is difficult; it depends on differences in regions, needs, and disciplinary perspectives. Drought always starts with the lack of precipitation, but may (or may not, depending on how long and severe it is) affect soil moisture, streams, groundwater, ecosystems and human beings which reflect the perspectives of different sectors on water shortages. Drought means scarcity of water, which adversely affects various sectors of human society, e.g. agriculture, hydropower generation, water supply, industry (Kasa *et al.,* 1999). A combination of droughts or sequence of droughts, and human activities may lead to desertification of vulnerable arid, semiarid and dry sub humid areas whereby soil structure and soil fertility are degraded and bio-productive resources decrease or disappear.

There are various definitions of drought used in different countries according to the purpose and area of interest of investigators. In the present study the following definition of term drought has been used for the analysis.

There are various definitions of drought used in different countries according to the purpose and area of interest of investigators. In the present study the following definition of term drought has been used for the analysis. The week was classified as drought week in which rainfall received less than 50 percent of average rainfall. The week was classified as surplus week in which rainfall received more than twice of average weekly rainfall. The week was classified as normal week in which rainfall received in between 50 percent and 200 percent of average weekly rainfall. (Susama Sudhishri, 2004). The month was classified as drought month in which precipitation received was less than 50 per cent of average monthly rainfall (Aher *et al.*, 2012)

The month was classified as surplus month in which precipitation received was more than twice of average monthly rainfall. The month was classified as normal month in which precipitation received was in between 50 per cent and 200 per cent of average monthly rainfall.

Materials and Methods

The study was conducted in Etawah district of uttar Pradesh in the year 2016 Etawah district lies entirely in the Gangetic plain, For the study,the rainfall etc data were collected For a period of 15 year (2001-2015) from meteorological Department of district Agriculture Etawah (U.P) Data were tabulated and analyzed with the using of percentage, rank order and Gumbel Distribution Method of calculated the mean, standard deviation and probability level

Probability analysis of rainfall for 15 years, using Weibull's method, was used for calculating the rainfall for drought, normal and surplus conditions. The weekly distribution of rainfall shown in The maximum weekly rainfall during 15 years period was 52.64mm in 30^{th} week and minimum weekly rainfall was 0 mm in 19^{th} week as shown in. For 15 years data, numbers of weeks under drought, surplus and normal conditions are shown in It may be observed from the maximum number of drought weeks during the 15 years period was 15 during in the 19^{th} week, and the minimum numbers of drought weeks i.e. 6 were found in the 33^{th} and 35^{th} standard week of the year during 15 years period. The maximum number of Surplus weeks during the 15 years period was

4 during in the 27th, 32th and 34th week, and the minimum numbers of surplus weeks i.e. 0 were found in the 6th, and 19th standard week of the year during 15 years period. The maximum number of Normal weeks during the 15 years period was 7 during in the 33rd week, and the minimum numbers of normal weeks i.e. 0 were found in the 1st, 2nd, 3rd, 7th, 8th 9th, 10th, 11th, 14th, 16th, 17th, 18th, 19th, 21st, 43th, 45th, 46th, 47th, 48th, 49th, 50th and 52th standard week (Fig. 1 and Table 1).

Drought, normal and surplus months

On the basis of definitions outlined earlier, the rainfall for a month to be normal, surplus and drought and the month wise distribution of months to be drought, surplus and months are given in the Table 2. It can be observed from table 2 that about 27.78 percent of the total numbers of months were normal, about 16.67 percent were surplus and 55.55 percent were drought months during the period of 15 years (2001-2015). It was also observed that the maximum numbers of drought months were 12 in the month of November and minimum numbers of drought months were 3 observed in August month during 15 years (2001-2015) period. Excess amount of rainfall were observed in the month of June were the total surplus months were 7 during the period of 15 years and the minimum number of surplus months were observed 0 in the month of August. The maximum numbers of normal months were 12 in the month of August and minimum numbers of normal months were 1 observed in June and November month during 15 years (2001-2015) period.

Drought, normal and surplus month in a year

The year wise distribution of number of months to be drought, surplus and normal are presented in Table 3. It can be observed from Table 3 that about 21.67 percent of the total numbers of months in the year (2001-2015) were normal, about 15.55 percent were surplus and 62.78 percent were drought months. Maximum numbers of drought months were observed to be 12 in the year 2013 and minimum numbers of drought months were observed to be 6 in the year 2001, 2002, 2004, 2006, 2007 and 2015. Excess amount of rainfall were observed in the year 2006 with a total of 6 months during the period of 15 years and the minimum number of surplus months were observed in the year 2013, with a total of 0 month. The maximum numbers of normal months were observed to be 5 in the 2006 and Minimum numbers of normal months were observed to be 0 in the year 2001, 2010 and 2013

Normal, Surplus and Drought months

Normal months

The analysis reveals that during 15 years, about 27.78% of the total number of months for 15 years of record was normal months. The probability distribution of normal months obtained in a year and the percentage of the total years having a given number of normal months are shown in table 4 and 5. Similarly month wise distribution of normality is shown in Table 5.

About 48% normal months occur between October to may and rest during monsoon. During 15 years, maximum 12 months were normal.

Surplus months

About 16.67% of the total number of months is surplus and about 63.35% of them occur between October to may and rest during monsoon. About 16.67%, which is the largest of the total surplus months coincide with December-January. Percent of total years having a given number of surplus months are

shown in table 5. During 15 years maximum 7 months were surplus.

Drought months

About 62.78% of the total number of months is drought months. The percent of total years with a given number of drought months are shown in table 5. During 15 years maximum 12 were drought months.

Of the total drought months, 23% occur between June and September and the percentage distribution of drought months during June, July, August and September are 7, 6, 3 and 7 respectively as shown in table 3. Similarly, during Rabi season (November to March), 52% of the total months are drought months.

This shows the likelihood of failure of Rabi crops under rain fed conditions in most of the years. The percentage distribution of drought months in Rabi season are 12, 9, 10, 10 and 11 during November, December, January, February and March and the percentage distribution of drought months in Jayad season are 8, 8 and 7 during April, May and June.

Similarly the percentage distribution of drought months in Kharif season are 6, 3, 7 and 9 during July, August, September and October respectively as shown in table 4. The percentage distribution of Surplus months in Rabi season are 6.67, 6.67, 10, 6.67 and 6.67 during November, December, January, February and March and the percentage distribution of Surplus months in Jayad season are 10, 10 and 23.33 during April, May and June. Similarly the percentage distribution of drought months in Kharif season are 6, 3, 7 and 9 during July, August, September and October respectively as shown in table 4. The percentage distribution of normal months in Rabi season are 2, 8, 4, 6 and 4 during November, December, January, February and March and the percentage distribution of normal months in Jayad season are 8, 8, and 2 during April, May and June.

Similarly the percentage distribution of normal months in Kharif season are 14, 24, 12 and 8 during July, August, September and October respectively as shown in table 5.

Normal, surplus and drought year

The normal, surplus and drought year was computed as per definition described in material and methods and yearly distribution of the same is presented in Table 5 and Table 6.

Drought year

The mean annual rainfall of Etawah is 498.77 mm and the value of standard deviation is 222.44. Therefore, any year receiving the rainfall less than or equal to 670.12mm would be the drought year. Thus, drought year is about 33.33% of total 15 years.

Surplus year

The year receiving the annual rainfall amount equal or more than 596.52 mm would be the surplus year. Thus, surplus year is about 33.34% of the total 15 years.

Normal year

The year receiving the rainfall between 399.02 and 596.52 mm would be the normal year, which revealed that there are 5 normal years, which comes about 33.33% of the total 15 years.

Table.1 Number of drought, normal and surplus weeks during 2001-2015

Standard weeks	Average rainfall (mm)	Value of rainfall (mm)to be a			Total number of weeks		
		Drought Week (less than)	Surplus week (more than)	Normal week (between)	Drought	Surplus	Normal
1	0.2	0.1	0.4	0.1-0.4	14	1	0
2	0.65	0.327	1.31	0.33-1.31	13	2	0
3	3.167	1.584	6.33	1.58-6.33	13	2	0
4	3.3	1.65	6.6	1.65-6.6	11	1	3
5	0.572	0.286	1.144	0.29-1.14	13	1	1
6	0.067	0.034	0.133	0.03-0.13	14	0	1
7	4.533	2.267	9.067	2.27-9.07	13	2	0
8	3.733	1.867	7.467	1.87-7.47	12	3	0
9	0.347	0.173	0.693	0.17-0.69	14	1	0
10	0.233	0.117	0.467	0.12-0.47	13	2	0
11	0.6	0.3	1.2	0.3-1.2	13	2	0
12	2.027	1.013	4.053	1.01-4.05	12	2	1
13	5	2.5	10	2.5-10	13	1	1
14	2.067	1.033	4.133	1.03-4.13	14	1	0
15	1.733	0.867	3.467	0.87-3.47	13	1	1
16	0.867	0.433	1.733	0.43-1.73	14	1	0
17	1.1	0.55	2.2	0.55-2.2	12	3	0
18	0.4	0.2	0.8	0.2-0.8	14	1	0
19	0	0	0	0-0	15	0	0
20	0.707	0.353	1.413	0.35-1.41	13	1	1
21	0.634	0.317	1.267	0.32-1.27	12	3	0
22	7.647	3.823	15.293	3.82-15.29	9	3	3
23	1.6	0.8	3.2	0.8-3.2	12	1	2
24	2.62	1.31	5.24	1.31-5.24	9	3	3
25	7.233	3.617	14.467	3.62-14.47	8	3	4
26	8.721	4.361	17.443	4.36-17.44	10	2	3
27	6.953	3.477	13.907	3.47-13.90	9	4	2
28	30.093	15.047	60.187	15.05-60.19	9	3	3
29	37.473	18.737	74.947	18.74-74.94	8	3	4
30	52.64	26.32	105.28	26.32-105.28	8	2	5
31	31.1	15.55	62.2	15.55-62.2	7	2	6
32	20.201	10.101	40.403	10.10-40.40	8	4	3
33	36.14	18.07	72.28	18.07-72.28	6	2	7
34	29.207	14.603	58.413	14.60-58.41	7	4	4
35	28.073	14.037	56.147	14.04-56.14	6	2	7
36	39.93	19.964	79.856	19.96-79.86	8	3	4
37	35.746	17.873	71.492	17.87-71.49	11	2	2
38	35.913	17.957	71.827	17.96-71.82	8	3	4
39	21.92	10.96	43.84	10.96-43.84	8	2	5
40	9.553	4.777	19.107	4.78-19.10	10	3	2
41	4.667	2.333	9.333	2.33-9.33	13	1	1
42	8.96	4.48	17.92	4.48-17.92	12	2	1
43	0.573	0.287	1.147	0.29-1.14	14	1	0
44	1.6	0.8	3.2	0.8-3.2	12	2	1
45	0.267	0.133	0.533	0.13-0.53	14	1	0
46	0.6	0.3	1.2	0.3-1.2	14	1	0
47	0.533	0.267	1.067	0.27-1.07	14	1	0
48	0.8	0.4	1.6	0.4-1.6	14	1	0
49	0.533	0.267	1.067	0.27-1.07	14	1	0
50	0.067	0.033	0.133	0.03-0.13	14	1	0
51	2.96	1.48	5.92	1.486.6-5.92	12	1	2
52	**0.653**	**0.327**	**1.307**	**0.33-1.31-1.30**	**12**	**3**	**0**

Table.2 Month wise distribution of number of month to be drought, surplus and normal

Months	Average rainfall (mm)	Values of rainfall to be			Drought month	Surplus month	Normal month
		Drought (less than)	Surplus (more than)	Normal (in between)			
January	7.37	3.686	14.74	3.69-14.74	10	3	2
February	8.61	4.31	17.22	4.31-17.23	10	2	3
March	11.39	5.69q	22.79	5.69-22.79	11	2	2
April	4.1	2.05	8.2	2.05-8.2	8	3	4
May	8.59	4.29	17.17	4.29-17.17	8	3	4
June	31.35	15.68	62.71	15.68-62.71	7	7	1
July	161.38	80.69	322.77	80.69-322.77	6	2	7
August	122.16	61.08	244.32	61.08-244.32	3	0	12
September	122.65	61.33	245.31	61.33-245.31	7	2	6
October	13.75	6.87	27.49	6.87-27.49	9	2	4
November	2.13	1.07	4.27	1.07-4.27	12	2	1
December	5.2	2.6	10.4	2.6-10.4	9	2	4
Total					100	30	50

Table.3 Year wise distribution of number of months to be drought, surplus and normal

Year	Average Rainfall (mm)	Values of rainfall (mm) to be			Drought Month	Surplus Month	Normal Month
		Drought (less than)	Surplus (more than)	Normal (in between)			
2001	64.14	32.07	128.28	32.07-128.28	6	6	0
2002	41.18	20.59	82.36	20.59-82.36	6	2	2
2003	81.27	40.64	162.54	40.64-162.54	8	1	3
2004	42.91	21.46	85.82	21.46-85.82	6	2	4
2005	7	3.5	14	3.5-14	7	3	2
2006	32.45	16.23	64.9	16.23-64.9	6	1	5
2007	23.28	11.64	46.56	11.64-46.56	6	2	4
2008	63.34	31.67	126.68	31.67-126.68	8	2	2
2009	44.38	22.19	88.76	22.19-88.76	8	2	2
2010	53.18	26.59	106.36	26.59-106.36	9	3	0
2011	53.025	26.51	106.05	26.51-106.05	8	2	2
2012	39.89	19.95	79.78	19.95-79.78	9	2	1
2013	0	0	0	0-0	12	0	0
2014	27.56	13.78	55.12	13.78-55.12	8	3	1
2015	50.05	25.03	100.1	25.03-100.1	6	3	3
Total					113	28	39

Table.4 Distribution of Drought (D), Surplus (S) and Normal (N) months

Month	Percentage of month falling in the given month as			Percentage of total years having the given month as		
	D	S	N	D	S	N
Jan	10	10	4	66.67	20	13.33
Feb	10	6.67	6	66.67	13.33	20
Mar	11	6.67	4	73.33	13.33	13.33
April	8	10	8	53.33	20	26.67
May	8	10	8	53.33	20	26.67
June	7	23.33	2	46.67	46.67	6.67
July	6	6.67	14	40	13.33	46.67
Aug	3	0	24	20	0	80
Sep	7	6.67	12	46.67	13.33	40
Oct	9	6.67	8	60	13.33	26.67
Nov	12	6.67	2	80	13.33	6.667
Dec	9	6.67	8	60	13.33	26.67

Table.5 Yearly distribution of Normal, Surplus and Drought year according to I.M.D. method

Year	Total Rainfall (mm)	Normal	Surplus	Drought
2001	562.18	N		
2002	494.2	N		
2003	975.2		S	
2004	514.9	N		
2005	392			D
2006	384.8			D
2007	280			D
2008	760.1		S	
2009	532.6	N		
2010	638.2		S	
2011	636.3		S	
2012	478.7	N		
2013	0			D
2014	231.7			D
2015	600.6		S	
TOTAL=15	AVERAGE = 498.77			

Table.6 Yearly distribution of normal, surplus and drought year according to standard deviation method

Year	Total Rainfall	Normal Year	Surplus Year	Drought Year
2001	562.18	N		
2002	494.2	N		
2003	975.2		S	
2004	514.9	N		
2005	392	N		
2006	384.8	N		
2007	280	N		
2008	760.1	N		
2009	532.6		S	
2010	638.2	N		
2011	636.3	N		
2012	478.7	N		
2013	0			D
2014	231.7			D
2015	600.6	N		

Table.7 Yearly rainfall distribution of Seasonal and non –seasonal rainfall (mm)

Year	Seasonal (June-September)	Non- Seasonal (October-May)	% (Non- Seasonal/ Seasonal rainfall)
2001	474.38	87.8	18.51
2002	377.3	116.9	30.98
2003	933.82	41.38	4.43
2004	373.8	141.1	37.75
2005	374.5	17.5	4.67
2006	342.2	42.6	12.45
2007	194	86	44.33
2008	710.6	49.5	6.97
2009	442.8	89.8	20.28
2010	600.6	37.6	6.26
2011	631.1	5.2	0.82
2012	457.7	21	4.59
2013	0	0	0
2014	221.7	10	4.51
2015	429.8	170.8	39.74

Fig.1

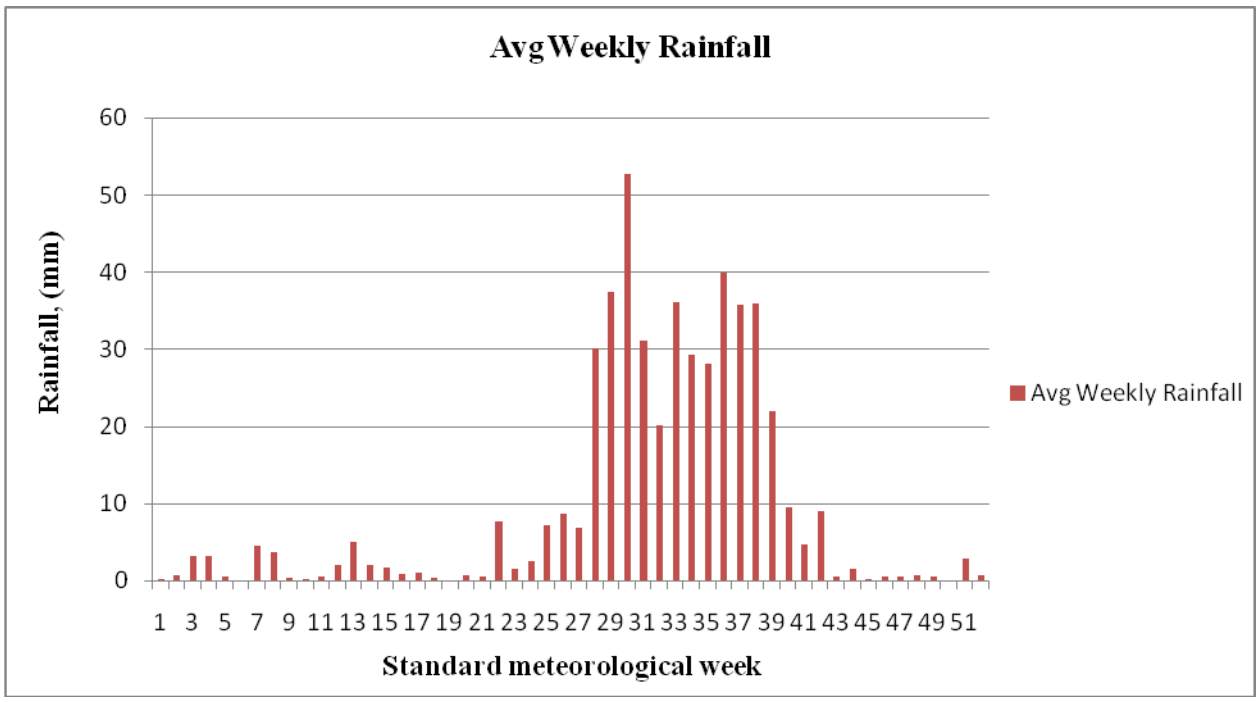
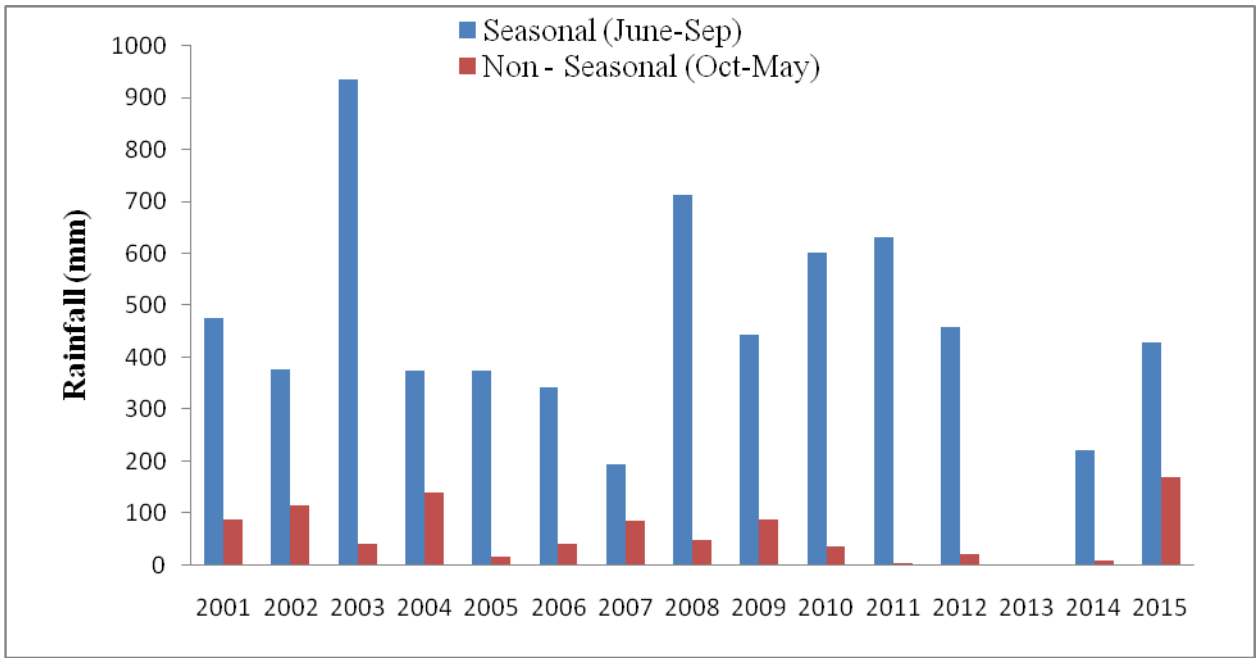


Fig.2 Seasonal and Non- Seasonal rainfall during (2001-2015)



The Drought, Surplus and Normal year are classified by using IMD method. The Yearly distribution of Normal, Surplus and Drought year according to I.M.D. method are shown

Drought year = Average rainfall - 20% of Average rainfall
= 498.77% - 20% of 498.77
= 399.02 mm

Surplus year = Average rainfall + 20% of Average rainfall
= 498.77% + 20% of 498.77
= 596.52mm

Normal year = Rainfall between
= 399.02 and 596.52 mm

Percentage

% of Drought year = 33.33%
% of Surplus year = 33.34%
% of Normal year = 33.33%

The Drought, Surplus and Normal year are classified by using Standard deviation method. The Yearly distribution of Normal, Surplus and Drought year according to Standard deviation method are shown in table 6.

Standard Deviation (S.D.) = 222.44 mm

Average Rainfall (X) = 498.77 mm

Drought Year = X-S.D. = 498.77-222.44 = 276.33 mm

Surplus Year = X+S.D. = 498.77-222.44 = 721.21 mm

Normal Year = Rainfall between 276.33 and 721.21 mm

Percentage (%) of Drought Year = 13.33%

Percentage (%) of Surplus Year = 13.33%

Percentage (%) of Normal Year = 73.34%

Seasonal and Non- Seasonal rainfall

The Seasonal and Non- Seasonal rainfall occurring in June to September and October to May in a year. The yearly rainfall during Seasonal and Non- Seasonal rainfall as shown in Table 7 and Fig.2. The maximum rainfall is 933.82 mm observed in year 2003 and the minimum rainfall is 0 mm observed in year 2013 during seasonal rainfall. The maximum rainfall is 170.8 mm observed in year 2015 and the minimum rainfall is 0 mm observed in year 2013 during non- seasonal rainfall.

The percentage of non-seasonal rainfall with respect to seasonal rainfall for 15 years period is also shown in Table 7. From the table, it was noticed that the percentage of non-seasonal rainfall with respect to seasonal rainfall was maximum with 39.74 percent during the year 2015 and minimum with 0 percent during the year 2013.

The analysis of average monthly rainfall pattern indicates that July month receives highest rainfall (161.38 mm) and November month receives the least rainfall (2.13 mm).

Out of total number of months for 15 years the percentage of normal, surplus and drought months are 27.78%, 16.67%, and 62.78% respectively.

The percentage of drought, surplus and normal years are 13.33%, 13.34% and 73.33% respectively.

It was also found that maximum number of severe drought occurs in November, January, February and March month.

The analysis also revealed erratic distribution of precipitation during Rabi season thereby preventing the farmers to go for Rabi crops. Therefore, the irrigation must be assured for sowing Rabi crops. The monthly maximum rainfall at different probability level was calculated by Gambel's Distribution method. From the drought analysis it was observed that study area is drought prone at two stages; firstly, at the beginning of the season which can cause delay in transplantation and secondly, at the beginning of the grain

ripening stage, which can drastically reduce the crop yield. The annual daily maximum rainfall received at any time ranged between zero (minimum) to 975.2 mm (maximum) indicating a very large range of fluctuation during the period of study

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How to cite this article:

Avanish Yadav, H. C. Singh, Aftab Alam, P. S. Kashyap, Awadhesh Kumar and Yadav, J. P. 2021. Estimate of the Variation Rainfall with Respect to Normal, Surplus and Drought Months in Etawah District of U.P. *Int.J.Curr.Microbiol.App.Sci.* 10(03): 1026-1036.
doi: https://doi.org/10.20546/ijcmas.2021.1003.130