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Probability of aberrations in monsoon rainfall and suitable crop planning for Balasore region of Orissa

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ABSTRACT

Daily rainfall data for twenty five years (1980 – 2004) of Balasore ($23^0 59^/$ N latitude and $86^0 16^/$ E longitude), located in the 'North-eastern Coastal Plain' agro-climatic zone of Orissa, were critically examined for establishing the long term averages of monthly rainfall during the monsoon season and its temporal variability. The average monsoon rainfall (monthly total) of 1315.2 mm was distributed in the proportion of 21.3, 23.1, 24.1, 19.2 and 12.3% from June through October, respectively. The variabilities in monthly rainfall during crucial months of June (47%) and October (80%) were relatively higher than in the remaining monsoon months. The probabilities of both the normal onset (23^{rd} standard meteorological week) and withdrawal (41^{st} standard meteorological week) of monsoon rain were 48%. The probabilities of aberrations in seasonal (June to October) amount of rainfall was 64.8% with higher proportion of below normal (38.3%) than its above normal rainfall (26.0%) during June to October. At 25% and 50% probabilities, a stable quantum of rainfall was observed during 23^{rd} – 41^{st} and 25^{th} – 37^{th} standard meteorological week respectively.

Key words: *Rainfall probability, crop planning, Balasore region*

Balasore, one of the most important agricultural districts of Orissa, is situated in North-eastern Coastal Plain Agro-climatic zone. Although the normal annual rainfall of the district is 1663 mm and of which 79% is received during monsoon season (June – October), the region experiences either intermittent or terminal drought or flash flood almost every year due to uneven distribution of monsoon rain during the crop growing season. As the qualitative (time of onset and withdrawal of monsoon, its persistence) and quantitative (magnitude, intensity and distribution) properties of south-west monsoon rainfall is highly variable over time and space (Patil *et al.*, 1992), the assessment of nature and degree of aberrations in rainfall would provide first hand information to combat its associated hazards (Sondge *et al.*, 2000). Rainfed rice is the main crop grown during the wet season in this region. The productivity of the crop is largely influenced by the rainfall-distribution pattern and the intensity of rainfall received during the monsoon season. As rainfall is the single major limiting factor in rainfed rice production system, a sound knowledge and an understanding in its distribution pattern over the years, intensity and other characteristics like onset, withdrawal etc. was very much essential for suitable crop planning (Saha and Biswal, 2004). Keeping in view the importance of variability in rainfall during monsoon season in crop planning, efforts were made to examine the nature of aberrations in southwest monsoon rainfall in Balasore region of Orissa.

MATERIALS AND METHODS

The daily rainfall events (rainfall > 2.5 mm/day) of Balasore (23^0 $59^/$ N latitude and 86^0 $16^/$ E longitude) during monsoon season (June to October) from 1975 – 2000 were collected from Indian Meteorological Department, Pune for the present study. These data were cumulated over calendar months and statistically analyzed for establishing the monthly normal time of onset and withdrawal of monsoons, depths of rainfall (monthly and seasonal) and their distribution. The 23^{rd} and 41^{st} standard meteorological week (SMW) with more than 40 mm of rain during 2 consecutive days were defined as normal onset and withdrawal of monsoon (Saha and Biswal, 2004). The 21^{st}–22^{nd} SMW and 24^{th}–25^{th} SMW were defined as early (ES) and

Late (LS) onset of monsoon while the 39th – 40th SMW, and 42nd- 43rd SMW were considered as early (EW), and late (LW) withdrawal of monsoon rainfall respectively. The deviations from normal onset and withdrawal of monsoons, normal depths of rainfall (monthly and seasonal) and its distributions were noted as aberrations in respective proportions of monsoon. The severities of aberrations in depths of rainfall (monthly and seasonal) were assessed by deploying the standard meteorological techniques (Acharya and Gupta 1990) as detailed in Table 1. The individual months in each monsoon season and seasons as a whole in a sample year were schematically coded into different hydrological regimes (Table 1) and their conditional frequencies were worked out as for determining the persistence of hydrological status (ie. normal, deficit or surplus) The expected rainfall (mm) at probability 25% and 50% (initial) and conditional probabilities (probability % of getting 10, 15 and 20 mm rainfall) were worked out for weekly rainfall events by using the following formula (Munn, 1970).

Table 1. Standard meteorological schemes for delineating the rainfall aberration.

Criteria (%)	Scale of Severity	Symbol
(-) 0.59 from normal	Severely deficit	D
(-) 0.19 to (-) 0.59 from normal	Moderately deficit	d
± 0.19 from normal	Normal	N
+ 0.19 to 0.59 from normal	Moderately surplus	H
+ > 0.59 from normal	Highly surplus	H

Initial probability = np/100 where n, number of years and P, probability in %

Conditional probability = (mean X – X) x 100/ SD where Mean X, average rainfall of a particular week; SD, standard deviation of that week and X, threshold rainfall.

RESULTS AND DISCUSSION

The normal rainfall during monsoon season (June-October) at Balasore was 1315.2 mm (Table 2). The averages of monthly total increased from 280.7 mm in June to 317.2 mm in August and then it declined to 252.3 mm in September and 161.2 mm in October contributing 21.3, 23.1, 24.1, 19.2 and 12.3% during June to October respectively towards seasonal total rainfall. The coefficient of variability revealed peaks during June and October with depression during July-August-September. Thus, the rainfall was less dependable in October followed by June. The variability in monthly rainfall was relatively high (34.0– 80.0%) than seasonal rainfall (21.0%) during the monsoon period indicating the stability of monsoon rain over the years.

As the time of onset and withdrawal of monsoon decides the length of safe-growing period of crops, the frequency and probability of onset and withdrawal were worked out and presented in Table 3. The total probabilities of normal onset and withdrawal were same, i,e., 48.0% and so their corresponding aberrations were also same, i.e., 52.0%. But the probabilities of aberrations in early and late onset were 44.0 and 8.0%, respectively, while the probabilities of early and late withdrawal were 24.0% and 28.0%, respectively. This showed that the total probabilities of early onset of monsoon were high than in their early in withdrawals while the probability of late onset was much less than in late withdrawals. Among the early onset of monsoons the probabilities of late withdrawal

Table 3. Probabilities of onset and withdrawal of rainy season at Balasore

Onset	Withdrawal Probabilities (%)			
	Early	Normal	Late	Total
Early (E)	8.0	20.0	16.0	44.0
Normal (N)	12.0	24.0	12.0	48.0
Late (L)	4.0	4.0	0.0	8.0
Total	24.0	48.0	28.0	100.0

Table 2. Rainfall (mm) and its variability parameters (June-October) in Balasore

Particulars	Months					Monsoon season
	Jun	Jul	Aug	Sep	Oct	
Average rainfall(mm)	280.7	303.8	317.2	252.3	161.2	1315.2
Standard. Deviation (±)	131.6	108.7	107.6	95.4	128.3	270.7
Coefficient of variation (%)	47.0	36.0	34.0	38.0	80.0	21.0
Contribution to seasonal distribution (%)	21.3	23.1	24.1	19.2	12.3	100.0

were high (16.0%) than in its early withdrawal (8.0%), while in case of late onset of monsoon the probabilities of early withdrawal was 4.0% while the late withdrawal was 0%.

The data indicated that the early onset of monsoon might cause early withdrawal but the late onset monsoon might not get withdrawal late. This analysis further revealed that the possibility of normal onset and normal withdrawal was once in 4 years, resulting in 18 weeks rainy season length. Similarly, the possibility of getting longest monsoon rain period (20 weeks) by early onset and late withdrawal was once in 6 years and the possibility of getting shortest monsoon rain period (16 weeks) by early onset and early withdrawal was once in 25 years.

Data on probabilities of intra and inter month aberration in rainfall patterns are presented in Table 4. The probabilities of inter monthly aberrations showed that the chances of receiving normal rainfall in each month were 35.2% and the chances of aberrations were 64.8 %. These data further revealed that the rainfall received below and above normal were 38.8 and 26.0% respectively. The probabilities of monthly rainfall with severely deficit (7.8%) and excessively surplus (9.9%) were less than moderately deficit (31.0%) and moderately surplus (16.1 %).

Investigation on inter-monthly aberrations showed that the probabilities of receipts of normal rainfall were higher during July–August–September than deficit or surplus totals. The chances of monsoon months with deficits were higher than in the months with surplus. The chances of severe deficit or excessively surplus were very less during the 3 months period of July-August-September. The chances of both excessively surplus rainfall and severe deficit rainfall were relatively higher in October (13.1 and 18.2%, respectively). However, they were least (5.3 and 0%, respectively) in August.

The rain due to southwest monsoon activity normally starts on 23rd standard meteorological week and ceases on 41st standard meteorological week in this region (Table 5). The coefficient variability of mean weekly rainfall revealed that the period of 25th – 37th standard meteorological week was considered to be the stable rainfall period when the mean weekly average rainfall was >50 mm and corresponding coefficient of variation was <100%. At 25 % and 50% probability, the stable quantum of rainfall was observed during 23rd –41st and 25th– 37th standard meteorological weeks. The conditional probabilities of receiving 10, 15 and 20 mm mean weekly rainfall exceeded 75% from 23rd – 37th; 24th–37th and 25th– 36th standard meteorological week respectively.

The rainfall quantum of monsoon season (1315.2 mm) clearly indicated the suitability of this region for rainfed rice cultivation during the wet season (June – November) considering the water requirement of rice crop 1100 – 1200 mm for medium and late-maturing varieties. However, the total amount and distribution pattern of monsoon rain is the most critical weather component in rainfed rice ecologies. So, good productivity can be obtained only by adopting suitable water conservation and recycling methods and packages. Sastri *et al.* (1999) also opined alike while studying the influences of climatic variability on the productivity of rainfed rice in Chattisgarh region.

From the analysed data on rainfall climatology of Balasore region, it revealed that a good amount of rain occurs during the month of May that would help for early establishment of long duration rice varieties in lowlands. The long-duration photo-sensitive rice varieties like Gayatri, Savitri, Durga, Sarala etc.(155 –

Table 4. Percent probabilities of aberrations in total rainfall during individual months and seasons

Category of aberration	Probability (%)					Season
	June	July	Aug	Sep	Oct	
D	9.1	4.3	0.0	7.7	18.2	7.8
D	36.4	26.5	24.3	31.8	36.4	31.0
N	27.3	40.7	47.1	33.7	27.2	35.2
H	13.2	19.5	23.3	18.6	5.1	16.1
H	14.0	9.0	5.3	8.2	13.1	9.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table 5. Characteristics of weekly rainfall (mm) during monsoon season at Balasore

Standard Week	Average Rainfall(mm)	Standardd eviation (±)	Coefficient of variation (%)	Probability(%) of getting rainfall			Expected rainfall (mm) at probability	
				10mm	15mm	20mm	25%	50%
23(Jun 4-10)	63.4	81.8	129	75.8	72.6	69.2	72.7	47.7
24(Jun 11-17)	57.6	59.7	103	78.8	75.8	72.6	100.3	37.4
25(Jun 18-24)	80.4	57.6	72	88.5	86.4	84.1	131.7	73.8
26(Jun 25-Jul 1)	64.2	52.8	82	84.1	81.6	78.8	101.3	55.3
27 (Jul 2-8)	53.5	31.0	58	91.9	88.5	86.4	81.8	43.9
28 (Jul 9-15)	52.6	36.0	68	88.5	84.1	81.6	83.1	45.1
29(Jul 16-22)	108.6	101.8	94	84.1	81.6	81.6	143.6	92.5
30(Jul 23-29)	65.8	64.4	98	78.8	78.8	75.8	103.0	39.6
31(Jul 30-Aug 5)	69.8	50.5	72	88.5	86.4	84.1	116.3	65.7
32(Aug 6-12)	84.2	68.7	82	86.4	84.1	81.6	132.8	76.1
33(Aug 13-19)	76.4	64.2	84	84.1	84.1	81.6	121.7	53.7
34(Aug 20-26)	45.4	38.5	85	81.6	78.8	75.8	73.7	36.4
35(Aug 27-Sep 2)	64.7	42.9	66	90.3	88.5	84.1	103.5	64.6
36 (Sep 3-9)	52.7	45.6	87	81.6	78.8	75.8	83.0	46.9
37 (Sep 10-16)	69.8	65.3	94	80.9	77.7	72.8	91.1	55.1
38 (Sep 17-23)	57.1	88.4	155	69.2	69.2	65.5	80.7	30.6
39 (Sep 24-30)	72.7	92.5	127	75.8	72.6	72.6	119.2	48.5
40 (Oct 1-7)	67.2	83.2	124	75.8	72.6	72.6	110.8	39.1
41 (Oct 8-14)	40.5	49.5	122	72.6	69.2	65.5	67.8	33.4

170 days) can be sown in intermediate and medium deep lowlands by direct seeding during late May or early June (21st – 22nd standard meteorological week) prior to onset of monsoon. Cultivation of upland rice entirely depends on monsoon rain. So, sowing of upland rice with varieties like Vandana, Kalinga III, Anjali, Annada etc. (90 – 105 days) could be done during middle of June, i.e. 23rd – 24th standard meteorological week as early monsoon rain help for quick establishment. Early sowing of upland rice help for raising a short duration (80-90 days) second crop of horsegram, mustard or castor etc. immediately after the harvest of upland rice during second fortnight of October as a good amount of rain generally occur during that time. Intercropping of rice+pigeonpea and groundnut+pigeonpea etc. could also be done in the uplands during wet season. The planting of transplanted rice under favourable shallow lowland with early medium to medium duration rice varieties like IR 36, Padmini, Vijeta, Surendra, Swarna etc. (125 – 140 days) should be completed before middle of July because of high intensity of rain generally occurring from 29th - 33rd standard meteorological week which may hinder the establishment of rice crop. There is ample opportunity to harvest the excess rainwater during the period from July to September. This excess water can be stored in some lower elevation through the construction of water harvesting structure as on-farm reservoir. It can be utilized for providing life-saving irrigation to rainfed lowland rice crop during any scarcity at later stage of crop growth in the months of October - November or it can be utilized in raising a second crop of short-duration pulses (70-80 days) like blackgram (*Phaseolus mungo*) or greengram (*Phaseolus radiata*) or oilseeds (80-100 days) like mustard (*Brassica campestris*), sunflower (*Helianthus annuus*) or groundnut (*Arachis hypogaea*) during the winter or dry season with limited irrigation (2-3) under rainfed rice-based production system.

Rainfall pattern indicated that the monsson rainfall normally ceases during middle of October. Under rainfed shallow lowlands where medium duration rice varieties (130-140 days) are raised, soil moisture recedes very quickly at rice harvest during November and there is least opportunity to grow a second crop after harvest of rice with proper land preparation. Under such situation, crops of 80-100 days duration like blackgram (*Phaseolus mungo*), linseed (*Linum usitatissimum*), lathyrus (*Lathyrus sativus*) or fieldpea (*Pisum sativum*) can be raised as *utera* or paira crop by sowing the seeds on the standing crop of rice at two weeks before harvesting of rice (Saha and Moharana, 2005).

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