

Original Research Article Rainfall Probability Analysis for Crop Planning of Unakoti & West Tripura districts of Tripura, India

ABSTRACT

Rainfall is one of the most important climatic variables that determine the spatial and temporal patterns of climate variability of a region, which provides useful information for the planning of agricultural production. For the purpose of crop planning, rainfall data of two districts of Tripura viz., Unakoti and West Tripura for 20 years (2001-2020) were collected and used to analyze probability of annual, seasonal, monthly and weekly rainfall. The incomplete Gamma distribution probability analysis using the method suggested by Victor (2000) was used to find and analyze weekly rainfall probability for the studied districts. The investigation revealed that total annual rainfall of Unakoti at 90%, 75% and 50% probability is predicted to be 1640 mm, 1686 mm & 1722 mm respectively. The total annual rainfall of the West Tripura at 90%, 75% and 50% probability is likely to be 1631 mm, 1847 mm and 2108.4 mm respectively. Crops found suitable for *kharif* season are blackgram, greengram, *aman* rice. The crops which can be grown in *rabi* season include cole crops, tomato, chilli, potato, pea, toria etc. Based on the study, crops suited to summer season include short duration greengram, *aush* rice, sesame, jute in all land situations.

Keywords: Rainfall probability, gamma distribution, Crop planning, Cropping pattern.

1. INTRODUCTION

Rainfall analysis is important for crop planning for any region. In order to stabilize crop yields at reasonable levels in rainfed situation, it is essential to plan rainfed crops and their management practices in consonance with the rainfall pattern prevalent in the region (Deka and Nath, 2000). The rainfall pattern determines the development of crops, their varieties, reception of cultural operations and gathering of overabundance rain water of any district (Sinhbabu 1977, Budhar *et al.*, 1987, Kar 2002). For the most part, the cropping pattern is recommended considering the rainfall probabilities at various levels (Mahale and Dhane, 2003). Studies on rainfall probability in India have additionally been completed before by numerous workers (Gabrial and Neuman 1962, Panigrahi 1998). Rainfall is the single most significant factor in rainfed farming. The variation in monsoon and yearly rainfall is notable and its yearly inconstancy extensively affects crop production, water management and energy generation. Analysis of yearly, occasional and monthly rainfall of an area is valuable for configuration of water harvesting structures. Likewise week by week rainfall analysis gives more valuable data in crop planning (Sharma *et al.*, 1979). There have been various strategies for deciding probability distribution on rainfall analysis and best fit probability distribution function like typical, log-ordinary, Gumbel, Weibull and Pearson type circulation have been distinguished according to various research workers (Kumar, 2016). Various studies have been done for area explicit agricultural planning overall and crop planning specifically by analyzing day by day, week after week, month to month, seasonal and yearly rainfall information. Stern and Coe (1982) broke down day by day rainfall information for crop planning in semi-arid & tropics. Comparable

analysis of rainfall information has been done for crop planning in coastal, semi-arid, dry farming, sub-humid and Himalayan foothill regions by Panigrahi (1998) and Sharda and Das (2005). Rainfed farming possesses around 51% of nation's net sown area and records for almost 40% of the total food production (Department of Agriculture, Cooperation and Farmers Welfare, Govt. of India). Indian agriculture is ascribed to the changeability of seasonal rainfall and the vulnerability in the sum and dissemination of the same (Singh *et al.*, 2008).

The cropping pattern in Tripura is portrayed by two particular cultivating frameworks which are settled development in the plain areas and shifting cultivation in the hills. Paddy, Pulses and Oilseeds are the significant crops cultivated. Paddy is grown in 55% of gross cropped area in three seasons viz. *Aush* (pre kharif), *Aman* (*kharif*) and *Boro* (summer) while pulses and oilseeds along with different other crops cover around 5% region. Leafy foods are grown in 21% of gross cropped area, 10% region is under rubber and 9% under other different crops like tea, medicinal plants and so forth. The major *kharif* crops are rice, maize, pigeon pea, blackgram, greengram, cowpea, ground nut, sesame, jute, mesta, cotton, and *kharif* vegetables. Various crops grown during *rabi* season are rice, wheat, pea, greengram, lentil, rapeseed-mustard, potato, and *rabi* vegetables.

2. MATERIAL AND METHODS

Daily rainfall data of two districts namely Unakoti (24° 14' N latitude and 92° 1' E longitudes) and West Tripura (23°16' N to 24°14' N latitude and 91°09' E to 91°47' E longitudes) of Tripura for 20 years (2001-2020) was collected from Weather Stations of Kailasahar & Agartala which are under Airport Authority of India through Regional Meteorological Centre, Guwahati. The daily data was converted to weekly values & subsequently to monthly, seasonal & annual values. The rainfall database for each district was analyzed to find the mean, standard deviation (SD) and coefficient of variation (CV) on weekly, monthly, seasonal & annual basis.

The incomplete Gamma distribution probability analysis as suggested by Victor (2000) was used to obtain the weekly rainfall probability. The probability was calculated using WEATHER COCK software developed by ICAR-CRIDA, Hyderabad. The probability values on weekly basis was evaluated at 3 different probability levels which are 90%, 75% & 50%. The probability analysis was done on SMW (Standard Meteorological Week).

The general formula for the probability density function of the gamma distribution is

$$f(x) = \frac{\left(\frac{x-\mu}{\beta}\right)^{\gamma-1} \exp\left(-\frac{x-\mu}{\beta}\right)}{\beta \Gamma(\gamma)} \quad x \geq \mu; \gamma, \beta > 0$$

Where, γ is the shape parameter, μ is the location parameter, β is the scale.

3. RESULTS AND DISCUSSION

3.1 Annual rainfall: The daily rainfall data recorded at both the district for the period of 20 years (2001 – 2020) for Unakoti & West Tripura was summed up and presented in Table 1. The data indicates that the mean annual rainfall of Unakoti (2597.5 mm) was moderately higher than the mean annual rainfall of West Tripura (2138.4 mm) for last 20 years. The CV value (20.1%) of West Tripura is higher than Unakoti (18.1%) while for SD, it was higher in Unakoti (470.5 mm) than West Tripura (426.7 mm).

Table 1: Annual rainfall variability of two districts

District	Mean Rainfall (mm)	SD(mm)	CV (%)
Unakoti	2597.5	470.5	18.1
West Tripura	2138.4	426.7	20.0

3.2 Seasonal rainfall: Seasonal mean rainfall and CV of Unakoti and West Tripura has been presented in figure 1 and 2. The analysis of mean seasonal rainfall revealed that during Monsoon total mean rainfall in Unakoti & West Tripura district was 1510.7 mm and 1272.5 mm, in Post monsoon 206.3 mm and 199.8 mm, in Pre monsoon 854.3 mm and 566.8 mm while in winter it was recorded 42.1 mm and 75 mm respectively. The percentage contribution of the seasonal rainfall to the total rainfall of Unakoti and West Tripura district was in the following order. Approximately, in winter 1.6% and 3.5%, in Pre monsoon 32.9% and 26.5 %, in post monsoon 7.9% and 9.3 % whereas maximum percent was recorded in monsoon 58.2% and 59.5 % respectively for Unakoti & West Tripura. The seasonal co-efficient of variation (CV) of Unakoti and West Tripura district in monsoon was 18.2% and 26 %, in post monsoon it was 52.7% and 47.6 %, in pre monsoon it was 29.3% and 30.6 % while in winter it was recorded 112.1% and 88.9 % respectively.

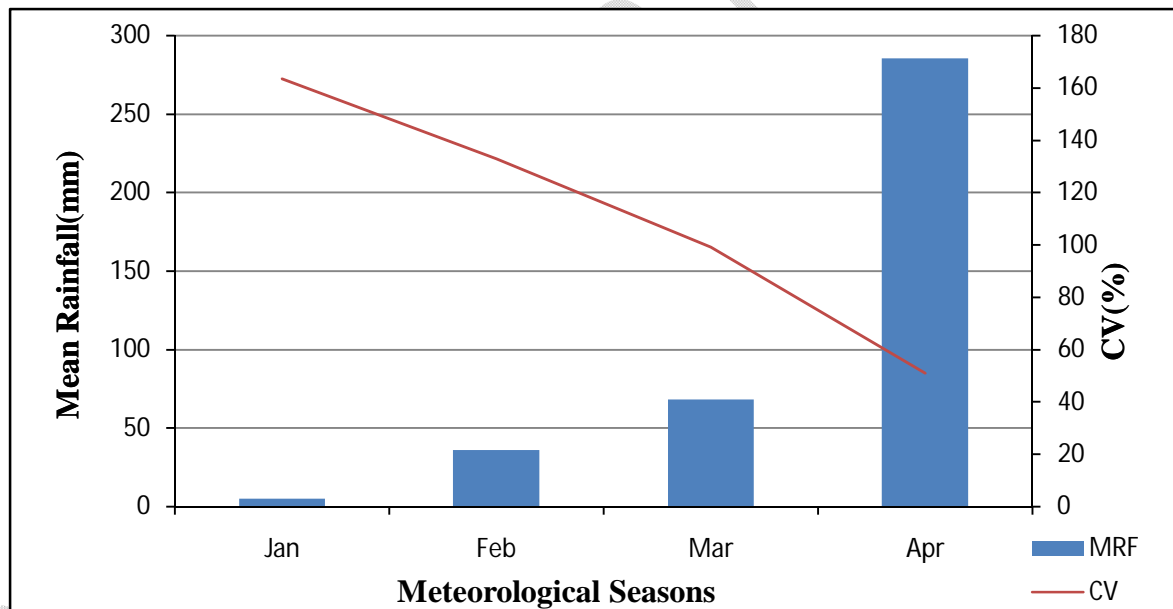


Fig 1: Seasonal mean & CV of Unakoti

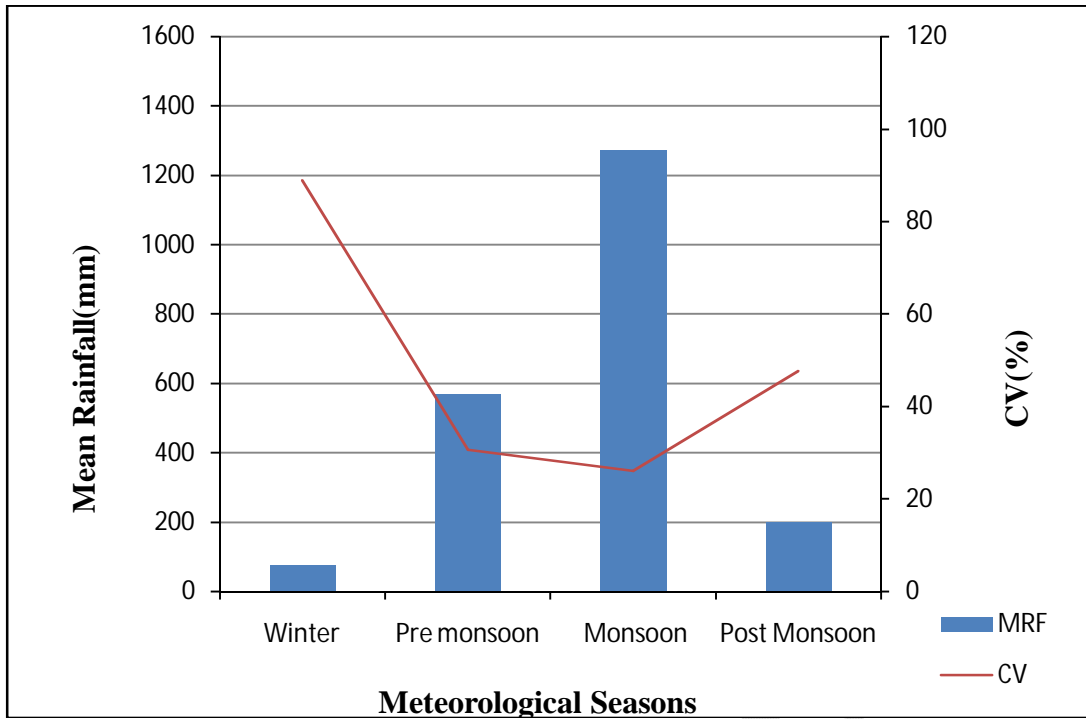


Fig 2: Seasonal mean & CV of West Tripura

3.3 Monthly rainfall: Monthly mean rainfall and CV of Unakoti and West Tripura has been presented in figure 3 and 4. The data on mean monthly rainfall of Unakoti district revealed that during the month of May highest mean rainfall of 500.2 mm was recorded contributing about 19.3% to the total annual rainfall while in West Tripura during the month of June highest mean rainfall of 450.3 mm was recorded contributing about 21.1% to the total annual rainfall. The least rainfall of 5.5 mm & 2.7 mm was recorded in the month of January in Unakoti & West Tripura districts respectively with similar contribution of 0.2% to total rainfall. The co-efficient variation due to monthly rainfall ranges from 33.3% (May) to 204.5% (December) in Unakoti while in West Tripura it ranges from 28.8% (August) to 197.5% (December).

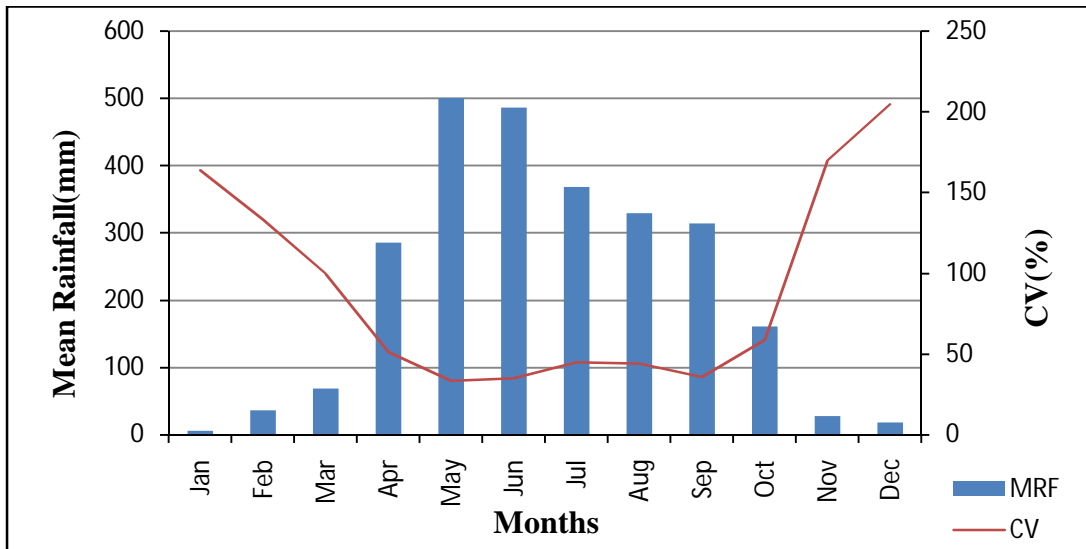


Fig 3: Monthly mean & CV of Unakoti

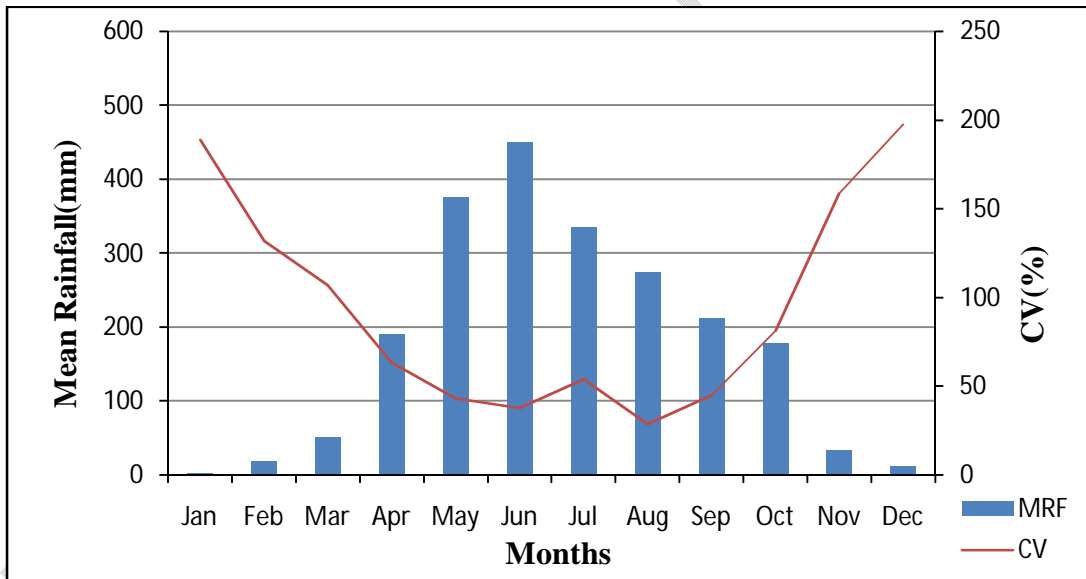


Fig 4: Monthly mean & CV of West Tripura

4. Weekly rainfall: Weekly mean rainfall and CV of Unakoti and West Tripura has been presented in figure 5 and 6. Highest rainfall was observed in 23rd SMW (149.5 mm) & 24th SMW (123.3 mm) in Unakoti & West Tripura respectively. 47th, 48th & 52nd SMW was recorded as dry in Unakoti while 47th & 48th week was for West Tripura. However maximum rainfall occurred during 13th to 43rd SMW for both the districts. The total rainfall received during this period was 2475.8 mm representing 95.3% of the mean annual

rainfall in Unakoti & 2032 mm representing 95% of the mean annual rainfall in West Tripura. The Coefficient of variation of rainfall rose from 3.85% in 49th week to 471.4% in 1st week in Unakoti & from 62.9% in 49th week to 425% in 1st week in West Tripura. However it was less than 100 maximally during the period from 21st week to 40th week i.e. from May to September in Unakoti & from 13th week to 39th week which were distributed from March to September in West Tripura.

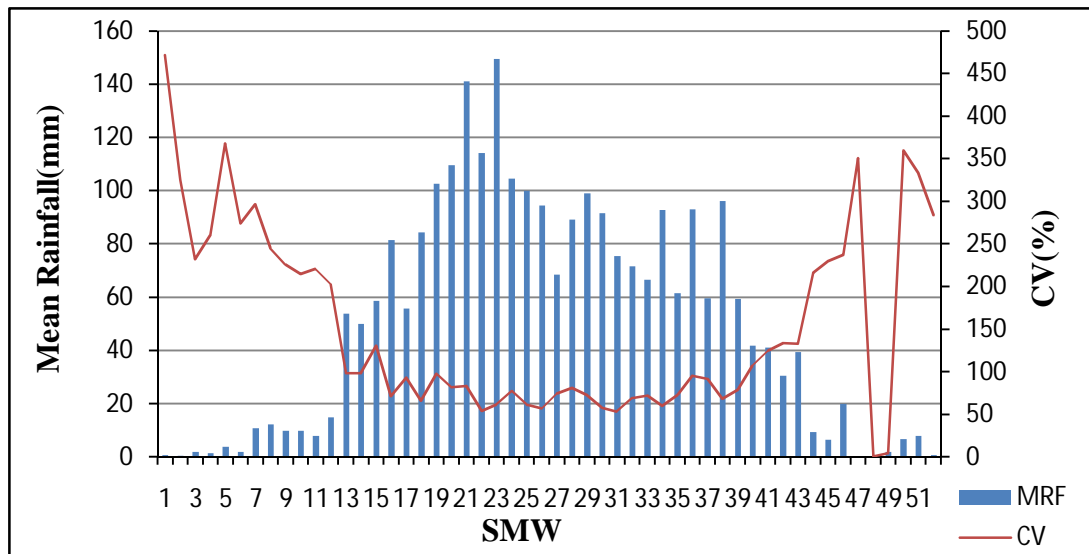


Fig 5: Weekly mean & CV of Unakoti

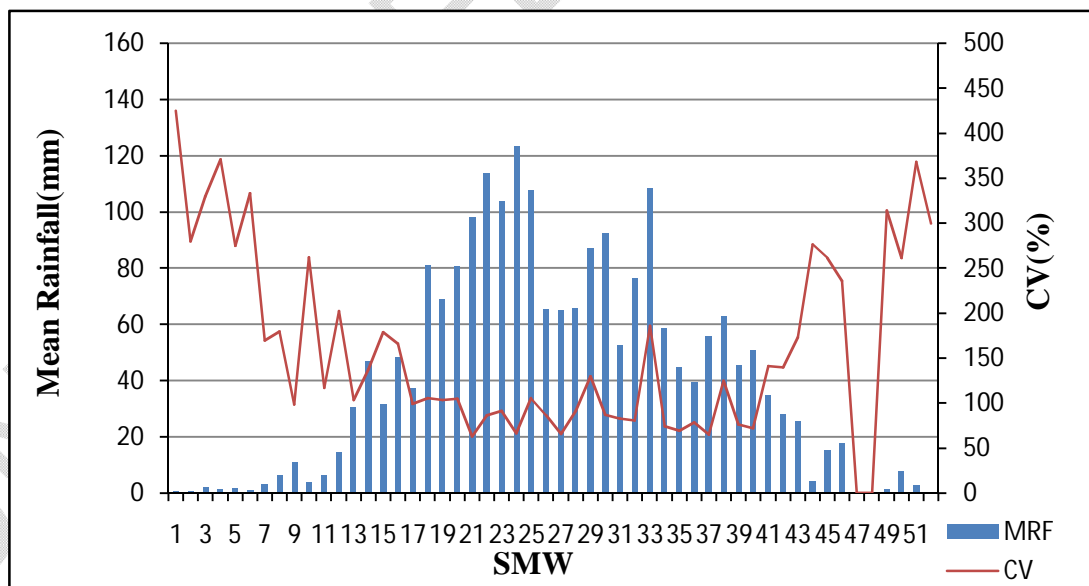


Fig 6: Weekly mean & CV of West Tripura

3.5 Weekly rainfall probability: At 75% probability, significantly less rainfall (<10mm) before the onset of summer that is before 14th Standard Meteorological Week (SMW) for both the districts was observed.

After SMW 22 in Unakoti & SMW 23 in West Tripura a very good amount of rainfall may be received up to SMW 38 and decreased thereafter upto 40th week (becoming less than 10 mm after that) which indicates withdrawal of monsoon for both districts. In SMW 23 the Unakoti district may receive highest rainfall of 83.4 mm while it is SMW 24 for West Tripura with rainfall of 66.3 mm. Also, SMW 6, 7 & 8 may not receive any rainfall in Unakoti & SMW 6 & 8 may not receive any rainfall in West Tripura.

Table 2: Annual and Weekly Rainfall Probability of West Tripura

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SMW	Rainfall Probability Levels			Mean (mm)	SMW	Rainfall Probability Levels			Mean (mm)
	90%	75%	50%			90%	75%	50%	
1	0.3	0.7	1.3	0.7	1	0.3	0.7	1.4	0.8
2	0.5	0.8	1.3	0.4	2	0.5	0.8	1.3	0.5
3	0.3	0.8	2.0	1.9	3	0.2	0.7	1.9	2.0
4	0.3	0.8	1.8	1.5	4	0.2	0.7	1.6	1.4
5	0.1	0.7	2.5	3.9	5	0.3	0.8	1.9	1.6
6	0.0	0.0	1.9	1.9	6	0.0	0.0	0.9	0.9
7	0.0	0.0	10.8	10.8	7	0.0	0.3	3.0	3.0
8	0.0	0.0	12.1	12.1	8	0.0	0.0	6.3	6.3
9	0.2	1.0	4.8	9.7	9	0.2	1.2	5.4	10.9
10	0.2	1.2	5.2	9.9	10	0.2	0.9	2.7	3.7
11	0.2	1.2	4.5	8.0	11	0.2	0.9	3.7	6.5
12	0.4	1.9	7.8	14.8	12	0.3	1.7	7.3	14.5
13	2.2	9.3	30.7	53.8	13	0.7	3.9	15.6	30.6
14	4.5	13.3	34.1	50.0	14	3.2	10.7	30.0	46.8
15	2.5	10.4	33.9	58.7	15	0.9	4.4	16.7	31.6
16	20.6	38.3	68.3	81.4	16	3.7	11.7	31.7	48.3
17	4.9	14.6	37.7	55.8	17	2.0	7.6	22.9	37.4
18	16.4	34.2	67.0	84.2	18	4.6	16.7	49.6	81.2
19	9.9	28.2	70.2	102.5	19	4.5	15.3	43.6	69.2
20	21.4	44.6	87.1	109.6	20	9.9	25.3	58.3	80.8
21	11.9	36.0	93.6	141.0	21	31.8	52.9	86.3	98.3
22	40.3	64.5	101.8	114.2	22	23.6	47.8	91.6	113.9
23	51.7	83.4	132.5	149.5	23	10.9	29.9	72.5	103.9
24	23.7	46.2	85.6	104.4	24	39.8	66.3	108.0	123.3
25	31.9	53.4	87.6	100.0	25	13.8	34.7	78.5	107.8
26	33.7	53.7	84.4	94.4	26	14.3	28.4	53.4	65.4
27	15.6	30.4	56.3	68.4	27	17.6	31.7	55.4	65.0
28	25.7	45.1	76.7	89.2	28	11.2	24.9	51.2	66.0
29	33.9	55.0	87.8	98.9	29	7.6	22.7	58.5	87.0
30	34.2	53.4	82.5	91.4	30	17.6	37.1	73.3	92.6
31	28.5	44.4	68.3	75.5	31	13.9	25.4	44.7	52.6
32	24.0	39.4	63.5	71.6	32	13.9	30.0	60.1	76.5
33	16.1	30.5	55.4	66.5	33	11.7	31.8	76.1	108.4
34	32.9	52.6	82.8	92.6	34	11.9	24.4	47.3	58.7

35	16.0	29.4	52.1	61.5	35	13.2	23.0	39.1	44.8
36	17.4	36.9	73.3	93.0	36	7.2	15.5	31.1	39.2
37	10.7	23.2	46.8	59.5	37	5.7	15.9	39.0	55.9
38	28.9	49.7	83.3	96.2	38	10.2	23.2	48.4	62.9
39	9.8	22.1	45.9	59.4	39	6.7	15.9	34.5	45.6
40	3.7	11.1	28.5	41.8	40	5.8	15.4	36.3	50.6
41	1.3	6.3	22.4	41.0	41	1.6	6.5	20.6	34.6
42	1.1	5.0	17.2	30.5	42	0.6	3.4	14.0	27.8
43	0.5	3.4	17.0	39.3	43	0.3	2.2	11.0	25.3
44	0.2	1.1	4.9	9.4	44	0.2	0.9	3.0	4.3
45	0.2	1.1	4.0	6.5	45	0.1	1.0	6.0	15.1
46	0.1	1.2	7.5	19.8	46	0.1	0.8	6.0	17.6
47	0.6	0.8	1.1	0.2	47	0.0	0.3	0.0	0.0
48	0.5	0.7	0.9	0.0	48	0.0	0.3	0.0	0.0
49	0.2	0.6	1.8	2.0	49	0.3	0.7	1.7	1.4
50	0.1	0.6	3.1	6.7	50	0.1	0.7	3.6	7.8
51	0.1	0.6	3.5	7.9	51	0.2	0.7	2.2	2.8
52	0.4	0.8	1.3	0.6	52	0.6	0.8	1.2	0.3
Annual	1640.0	1686.0	1722.0	2604.4	Annual	1631.2	1847.0	2108.4	2133.3

3.6 Proposed cropping pattern: Crops that are suitable growing in summer season are greengram, aush rice, maize, sesame & Jute. Summer ploughing can be done from 15th SMW for receiving less than 10 mm & can be continued upto 18th SMW. Short duration greengram can be sown from 14-16 SMW as rainfall at 75% level is less than 10 mm & also that at pod initiation & development, sufficient rainfall is available at 16-18 SMW at Unakoti but irrigation is to be provided at West Tripura as it shows less rainfall during that time. Direct seeded aush rice done from 14th SMW as at 75% rainfall probability level rainfall which is available is >10 mm. At critical stages i.e., at 18th SMW (Unakoti) & 20th SMW (West Tripura) onwards at 75% probability level rainfall is >20 mm. Aush rice varieties that are recommended includes NDR-97, MTU-1010 etc. Early varieties of aush can also be done from 10th to 11th SMW. During harvesting period, as rainfall at 75% probability level is >20 mm & 30 mm & so proper drainage is recommended. Maize can also be grown from 14th to 15th SMW & harvested at 28th to 29th SMW. Jute can also be planted from 9th to 21st as districts are likely to get 150 mm to 250 mm rainfall which is required for production of Jute.

Prior to monsoon at 22nd to 23rd week, sowing of direct seed rice in medium & low land can be carried out for better germination by getting 1st monsoon showers and also due to monsoon departure in 39th week onwards medium duration rice in medium land & non paddy crops in upland can be harvested in 41st week. The sowing of aush rice can be advanced upto 14th or 15th week as rainfall at 75% probability is >10 mm which is optimum. In medium land, however rice can be taken of 130 days duration so that vegetables like cole crops can be grown as second crop. Crops like aman rice, kharif greengram, blackgram, sesame, jute found to be good in kharif. Blackgram

& greengram at 38th to 41st SMW with low temperature tolerant varieties can be grown by using residual moisture at critical stages. Surface drainage should be done as when required. Rainfed lowland rice often prone to submergence and so submergence tolerant varieties like Ranjit sub-I, Bahadur sub I etc should be preferred. Late aman rice at 31st to 33rd SMW of short duration can be done & harvested at 41st to 43rd week.

As little chances of rainfall occur after 46th week so no crop is advised after that in upland & medium land. During winter for sowing rabi crops, moisture conservation is essential after ample water harvesting at July to September which can be used as life saving irrigation during critical stages of crop growth. For medium & upland crops like peas, potato, lentil, rabi vegetables along with rapeseed & mustard, sowing can be done from 44th SMW. During critical growth stages (2 - 6 SMW), rainfall at 75% probability level is less than 10 mm & irrigation must be provided. Potato harvesting is to be completed within 13th SMW as from 14th SMW rainfall at 75% probability level is more than 10 mm which is not suitable & rotting occurs. Sowing of vegetable crops like bitter melon, pumpkins are done after harvesting aman paddy using residual moisture. Transplanting vegetables should be done from 41st SMW as at 75% probability level rainfall received is less than 10 mm. For Ginger & turmeric, sowing is to be done from 14th SMW because at 75% probability level rainfall is >10 mm. Also, rabi maize can be grown from 41st to 44th SMW.

4. CONCLUSION

The risk proof crop which can be best suitable for *khari* season are blackgram, greengram in medium and upland, *aman* rice in medium land and late *aman* can be grown in lowland condition. The crops which can be grown in *rabi* season are vegetables like cole crops, tomato, chilli etc along with potato, pea, toria. The crops grown in summer include short duration greengram, *aush* rice, sesame, jute in all land situations while early *aush* can be grown in lowland. Proper irrigation at critical stages recommended at winter season as rainfall is less. Vegetable crops to be sown immediately after harvesting of *aman* paddy to utilize residual soil moisture. Most erratic rainfall occurs in winter season.

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