Journal of Agrometeorology 15 (Special Issue-II) : 253-256 (December 2013)

Short Communication

Rainfall variability and its impact on *kharif* rice in Nalanda district of Bihar

ABDUS SATTAR* and S.A. KHAN[1]
All India Coordinated Research Project on Agrometeorology
Rajendra Agricultural University, Pusa, Samastipur - 848 125, Bihar
[1]Bidhan Chandra Krishi Viswavidyalaya, Mohanpur -741 252, West Bengal
**E-mail: sattar.met@gmail.com*

Rainfall is a very important natural resource, which plays a pivotal role in the success or failure of agricultural crop production in an area. In the recent years, successful and profitable production of *kharif* rice, which is a very important crop in Bihar, has been a gamble with erratic monsoon system. Thus, study of rainfall variability during *kharif* crop growing season assumes significance for evolving better crop management strategy under *rainfed* condition. As Nalanda district is situated in Zone IIIB (south Bihar alluvial plains) where average rainfall is relatively less than other zones of Bihar and most of the annual rainfall is received during monsoon season, there is ample scope of rain water harvesting for supplemental irrigation and pre-sowing irrigation for subsequent *rabi* crops. Several authors have carried out rainfall analysis for crop planning at district level (Ramana Rao *et al*., 1979; Gupta *et al*., 2010). But variability of rainfall within a district is too large. The variability of rainfall at block level plays important role in crop planning. Kothari *et al.,* (2008) opined that district crop planning was required at micro (*tehsil*) level for efficient utilization of natural resources. Swaminathan (2005) suggested for developing contingency crop planning to suit different rainfall patterns and work out comprehensive production programme down to village level for proactive monsoon management. Keeping this mind, an attempt has been made in this paper to study the rainfall variability down to block level of Nalanda district for better rice crop planning. Probability analysis of rainfall, identifying the moisture stress condition during the growing season of rice crop and the effect of monsoon rainfall on rice productivity have also been studied.

Daily rainfall data for the period from 1974 to 2010 of four blocks *viz*. Biharsharif, Asthawan, Nursarai and Rahui of Nalanda district in the Zone IIIB of Bihar were collected from the Directorate of Statistics and Evaluation, Government of Bihar. The growing season of rice crop was divided into three growth phases *viz*. vegetative phase (transplanting to 50 % booting stage) during 28 standard meteorological weeks (SMW) [9-15 July] to 38 SMW (17-23 September), reproductive phase (50% booting to 50% flowering stage) during 38 SMW (17-23 September) to 41 SMW (8-14 October) and ripening phase (50% flowering to maturity stage) during 41 SMW (8-14 October) to 44 SMW (29 October – 4 November). Daily rainfall data for the period from 1974 to 2010 of the four blocks of the district were analyzed to obtain annual, seasonal and monthly rainfall, rainy days, expected weekly rainfall at different probability levels and accumulated rainfall during different phases of growth of *kharif* rice pertaining to four blocks were computed. Agricultural droughts of these blocks during the period from 1974 to 2010 were also characterized. Length of growing period (LGP) was worked out for efficient crop planning for growing *kharif* rice in the district. Conditional probabilities of occurring two consecutive wet weeks with 30 mm threshold rainfall per week during *kharif* season in different blocks have been computed for working out moisture stress period during growing season of rainfed rice. Daily rainfall data were summed up over different growth phases. Simple correlation coefficient values between *kharif* rice productivity and accumulated rainfall prevailing at different phases of growth were computed.

Variation in agroclimatic environment

The mean annual rainfall varied from 777.1 mm received in 39 rainy days in Rahui block to 926.1 mm in 45 rainy days in Biharsharif block. The C.V. of annual rainfall and rainy days were highest (34.2% and 32.3%, respectively) at Rahui, whereas the lowest C.V. values were recorded at Biharsharif (28.1% and 19%, respectively) followed by Nursarai (30.8% and 26.3% respectively). It is evident that annual rainfall and rainy days were more variable at Rahui than those in remaining blocks. Results further revealed that the C. V. of monsoon season rainfall ranged between 27.5% at Biharsharif and 37.0% at Rahui, indicating more stable monsoon rainfall at Biharsharif. However, the highest C.V. of rainy days during monsoon season (28.2%) was observed at Rahui and the lowest C. V. (17.6%) was recorded at Biharsharif implying better distribution of monsoon rainfall for *kharif* rice in Biharsharif block in the district. Monsoon rainfall contributed 87.3 to 89.5% of the total annual rainfall over different blocks under study, signifying ample scope

for rain water harvesting for life saving irrigation. During post monsoon season, the C.V. of rainfall varied from 107.3% at Asthawan to 114.0% at Biharsharif. The C. V. of monthly rainfall during June to September were found to vary from 50.8 to 65.3% for Biharsharif, 49.6 to 79.5% for Asthawan, 41.4 to 91.1% for Nursarai and 56.6 to 87.4% for Rahui, indicating higher dependability of rainfall for *kharif* rice cultivation in Biharsharif block, followed by Asthawan, Rahui and Nursarai. Variability of weekly rainfall in the district showed that at Biharsharif, the C.V. of weekly rainfall was within 100 % during 29 SMW (16-22 July) to 33 SMW(13-19 August), 29 SMW (16-22 July) to 31 SMW (30 July -5 August) at Asthawan, during 31SMW (30 July - 5 August) to 33 SMW (13-19 August) at Nursarai. However, at Rahui, except 27 SMW (2-8 July) to 30 SMW (23-29 July), all other weeks over 23 SMW (23-29 July) to 43 SMW (22-28 October) showed C.V. values above 100%. Thus, it is evident that Biharsharif is proved to be the most favourable block for crop productivity, followed by Asthawan, Nursarai and Rahui.

Rainfall trends during kharif rice growing season

Trends of accumulated rainfall during vegetative, reproductive and ripening phases of *kharif* rice crop revealed that in most of the blocks, phasic rainfall tend to increase. At Biharsharif, increasing trend of rainfall has been observed during vegetative and reproductive phases, whereas decreasing trend was noticed during ripening phase of rice crop. At Asthawan, increasing trend of rainfall was recorded in both vegetative and ripening phases, whereas decreasing trend was observed at reproductive phase. At Nursarai block of the district, increasing trend of rainfall was registered at all three phases of the rice crop. At Rahui block, excepting vegetative phase, other two stages like reproductive and ripening phases were experienced with increasing trend in rainfall. Although annual rainy days exhibited very slight decreasing trend, annual rainfall showed increasing trend in the district. While studying down to the individual block level, excepting Asthawan block, all the remaining blocks were associated with increasing trend of annual rainfall.

Kharif rice growing period

The mean rainfall during *kharif* growing season varied from 689.9 mm at Rahui to 808.2 mm at Biharsharif. Length of *kharif* rice growing season varied from 94 to 97 days, with number of rainy days extending from 33 to 37 in the district (Table1). Start and end of growing season are delayed with increase in frequency percentage/ probability percentage. At 75% probability (7.5 years out of 10 years), starting of sowing week was attained at 26 SMW (25 June - 1 July) in all the blocks uniformly. At 50% probability, growing season ended at 39 SMW (24-30 September) at Biharsharif, Nursarai and Rahui and 40 SMW at Asthawan. At 75 % probability level, growing season ended at 40 SMW (1-7 October) at Nursarai, 41 SMW (8-14 October) at Biharsharif and Rahui and 42 SMW (15-21 October) at Asthawan. At 75 % probability level, the highest LGP was obtained from Asthawan (119 days), followed by 112 days at Biharsharif and Rahui and 105 days at Nursarai and accordingly selection of varieties under *kharif* rice need to be made by matching with estimated duration (Table 1).

The probabilities of weekly rainfall at 50% and 75% probability level have been worked out for different blocks of Nalanda district and presented in the Table 2. At least 30 mm rainfall at 50% probability could be expected during 26-34 SMW (25 June-26 August) at Biharsharif, during 27-33 SMW (2 July-19 August) excepting 31 SMW (30 July-5 August) at Asthawan, during 27-33 SMW (2 July-19 August) excepting 30 SMW (23-29 July) and 31 SMW (30 July - 5

Table 1 : Percentage frequency occurrences and mean start and end of growing period, mean LGP, annual and monsoonal rainfall and rainy days in Nalanda district

Blocks	Start/end of LGP in SMW	Probability (%)			Mean	Mean LGP (days)	Annual/monsoon rainfall (mm)	Rainy days (Annual/monsoonal)
		25	50	75				
Biharsharif	Start	25	25	26	25.4	94	926.1/808.2	45/37
	End	37	39	41	39.3			
Asthawan	Start	23	25	26	26.0	97	884.7 / 773.4	42/ 35
	End	39	40	42	39.6			
Nursarai	Start	25	25	26	25.7	95	823.9/732.0	41/34
	End	38	39	40	39.1			
Rahui	Start	25	26	26	26.0	95	771.1/689.9	39/33
	End	38	39	41	39.6			

Table 2 : Expected rainfall (mm) at different probability levels in different blocks of Nalanda district

SMW	Biharsharif		Asthawan		Nursarai		Rahui	
	50 % Prob.	75 % Prob.	50 % Prob.	75 % Prob.	50 % Prob.	75 % Prob.	50 % Prob.	75 % Prob.
23	6.0	1.5	7.2	1.4	5.9	1.0	6.4	1.1
24	7.2	1.7	6.6	1.4	8.5	2.1	8.2	1.9
25	21.6	6.4	26.5	8.4	22.4	6.3	17.0	5.1
26	34.9	9.2	29.1	7.7	29.3	7.0	21.9	4.8
27	41.8	17.0	44.3	18.4	33.5	9.8	37.7	13.0
28	45.6	14.5	39.9	14.2	34.4	10.9	41.3	13.1
29	52.3	27.3	50.5	23.2	42.4	17.1	45.1	18.2
30	45.0	17.9	34.1	11.8	29.1	9.9	29.1	9.9
31	38.5	18.3	29.2	12.2	25.6	9.9	19.7	6.8
32	39.7	19.8	32.7	12.3	34.2	15.6	23.2	8.4
33	37.9	15.6	41.2	17.1	40.3	16.0	27.8	8.3
34	35.9	14.4	29.7	11.3	28.0	11.0	27.5	10.0
35	28.8	10.0	24.0	6.6	17.0	4.6	22.4	6.9
36	30.1	10.8	26.7	8.2	24.5	6.3	31.1	11.8
37	31.4	15.0	29.1	11.7	19.8	5.9	19.3	6.4
38	22.7	9.3	23.3	6.8	17.3	4.4	20.8	6.3
39	14.8	3.7	12.6	2.9	14.5	3.1	13.5	3.7
40	8.3	1.5	6.5	1.3	7.7	1.6	6.6	1.4
41	5.0	1.3	4.5	1.1	4.1	1.1	4.4	1.1
42	5.2	0.9	4.7	1.0	4.3	0.9	2.9	0.7
43	2.0	0.7	2.2	0.5	2.1	0.5	2.5	0.5

August) at Nurasrai and 27-29 SMW (2 - 22 July) at Rahui block indicating better rainfall scenario during *kharif* rice growing season at Biharsharif block. At 50% probability, the same amount of rainfall (30 mm) is received in very less period at Rahui block. Thus, as compared to other blocks in the district, the prospect of growing *kharif* rice seems not to be good at Rahui block.

It is apparent that early season drought occurred more frequently at all locations, except Biharsharif where late season drought occurred with high frequency. Out of 37 years, agricultural drought was highest in Nursarai (20 years) and the lowest was at Asthawan (16 years), with Rahui and Biharsharif experiencing drought in 19 and 18 years, respectively. The probability of two consecutive wet weeks was highest at Biharsharif block during *kharif* rice growing season, ascribing to the fact that there is low probability of occurrence of moisture stress to rice crop at Biharsharif than those at Rahui and Nursarai blocks.

Impact of rainfall on kharif rice

The study also revealed that both at district and block level accumulated rainfall at vegetative (GS 1), reproductive (GS 2), ripening (GS 3) and entire growth period (GS 1 to GS 3) showed positive correlation with grain yield, implying higher productivity of *kharif* rice with higher rainfall (Table 3).

Table 3 : Correlation coefficients between accumulated rainfall (mm) during different phases of growth and *kharif* rice yield (Kg ha^{-1})

Phases of growth	Names of blocks				District
	Biharsharif	Nursarai	Asthawan	Rahui	
GS 1	0.36	0.43	0.25	0.42	0.42
GS 2	0.39	0.16	0.14	0.32	0.20
GS 3	0.33	0.12	0.11	0.14	0.02
GS 1- GS3	0.46*	0.25	0.23	0.49*	

GSI= vegetative phase (15 July to 20 September); GS2= reproductive phase (21 September to 10 October); GS3= maturity phase (11 October to 30 October); * Significant at 5 % level.

The study on rainfall variability during the *kharif* rice growing season in different blocks of Nalanda district of Bihar has provided an idea of micro-level agro-climatic resource characterization for proper crop planning, which assumes greater significance in view of erratic rainfall situation under climate change scenarios. The selection of varieties under *kharif* rice needs to be made by matching with estimated length of growing period for different blocks in the district.

ACKNOWLEDGEMENT

The study was conducted under All India Coordinated Research Project on Agro-Meteorology (ICAR) at RAU, Pusa (Samastipur), Bihar and the financial support received from ICAR for the project is gratefully acknowledged. Special sincere thanks and gratitude are also due to Dr. V.U.M. Rao, Project Coordinator, AICRP on Agrometeorology (ICAR), CRIDA, Hyderabad for his constant encouragement and suggestions.

REFERENCES

Gupta, A., Khan, S.A. and Saha, A. (2010). Characterization of agricultural climate for crop planning under rainfed condition in laterite region of West Bengal. *In:* "Agrometeorological Services for Farmers".(Ed.Vyas Pandey). (Anand Agricultural University, Anand). Pp. 90-97.

Kothari, A.K., Jain, P.M. and Kumar,V. (2008) Micro level variation in rainfall characteristics and its impact on climate for crop planning in Bhilwara district of Rajastan. *J. Agrometeorol.,* (Special issue- Part 2): 470-475.

Ramana Rao, B.V., Biradar, B.R., Supur,S.S. and Rao, M.G. (1979). A climatological study on water availability to crops in different types of soils in Gulbara region. *J. Ind. Soc. Soil Sci.,* 27: 441-446.

Swaminathan, M.S. (2005). Proactive monsoon management plan is needed. *Frontline,* Vol.17(11), May 27- June 9, 2000, pp 25-32, *In*. Compendium of Training Programme on "Management of Agricultural Drought Prone Area" 4-9 July, Edited by Ch. Radhika Rani and M.R. Girish, National Institute of Rural Development, Hyderabad, P.92.