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Short Communication

Assured rainfall analysis for enhanced crop production under rainfed condition in Bihar

A. SATTAR[1*], S.A. KHAN[2] and SAON BANERJEE[2]

[1]Agrometeorology Division, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar-848 125

[1]Department of Agril. Meteorology & Physics, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal-741 252

[*]Email : sattar.met@gmail.com

Rainfed agro-ecosystem has a very important role in Indian agriculture having diverse farming systems with a large variety of crops, cropping systems and agroforestry practices. It contributes about 40 per cent to the total food grain production, supports 40 percent of the human and 65 per cent of the livestock population (Venkateswarlu and Prasad, 2012).Currently, about 56 per cent the total cropped area in India is rainfed, and even after realizing the full irrigation potential of the country, about 50 per cent of the total net sown area will still remain under rainfed agriculture in the country (NRAA, 2012).Nearly 60 per cent area under cultivation in the Bihar is rainfed. Thus, crop production under rainfed condition requires interaction of agro-climatic measures to slice down the climatic risks. Hence, precise evaluation of water availability period is an important pre-requisite for crop planning under rainfed condition.Sattar (2010) and Sattar and Khan (2016) have worked out probability analysis and length of growing period at selected locations of Bihar. The information on sowing window, growing period length, crop suitability based on water availability down to district level for the entire state of Bihar are not available. In view of this, an attempt has been made in this paper to estimate the start, end and length of water availability based on assured rainfall for appraisal of agroclimatic potential for efficient rainfed crop production across the state.

The study was conducted for all 38 districts located under different agroclimatic zones of Bihar. It is broadly divided into three agro-climatic zones *viz.,* Zone I (North-west alluvial plains), Zone II (North east alluvial plains) and Zone III (South Bihar alluvial plains). Zone III is further subdivided into Zone IIIA and Zone IIIB on the basis of rainfall variability and topography. Historical rainfall data for a period of 30 to 55 years collected from the India Meteorological Department, Pune and Agrometeorology Division, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar, India were used in the study.The assured rainfall amounts at different probability levels, *viz.* 25, 50 and 75 per cent were computed through incomplete gamma distribution technique developed by Thom (1958) and described by Sarker and Biswas (1986). Rainfall at different probability level, *viz.* 25, 50 and 75 is termed as assured rainfall at respective probability level. Using software based on these methodologies, the amounts of assured rainfall at different probability level were computed.Water availability periods based on 20 mm weekly assured rainfall and stable rainfall period based on 50 mm weekly assured rainfall have been determined.Starting week, ending week, and length of water availability with two threshold values of rainfall *viz.* 20 mm per week (suitable for growing upland crop) and 50 mm per week (suitable for growing transplanted rice) have been determined (Table 1).

Sowing window and cessation of growing period

The rainfall amount of 20 mm per week was found to provide enough moisture for sowing of uplands crops and so 20 mm rainfall per week in the beginning of the season was considered as sowing rain (Virmani, 1975; Ramana Rao *et al*., 1983).Accordingly, at 25 per cent probability level (*i.e.* in 25 out of 100 years), the earliest sowing week with 20 mm weekly rainfall was observed at 16 SMW (standard meteorological week) in Araria and Kishanganj districts under Zone II, while the delayed sowing week was found to occur at 24 SMW in Arwal district under Zone IIIB (Table 1). As a whole, at 25 per cent probability level, all the districts under Zone II showed the earliest sowing week as against the delayed sowing weeks being registered in the districts under Zone IIIB, which also showed the earliest ending week of having 20 mm rainfall.

In case of 50 per cent probability level, *i.e.* in 50 out 100 years,it is observed that starting week with 20 mm threshold rainfall (sowing week) varied from 22 to 25 SMW

Table1: Start, end and duration of water availability period with 20 and 50 mm threshold weekly rainfall at different probability levels in various districts of Bihar.

Zone/district	20 mm threshold rainfall at 25 % probability			20 mm threshold rainfall at 50 % probability			20 mm threshold rainfall at 75 % probability			50 mm rainfall at 50 % probability		
	Start week	End week	Duration (week)	Start week	End week	Duration (week)	Start week	End week	Duration (week)	Start week	End week	Duration (week)
Zone I (North west alluvial plains)												
Darbhanga	20	42	23	24	39	16	27	34	8	27	32	6
Samastipur	20	42	23	24	39	16	27	36	10	27	34	8
Muzaffarpr	20	41	22	25	39	15	27	34	8	27	34	8
Madhubani	19	41	23	23	39	17	26	37	12	27	34	8
E. Champaran	20	41	22	23	40	18	25	35	11	26	34	9
Goapalganj	20	42	23	25	39	15	26	35	10	27	34	8
Saran	21	42	22	25	39	15	27	35	9	27	34	8
Sitamarhi	18	41	24	23	39	17	26	36	11	26	34	9
Sheohar	19	41	23	23	40	18	26	36	11	26	34	9
Siwan	21	41	21	25	39	15	26	34	9	27	34	8
Vaishali	21	42	22	25	39	15	26	36	11	27	30	4
W. Champaran	17	42	26	22	40	19	25	37	13	25	37	13
Begusarai	20	42	23	24	39	16	27	36	10	27	34	8
Zone II (North east alluvial plains)												
Araria	16	42	27	20	40	21	25	37	13	25	37	13
Katihar	17	42	26	21	40	20	25	38	14	26	37	9
Khagaria	20	41	22	24	39	16	26	34	9	27	34	8
Kishanganj	16	42	27	19	40	22	21	39	19	23	39	17
Madhepura	18	41	25	21	40	20	25	38	14	28	35	9
Saharsha	20	42	23	23	39	17	27	34	8	28	34	7
Supaul	18	42	25	21	40	20	25	37	12	26	37	12
Purnia	17	42	26	21	40	20	25	38	14	25	37	13
Zone IIIA (South Bihar alluvial plains)												
Banka	21	42	22	24	40	17	25	34	10	28	34	7
Bhagalpur	19	42	24	24	40	17	25	35	11	26	34	9
Jamui	21	42	22	24	40	17	25	37	13	26	34	9
Lakhisarai	21	41	21	24	39	16	25	34	10	26	30	5
Sheikhpura	21	41	21	25	39	15	25	35	11	26	31	6
Munger	19	41	23	24	39	15	26	37	12	28	35	9
Zone IIIB (South Bihar alluvial plains)												
Gaya	23	40	18	24	39	16	26	36	11	28	34	7
Auranagabd	23	40	18	25	38	14	27	37	11	27	34	8
Jahanabad	23	40	18	25	39	15	27	34	8	28	-	1
Kaimur	23	40	18	25	38	14	28	36	9	28	34	7
Nalanda	23	40	18	25	38	14	27	34	8	29	-	1
Nawada	23	41	19	25	39	15	26	34	9	28	29	2
Rohtas	23	40	18	25	38	14	27	34	8	28	34	7
Bhojpur	23	40	18	25	38	14	27	37	11	28	33	6
Buxar	23	40	18	25	39	15	27	37	11	28	34	7
Arwal	24	41	18	26	38	13	27	36	10	27	30	4
Patna	22	41	20	25	39	15	27	37	11	28	34	7

and ending week from 39 to 40 SMW across the districts under Zone I (Table 1). Hence, on the basis of informationon sowing rain, the earliest sowing of rainfed crops could be possible in West Champaran district at 22 SMW and the latest at 25 SMW in Vaishali, Siwan, Saran, Gopalganj and Muzaffarpur districts in Zone I. In Zone II, the sowing week was observed to vary from 19 SMW in Kishanganj district to 24 SMW in Khagaria district, while the ending week of having 20 mm rainfall extended from 39 to 40 SMW across various district. As compared to the sowing weeks in the districts under Zone II, the sowing as well as ending weeks across the districts of Zone IIIA did not show much variation, with sowing week recording between 24 to 25 SMW and the ending week during 39-40 SMW. Similar variation in sowing and as well as ending weeks was also observed in the districts under Zone IIIB. In this zone, the sowing week ranged from 25 to 26 SMW and the ending week terminated comparatively little earlier during 38-39 SMW, with six out of eleven districts showing cessation of having 20 mm threshold rainfall at 38 SMW. Thus, considering all the districts of the state, the earliest sowing of rainfed upland crops could be possible in Kishanganj district at 19 SMW, as against the maximum delayed sowing occurring at 26 SMW in Arwal.

Growing period at different probability levels

Durations in weeks with assured rainfall ≥ 20 mm were considered to determine the length of cropping period. Accordingly, the length of growing period presented in Table 1 revealed that at 25 per cent probability level, cropping period (water availability period for growing rainfed crops) varied from 21 to 26 weeks in Zone I, 22 to 27 weeks in Zone II, 21 to 24 weeks in Zone IIIA and 18 to 20 weeks in Zone IIIB, where nine out of eleven districts recording 18 week-duration.

At 50 per cent probability level, all the districts under Zone I registered water availability period ranging from 15 weeks in Vaishali to 19 weeks in West Champaran district (Table 1). In Zone II, Araria district recorded the longest cropping period (21 weeks) and the shortest (16 weeks) in Khagaria district. Such duration of water availability was found to prevail for 15 to 17 weeks in the districts under Zone IIIA and 13 to 16 weeks under Zone IIIB with a majority of the districts recording 14-week growing period.

At 75 per cent probability, the durations of rainfed cropping period were 8 to 13 weeks in Zone I, 8 to 19 weeks in Zone II, 10 to 13 weeks in Zone IIIA and 8 to 11 weeks in Zone IIIB (Table 1). The lowest duration of 8 weeks was observed in Darbhanga and Muzaffarpur districts in Zone I, Saharsha district in Zone II and Nalanda, Rohtas and Jahanabad districts in Zone IIIB. On the contrary, Kishanganj district recorded cropping period of highest duration (19 weeks).

Stable rainfall period for evaluation of rice growing period

Considering the evapotranspiration and percolation losses from rice fields of 3 and 4 mm per day respectively, in eastern India, the water requirement of rice without water stress was taken as 50 mm per week (Singh and Singh, 2000). Based on this, the stable rainfall periods at 50 per cent probability level over various districts of Bihar were worked out (Table1). Results indicated that stable rainfall period at 50 per cent probability level started during 25-27 SMW and ended earliest at 30 SMW in Vaishali district, as against the last ending occurring at 37 SMW in West Champaran district under Zone I, indicating that the duration of stable rainfall period varied from 4 to 13 weeks. In Zone II, the starting week with similar amount of stable rainfall (50 mm) varied from 23 to 28 SMW and ended during 34 to 39 SMW over all districts. Thus, the duration of growing period varied from 7 to 17 weeks over different districts of Zone II. The stable rainfall period started in the districts of Zone IIIA and Zone IIIB during 26-28 SMW and 27-29 SMW respectively, whereas it terminated during 30-35 SMW in Zone IIIA and 28-34 SMW in Zone IIIB. Thus the duration of stable rainfall period were 5-9 weeks in Zone IIIA and 1-8 weeks in Zone IIIB at 50 per cent probability level.It is worth mentioning that the districts of Jahanabad and Nalanda under Zone IIIB did not show any stable rainfall period longer than a week at 50 per cent probability level.Considering 20-25 days period for seedling establishment and 25-30 days for the maturity stage, growing of short duration rice varieties (*Prabhat, Dhanlaxmi, Richhariya, Turanta*) maturing in 90 to 100 days could be recommended in Banka, Bhagalpur, Jamui and Munger districts under Zone IIIA and Gaya, Auranagbad, Kaimur, Rohtas, Buxar and Patna districts under Zone IIIB with such stable rainfall period as computed at 50 per cent probability level. On the other hand, short to medium duration rice in Zone I and medium to long duration rice in Zone II could be grown. The results further revealed that the vast geographical area underZone IIIB, Vaishali district under Zone I, and Lakhisarai and Sheikhpura districts under Zone IIIA area not conducive for growing rice as rainfed crop. Considering very short period of occurrence of 50 mm weekly rainfall, the growing of rice in Nalanda, Jahanabad, Nawada, Arwal, Bhojpur and Lakhisarai districts

during *kharif* season could not be feasible under rainfed condition.Chaudhary *et al.,* (2015) also suggested rice crop varieties based on estimated duration of stable rainfall period in four districts *viz.* Raipur, Bilaspur, Jagdalpur and Ambikapur of Chhatisgarh state. Pigeon pea is regarded as the potential component crop of the intercropping system in the drought prone region (Singh *et al.,* 1981). So, introduction of inter cropping with pigeon pea and maize or sequential cropping with short duration rice followed by chickpea / lentil could be promising with regard to total productivity under short availability of stable rainfall period.

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