*Journal of Agrometeorology 10(2) : 198- 203 (Dec. 2008)*

# Rainfall distribution pattern and crop planning at Pusa in Bihar

**K. A. SINGH , A. K. SIKKA and SUCHIT K. RAI[1]**

*ICAR Research Complex Eastern region WALMI, Complex Phulwari Sarif , Patna -801505*

*[1]Indian Grassland and Fodder Research Institute, Jhansi-284003*

*Email: Suchitrai67@yahoo.co.in*

## ABSTRACT

Daily rainfall data of fifty two years (1952-2004) have been analyzed for establishing the long term averages of weekly, monthly, seasonal and annual rainfall and its variability. The annual rainfall at Pusa was 1222.3 mm and coefficient of variability indicated that rainfall was more or less stable over the years. Monthly rainfall had unimodel peak, July receives maximum rainfall of 331 mm followed by August (298.5 mm). The stable rainfall period was of 9 weeks, which spread over 27 to 37$^{th}$ standard meteorological weeks (SMW) except 32$^{nd}$ and 34$^{th}$ SMW. The average duration of rainy season is from 26 to 40$^{th}$ SMW. The initial and conditional probability of receiving 10 mm and 20mm weekly rainfall revealed that dependable rainfall occurs between 25 to 37$^{th}$ weeks. At 75% probability level rainfall of 9.5 mm can be expected to occur during 25$^{th}$ week. These pre-monsoon rains at 75 % probability level can be utilized for seedbed preparation for raising rice seedlings. Since, at 50% probability level, rainfall during 22 to 24$^{th}$ SMW ranges from 8.8 to 13.8 mm, thus summer crops (cowpea, black gram, green gram, maize and direct sown rice etc) could also be grown successfully in this region with supplemental irrigation.

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

Among all weather parameters, rainfall is primary source of water and is the main consideration for raising the crops particularly in rainfed condition. Understanding of the time and spatial variability of rainfall is essential for improved crop production. Weekly rainfall data can be used for determining (i) date of start (ii) date of cessation (iii) length of the rainy season. Occurrence of continuous dry spell in monsoon is common phenomenon.. It is well known that the crop development is affected if the dry spells coincide with the sensitive phenological stages of the crop. The probability analysis of occurrence of wet and dry spells is essentially required for successful crop planning, development of suitable agro-techniques, recommendation of suitable crop varieties, design of water harvesting tanks, earthen dams and other soil conservation structures. Victor *et al.* (1991) analyzed the weekly rainfall data of 21 districts of Andhra Pradesh for contingency crop planning. Pandarinath (1991) used Markov chain model to study the probability of dry and wet spell in terms of the shortest period like week. The Markov chain model has been extensively used to study the probabilities of rainfall occurrence (Gaberial and Newman,1962; Victor and Sastry, 1979; Kar 2002, Jat *et al.* 2003). Also in most of the studies the workers ( Srivastava *et al.* 1998; Mahale and Dhane, 2003; Rana and Thakur,1998) have suggested the cropping pattern considering the rainfall amount at different probability levels. Gupta *et al.* (1975) suggested that the rainfall at 80% probability can safely be taken as assured rainfall, while 50% probability is the medium limit for taking risk. In view of this, an attempt has been made to analyze the rainfall data of Pusa, Bihar for evolving rainfall based cropping system.

## MATERIAL AND METHODS

The daily rainfall data of 52 years (1953-2004) were collected from the Meteorological observatory at ICAR Research Complex for Eastern Region (erstwhile Central Tobacco Research Institute Station) located at 25.98$^0$ N and 85.670$^0$ E at Pusa, Samastipur for analysis. Weekly, monthly and seasonal rainfall distribution pattern were computed. The start and end of rainy season were computed by forward and backward accumulation of weekly rainfall data (Morris and Zandstra,1979). In forward accumulation method, weekly rainfall was summed (17 +18+….52) until 100 mm rainfall is accumulated. If this process is repeated for along period, then the probability of onset of rainy

season will be determined for each week. The end of rainy season was determined by backward accumulation of rainfall (52+51…+ 40 weeks) data. Accumulation of 30mm rainfall was chosen to compute end of rainy season. The initial probability of wet week, P(W) and conditional probabilities of a wet week followed by wet week, P(W/W) were estimated using Markov-Chain model for receiving 10 and 20 mm rainfall . Also, probability of consecutive 2 and 3 wet weeks for 10 and 20 mm rainfall level have been estimated by process. The weekly probabilities of rainfall at 75, 60, 50 and 25% confidence level were also worked out with help of Weibull formula.

$$P= (m/N+1)*100$$

Where, P is plotting percentage, N is the total numbers of years and m is the rank of observed rainfall values when arranged in descending order of magnitude.

## RESULTS AND DISCUSSION

### *Annual rainfall*

The mean annual rainfall was 1222.3 mm spread over 55 rainy days with standard deviation (SD) of 328.4 mm and coefficient of variation (CV) of 26.9% . The maximum annual rainfall (1978.7 mm), recorded in the year 1974, and was 61.8 percent above normal and occurred in 65 rainy days. The lowest rainfall of 509.3 mm was recorded in the year 1992 in 38 rainy days and was 58.3 percent below normal. During the reported period, in 24 years the rainfall was above normal and in 28 years it was below normal. The number of rainy days per year ranged from 38 to 79 days (SD: 8.9 days; CV :16.2% )

### *Seasonal rainfall*

Southwest (SW) monsoon season (June to September) contributes 83 % of annual rainfall. Rainfall during this period varied between 419 mm in 1992 to 1750 mm in 1974 with mean value of 1020 mm at Pusa. The SD and CV of SW monsoon rainfall was 313 mm and 31%, respectively. Mean number of rainy days during SW monsoon season was 43 days with SD of 68 days and CV of 16 %. Total amount of rainfall received during Northeast monsoon season (October to December) was 7.0% of the annual rainfall. The mean rainfall during this period was 85.3 mm with a SD of 94 mm. High degree of variability (CV: 110.1%) was found during NE monsoon season. Pre -monsoon season (March to May) contributed 7.1% (86.6 mm) of the annual rainfall. Variability (CV: 56.3 %) in rainfall during pre-monsoon season was lower than NE monsoon season. Mean annual rainfall during winter season (Jan and Feb) was 30.5 mm during 2 rainy days. The winter rainfall contributed 2.5% to the annual rainfall and varied from 0 to 121 mm (2003) with SD and CV of 30 mm and 30 %, respectively.

### *Monthly rainfall*

Rainfall quantum and distribution during different months are shown in Fig. 1. It is evident that monthly rainfall had unimodal peak. July receives maximum rainfall of 331 mm distributed in 13.6 rainy days followed by August (298.5 mm) in 12.4 rainy days. Monthly rainfall during October to May remained lowest in the range of 4.8 to 72.4 mm, however highest rainfall of 811.6 mm was recorded during July.

### *Weekly rainfall*

Mean weekly rainfall distribution at Pusa showed that it has four peaks (Fig.2). At least two distinct sets of weeks are evident i.e from 41$^{st}$ to 23$^{rd}$ week; the weekly rainfall is below 20 mm. The total average rainfall during this period is 151.4 mm. In another set (24 to 40$^{th}$ week), there is a quantum jump in rainfall amount during 24$^{th}$ SMW (11-17, June) and a value of more than 30 mm per week is maintained up to 40$^{th}$ week (1-7, Oct).

### *Stable rainfall Period*

A stable weekly rainfall period was essential for suitability of crops/cropping pattern of different durations. In this region, the daily evapotranspiration and percolation losses accounted for 3-5 mm per day each: thus 50 mm rainfall is essential to meet the requirement of rice crop. Hence, the week that has rainfall greater than 50 mm and corresponding CV is less than 100 % then the week has been considered as stable rainfall period. With this assumption, the stable rainfall period was of 9 weeks found, which spread over 27$^{th}$ (July 2-8) to 37$^{th}$ SMW ( 10-16 September) except in 32$^{nd}$ (6-12 August) and 34$^{th}$ SMW (20-26

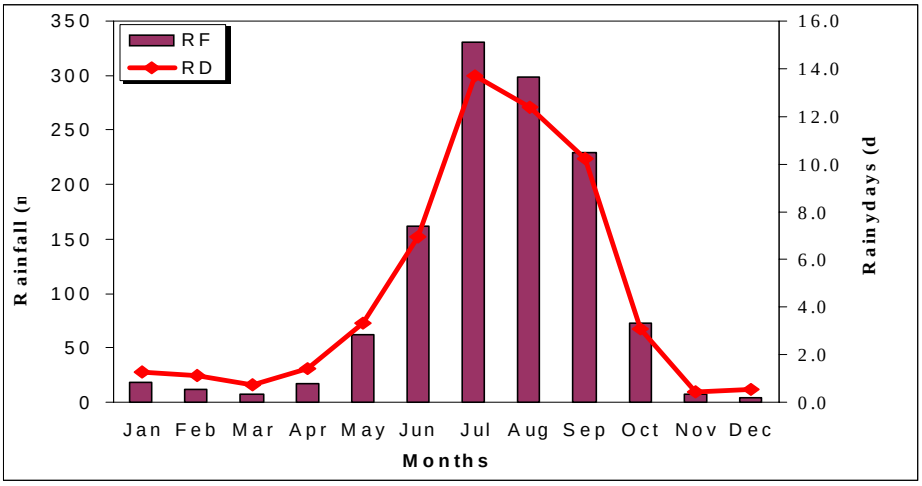



**Fig. 1:** Monthly rainfall distribution pattern and number of rainy days at Pusa

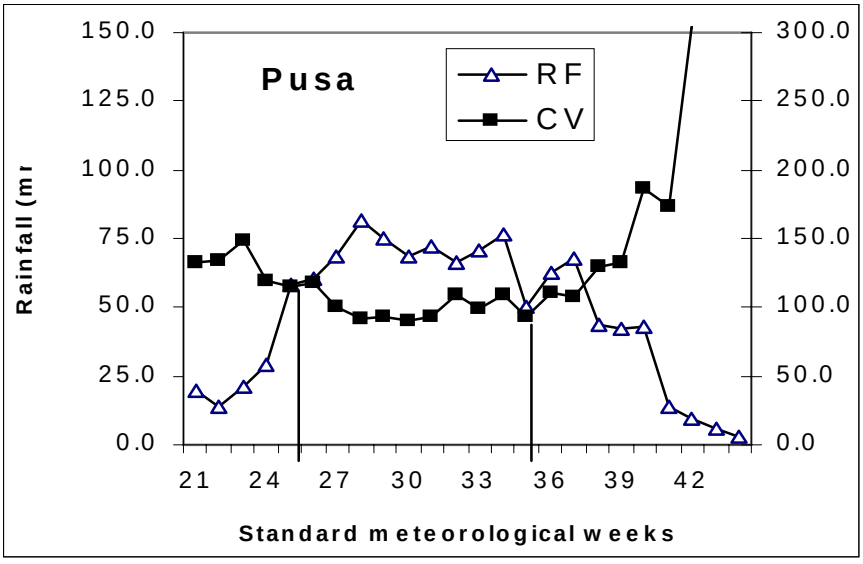



**Fig. 2:** Weekly rainfall pattern and stable rainfall period during pre monsoon and monsoon season at Pusa

August). Predictably, the CV of weekly rainfall during this period varied from 92.3 to 132.8%.

***Onset and end of rainy season***

It can be seen from the table 1 that earliest start of rainy season had occured during 24th week (11-17 June) and latest by 31st week (30 Aug. to 5 Sept.), the normal start of rainy season is found to be 26th week (25 June –1 July). The probability of start of rainy season in 27th week is 81 % i.e. the rainy season can be expected to start on an average in 4 out of 5 years during 27th week (Table 2). Data revealed that the chance of earliest withdrawal of southwest monsoon is 97% during 36th week. The normal cessation of rainy season was by 40th week with a chance of 51 %. The length of rainy season ranges from 9-20 weeks with a mean of 14 weeks and CV of 19 %.

***Initial and conditional probability of wet weeks***

Initial, P(W) and conditional, P(W/W), probabilities of getting 10 and 20 mm of rainfall in a week are shown in fig.3 a & b. Probabilities, of getting 10 mm rainfall per week is more than 75 % in 25th week ( 18-24 June) and continues to be so up to 37th (10-16

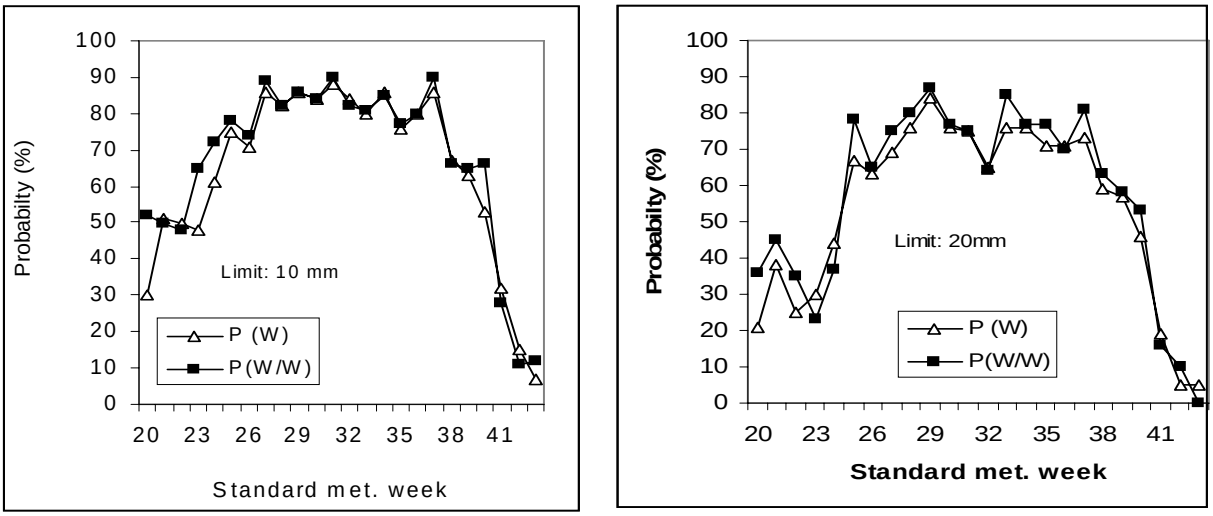



**Fig. 3 :** Initial P(W) and conditional P (W/W) probability at different limits of rainfall

**Table 1:** Start, end and duration of rainy season at Pusa

| Start of rainy season (week number) | | | | End of rainy season (week number) | | | | Length of rainy season (weeks) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Early | Late | Mean | CV | Early | Late | Mean | CV | Max. | Min. | Mean | CV |
| 24 | 30 | 26 | 6.4% | 36 | 45 | 40 | 5% | 20 | 9 | 14 | 19% |

**Table 2:** Probability of the start of rainy season in different weeks

| Weeks | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|
| Probability (%) | 12.2 | 48.4 | 67.3 | 79.5 | 88.2 | 94.2 | 97.1 |

**Table 3:** Probability of the end of rainy season in different weeks

| Weeks | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
|---|---|---|---|---|---|---|---|---|---|---|
| Probability (%**)** | 97.1 | 91.8 | 81.6 | 65.3 | 46.9 | 30.6 | 16.3 | 7.2 | 4.1 | 2.1 |

Sept) week. An amount of 10 mm rainfall per week can be taken as the minimum requirement for land preparation and sowing rainfed summer crops. On the other hand initial probability of receiving 20 mm rainfall per week exceeds 75% from 28$^{th}$ to 34$^{rd}$ weeks. However conditional probability of wet followed by wet of 20 mm rainfall exceeds 75 % from 25$^{th}$ to 35$^{th}$ week except in 32$^{nd}$ week (Fig. 3b), and 20 mm rainfall at 75% level can be utilized for sowing of crops. The rainfall (>25 mm/week) may occur once in 2 or 3 years. If the land is not properly prepared in advance of the receipt of rains, the early monsoon rainfall is likely to produce runoff even before the soil profile is filled. Surface runoff might take place in light soils and through drains and canal in this area.

The probabilities of occurrence of two and three consecutive wet weeks at different levels of rainfall are given in Fig. 4a and 4b. Probability of two consecutive weeks being wet (10 mm rainfall) is higher

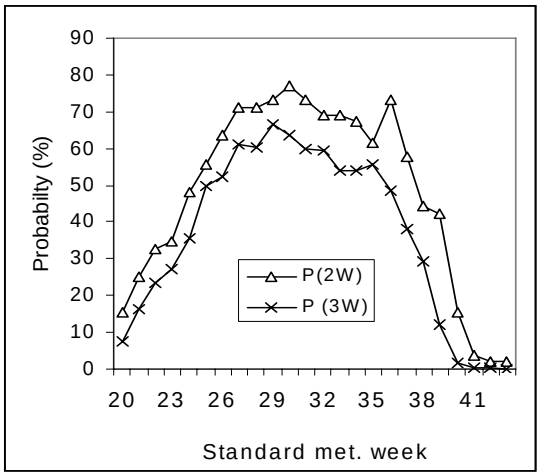
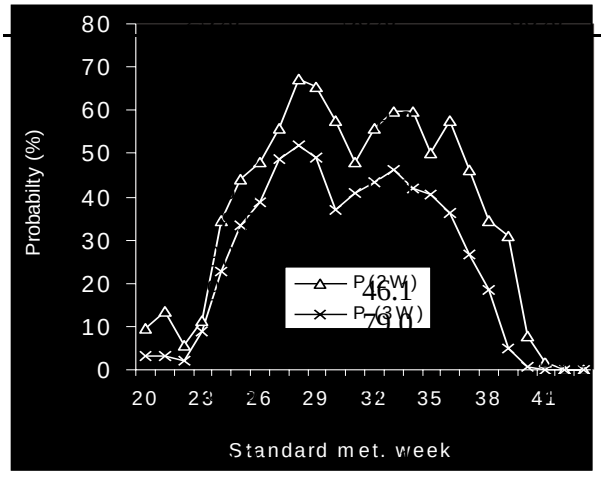



**Fig. 4 :** Probability two and three consecutive wet spells during different weeks at a) 10 mm and b) 20mm rainfall limits

**Table 4:** Monthly expected amount of rainfall(mm) at different levels of probability during different weeks

| | | | | 75% |
|---|---|---|---|---|
| | | | | 0.0 |
| | | | | 0.0 |
| | | | | 0.0 |
| | | | | 0.0 |
| | | | | 2.2 |
| | | | | 9.5 |
| | | | | 8.7 |
| | | | 46.1 | 12.5 |
| | | | 79.0 | 22.4 |
| | | | | 25.0 |
| | | | | 21.0 |
| | | | | 17.3 |
| | | | | 15.6 |
| 33 | 108.0 | 56.0 | 31.8 | 20.4 |
| 34 | 102.5 | 46.6 | 35.1 | 20.0 |
| 35 | 66.6 | 32.0 | 27.4 | 11.5 |
| 36 | 85.2 | 37.5 | 27.0 | 13.8 |
| 37 | 82.8 | 44.8 | 31.3 | 16.3 |
| 38 | 47.0 | 22.6 | 18.5 | 4.8 |
| 39 | 53.0 | 23.6 | 10.8 | 4.4 |
| 40 | 40.4 | 13.7 | 4.2 | 0.0 |
| 41 | 16.5 | 2.2 | 0.0 | 0.0 |
| 42 | 4.0 | 0.0 | 0.0 | 0.0 |
| 43 | 0.0 | 0.0 | 0.0 | 0.0 |




during 27 to 31st week in the range of 71 to 78 % and then gradually decreases to 61 % in 35th week. The probability of three consecutive weeks was less than 50% till 26th week thereafter probability remains highest during 27th to 35th weeks in the range of 54 to 67%. The probability of two consecutive weeks with 20 mm rainfall is 50 to 67 % during 27th to 36th weeks. However, probability of three consecutive wet weeks at (20mm

rainfall) was poor and maximum (52%) in 28th week and then reduces to 27 % in 38th week.

The minimum expected weekly rainfall amount at 25, 50, 60 and 75 % probability level are given in table 4. At 75% probability level rainfall of 9.5 mm can be expected to occur during 25th week. Rains at 75 % probability level can be utilized for seedbed preparation for raising rice seedlings of short duration (100 days) or direct sown rice. The transplanting of *kharif* rice in first week of July will have additional advantage of almost assured water supply through rain during August and September. Since the winter rainfall is uncertain and erratic, residual moisture in lowland area can be utilized for growing a second crop under rain fed conditions. However, wheat can be grown only with assured irrigation during *rabi* season starting from first week of November. Green gram, Cowpea, black gram could be grown during summer in upland areas. Less water demanding short duration smaller millets (finger millet, fox tail millet, *kodon* etc) can be raised during summer season. Maize can be sown in the 22nd week with low risk, as rainfall at 50 % probability is 8.8mm.

## 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( 375):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. Agrometeorol.,* 5(2):82-86.

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

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

Pandarinath, N. (1991). Markov chain model probability of dry and wet week during monsoon period over Andhra Pradesh, *Mausam*, 42(4): 393-400.

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.

Srivastav,S.K., Mishra,S.K., Sahu, A.K. and Anmed A. (1998). Probability analysis of rainfall for crop planning at N. Lakhimpur, Assam. *Ind.J. Soil Cons.*, 24(2):162-165.

Victor, U.S. and Sastry, P.S.N. (1979). Dry spell probability by Markov chain and its application to crop development stages, *Mausam*, 30 (4): 479-84.

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 Agriic. Res. & Dev.,* 6(1&2):1-12.

Morris,R.A. and Zandstra,H.G.(1979). Land and Climate in relation to cropping patterns. In: Rainfed low land rice. Selected papers.Int.Rice Res. Inst. Manila.pp 255-274.

*Received: October 2007; Accepted: August 2008*