Journal of Agrometeorology 11 (1): 42-46 (June 2009)

Rainfall variability and probability for crop planning at Madhepura in Bihar

SUCHIT K RAI and K A SINGH
Indian Grassland and Fodder Research Institute, Jhansi-284003
Email: Suchitrai67@yahoo.co.in

ABSTRACT

Daily rainfall data of thirty years (1974-2004) have been analyzed for establishing the long term averages of weekly, monthly, seasonal and annual rainfall and its variability. July receives maximum rainfall of 386.5 mm followed by August (330.6 mm). The stable rainfall period was of 13 weeks spread over 25 to 37th standard meteorological weeks (SMW). The probability of receiving 10 and 20 mm of average weekly rainfall during 25 to 39th SMW exceeds 70%. At 75% probability level rainfall of 45.8 mm can be expected to occur during the month of May that can be utilized for summer ploughing or seedbed preparation for raising rice seedlings; maize sowing may be advanced to last week of April to first week of May. Sowing of jute and other crops (cowpea, groundnut, pigeon pea, black gram, direct sown rice etc) could also be performed in this region.

Key Words: Rainfall pattern, initial and conditional probability, crop planning

Rice (Oryza sativa L.) is an important crop of Bihar and it is grown over 3.67 M ha under rainfed situations followed by wheat and maize. Rainfall is the main limiting factor affecting crop productivity. Therefore, its amount, time of occurrence, and spatial variability controls the agricultural practices adopted in the region. Occurrence of continuous dry spell in monsoon season is a common phenomenon. Hence, the probability analysis of occurrence of initial wet and dry spells as well as conditional probabilities of wet followed by dry, dry followed by wet and dry followed by dry, may be utilized for minimizing risk factor due to weather in crop cultivation. The Markov chain model has been extensively used to study the probabilities of rainfall occurrence (Gaberial and Newman,1962; Kar 2002, Jat *et al.* 2003). Also in most of the studies, the workers (Mahale and Dhane, 2003; Rana and Thakur,1998) have suggested the cropping pattern considering the rainfall amount at different probability levels.

Victor *et al.* (1991) analyzed the weekly rainfall data of 21 districts of Andhrapradesh for contingency crop planning. Panigrahi (1998) used Markov chain model to study the probability of dry and wet spells at different coastal stations of Orissa. Gupta *et al.* (1975) suggested that the rainfall at 80% probability could safely be taken as assured rainfall, while 50% probability is the medium limit for taking risk. In this paper an attempt has been made to analyze temporal and spatial rainfall variability on weekly, seasonal and annual basis. Probability of occurrence of dry and wet spell and their distribution was also analysed

MATERIAL AND METHODS

The daily rainfall data for the period of 30 years (1974-2004) have been collected from the meteorological observatory situated at Indian Railway Station (IRS), Madhepura (25.93° N latitude and 86° E longitude) in north Bihar for analysis. Weekly, monthly and seasonal rainfall distribution pattern were critically examined and analyzed adapting procedure suggested by Panse and Sukhatme (1985). The weekly initial and condition probabilities of rainfall was estimated using Markov Chain process for receiving 10 and 20 mm rainfall in a given week. Also, probabilities of consecutive two and three dry or wet weeks have also been estimated by Markov-Chain process. The first order Markov chain model is given as the number of occasions the weekly rainfall of week 'i' (R_i) is greater than or equal to a threshold limit 'x'. Monthly probability of rainfall amount expected at 90%, 75%, 50% and 25% and 10% confidence level was computed using incomplete Gamma distribution (Thom, 1958). The probability density function of the gamma distribution is given by

$$f(x) = ë^n x^{(n-1)} \exp(-ëx)/ (n-1)!$$

Where, ë and n are scale and shape parameters.

RESULTS AND DISCUSSION

Annual and seasonal rainfall

The mean annual rainfall of Madhepura is 1546.3 mm (range: 903 to 2274 mm) spread over 84 rainy days with a standard deviation (sd) of 385.6 mm and coefficient of variation (cv) 24 percent. Out of 30 years, 15 years received deficit of rainfall from normal (Fig.1) in the range of 6 (in 1976) to 41 percent (in 1975). Since, 1995 onwards, it is evident that none of years has experienced drought (rainfall deficiency is not more than 20. percent from normal). Maximum number (six) of years experienced moderate (deficiency, 20-30 percent from normal) to large (deficiency,

Table 1: Characteristics of seasonal rainfall at Madhepura

Season	Particulars	Lowest (mm)	Highest (mm)	Mean (mm)	Standard Deviation (mm)	Coefficient of variation (%)
Annual	Rainfall	903.0	2274.2	1546.3	385.6	24.9
	Rainy days	56	126.0	84.0	18.3	21.8
SW Monsoon (Jun-Sep)	Rainfall	665.5	2025.9	1225.1	344.0	28.1
	Rainy days	36	96.0	62.0	13.5	21.7
N-E Monsoon (Oct-Dec)	Rainfall	0	366.4	115.0	93.3	81.1
	Rainy days	0	39.0	7.0	6.8	97.2
Winter (Jan-Feb)	Rainfall	0	89.8	27.3	25.9	94.9
	Rainy days	0	7.0	2.4	2.2	93.8
Pre Monsoon (Mar-May)	Rainfall	0	427.8	178.9	93.4	52.2
	Rainy days	0	25.0	12.0	6.0	50.4

Table 2: Monthly mean, highest and lowest rainfall (number of rainy days) along with SD and CV at Madhepura

Month	Lowest (mm)	Highest (mm)	Mean (mm)	Standard deviation (mm)	Coefficient of variation (%)
January	0.0 (0)	72.9 (6)	15.9 (1.2)	18.4 (1.5)	116 (125)
February	0.0 (0)	40.0 (4)	11.4 (1.1)	13.1 (1.3)	115(119)
March	0.0 (0)	91.2 (6)	20.5 (1.5)	29.1 (1.8)	142 (121)
April	0.0 (0)	110.3 (7)	38.7 (2.8)	32.2 (2.1)	83 (76)
May	0.0 (0)	246.4 (20)	119.6 (8.1)	38.4 (4.7)	57 (57)
June	0.0 (0)	512.3 (25)	241.8 (13.2)	124.7 (5.5)	52 (41)
July	140.7 (10)	735.3 (27)	386.5 (17.8)	149.4 (4.9)	39 (27)
August	160.6 (8)	592.3 (25)	330.6 (17.4)	137.0 (4.7)	41 (27)
September	103.3 (5)	1074.9 (29)	266.2 (13.7)	193.4 (5.4)	73 (40)
October	0.0 (0)	366.4 (17)	91.2 (5.2)	85.2 (3.2)	93(62)
November	0.0 (0)	147.7 (9)	12.0 (0.9)	30.5 (1.8)	253 (205)
December	0.0 (0)	73.8 (13)	11.8 (1.3)	17.3 (2.5)	146 (189)

30-40 percent from normal) intensity of drought during the period 1982 to 1994. Rainfall deficiency was more than 38 percent in the years 1986 and 1989. Since last 30 years, no disastrous (rainfall deficiency is more than 50% from normal) drought occurred at Madhepura. The 1975 drought was one of severe droughts, with rainfall deficiency of 41 percent. An increasing trend in annual rainfall was observed over the 30 years (Fig. 1). Mean annual rainfall during Southwest (SW) monsoon season (June to September) at Madhepura was 1225.1 mm that accounted for 79 % of the total annual rainfall. The number of rainy days during SW monsoon season varied from 36 to 96 days with an average of 62 days (Table 1).

Rainfall during pre monsoon season (March to May) contributed 12 percent of the annual rainfall. Mean rainfall during this season was 178.9 mm received in 12 rainy days with a standard deviation of 93 mm and cv of 52 percent. The pre-monsoon showers during this season triggered early start of the *kharif* season. The contribution of winter and NE monsoon was only 7.0 and 2.5 percent to the annual rainfall, respectively (Table 1).

Monthly and weekly rainfall

The highest rainfall of 386.5 mm received during July occurred in 17.8 rainy days followed by August (330.6 mm) and September (266.6 mm). Mean monthly rainfall, its extreme, their standard deviation and coefficient of variation showed that highest and lowest monthly rainfall of 1074.3 and 160 mm was recorded in the month of September and August respectively (Table 2).

Mean weekly rainfall during 25th to 40th standard meteorological week (SMW) varied from 46.5 (40th SMW) to 103.2 mm (29th SMW). The first peak appeared during 28th SMW with rainfall of 101.3 mm, and second peak during 29th SMW with rainfall of 103.1mm (Fig 2). Lowest variability (7.3%) during the period was observed in 25th SMW. Coefficient of variation during 25 to 37th SMW was less than 100%. However, the second fortnight of September (38 and 39th SMW) and first week of October (40th SMW)

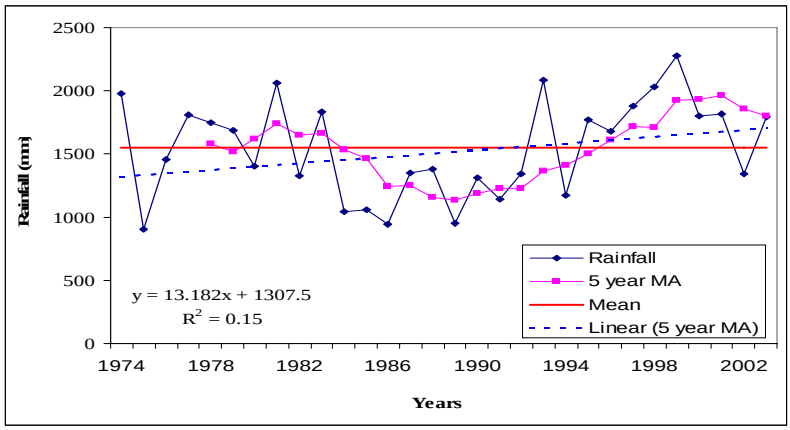

Fig 1: Annual march of rainfall along with 5 year moving average and its trend at Madhepura

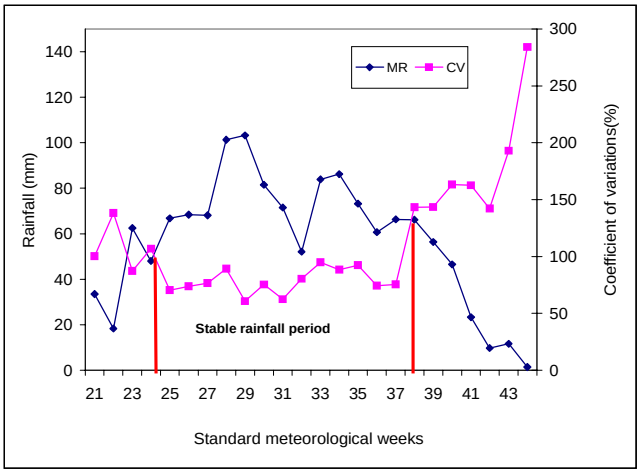

Fig 2: Mean weekly rainfall (MR) pattern at Madhepura

showed higher rainfall variability in the range of 143.2 to 163.2%. Mean weekly rainfall shows that 25 to 37th SMW are considered as a stable rainfall period since, mean weekly average rainfall is greater than 50 mm and corresponding CV is less than 100 %. Thus, the total average growing period is of 13 weeks at Madhepura.

Weekly rainfall probabilities and crop planning

During the premonsoon season (19th to 24th SMW), the data (Fig 3a) reinforce that the initial, (P(W) probability of getting rainfall of 30(40)mm/ week ranged from around 23 (17) to 70 (50) percent. The conditional probability of wet week preceded by wet week , P (W/W) for both 30 and 40 mm rainfall exceeds by 30 % in each week (Fig 3b) during 25 to 39th SMW. Thus it is evident from initial probability of 30 mm that the rainfall in the monsoon period extending from 25-37th SMW is dependable both in the early as well as later part of the season. In general there is a high probability of the season to be dry in the post monsoon period, once the recession of monsoon rains took place. Some rains (10 mm about 1 in 2 years) has tendency to occur during 40 to 43rd SMW. The probabilities of occurrence of two and three consecutive wet weeks at different levels of rainfall are presented in Fig 4(a and b). The probability of two consecutive wet weeks with 20 mm rainfall exceeds 70 % during 25 to 34th SMW except in 26th and 32 SMW.

Rainfall of 45.8 and 158.7 mm at 75% probability level can be expected to occur during the month of May and June respectively. Hence, Madhepura has good potential for growing early *kharif* maize crop. Maize sowing may be advanced to last week of April to first week of May, as 45.8 mm rainfall is considered sufficient to raise maize crop. These pre-monsoon rains can be utilized for summer ploughing or seedbed preparation as well as raising rice seedlings. The long duration photo sensitive rice varieties like Sarala, Durga, Sabatri and Gyatri can be sown in lowland by direct seeding during 20 to 22nd (20-30, May) as rain

Table 3: Monthly expected amount of rainfall at different levels of probability at Madhepura

	Rainfall (mm) at different levels of probability(%)					Normal
Month	90	75	50	25	10	
January	1.1	3.7	10.5	23.4	41.2	11.4
February	0.6	2.4	7.3	17.1	31.0	20.5
March	0.5	2.8	10.8	29.0	56.8	38.7
April	3.1	9.7	25.8	55.0	94.8	119.6
May	21.0	45.8	93.0	165.9	256.8	241.8
June	83.0	158.7	241.8	327.0	402.7	386.5
July	196.0	286.7	386.5	488.2	578.9	330.6
August	156.0	239.2	330.6	424.0	507.1	266.2
September	101.4	156.7	239.6	347.8	469.0	91.2
October	13.3	31.6	68.3	127.4	202.7	12.0
November	0.1	1.1	5.5	17.0	35.9	11.8
December	0.4	1.9	6.8	17.4	33.1	15.9
Annual	1072.9	1269.3	1514.6	1789.7	2063.7	1546.3

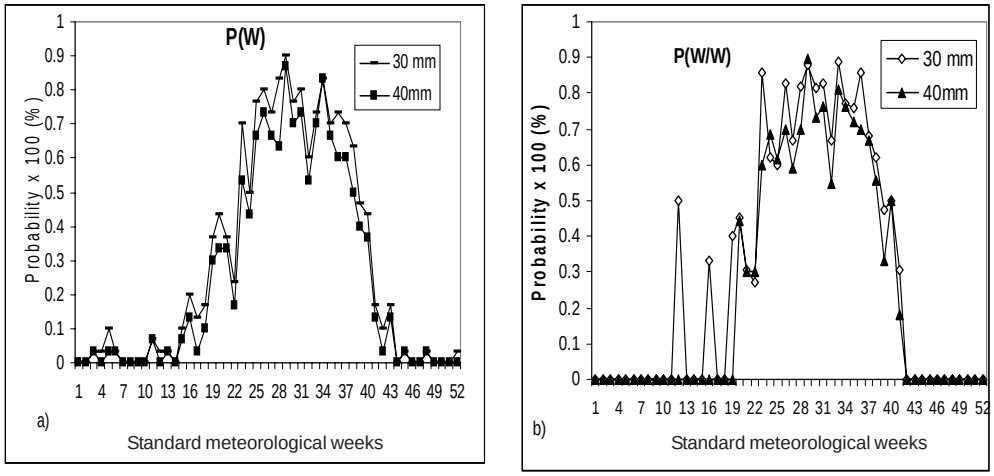

Fig. 3: a) Initial P(W) and b) conditional P (W/W) probability at different limit of rainfall at Pusa

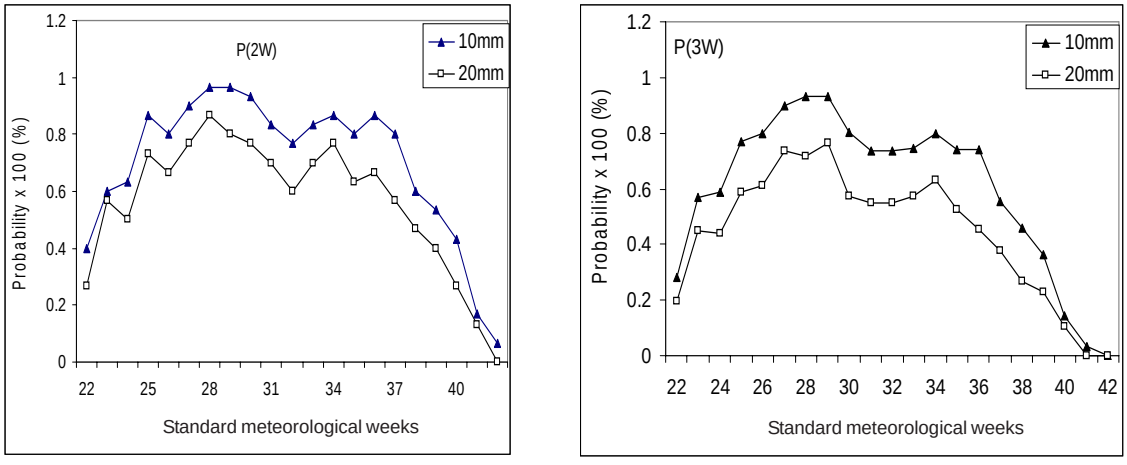

Fig. 4: Probability a) 2 consecutive wet spell weeks and b) 3 consecutive wet spell weeks during monsoon months at Pusa

occurring during this period would be sufficient for land preparation and sowing of rice crops. While, the sowing of upland rice varieties of 90-105 days duration can be done during 24th SMW (middle of June) as early monsoon rain may help for quick establishment of rice crop. Also higher amount of rainfall at 90% probability level can be utilized

for rice transplanting starting from second fortnight of July, which will have additional advantage of almost assured water supply through rain during July to September. .

Sowing of jute and other crops (cowpea, groundnut, pigeon pea, black gram, direct sown rice etc) could also be performed in this region. Intercropping of rice + pigeonpea and groundnut + pigeonpea etc., in the uplands can be done during this period. While the transplanting of rice crop under favorable shallow lowland should be completed before middle of July (because of high intensity of rain that generally occur afterwards from 30 to 33rd SMW) may hinder the establishment of rice crop. Besides this, the less water demanding crops such as finger millet, fox tail millet; *kodon* etc could also be taken successfully. Early sowing may help in escaping the risk of flood by taking catch crops in early *kharif* season. Since the winter rainfall is uncertain and erratic, residual moisture and lowland area can be utilized for growing a second crop under rain fed conditions. Wheat may be grown only with assured irrigation during *rabi* season starting from first week of November. A second crop of horse gram or mustard can be taken immediately after the harvest of upland rice during second fortnight of October. The excess rain water may be utilized by adopting and integrated rice – fish integrated farming system model through in situ water (Sinhababu,1977)

REFERENCES

Gabriel K R and Neuman I. (1962). A markov chain model for daily rainfall occurrences at Tel Aviv. *Quart. J.roy. Meteorol Soc.,* 88:90-95.

Gupta R K, Rambabu and Tejawani K G. (1975). Weekly rainfall of India for crop planning programme. *Soil Cons.Digest,*3:31-39.

Jat M L , Singh Rajvir, Kumpawat B S and Balyan J K. (2003). Rainy season and its variability for crop planning in Udaipur region. *J. Agrometerol.,* 5(2):82-86.

Kar G. (2002). Rainfall probability analysis for sustainable production strategies in coastel Orissa. *J. Agrometerol.,* 4(2):181-185.

Mahale D and Dhane S S. (2003). Rainfall analysis in relation to paddy crop in coastel saline soils at panval. *J. Agrometerol.,* 5(1):89-92.

Panigrahi B. (1998). Probability analysis of short duration rainfall for crop planning in coastal Orissa. Ind. *J. Soil Cons.* 26 (2):147-152.

Panse R S and Sukhatme P V. (1985). Statistical methods for agriculture workers. Indian Council of Agricultural Research, New Delhi.14-33.

Rana R S and Thakur D R.(1998). Rainfall analysis for crop planning in Kullu Vally, Himachal Pradesh, *Ind. J.Soil Cons.,* 26(2):144-146.

Sinhababu, D.P. (1977). rice-fish- an integrated farming system for waterlogged lowland. Information Bulletien, Directorate of Extension, MoA,Govt. of India. Pp 1-13.

Thom H C S. (1958). A note on the gamma distribution . *Mon. Weath.Rev.,* 86 (4): 11-13.

Victor U S , Ramana Rao B V, Srivastava N N and Vijaykumar P. (1991). Rainy season and its variability for crop planning in Andhra Pradesh. *Indian J. Dryland Agri. Res. & Dev.,* 6(1&2):1-12.

Received : March 2008; Accepted : January 2009