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Rainfall variability study for crop planning under rainfed production system in Western Orissa

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ABSTRACT

Daily rainfall data for 30 years (1975-2004) of seven different locations in Western Orissa viz, Sundergarh, Jharsuguda, Sambalpur, Bolangir, Titlagarh, Bhawanipatna and Koraput were analyzed for establishing long term averages of annual and seasonal rainfall and its temporal variability by deploying appropriate statistical techniques. The results revealed that the average annual rainfall in different parts of western Orissa varied from 918 mm in Sundergarh to 1541 mm in Sambalpur at different locations 78 to 86% of the total annual rainfall was received during monsoon months (June to September). The data on weekly rainfall revealed that the rain due to Southwest monsoon generally started during 24th standard meteorological week (SMW) except at Sundergarh in the extreme northern parts of western Orissa where it is delayed for a week. The monsoon rain normally ceased during 40thto 41st SMW except Bolangir, Bhawanipatna and Koraput where it ceased early during 37th to 38th SMW. At 75% confidence level, assured rain (800 to 1000 mm) for cultivation could be expected at all the locations except Sundergarh and Bhawanipatna. Except the extreme northern part of Sundergarh region, the average rainfall during monsoon (1072-1339 mm from June-September) indicated the suitability of rainfed rice cultivation in this part of Orissa with appropriate rain water management while the winter rain was meager (average rainfall 12-57 mm during December–February) for agricultural operations at all the locations even at 50% probability level.

Key words: *Rainfall variability, crop planning, rice-based production system, western Orissa*

Crop productivity of a particular region is largely determined by its climate and prevailing weather. Climate variability, particularly of rainfall is the major factor influencing the sustainable agricultural productivity in the tropics (Virmani, 1994). The Western zone of Orissa lies between 19^{0}30$^/$ and 22^{0}11$^/$ North latitude and between 82^{0}20$^/$ and 88^{0}47$^/$ East longitude and spread over nine districts from Sundergarh in north to Koraput in south. Annual rainfall in this region is highly variable and it ranges from 900 – 1500 mm. About 80% of the annual total rainfall is received during the monsoon season. Rice is the staple food crop in this region and farmers generally grow rice during the wet season under rainfed situation. The productivity of rainfed rice is highly uncertain in most parts of this region as it is largely influenced by the rainfall distribution pattern and its intensity during the monsoon season. About 1200-1400 mm of water is required for medium/late maturing rice varieties. When rainfall is less than 1200 mm, there are more chances of water stress depending on its distribution pattern (Sastri *et. al.*, 1999). As rainfall is the single major limiting factors in rainfed crop production system, a sound knowledge and an understanding of its distribution pattern over the years, intensity and other characteristics like time of onset and cessation of monsoon etc. are essential for suitable crop planning (Saha and Biswal, 2004). Farmers' crop planning is also greatly influenced by the onset of monsoon and its weekly variability (Victor *et. al.*, 1991). The pressure on rainfed agricultural land would increase to meet the increasing demand of food and feed in the future (Abrol, 1996). Thus, alternate cropping patterns should be explored by redesigning of the system to maximize production or sustaining rice with an alternate crop that is not vulnerable to hostile weather. Keeping these in view, the present study was undertaken to assess the rainfall variability at different parts of Western Orissa and its distribution pattern during the years for suitable crop planning under rainfed production system.

MATERIALS AND METHODS

The analyses were carried out using historical daily rainfall data. Thirty years' rainfall data (1975 to 2004) of seven different locations of Western Orissa viz., Sundergarh, Jharsuguda, Sambalpur, Bolangir, Titlagarh, Bhawanipatna and Koraput were analyzed for computing annual and seasonal distribution of rainfall. The standard deviation (SD) and coefficient of variability (CV) and weekly rainfall distribution pattern were computed adopting standard statistical procedures. The onset and cessation of monsoon rainfall at different locations were also computed for identifying the crop growing season. The probability of seasonal rainfall at 90%, 75%, 50% and 25% confidence level was estimated by using incomplete gamma distribution.

RESULTS AND DISCUSSION

The rainfall data (1975-2004) revealed that the average annual rainfall of this region varied from 918 mm in Sundergarh to 1541 mm in Sambalpur. The rainfall variability showed a standard deviation of 384, 278, 435, 373, 367, 371and 283 mm and coefficient of variation (cv%) of 40, 20, 29, 29, 27, 31 and 31 for Sundergarh, Jharsuguda, Sambalpur, Bolangir, Titlagarh, Bhawanipatna and Koraput, respectively (Table 1). The large CV values for annual rainfall indicated higher variability of annual rainfall for all the locations except Jharsuguda with the lowest CV values (20%) which indicated that the rainfall was relatively more dependable at this place (Table 1).

Average seasonal rainfall and its variability are presented in Table 1. The rainfall during the pre-monsoon season (March to May) varied from 56 mm in Sambalpur to 172 mm in Koraput which contributed about 4 to 12 % towards annual total rainfall. The rainfall received from the Southwest monsoon (June-September) ranged from 757 mm in Sundergarh to 1339 mm in Sambalpur which contributed 78 to 86% of the annual total rainfall at different locations. The rainfall during post-monsoon season ranged from 43 mm at Sambalpur to 103 mm at Titlagagh contributed only 5 – 8% of the total annual rainfall except Koraput. A good amount of rainfall (134 mm) was received during post-monsoon season (October to November) at Koraput. The winter rainfall was normally low in the entire zone and contributed only 1 – 5% of the total annual rainfall.

Except the Sundergarh region (average total rainfall 757 mm during June-September), the rainfall quantum of monsoon season (1072-1339 mm) in different parts of western Orissa indicated the suitability of rainfed rice cultivation during the wet season considering the water requirement of rice crop as 1000-1200 mm for medium duration (130-145 days) rice varieties (Sastri *et al*. 1999). However, keeping aside total amount, the distribution pattern of monsoon rain becomes critical in rainfed rice cultivation. The high CV values in most of the locations indicated the uncertainty in monsoon rainfall over the years. So, good productivity of rice can be obtained only by adopting suitable water conservation practices. Low rainfall during the post-monsoon season in most of the parts of western Orissa indicated that the rainfed rice crop may

Table 1. Annual and seasonal rainfall features at different locations of Western Orissa

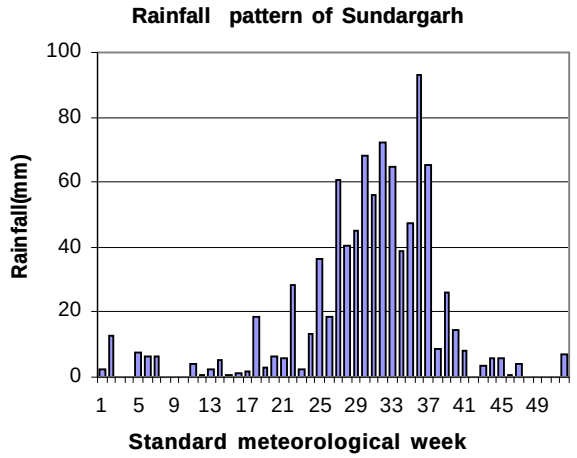
Locations	Pre-monsoon			Monsoon			Post-monsoon			Winter			Total			Crop Growing Season (days)
	RF	SD	CV	RF	SD	CV	RF	SD	CV	RF	SD	CV	RF	SD	CV	
Sundergarh	76	131	172	757	474	63	43	65	151	42	57	135	918	384	40	105
Jhansuguda	82	61	75	1187	225	19	68	56	82	39	39	100	1376	278	20	119
Sambalpur	56	45	81	1339	486	36	89	180	202	57	76	135	1541	435	29	119
Bolangir	81	43	54	1119	346	31	72	91	127	28	224	80	1300	373	29	91
Titlagarh	76	35	46	1226	431	35	103	127	123	31	270	87	1436	367	27	112
Bhawanipatna	72	62	86	1072	190	18	94	133	141	23	230	100	1261	371	31	98
Koraput	172	85	49	1166	85	35	134	87	65	12	135	112	1484	343	31	98

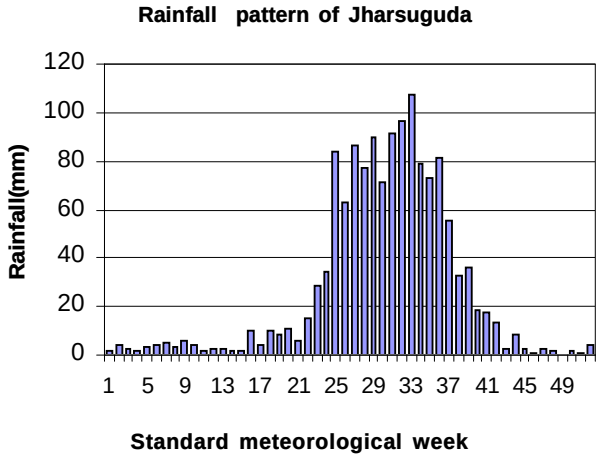
RF – Rainfall in mm; SD – Standard Deviation; CV – Coefficient of variability

face terminal drought during the flowering/ maturity stage in shallow lowlands. Thus, there is a need to select early medium to medium duration rice varieties (125-140 days) like Naveen, IR 36, Swarna, Vijeta, Surendra etc. for escaping water scarcity during October-November. This region needs crop diversification/ substitution slowly by some low-duty crops like short duration pulses viz., greengram, blackgram, horsegram etc. or oilseeds viz., sesamum, groundnut etc. in rainfed uplands and shallow lowlands where the chances of water stress are more for rice crop. Water management practices should be adopted for improving the productivity of rice under rainfed situation. Weekly precipitation amount and its assurance during rainy season are quite important for crops like rice that requires water throughout the growing period (Saha *et al.*, 2004). The weekly rainfall data revealed that the rainfall due to Southwest monsoon generally starts during 24th Standard Meteorological Week (SMW, 11-17 June) except at Sundergarh in the extreme north where it starts little late on 25th SMW (18 - 24 June). The monsoon reaches the peak (rainfall >70 mm/week) during 25th - 26th SMW (second fortnight of June) and continues up to 36th SMW (3-9 September) at Sambalpur, Jharsuguda and Titlagagh i.e., starting from central to northern part of western Orissa while the peak rainfall period is of short duration from 29th to 33rd SMW (mid July to mid August) at central to southern part of this region i.e., Bolangir, Bhawanipatna and Koraput The shortest period of two weeks i.e., from 36th to 37th SMW (first fortnight of September) was the peak monsoon period at Sundergarh in the extreme northern part of Western Orissa. The monsoon ceases early during 37th to 38th SMW (middle of September) at Bolangir, Bhawanipatna and Koraput i.e., central to southern parts of western Orissa while it ceases during 40th or 41st SMW (first fortnight of October) at other locations (Fig 1).

The crop growing season at different locations was calculated based on the onset and cessation of monsoon. It was observed that the total crop growing season was 17 weeks (119 days) from 24th to 41st SMW at Sambalpur and Jharsuguda, while it was only 91 days (24th to 37th SMW) at Bolangir because of very early cessation of monsoon rain (Table 1). Based on the weekly rainfall pattern, the entire area of western Orissa can be divided into 3 zones, the extreme north of Sundergarh where rain starts late and having very short spell of peak rainfall (2 weeks) with total crop growing season of 15 weeks (105 days); the central to southern part of western Orissa including Bolangir, Bhawanipatna and Koraput where peak rainy season is extend upto 5 weeks with total crop growing season upto 14 weeks (98 days) due to early cessation of rain and the central to northern part of Orissa where peak rainy season prolongs for 10 weeks with maximum crop growing season of 17 weeks.

The weekly rainfall pattern indicated that the northern part of Western Orissa i.e., Sundergarh region is not suitable for growing a good crop of rice from rainfed uplands and shallow lowlands because of less rainfall (average total rainfall of about 757 mm received from South-west monsoon) during the cropping period, short crop growing season (105 days) due to delayed start of rain and very short spell of peak monsoon during first fortnight of September (Table 1). Some low water requirement crops like greengram, blackgram, maize,





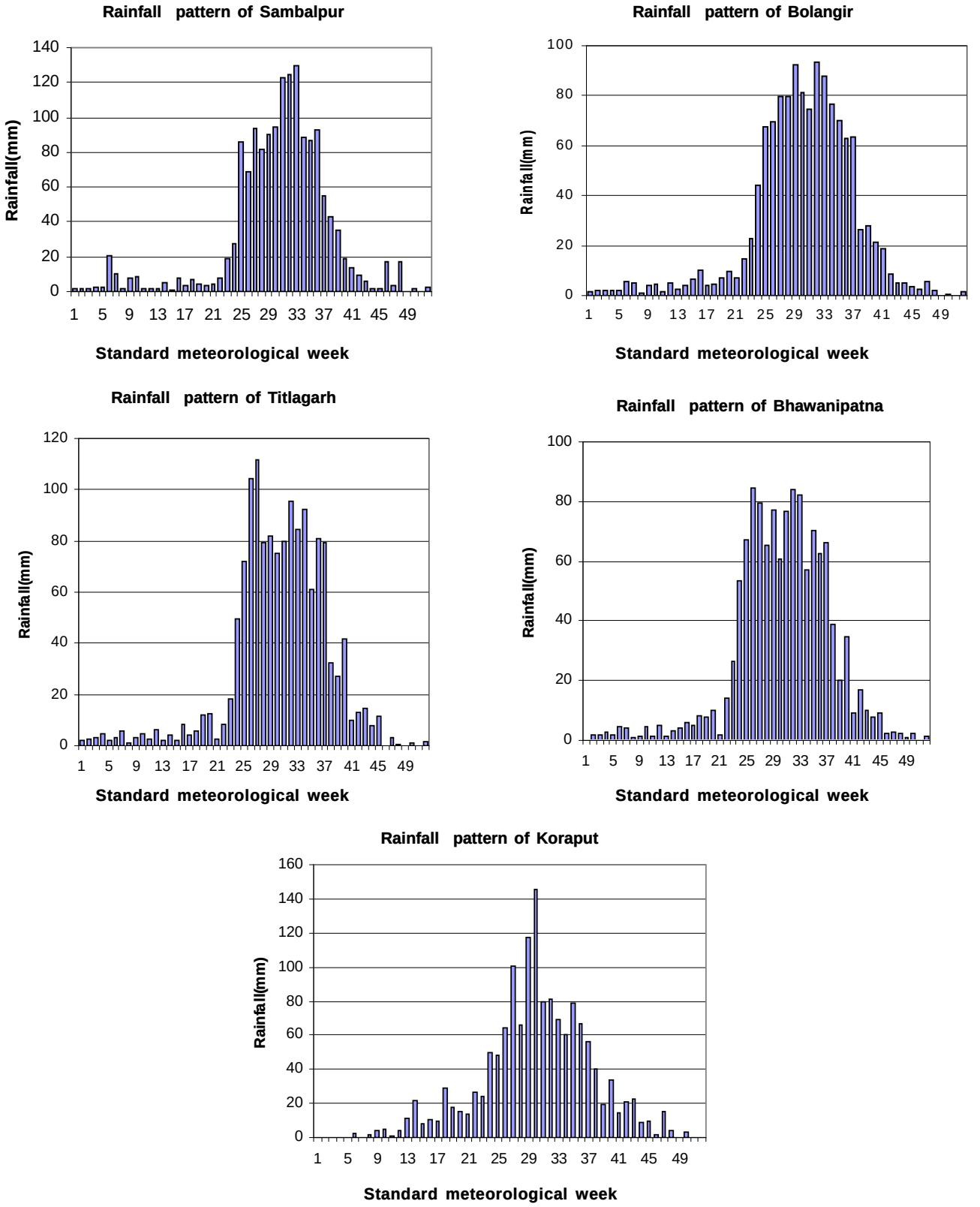


Fig 1. Weekly Rainfall Distribution Pattern (Year : 1975-2004) at Different Locations of Western Orissa

pigeonpea, sesamum, groundnut, sunflower etc. have been found to perform well during wet season by sowing early with the onset of monsoon during third week of June (Saha *et al.* 2004). However in lowlands, early medium duration rice varieties (115 – 125 days) like Naveen, Lalat, IR 36 etc. can be grown by planting early during first fortnight of July with good water management practices viz., *in situ* rain water conservation by bunding (about 30 cm high) around the crop field, arrangement for life saving irrigation during dry spell from stored surface water etc.

The uplands of central to southern part of western Orissa viz., Bolangir, Bhawanipatna and Koraput region, may not be suitable for rice cultivation because of early cessation of rain (during middle of September). Under such situations, some early maturing short duration crops (70-80 days) like greengram, blackgram, horsegram or sesamum can be grown successfully in rainfed uplands by sowing early during middle of June with the onset of rain. In medium lands (bunded uplands/ or shallow lowlands), where there are some possibilities to conserve rain water through raised bunds, early maturing rice varieties (90 days) like Vandana, Kalinga III etc. have been found to be successful (Saha and Biswal, 2003). However, crops like hybrid cotton, soybean, sunflower, groundnut and vegetables have also been found to fetch higher return with insurance against intermittent drought. The crops can be grown early during middle of June with the onset of monsoon to escape drought during ripening phase. However, a good amount of rain (about 1100 mm) is obtained during June-September. In lowlands, early medium to medium duration rice varieties (115-135 days) like Naveen, Lalat, Surendra, Vijeta, Padmini etc. can be grown based on land situation as well as proper rain water management. Planting early at the beginning of July can help a good harvest of the rice crop by escaping moisture scarcity during maturity stage (October-November).

The prospect of rainfed rice cultivation is more in central to northern part of western Orissa viz., Sambalpur, Jharsuguda and Titlagagh where monsoon is prolonged up to first fortnight of October. There is an opportunity of *in situ* rain water conservation by storing the harvested rain water in lower elevation during July to September (about 1100 - 1200 mm rainfall received during this period). It can either be utilized for giving life saving irrigation to rice in the years with low rainfall at reproductive phase during September – October or for growing a second crop of short duration pulses like greengram, bengalgram, linseed or oilseeds like mustard, castor, groundnut, sunflower etc. with limited irrigation. Long duration rice varieties (145-155 days) like Moti, Pooja, Ramchandi etc. have been found to grow successfully in intermediate lowlands. After the harvest of rice, some short duration crops like linseed, bengalgram, lentil, niger etc. can be taken as second crop with residual soil moisture. In rainfed shallow lowlands, rice varieties like Swarna, Pooja, Surendra, Vijeta etc. (135-140 days) have been found to be performed well. In these lands, soil moisture recedes quickly at rice maturity during late October to early November and there is least opportunity to grow a second crop after harvest of rice. However, crops like blackgram, linseed, lathyrus, mustard or fieldpea 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 in rainfed shallow lowlands (Saha and Moharana, 2005). In rainfed uplands, early sowing of short duration rice varieties like Vandana, Kalinga III etc. may help to take a second crop of horsegram, niger, mustard, castor or linseed immediately after rice harvest during early October. There is also high degree of risk for intermittent and terminal drought in the years with poor rain. In such situation, some pulses like greengram, blackgram and minor millets have been found to be successful in rainfed uplands. Intercropping of groundnut + pigeonpea or rice + pigeonpea has also proved to reduce risk factor besides fetching incremental return in rainfed uplands.

The seasonal rainfall probabilities at 25, 50, 75 and 90% confidence level were computed using incomplete gamma distribution and results are given in Table 2 for Sundergarh, Jharsuguda, Sambalpur, Bolangir, Titlagarh, Bhawanipatna and Koraput. Gupta *et al.*(1975) suggested that the rainfall at 80% probability can safely be taken as dependable rainfall while 50% probability is the medium limit for taking risk. Based on this assumption, it was observed that assured rainfall of 70 mm expected only at Koraput as pre-monsoon shower during May at 75% probability level that could be utilized for starting rice cultivation in advance in this region. While the expected rainfall received at 75% probability level was scanty (20 – 41 mm) and not suitable for carrying out agricultural

Table 2. Minimum assured rainfall (mm) at different probability levels

	Probability Level			
Sundergarh	25%	50%	75%	90%
Pre-monsoon	66	44	29	2
Monsoon	593	511	348	212
Post-monsoon	37	26	10	7
Winter	21	11	7	0
Jharsuguda				
Pre-monsoon	81	70	41	26
Monsoon	1347	1159	1013	809
Post-monsoon	69	55	19	16
Winter	29	19	12	6
Sambalpur				
Pre-monsoon	66	48	20	20
Monsoon	1595	1278	1148	927
Post-monsoon	67	58	21	8
Winter	41	21	12	4
Bolangir				
Pre-monsoon	64	51	37	21
Monsoon	1260	1111	806	540
Post-monsoon	75	53	24	11
Winter	32	17	4	0
Titlagarh				
Pre-monsoon	60	47	28	22
Monsoon	1373	1168	977	691
Post-monsoon	73	48	38	18
Winter	22	13	6	0
Bhawanipatna				
Pre-monsoon	71	56	27	10
Monsoon	1046	816	682	401
Post-monsoon	81	59	43	23
Winter	19	10	0	0
Koraput				
Pre-monsoon	138	108	73	28
Monsoon	1350	1190	796	532
Post-monsoon	96	70	49	30
Winter	17	11	0	0

operation early before the start of monsoon in other locations. It was also observed that assured rainfall for rice cultivation could be expected (at 75% probability level) during the monsoon season at all the locations within the range of 800 – 1150 mm except at Sundergarh and Bhawanipatna. While the rain during post-monsoon and winter months was less than 50 mm at 75% confidence level throughout the entire belt of western Orissa indicating least scope for cultivation during dry season without assured irrigation in this part of Orissa.

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