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Research Article

RAINFALL SUITABILITY FOR *KHARIF* CROPS IN SEMI ARID DANTIWADA TALUKA, GUJARAT

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Abstract: Rainfall determines the potential of any region in terms of crops to be grown, farming system to be adopted and the nature and the sequence of farming operations to be done. In the present study analysis of 30 years' rainfall data revealed that normal *kharif* rainfall of 740.2 mm in the study area appeared sufficient for normal water requirement of the regional crops of semi Dantiwada Taluka of Gujarat. Based on the forward calculation, probability analysis and average of weekly rainfall for the period from 1988-2017 it was found that 27th to 28th SMW appeared to be the onset of monsoon and appropriate period for the timely sowing of *kharif* crops. The average weekly rainfall (≥ 30 mm) was available at comparatively higher probability 67.20 % and 54.11% in 30th SMW and 31st SMW respectively, useful for all the crops at initial growth stages. For interculturing operation probability of occurrence of weekly rainfall <10 mm was found< 20% in 29th and 30th SMW week found suitable for pearl millet crop at tillering stage. Similarly, for plant protection measures probability of occurrence of weekly rainfall (<20 mm) was found to be 80 % found to be suitable during 38th SMW for pearl millet to protect from eargot, semi-looper in castor and pink ball warm in cotton. The weekly rainfall analysis and pattern revealed that *kharif* crops like pearl millet, green gram and castor were found most appropriate for the region.

Keywords: *Rainfall analysis, Crop planning, Onset and withdrawal of monsoon, Rainfall trend analysis*

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Introduction

Rainwater is the single potential source of water for rainfed agriculture. Fluctuation in rainfall directly governs the growth, development and yield of crops. Rainfall analysis with the application of statistical tools is useful in crop planning and land and water management practices. The rainfall data Probability analysis help determine the predictable rainfall at various chances [1-3]. Alam *et al*. (2015) [4] done weekly rainfall analysis using different two and three parameter statistical distributions for *Kharif* crop planning in Shivalik regions of India. Alam *et al.* (2016) [5] analyzed weekly rainfall data using different probability function and suggested appropriate period for sowing of *Kharif* crops for maximum utilization of rain water. The present study was undertaken to analyze the distribution pattern and on-set and cessation of rainfall to determine suitability of rainfall for timely sowing, interculturing operations and harvesting of crops for enhanced crop production.

Materials and Methods

Data Collection

Daily rainfall data of past 30 years (1988-2017) were collected from Department of Agricultural Meteorology, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar.

Onset and withdrawal of monsoon

Onset of effective monsoon was estimated following the criteria of forward calculation of minimum rainfall to be occurred in a Standard Meteorological Week (SMW) considered as onset of monsoon to decide for commencement of sowing operations. Likewise, backward accumulation of weekly rainfall was considered to decide the withdrawal of monsoon. The onset of monsoon in Standard meteorological weeks is considered if minimum weekly rainfall is >50 mm in that SMW [6]. The withdrawal of monsoon in a SMW was considered using backward accumulation of weekly rainfall <20 mm in that SMW.

Probability analysis

Probability analysis of weekly rainfall data was done by most widely used Weibull's formula. The probability analysis was carried out for the rainfall series comprising non-zero value rainfall data arranged in descending order and rank number from 1 to 30 was allotted. The Weibull's formula was used to estimate the probability of rainfall.

The Probability of exceedance was calculated as,

$P=M/N+1$ (1)

Where M = rank order (1 to 30); N= total no. of observation.

The weekly rainfall >50 mm is sufficient for germination of crops whereas weekly rainfall >30 mm was considered as sufficient as crop water requirement at maturity stages. The rainfall availability at different critical crop growth stages were also assessed. Also, the rainfall suitability for smooth conduct of interculturing and plant protection measures was analyzed.

Results and discussion

Probability analysis of weekly rainfall

The rainfall suitability for crops of *Kharif* season was studied for obtaining better crop growth and production from the available rainfall for the region. The weekly rainfall analysis has more significance for crop growth hence, mean weekly rainfall analysis is done for crop planning particularly for *Kharif* crops of the area [Fig-1]. Based on rainfall analysis and forward calculation the appropriate sowing time was found in 27th SMW as >50 mm rainfall is available at 22.17% probability level where as weekly rainfall more than >60 mm is available in 28th SMW at 44.72% probability level [Table-2]. Therefore, appropriate duration for sowing of *Kharif* crop is found to be 27th to 28th SMW. The mean weekly suitable rainfall (>30 mm) was available from 28th SMW to 37th SMW with probability >31% except 34th SMW for better crop growth. This duration is found to be better for germination as well as for establishment of the crops.

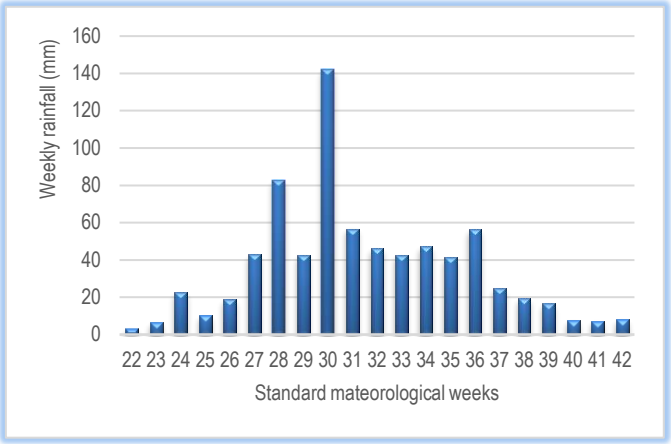

Fig-1 Average weekly rainfall for the period 1988-2017

Table-1 *Weekly mean of rainfall for the period 1988-2017*

SNo	Standard meteorological weeks	Weekly mean of rainfall (mm)
1	22	3.3
2	23	6.7
3	24	22.5
4	25	10.2
5	26	18.9
6	27	43
7	28	82.7
8	29	42.2
9	30	142
10	31	56.6
11	32	46.1
12	33	42.4
13	34	47
14	35	41.2
15	36	56.3
16	37	24.6
17	38	19.2
18	39	16.7
19	40	7.6
20	41	7.3
21	42	8.1

Suitability of weekly rainfall to *Kharif* crops

Pearl millet is most important *Kharif* cereal crop of area. The crop has significance for fodder production for the crucial animal husbandry occupation which is considered remunerative next to the agriculture [Table-3]. Based on mean weekly rainfall the appropriate sowing time of pearl millet is found to be in the 27th SMW to 28th SMW. Accordingly, weekly rainfall >50 mm and is available for better germination during the period *i.e.*, weekly rainfall 54 mm at 22.17% probability level and 61 mm at 44.72% probability levels. The evaporative demand is 15 mm at the early stage of the crop and may reach to maximum 30mm/week during reproductive stage. A week receiving rainfall of about 20 mm to 30 will be able to meet 0.5 to 0.75 times the evaporative demand [7]. During the early stage of crop growth, the crop water requirement will be about half of the evaporative demand subsequently, increases to total evaporative demand during reproductive stage of growth. In the present study 30 mm/week of rainfall is considered sufficient for better growth of *Kharif* crop with respect to the normal water requirement of the crops [Table-4]. The timely sown pearl millet crop riches to tillering stage during 28th to 30th SMW vital for enhancement of grain as well as fodder yield where it received average 42 mm to 142 mm of rainfall available at probability more than 31%. The second critical growth stage of the pearl millet is flowering reaches in 33th to 34th SMW and received the average weekly rainfall of 42.4 mm to 47.0 mm [Fig-1] with probability of 30% to 20% [Table-2], respectively. The crop reaches to maturity stage during 38th to 39th SMW during which the monsoon is on the verge of recession and weekly rainfall is available less than 20 mm only (at probability level <20 %). Therefore, crop suffers due to the moisture stress affecting directly to the grain production. The average grain yield (1600-1800 kg/ha) of *Kharif* pearl millet is less than the 50 percent of average yield (3200- 3600 kg/ha) of irrigated summer [8]. The crop variety GHB 558 of pearl millet is being preferred for the normal monsoon. The recommended dry land agriculture technology such as compartmental bunding certainly help increase in situ moisture conservation in a situation when monsoon departs earlier than normal.

Table-3 *Area under different Kharif crops of Dantiwada Taluka*

SN	*Kharif* crops	2017 Area (ha)	2018 Area (ha)
1	Pearl millet	2750	1493
2	Castor	5000	2260
3	Groundnut	12533	15420
4	Sesame	100	60
5	Green gram	10	40
6	Black gram	10	64
7	Cluster bean	297	324
8	Cotton	50	431
9	Fodder crops	3119	2835
10	Vegetables	200	435
Total area (ha)		21770	23619

The castor crop is the most popular crop of the north Gujarat. The castor productivity has increased exponentially due to improved hydride varieties as well as irrigation-based cultivation. As the castor crop is tolerant to the moisture stress, may reach to maturity even if, there is a moisture stress. The crop needs least plant protection and if normal monsoon occurs it gives higher return with lowest investment [9]. For rainfed castor cultivation, crop may be sown during the 28th SMW as rainfall > 60 mm is available with 44.72 % of probability level.

Table-4 *Water requirement, critical growth stages and days to maturity of kharif crops of the Dantiwada Taluka*

Main rainfed *kharif* crops	Crop water requirement (mm)	Critical growth stages	Days to reach critical growth stage DAS*	Crop period (Days)
Green gram	250-300	Flowering	35-40	90-100
		Pod formation	45-60	
		Pod development	70-75	
Black gram	250-300	Flowering	50-55	90-100
		Pod formation	65-80	
		Development	90-95	
Cluster bean	350-450	Flowering	50-55	90-100
		Pod formation	65-80	
		Pod development	85-90	
Pearl millet	350-400	Tillering	15-20	105-110
		Flowering	40-50	
		Maturity	75-85	
Groundnut	500-550	Flowering	26-30	
		Peg formation	45-30	90-105
		Pod development	66-105	
Castor	450-550	Flowering	55-60	210-230
		Branching	70-85	
		capsule formation	90-100	
Cowpea	250-300	Flowering	35-40	
		Pod formation	45-60	60 - 65
		Maturity	85-95	
Sesame	350-400	Flowering	40-50	80-90
		Seed development	60-75	
Cotton	1200-1400	Vegetative growth	25-35	140-150
		Squaring	45-50	
		Flowering	85-95	
		Ball formation	115-125	
Maize	300-400	Fourth leaf	30-35	100-110
		Vegetative growth	40-45	
		Squaring	55-60	
		Milking	70-90	
Sorghum (Jowar)		Booting	20-35	75-80
		Flowering	40-60	
		Milking	65-70	

Table-2 *Probability analysis of weekly rainfall for the period 1988 to 2017*

Probability (%) of weekly rainfall(mm) during different standard meteriologycal weeks																			
22		23		24		25		26		27		28		29		30		31	
RF	P	RF	P	RF	P	RF	P	RF	P	RF	P	RF	P	RF	P	RF	P	RF	P
0	80.00	0	63.30	0	36.70	0	70.00	0	60.00	0	36.70	0	23.30	0	13.30	0	20.00	0	23.30
1	14.29	2	30.56	1	57.00	2	27.00	1	36.92	4	53.83	1	73.47	2	83.46	1	76.80	6	73.47
1	14.29	2	30.56	1	57.00	3	24.00	2	33.85	4	53.83	6	63.89	3	80.25	2	73.60	8	70.28
2	11.43	6	24.44	2	53.83	6	21.00	7	30.77	4	53.83	6	63.89	4	77.04	4	70.40	11	67.08
13	8.57	6	24.44	3	50.67	7	18.00	8	27.69	22	50.67	6	63.89	7	73.83	30	67.20	14	63.89
27	5.71	11	15.28	4	47.50	8	15.00	9	24.62	24	44.33	9	60.69	8	70.62	38	64.00	15	60.69
55	2.86	11	15.28	4	44.33	24	12.00	47	21.54	24	44.33	25	54.31	9	64.20	39	60.80	18	57.50
		11	15.28	8	41.17	68	9.00	48	18.46	30	44.94	25	54.31	9	64.20	53	57.60	22	54.31
		16	12.22	9	38.00	87	6.00	58	15.38	30	38.00	29	51.11	12	60.99	58	54.40	32	51.11
		18	9.17	11	34.83	101	3.00	63	12.31	31	34.83	34	47.92	14	57.78	61	51.20	35	47.92
		24	6.11	12	31.67			80	9.23	32	31.67	61	44.72	18	54.57	63	48.00	37	44.72
				17	28.50			100	6.15	34	28.50	69	41.53	22	51.36	66	44.80	38	41.53
				28	25.33			144	3.08	40	25.33	86	38.33	25	44.94	71	41.60	40	38.33
				38	22.17					54	22.17	97	35.14	25	44.94	77	38.40	42	35.14
				40	19.00					67	19.00	101	31.94	27	41.73	78	35.20	46	31.94
				57	15.83					70	15.83	138	28.75	37	38.52	96	32.00	73	28.75
				65	12.67					81	12.67	152	25.56	43	32.10	105	28.80	98	25.56
				86	9.50					221	9.50	156	22.36	43	32.10	105	25.60	106	22.36
				116	6.33					229	6.33	166	19.17	54	28.89	108	22.40	110	19.17
				175	3.17					300	3.17	167	15.97	56	25.68	155	19.20	115	15.97
												215	12.78	79	22.47	187	16.00	125	12.78
												230	9.58	79	19.26	353	12.80	186	9.58
												249	6.39	105	16.05	384	9.60	240	6.39
												455	3.19	107	12.84	832	6.40	283	3.19
														110	9.63	1296	3.20		
														133	6.42				

Probability(%) of weekly rainfall (mm) during different standard meteorological weeks															
32		33		34		35		36		37		38		39	
RF	P	RF	P	RF	P	RF	P	RF	P	RF	P	RF	P	RF	P
0	20.00	0	33.30	0	30.00	0	26.70	0	46.70	0	56.70	0	50.00	0	66.70
1	70.40	3	63.49	1	63.64	2	70.14	16	47.06	13	40.24	2	43.75	2	30.30
1	70.40	3	63.49	1	63.64	3	63.77	16	47.06	14	37.14	2	43.75	4	27.27
1	70.40	4	60.32	2	57.27	3	63.77	17	43.92	16	34.05	10	37.50	6	24.24
2	67.20	5	57.14	2	57.27	5	60.58	18	40.78	23	30.95	10	37.50	7	21.21
7	64.00	15	53.97	3	54.09	13	57.39	20	37.65	27	27.86	11	31.25	9	18.18
8	60.80	16	50.79	17	50.91	13	57.39	26	34.51	39	21.67	11	31.25	11	15.15
12	57.60	19	47.62	18	44.55	15	54.20	31	31.37	39	21.67	14	28.13	12	12.12
23	54.40	19	47.62	18	44.55	23	51.01	33	28.24	53	18.57	15	25.00	31	9.09
23	54.40	19	47.62	19	38.18	25	47.83	41	25.10	54	15.48	19	21.88	52	6.06
27	51.20	20	38.10	19	38.18	44	44.64	90	21.96	64	12.38	21	18.75	369	3.03
32	48.00	30	34.92	20	35.00	48	41.45	101	18.82	65	9.29	32	15.63		
44	44.80	60	31.75	22	31.82	60	38.26	111	15.69	110	6.19	65	12.50		
47	41.60	61	28.57	27	28.64	66	35.07	150	12.55	220	3.10	80	9.38		
64	38.40	81	25.40	51	25.45	76	31.88	201	9.41			93	6.25		
65	35.20	91	22.22	58	22.27	81	28.70	206	6.27			190	3.13		
85	32.00	115	19.05	68	19.09	91	25.51	614	3.14						
87	28.80	130	15.87	121	15.91	97	22.32								
88	25.60	158	12.70	130	12.73	99	19.13								
100	22.40	175	9.52	185	9.55	107	15.94								
101	19.20	250	6.35	270	6.36	110	12.75								
115	16.00			360	3.18	122	9.57								
121	12.80					133	6.38								
126	9.60														
205	6.40														

This crop may get more than 30 mm of average weekly rainfall with probability more than 30% during 28th to 36th SMW [Table-2] till the flowering to branching stage [Table-4]. As the crop is deep rooted compared to other *Kharif* crops, the frequent inter-culturing operation towards the recession of the monsoon (during 37th to 39th SMW) may be beneficial. In the situations of permanent moisture stress after recession of monsoon, branching of the crop may remain limited however, crop may reach to maturity during the (41st to 43rd SMW). Besides interculturing, the compartmental bunding and ridge and furrow in- *in-situ* moisture conservation practices are recommended as dryland technology for enhanced crop production [10]. The frequent interculturing operation helps to sustain against moisture stress and crop reaches to flowering stage during the 39th to 40th SMW[11].

Groundnut is grown in sizable area (> 50%) in the Dantiwada Taluka [Table-3]. Other than seed production the crop has importance for the valuable fodder production. The sowing of groundnut is also done at the onset of the monsoon (*i.e.*, 27th SMW). The duration of crop is comparative longer than other *Kharif* crops [Table-4]. However, farmers rely on ground water irrigation to obtain better production. Normally, the crop receives good amount of weekly rainfall more than 50 mm with probability level 57% to 50% at flowering stage during 30th to 31st SMW respectively [Table-2]. Whereas the crop may receive, average 47.0 mm to 41.2 mm of rainfall during the 34th to 35th SMW respectively, at 26 % to 45% probability level, for peg formation stage [Fig-1], [Table-4]. As the monsoon starts receding after 36th SMW, the groundnut suffers moisture stress at the time of pod development.

Therefore, the groundnut is normally grown by the farmer who has assured irrigation facility. Besides groundnut, sowing of sesame is done at the onset of the monsoon. As per the availability of weekly mean rainfall the short- duration crop like green gram may get average 42.4 mm to 46.1 mm during 32th to 34th SMW of weekly rainfall at flowering stage (with probability 30% to 50 % level) at pod formation to maturity stage and reach to the maturity stages before the 39nd week [12]. The reform, the normal weekly rainfall is enough for groundnut crop. Likewise, for black gram also, the average weekly rainfall availability was 42.2 mm to 47.0 mm (at 30% to 20% probability levels) during 33th to 34th SMW when crop reaches to flowering stage. However, at pod formation stage (black gram) average weekly rainfall of 19.2 mm to 24.6 mm only (at probability level less than 20%) at 38th SMW and 39th SMW. Therefore, for the black gram the rainfall will be deficient at the pod formation to development stage. However, the regular inter-culturing operation and removal of weeds, particularly during the 37th to 38th SMW may help the conserve the *in-situ* moisture which may help crop to sustain against the moisture stress. The sowing time of cluster bean is recommended during 30th SMW. The crop received 40 mm of weekly average rainfall at (60% probability level) initial stages only. The crop received 41.2 mm to 47.0 mm of rainfall (during initial stages but received 24.6 mm to 19.2 mm of rainfall during 37th to 38th SMW at flowering stage. Therefore, interculturing operation during the 37th to 38th SMW is beneficial for removal of weeds and conservation of in situ moisture. At pod formation to development stage during the 40th to 41th SMW the monsoon is almost withdrawn. However, the crop is comparatively deep rooted and robust against moisture stress. Therefore, the crop sustains even after withdrawal of monsoon and considered better remunerative next to green gram for the study area. The *Kharif* cluster bean is considered better for addition of organic matter and fixing nitrogen in soil which improves fertility of soil for following rabi crop.

The sorghum is grown for the fodder purpose. The fodder production may be better obtained if, monsoon is observed normal. The booting stage of sorghum may arrive during 30th to 32nd SMW if, sowing is done at normal onset of monsoon. During booting and flowering growth stages the drop received > 40 mm of average weekly rainfall during 30th to 34th SMW at 60% and 46.5% probability level, respectively [Table-2], [Table-4].

Suitability of interculturing operation

In the present study it was considered that rainfall < 10 mm or no rain in the week may be suitable for interculturing operation. From weekly rainfall analysis it was obvious that almost all crops get the opportunity of < 10 mm or 0 mm rainfall in suitable SMWs at different probability levels [Table-5]. For pearls millet the period from 29th SMW to 34th SMW is the period for interculturing operations where the probability of getting rainfall is 13.33% to 30.00%. For castor the period for interculturing is required in 32nd to 35th SMW during which probability of getting < 10 mm or 0 mm rainfall is 20% to 30% respectively. For groundnut, green gram and black gram, the period from 32nd SMW to 34th SMW may be required period for interculturing operation and probability of getting in < 10 mm or 0 mm rainfall is also 20% to 30%. Likewise, for cotton and seasamum the period from 27th SMW to 32nd SMW and 29th SMW to 32nd SMW may be suitable for interculturing operation where rainfall <10% may be available at probability of 20.00% to 36.67% and 13.33% to 23.33%, respectively [13].

Rainfall suitability for plant protection measures

For rainfed cultivation in semi-arid region, interculturing operation is one of the most important intervention for *in-situ* moisture conservation. Here, it was considered that average rainfall < 20 mm per week may be suitable for plant protection operation. From weekly rainfall analysis it was obvious that almost all crops get the opportunity of receiving average weekly rainfall < 20 mm in suitable period at different probability levels [Table-6]. For pearls millet the period from 38th SMW and 39th SMW found to be suitable period for plant protection operation against ergot where the probability of getting rainfall < 20 mm was 63.33% and 83.33%, respectively. For castor the period for plant protection operation may be in the 32nd to 38th SMW during which probability of getting rainfall < 20mm was found to be 40.00% to 63.33 % respectively.

Table-5 *Probability of rainfall suitability for interculturing operation*

SN	Crop	Interculturing operation		
		Suitable Period		Probability of getting weekly rainfall < 10 mm,%
		DAS	SMW	
1.	Pearl millet	15-45	29	13.33
			30	20.00
			31	23.33
			32	20.00
			33	33.33
			34	30.00
2.	Castor	25-60	32	20.00
			33	33.33
			34	30.00
			35	26.67
3.	Groundnut	30-35	32	20.00
			33	33.33
			34	30.00
4.	Cotton	25-60	27	36.67
			28	23.33
			29	13.33
			30	20.00
			31	23.33
			32	20.00
5.	Seasamum	15-40	29	13.33
			30	20.00
			31	23.33
			32	20.00
6.	Cluster bean	15-45	32	20.00
			33	33.33
			34	30.00
			35	26.67
			36	46.67
7.	Green gram	30-50	32	20.00
			33	33.33
			34	30.00
8.	Black gram	15-40	32	20.00
			33	33.33
			34	30.00

Table-6 *Probability of rainfall suitability for plant protection measures*

Crop	Plant protection		
	Period of pest/disease infestation DAS	Probable period of pest/disease infestation, SMW	Probability of getting weekly rainfall< 20 mm
Pearl millet	Eargot	38	80.00
		39	90.00
Castor	Semi looper	32	43.33
		33	66.67
		34	66.67
		35	50.00
		36	63.33
		37	66.67
		38	80.00
Groundnut	White grub	32	43.33
		33	66.67
		34	66.67
Cotton	Meili bug	25	86.67
		26	76.67
	Pink ball warm, Para wilt, root rot	36	63.33
		37	66.67
		38	80.00
		39	90.00
Seasamum	Leaf waber	33	66.67
		34	66.67
		35	50.00
Cluster bean	Sucking pest, blight	31	43.33
		32	43.33
		33	66.67
		34	66.67
		35	50.00

To protect crop from probable infestation of semi looper. For groundnut, green gram and black gram the period from 32nd SMW to 34th SMW may be period for plant protection operation and probability of getting rainfall < 20 mm was 40.00% to 46.67%. Likewise, for cotton and seasame the period from 25th to 39th SMW and 33th SMW to 35th SMW may be suitable period for plant protection operation with probability of getting < 20 mm rainfall was found to be 30.00% to 83.33%and 40.00% to 46.67%, respectively.

Estimation of withdrawal characteristics of monsoon

The minimum weekly rainfall was considered to decide the withdrawal of monsoon. The withdrawal of monsoon in a SMW was considered if weekly rainfall < 20 mm in that SMW. It was clear from [Fig-1] that the minimum weekly rainfall is obtained < 20 mm in the 39th SMW at 11.15% probability levels. Therefore, it can be stated that the monsoon withdrawal is expected in39th SMW hence; selection of *Kharif* crops should be done in a way that it reaches the maturity till 39th week [14].

Trend analysis

The trend analysis of different rainfall time series was carried out using trend test Sen (1968) [15]. The trend analysis results are presented in [Table-7] indicated no trend in weekly rainfall (of any week).

Table-7 *Trend analysis of weekly rainfall*

Standard Meteriologycal Week	Sen's slope	Qmin95	Qmax95	Significant/ Non-significant
22	0.000	0.000	0.000	NS
23	0.000	0.000	0.000	NS
24	0.000	-0.285	-0.285	NS
25	0.000	0.000	0.000	NS
26	0.000	0.000	0.000	NS
27	0.000	-0.667	0.732	NS
28	0.000	-1.5	3.896	NS
29	-0.833	-3	0.5	NS
30	1.769	-0.109	6.573	NS
31	0.000	-2.145	1.371	NS
32	0.333	-0.516	2.057	NS
33	0.000	-0.57	1.024	NS
34	0.000	-0.65	0.632	NS
35	0.083	-0.681	2	NS
36	0.000	0.000	1.511	NS
37	0.000	0.000	0.000	NS
38	0.000	-0.228	0.000	NS
39	0.000	0.000	0.000	NS

Conclusion

Based on rainfall analysis mean weekly rainfall >50 mm was found to be available during 27th to 28th SMW with probability levels 22.17 % and 44.72%, respectively. Therefore, period from 27th SMW to 28th may be suggested as onset of the monsoon for sowing of the pearl millet, groundnut, green gram, sesame, black gram and jowar. The sowing of *Kharif* castor is recommended in first fortnight of July whereas sowing of cluster bean is recommended in the second fortnight of July. The rainfall during 27th to 28th SMW help starting the sowing operations while rainfall during 29th to 35th SMW is important for majority of short and medium duration crops for moisture availability at critical growth stages. The rainfall during 36th to 38th is important for crops to reach maturity for crops like green gram, black gram, pearl millet and ensure better growth for crops like cluster bean and cotton. Also, weekly rainfall >30 mm at probability >40% indicated better rainfall suitability for regional *Kharif* crops like pearl millet, green gram, castor and cluster bean. The probability analysis for weekly rainfall < 10 mm and < 20 mm respectively, indicated better opportunities for interculturing and plant protection measures in the pearl millet, groundnut, green gram, sesame and black gram, castor and cluster bean at appropriate crop growth stages. The rainfall analysis suggested that withdrawal of monsoon is clearly indicated in 39th SMW therefore, crops like pearl millet, green gram and *Kharif* castor may reach to maturity safely.

Application of research: The research outcome presented in the outcome will be useful for *Kharif* crop planning for the farmers with respect to sowing window. The study on rainfall availability during the season at different probability levels and its distribution help decide choice of crops for better remuneration Also, the study on rainfall pattern will help plan interculturing and plant protection measures.

Research Category: Rainfall Suitability

Abbreviations: Cm: Centimetre, μ: Mean, D: Dry spells, W: Wet spell
ER: Effective Rainfall, Ha: Hectare, Mm: Millimetre, PM: Post Monsoon

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Study area / Sample Collection: Chimanbhai Patel College of Agriculture, Sardarkrushinagar, 385506

Cultivar / Variety / Breed name: Pearl millet, Castor, Groundnut, Cotton, Seasamum, Cluster bean, Green gram, Black gram

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