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Rainfall characteristics of north west alluvial plain zone of Bihar

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ABSTRACT

Rainfall data for the period 1960-2005 is used to analyze the probability of occurrence of deficit /normal / excess rainfall. The mean annual rainfall is 1200 mm with 28 percent variability; with standard deviation of 336 mm. July is the wettest month (average rains- 326.5 mm). Rainfall of August and September months shows lower coefficient variation- 57 percent. Each standard week from 25th to 40th receives a rainfall of more than 40 mm, indicating the crop suitable period from June third week to October 1st week.

Key words: Seasonal rainfall, Gamma probability and weekly probability by Markov Chain

The weather and its variability are well known to the farming community and have great impact on crop production. The economy of the farmer is well influenced by weather. The greatest risk to crop yields in Indian agriculture is attributed to the variability of seasonal rainfall and the uncertainty in the amount and its distribution in a given season. Rainfall pattern largely decides the crop planning in dry farming tracts. Amount, distribution and intensity of rainfall mainly determine the choice of any particular crop species and agronomic practices. Scientific study on the quantum and distribution of rainfall if made would enable the farming community to adjust or modify the cropping programme as well as the cultural operations. Hence, a study was undertaken at RAU, Pusa to understand the rainfall climatology for crop planning purpose.

MATERIAL AND METHODS

The basic data used comprises of daily rainfall data pertaining to Agromet observatory, RAU, Pusa (Samstipur) for the period 1960-2005 collected from India Meteorological Department, Pune. The station is located at 25°98'N latitude, 85°67'E longitude with altitude of 25 meters above MSL. The data were aggregated as annual, seasonal, monthly and weekly rainfall. The mean rainfall, standard deviation and coefficient of variation for annual, seasonal, monthly and weekly periods were worked out as described by Deka *et al.* (2000). The annual, seasonal rainfall was classified based on IMD (Indian Meteorological Department) specification as normal

The number of deficit, normal and excessive rainfall or flood months and weeks in a year were listed in descending order of magnitude and probability analysis were carried out by using Weibell's formula, (Chow, 1964)

$$P = m/(n + 1).$$

Where P is plotting positions percent, m is the rank of magnitude and n is the total no. of years for which analysis was carried out. Rainfall probability analysis was based on first order Marko chain as suggested by Virmani *et al* (1980 and1982).

The weekly probability of rainfall was estimated using Marko chain probability model for receiving 20 and 30 mm rainfall in a given week and results are reported for initial and conditional probabilities of a wet week, P (W) followed by a wet week, P (W/W).

RESULTS AND DISCUSSION

Annual rainfall

The daily rainfall data for the period from 1960-2005 was analyzed and the results presented under different heads for mean, standard deviation and coefficient of variation (%) of annual and monsoon rainfall and the percent deviation of monsoon vis-a-vis annual rainfall are shown in Table1.

However, monsoon rainfall deficiency might have caused a crop failure due to deficit during the crucial monsoon months. That is why we have considered both situations in our study. During the study period of 46 years, there were about (12 years) 26 percent deficit, (9 years) 20 percent excessive and (25 years) 54 percent normal years. Also in the monsoon period of 46 years, there were about 28 percent of deficit, 24 percent of excessive and 48 percent of normal occurrences. The annual rainfall was lowest (498 mm) in 1992 and the southwest monsoon rainfall was lowest (409 mm) in the same year (Fig.1). The mean annual rainfall was 1200 mm with coefficient of variation of 28 percent and standard deviation is 336 mm. The annual rainfall was highest (2080 mm) in the year 1974. A rainfall amount of 498 mm would be expected with 100 percent probability while 1007 mm, 1219 mm and 1366 mm of rainfall would be expected

Table 1: Characteristics and classification of rainfall at Pusa (1960-2005)

Year	Starting Week	Ending Week	Duration Week	Annual Rainfall (mm)	SW RF (mm)	Category of SW	SD (mm)	Coefficient variation (%)
1960	25	40	15	903	765	Deficit	98.7	131
1961	24	51	27	1362	770	Deficit	152.3	134
1962	25	40	15	1510	1425	Excess	188.7	150
1963	25	44	19	1676	1423	Excess	191.7	137
1964	25	41	16	1070	870	Normal	121.2	136
1965	30	40	10	937	895	Normal	128.6	165
1966	26	46	20	735	489	Deficit	55.0	90
1967	28	40	12	1007	894	Normal	150.5	179
1968	24	44	20	1023	849	Normal	120.7	142
1969	26	45	19	1351	1139	Normal	148.8	132
1970	25	39	14	769	608	Deficit	75.6	118
1971	25	41	16	1532	1164	Normal	138.0	108
1972	29	48	19	696	561	Deficit	89.8	155
1973	25	46	21	1219	914	Normal	104.9	103
1974	25	43	18	2080	1854	Excess	268.7	155
1975	26	41	15	1017	867	Normal	113.0	133
1976	24	40	16	1827	1566	Excess	211.5	139
1977	26	52	26	1132	757	Deficit	120.1	127
1978	25	40	15	1131	789	Deficit	95.4	101
1979	25	51	26	1226	1060	Normal	177.6	174
1980	25	42	17	1289	1121	Normal	162.5	151
1981	26	38	12	1784	1624	Excess	234.1	158
1982	23	45	22	765	688	Deficit	89.9	141
1983	25	52	27	937	807	Normal	104.9	134
1984	23	38	15	1344	1197	Excess	154.9	138
1985	25	42	17	1426	1141	Normal	143.3	121
1986	26	51	25	939	678	Deficit	90.7	116
1987	25	39	14	1615	1575	Excess	222.6	165
1988	24	52	28	1195	1072	Normal	127.2	128
1989	25	52	27	1402	1218	Excess	227.2	195
1990	25	39	14	1146	1067	Normal	158.1	166
1991	25	52	27	943	789	Deficit	100.6	128
1992	28	41	13	498	409	Deficit	60.7	146
1993	26	44	18	1147	916	Normal	129.8	136
1994	27	47	20	748	632	Deficit	86.2	138
1995	25	52	27	1336	1209	Excess	198.5	178
1996	23	40	17	1136	946	Normal	126.6	134
1997	26	50	24	1287	1117	Normal	151.7	141
1998	26	46	20	1521	1298	Excess	174.3	138
1999	25	42	17	1366	1124	Normal	147.9	130
2000	23	40	17	1250	1016	Normal	122.3	117
2001	25	41	16	1665	1254	Excess	154.1	111
2002	25	41	16	1141	991	Normal	137.1	144
2003	25	43	18	1410	1056	Normal	119.2	101
2004	25	37	12	1066	829	Normal	145.6	164
2005	25	43	18	643	533	Deficit	70.5	132
Average	25	44	19	1200	999			
SD (mm)				336	315			
CV(%)				28	32			

with 75, 50 and 25 percent probability. The deficits are less frequent on annual basis as compared to those on seasonal basis.

Seasonal rainfall

The mean rainfall of 999.3 mm is received in *kharif* season (Table 2) contributing 83 percent to total annual

Table 2: Seasonal rainfall at Pusa

Season	Rainfall				Rainy days		
	Mean	Percent of annual rainfall	SD (mm	coefficient variation (%)	Mean	SD Days	coefficient variation (%)
Winter (December to February)	24.3	2	21.7	89	2.3	1.8	79
Summer (March to May)	91.6	8	55.2	60	5	3.6	71
Kharif (June to September)	999.3	83	315.2	32	42	6.3	15
Post monsoon (October to November)	84.9	7	91.3	108	4	2.5	63

Table 3: Monthly rainfall at different probability levels by Gamma method at Pusa.

Month	Normal rainfall (mm)	Rainfall (mm) for the probability (%)				
		90	75	50	25	10
January	11.1	0.7	2.5	7.3	16.7	29.9
February	13.2	0.9	3.1	8.8	19.6	34.6
March	7.6	0.4	1.6	5	11.8	21.5
April	18.7	0.9	3.6	11.4	27	49.6
May	65.3	8.5	21.3	48	91.8	148.4
June	156.2	45.7	98.5	156.2	216	268.8
July	326.5	120.7	218.7	326.5	436.4	534.3
August	291.5	75	178	291.5	406.9	510
September	225	80.6	128	200.4	296.4	404.8
October	71.1	3.4	13.3	41.8	99	181.1
November	8.2	0.2	1	4.3	12.2	24.7
December	5.7	0.3	1.2	3.8	9.1	16.9

rainfall with coefficient of variations of 32 percent and standard deviation of 315 mm indicating its dependability. For post monsoon season the mean rainfall is 84.9 mm and contributes 7 percent to the total annual rainfall with coefficient of variation of 108 percent and standard deviation of 91.3 mm. Summer rainfall also contributes substantial amount of 91.6 mm and contributes 8 percent to the total.

Monthly rainfall

The monthly rainfall probability at 10, 25, 50, 75 and 90 percent confidence level was computed using incomplete Gamma distribution and results given in Table 3. At 75 percent confidence level, 98.5 mm rainfall occurred during the month of June, while at 50 percent it was 156 mm. Therefore, the rainfall at least assured level should be utilized for growing rainy season crop like direct sown rice, maize, cowpea, pigeonpea, black gram, etc. Maximum amount of rainfall occurred during July, i.e. 219 mm and 327 mm at 75 percent and 50 percent probability level respectively.

Weekly probability

The initial P (W) and conditional P (W/W) probability were worked out using Markov chain model for Pusa region (Table 4). Study revealed that initial and conditional probability of getting 20 and 30 mm rainfall were more than those at 50 percent. The probability of receiving 20 mm or more rainfall exceeded 50 percent in 25th week and continued till 39th week. Initial probability of getting 20 mm rainfall was less than 50 percent till 24th week, implying that rainfall incidence was not dependable during that period. In this zone, the probability exceeded the dependable level of 50 percent during the second week of June after the onset of monsoon.

The conditional probability, P (W/W) of occurring 20 and 30 mm and pattern of rainfall was almost same like initial probabilities in Table 4. The Markov chain model has been extensively used to study spell distribution and other properties of rainfall occurrence (Gabriel *et.al.* 1962, Singh and Bhandri 1998 and Gouranga Kar 2002).

This higher amount of rainfall at 75 percent confidence level could be utilized for rice transplanting starting from the first fortnight of July. Another advantage of growing these crops in the first fortnight of June was that these could be harvested within October and another crop like sesame, horse gram, green gram, mustard, maize crops could be sown immediately utilizing rainfall of October. Since the winter rainfall was uncertain, residual moisture in medium and low land could be utilized for growing second crop under rainfed conditions. High value winter crops could be grown only with supplemental irrigation during winter season, starting

Table 4: Weekly rainfall (mm) at different probability levels by Markov Chain at Pusa.

Week	Mean rainfall (mm)	20 mm			30 mm			SD	Coefficient variation (%)
		P(W)	P(W/W)	P(W/D)	P(W)	P(W/W)	P(W/D)		
20	14.1	0.24	0.36	0.20	0.17	0.22	0.16	27.5	195
21	21.8	0.41	0.45	0.40	0.33	0.50	0.29	28	128
22	14.6	0.26	0.32	0.22	0.17	0.13	0.19	19.5	134
23	22.1	0.30	0.25	0.32	0.26	0.25	0.26	31.7	143
24	28.6	0.46	0.36	0.50	0.37	0.33	0.38	33.7	118
25	52.3	0.70	0.71	0.68	0.63	0.71	0.59	48.8	93
26	62.9	0.65	0.69	0.57	0.52	0.52	0.53	67.3	107
27	75.1	0.72	0.73	0.69	0.63	0.63	0.64	74	99
28	74.8	0.76	0.79	0.69	0.65	0.69	0.59	73.4	98
29	75.8	0.83	0.86	0.73	0.70	0.70	0.69	71.6	94
30	64	0.72	0.71	0.75	0.63	0.63	0.64	63.5	99
31	68.7	0.76	0.79	0.69	0.67	0.66	0.71	61.9	90
32	60	0.67	0.63	0.82	0.59	0.55	0.67	62.4	104
33	69.3	0.76	0.90	0.47	0.63	0.85	0.32	71.9	104
34	75.2	0.76	0.74	0.82	0.63	0.66	0.59	88.8	118
35	54.1	0.76	0.83	0.55	0.59	0.62	0.53	44.5	82
36	64.3	0.70	0.71	0.64	0.54	0.59	0.47	67.1	105
37	52.7	0.67	0.81	0.36	0.61	0.68	0.52	51.9	99
38	46.5	0.61	0.65	0.53	0.48	0.54	0.39	67.1	144
39	47.5	0.54	0.50	0.61	0.46	0.41	0.50	59.6	125
40	42.8	0.46	0.52	0.38	0.35	0.33	0.36	84.1	197
41	14.2	0.20	0.14	0.24	0.17	0.13	0.20	25.9	183
42	10.6	0.07	0.11	0.05	0.07	0.13	0.05	31.4	297
43	3.1	0.07	0.00	0.07	0.04	0.00	0.05	10.3	335
44	2.7	0.02	0.00	0.02	0.02	0.00	0.02	8	293

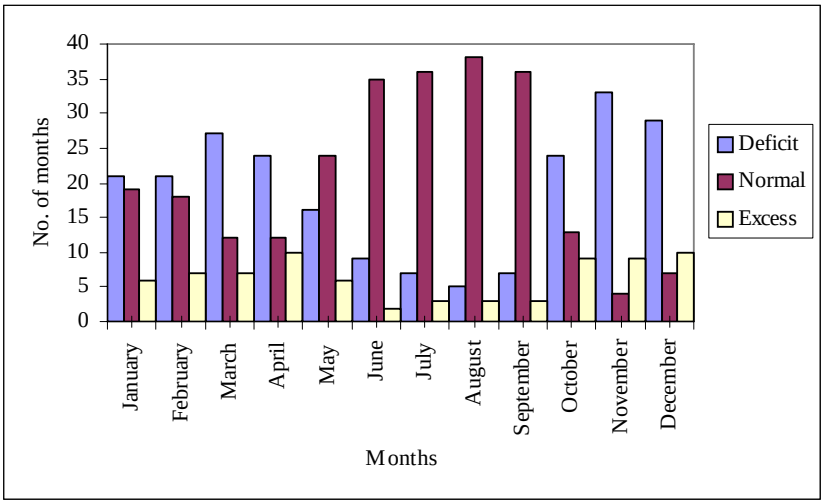

Fig.1: Relation between deficit, normal and excess rainfall months at Pusa region.

from the first week of November.

Mean and expected weekly rainfall at different probability level (Table 4) showed that from 25th SMW onwards the rainfall was recorded within the range of 52.3 mm to 75.8 mm per week and contributed up to 37th SMW. That 29th week has the highest rain, contributing 75.8 mm and 37th week recorded the lowest rainfall of only 52.3 mm.

At 50 percent chances rainfall is assured in 24th week. Rainfall more than 20 mm per week occurs from 25th to 39th week at 70 percent probability.

Seed sowing in nursery Pusa region generally takes places immediately after initiation of monsoon (23-25 week) and transplanting is carried out around 28th or 29th week. The tillering, 50 % flowering and dough stage are observed during 33-34th week, 35th –36th and 40-41st week respectively.

Crop planning

The long duration photosensitive rice varieties like Santosh, Satyam, Tulsi, Sarla and Rajshree can be sown in lowland of this region by direct seeding during 20th to 23rd week, as rain received during this period is sufficient for land preparation and sowing of rice crop. While, the sowing of upland rice varieties of 100-105 days duration like Sita, Pusa-44, Pusa basmati and IR-36 etc. can be done during 24th week as early monsoon rain. A second crop of mustard, sesame, rai, green gram etc can be taken after harvest of rice crop during last week of October. The 31st, 34th and 39th weeks would be tillering, panicle initiation and maturity respectively. The transplanting of paddy should be completed in the last month of July. There is scope for water harvesting in on farm reservoir during the 27th to 35th week.

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