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STUDIES ON RAINFALL CLIMATOLOGY AND LENGTH OF GROWING PERIOD FOR PADDY CULTIVATION OVER ORISSA

1. Orissa is a predominantly agrarian state having 41.3% of the total area under cultivation out of which kharif paddy occupies 65% area and 70% of the cultivated land is rainfed Orissa Agricultral Statistics (1990-91). Under rainfed condition the distribution pattern of the area under paddy and production potentiality of the crop in different parts of the state is closely linked with the length of growing period and frequency of dry spells of various length. Moreover, in erratic rainfall areas or where dry period is expected within the growing season knowledge on probability of having consecutive dry period of one or two weeks duration is of great importance. If such a dry period coincides with the critical growth stages, this could damage the crop. So, a comprehensive knowledge of the probability of rainfall for a particular area is of great importance because of economic implications of rain sensitive operations.

A number of research papers have been published on dry spell probabilities during the monsoon season by different authors namely Basu (1971), Victor and Sastry (1979), Chowdhury and Abhyankar (1984) and Khambete and Biswas (1984). So, an attempt has been made here to determine the length of growing period for kharif paddy on the basis of onset and end of rainy season following forward and backward accumulation method.

The study area relates to eight representative districts of Orissa. Table 1 gives details of the selected stations along with data period. These stations represent different agroclimatic zones. Balasore, Cuttack, Bhubaneswar and Ganjam (Gopalpur) are in coastal areas whereas, Koraput, Kalahandi (Bhawanipatna), Bolangir and Sambalpur are in interior part belonging to the drier tract of the state. Weekly (Standard Meteorological Week; SMW) rainfall needed for the computation of forward and backward accumulation of the stations were collected from the records of India Meteorological Department. Criterion like 75mm accumulated rainfall for onset of growing season of dry seeded crops and 200mm accumulated rainfall for initiation of puddling of wetland paddy as assumed by Morris and Zandstra (1978) has been adopted for the study. They stated that (500-300) mm accumulated amount represents termination of wet season after which sufficient rain would be expected to sustain a second paddy crop assuming a fully charged soil profile at planting. The same has also followed here. The variability of accumulated amount for the stations is studied according to the method described by Oldeman and Frere (1982). The method is the ranking order method described by Frere *et al* (1975) and Doorenbos and Pruitt (1977). In this, each rainfall record is assigned a ranking number m to give probability levels $Fa(m)$ which has calculated as -

$$Fa\ (m) = 100m/\ (n+1) \qquad (1)$$

Where n is the number of years. The frequency and probability of dry spells are calculated following Markov chain model described by Robertson (1976). Here, a dry

TABLE 1
Details of observation stations

Stations	Coordinates		Data Period	
	Latitude	Longitude		
Balasore	21°31′N	86°56′E	1960-69, 1974-90	
Cuttack	20°28′N	85°56′E	1960-90	except 1970
Bhubaneswar	20°15′N	85°50′E	1960-90	except 1974
Gopalpur	19°16′N	84°53′E	1960-90	
Sambalpur	21°28′N	83°58′E,	1960-90	except 1970 , 1979
Bolangir	20°42′N	83 °30 ′E	1960-90	except 1970, 1972
Kalahandi	19°50′N	83°11′E	1960-90	except 1970, 1974
Koraput	18°49′N	82°43′E	1960-84	

TABLE 2

Weekly probability of dry spell over coastal Orissa

Met. week	Bhubaneswar					Cuttack					Balasore					Gopalpur				
	F_D	F_{DD}	P_D	P_{DD}	P_{D2}	F_D	F_{DD}	P_D	P_{DD}	P_{D2}	F_D	F_{DD}	P_D	P_{DD}	P_{D2}	F_D	F_{DD}	P_D	P_{DD}	P_{D2}
	(%)					(%)					(%)					(%)				
17	29	29	.96	1.0	92	29	29	.96	1.0	92	24	21	.89	.87	77	30	28	.96	.93	92
18	29	28	.96	.96	92	30	29	1.0	.96	100	23	20	.85	.87	70	28	27	.90	.96	81
19	30	29	1.0	.96	100	28	28	.93	1.0	86	23	19	.85	.83	72	30	27	.96	.90	92
20	29	29	.96	1.0	96	30	28	1.0	.93	96	26	22	.96	.85	92	30	29	.96	.96	92
21	28	28	.92	1.0	85	29	29	.96	.96	92	25	24	.92	.96	85	29	28	.93	.96	86
22	30	28	1.0	.92	100	30	29	1.0	.96	100	24	22	.89	.92	75	31	29	1.0	.93	100
23	21	21	.70	1.0	52	24	24	.80	1.0	70	19	16	.70	.84	52	26	26	.84	1.0	70
24	23	17	.77	.74	55	24	21	.80	.87	65	19	14	.70	.74	49	25	21	.81	.84	62
25	18	13	.60	.72	37	21	17	.70	.81	56	14	10	.52	.71	20	22	17	.71	.77	52
26	18	11	.60	.61	51	15	12	.50	.80	25	13	05	.48	.38	22	23	17	.74	.74	58
27	13	11	.43	.85	24	14	07	.47	.50	20	13	06	.48	.46	22	24	19	.77	.79	55
28	14	08	.47	.57	23	12	05	.40	.42	15	13	06	.48	.46	30	24	17	.77	.71	35
29	10	05	.33	.50	14	16	06	.53	.37	22	08	05	.30	.62	16	20	09	.64	.45	29
30	12	05	.40	.42	12	12	05	.40	.42	18	09	05	.33	.55	12	22	10	.71	.45	56
31	13	04	.43	.31	18	11	05	.37	.45	11	08	03	.30	.37	12	19	15	.61	.79	40
32	12	05	.40	.42	14	10	03	.33	.30	12	10	04	.37	.40	17	17	11	.55	.65	37
33	11	04	.37	.36	12	16	06	.53	.37	33	13	06	.48	.46	20	21	14	.68	.67	44
34	09	03	.30	.33	10	16	10	.53	.62	22	12	05	.44	.42	20	20	13	.64	.65	43
35	09	03	.30	.33	08	12	05	.40	.42	12	11	05	.41	.45	08	18	12	58	.67	34
36	11	03	.37	.27	08	10	03	.33	.30	12	10	02	.37	.20	15	22	13	.71	.59	50
37	13	03	.43	.23	20	14	05	.47	.36	26	05	02	.18	.40	07	20	14	.64	.70	39
38	13	06	.43	.46	16	18	10	.60	.55	35	14	03	.52	.21	36	18	11	.58	.61	30
39	13	05	.43	.38	20	17	10	.57	.59	38	10	07	.37	.70	24	19	10	.61	.52	35
40	13	06	.43	.46	19	18	12	.60	.67	34	11	07	.41	.64	18	14	08	.45	.57	19
41	20	09	.67	.45	45	21	12	.70	.57	48	14	06	.52	.43	24	19	08	.61	.42	26
42	21	14	.70	.67	48	23	16	.77	.69	55	17	08	.63	.47	40	17	12	.55	.70	33
43	26	18	.87	.69	75	25	18	.83	.72	70	22	14	.81	.64	70	23	14	.74	.61	58
44	23	20	.77	.87	66	27	23	.90	.85	84	22	19	.81	.86	64	23	18	.74	.78	55
45	22	19	.73	.86	55	28	26	.93	.93	86	24	19	.89	.79	78	24	18	.77	.75	58

TABLE 3

Weekly probability of dry spell over interior Orissa

Met. week	Sambalpur					Bolangir					Kalahandi					Koraput				
	F_D	F_{DD}	P_D (%)	P_{DD}	P_{D2}	F_D	F_{DD}	P_D (%)	P_{DD}	P_{D2}	F_D	F_{DD}	P_D (%)	P_{DD}	P_{D2}	F_D	F_{DD}	P_D (%)	P_{DD}	P_{D2}
17	29	28	1.0	.96	96	28	26	1.0	.93	100	19	19	.95	1.0	90	21	19	.91	.90	81
18	28	28	.96	.96	92	28	28	1.0	1.0	100	19	18	.95	.95	90	19	17	.83	.89	68
19	29	28	1.0	.96	100	27	27	.96	1.0	92	19	18	.95	.95	95	22	18	.96	.82	92
20	29	29	1.0	1.0	100	27	26	.96	.96	92	18	18	.90	1.0	81	23	22	1.0	.96	100
21	29	29	1.0	1.0	100	27	26	.96	.96	92	20	18	1.0	.90	100	22	22	.96	1.0	91
22	29	29	1.0	1.0	100	28	27	1.0	.96	100	18	18	.90	1.0	85	22	21	.96	.95	90
23	28	28	.96	1.0	96	26	26	.93	1.0	89	18	17	.90	.95	90	18	17	.78	.94	58
24	25	25	.86	1.0	75	24	23	.86	.96	71	14	14	.70	1.0	48	16	12	.69	.75	45
25	16	14	.55	.87	35	18	15	.64	.83	47	13	09	.65	.69	43	17	11	.74	.65	61
26	19	12	.65	.63	11	19	14	.68	.74	18	06	04	.30	.66	19	11	09	.48	.82	26
27	06	03	.21	.50	06	19	05	.68	.26	37	08	05	.40	.62	20	09	05	.39	.55	05
28	07	02	.24	.28	07	11	06	.39	.54	13	06	03	.30	.50	12	07	01	.30	.14	13
29	07	02	.24	.28	05	12	04	.43	.33	21	05	02	.25	.40	14	07	03	.30	.43	24
30	09	02	.31	.22	18	10	05	.36	.50	27	09	05	.45	.55	22	05	04	.22	.80	04
31	07	04	.24	.57	12	08	06	.28	.75	14	04	02	.20	.50	13	06	01	.26	.17	17
32	04	02	.14	.50	02	08	04	.28	.50	09	03	02	.15	.67	02	03	02	.13	.67	02
33	08	01	.27	.12	04	09	03	.32	.33	18	08	01	.40	.12	17	06	01	.26	.17	11
34	06	01	.21	.17	03	07	04	.25	.57	09	07	03	.35	.43	14	07	03	.30	.43	20
35	14	02	.48	.14	24	13	05	.46	.38	14	10	04	.50	.40	21	03	02	.13	.67	05
36	14	07	.48	.50	22	10	03	.36	.30	10	07	03	.35	.43	06	05	02	.22	.40	06
37	15	07	.52	.47	31	15	04	.53	.27	30	06	01	.30	.17	10	07	02	.30	.28	10
38	22	13	.76	.59	61	21	12	.75	.57	56	15	05	.75	.33	55	09	03	.39	.33	19
39	16	13	.55	.81	31	24	18	.86	.75	75	15	11	.75	.73	61	14	07	.61	.50	42
40	21	12	.72	.57	50	23	20	.82	.87	66	16	13	.80	.81	72	16	11	.69	.69	52
41	26	18	.89	.69	78	26	21	.93	.81	89	18	16	.90	.90	77	20	15	.87	.75	76
42	25	22	.86	.88	76	24	23	.86	.96	71	14	12	.70	.86	72	16	14	.69	.87	51
43	27	24	.93	.89	80	24	20	.86	.83	73	19	14	.96	.74	92	19	14	.83	.74	70
44	28	24	.96	.86	96	26	22	.93	.85	85	18	17	.90	.96	85	19	16	.83	.84	66
45	28	28	.96	1.0	92	27	25	.96	.92	92	17	16	.85	.94	76	20	16	.87	.80	76

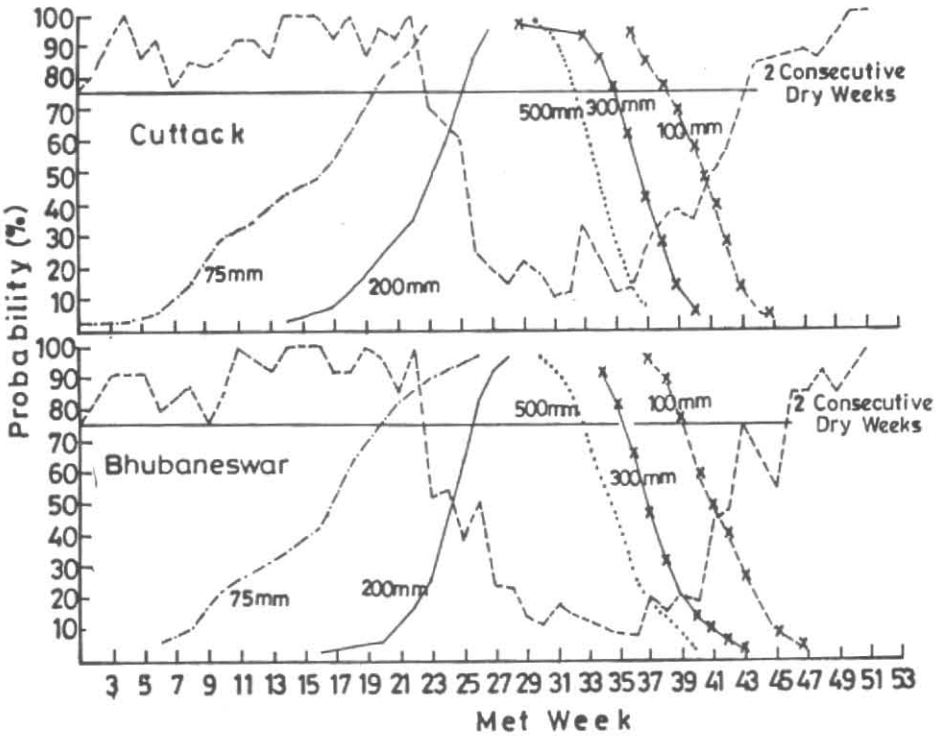

Fig.1(a). Cumulative probability of having received 75 mm & 200 mm rainfall and of still receiving 500 mm, 300 mm & 100 mm rainfall and the probability of having at least 2 (two) consecutive dry weeks

week is considered any week receiving rainfall less than the weekly potential evapotranspiration values of the respective week of the stations. Monthly potential evapotranspiration values for different stations of Orissa calculated by Lenka (1991) are interpolated for weekly values. The probabilities are then calculated as:

$$P(D) = F(D)/N \quad (2)$$

$$P(DD) = F(DD)/F(D) \quad (3)$$

Where $P(D)$ = Probability of dry week

$F(D)$ = Frequency of dry week

$P(DD)$ = Probability of a dry week preceded by a dry week

$F(DD)$ = Frequency of a dry week preceded by a dry week

N = No. of years.

Similarly,

$$P(W) = F(W)/N \quad (4)$$

$$P(WW) = F(WW)/F(W) \quad (5)$$

$P(W)$ = Probability of wet week

$F(W)$ = Frequency of wet week

$P(WW)$ = Probability of a wet week preceded by a wet week

$F(WW)$ = Frequency of a wet week preceded by a wet week and the probability of two consecutive dry weeks starting with first week of the month is:

$$P(D) \text{ week } 1^* \; P(DD) \text{ week } 2 \quad (6)$$

2. The onset and end of rainy season based on forward/backward accumulation of weekly rainfall and the cumulative probabilities of accumulated amount of the stations of coastal Orissa as determined by the aforesaid method alongwith 2 consecutive dry weeks are presented in Figs. 1(a-d). The results are discussed at 75% probability level only. It can be noticed from the above figures that at least 75mm rainfall accumulated on 17 and 24 SMW at Balasore and Gopalpur respectively. The date for the same is 20 SMW at both Cuttack and Bhubaneswar. Among the stations of interior Orissa the date for accumulation of at least 75mm rainfall is 24 SMW at both Sambalpur and Bolangir as compared to that of 25 and 23 SMW at Kalahandi and Koraput respectively. The above figures also reveal that the period of 200mm accumulated rainfall is 23, 24, 26, 27 and 28 SMW at Balasore, Cuttack, Bhubaneswar, Gopalpur and Koraput respectively. But the date of accumulation of 200mm rainfall is 27 SMW at stations – Bolangir, Sambalpur and Kalahandi.

From the above figures, it can also be seen that at Balasore and Bhubaneswar at least 100 mm rainfall can still be expected during 39 week (end of September). At

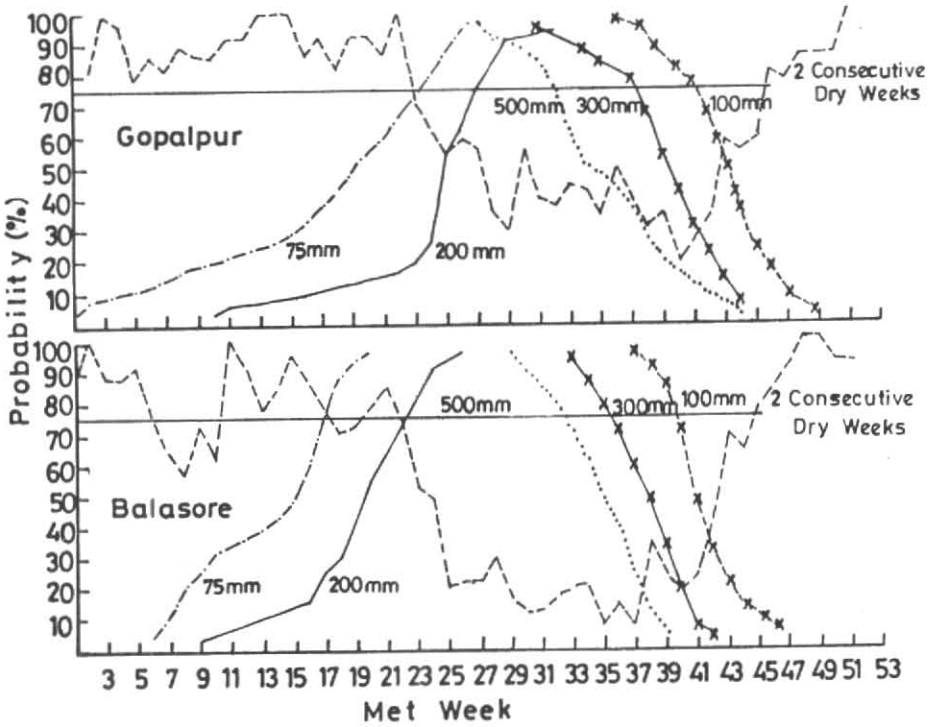

Fig.1(b). Cumulative probability of having received 75 mm & 200 mm rainfall and of still receiving 500 mm, 300 mm & 100 mm rainfall and the probability of having at least 2 (two) consecutive dry weeks

Sambalpur, Bolangir and Kalahandi the duration for the same is from 36 SMW, at Koraput it is from 37 SMW, while, at both Cuttack and Gopalpur the amount can be expected from 38 and 41 SMW respectively. The above figures also reveal that 300mm accumulated rainfall can be expected from 35 SMW (27 August -2 September) in all the stations of coastal Orissa except Gopalpur where the cut-off date for the same is 37 SMW. The date for accumulation of 300mm rainfall can be expected from 33 SMW at Sambalpur, Bolangir and Koraput but for Kalahandi the date for the same is 32 SMW. Besides this, for all the stations of coastal Orissa 500mm rainfall can still be expected from 32 SMW but among the stations of interior Orissa 500 rainfall can still be expected from 29 SMW at Kalahandi. At Sambalpur the date for the same is 31 SMW whereas, at both Koraput and Bolangir the cut-off date for the same is 30 SMW.

From the above discussions it can be noticed that among the stations of coastal Orissa, in case of dry seeding, growing season starts at the earliest delayed (17 week) at Balasore and gets delayed with decrease in latitudinal values of the stations. The stations show similar trend in case of 200mm accumulation also. In case of backward accumulation, with increase in accumulated values from 100 to 500mm the cut-off date of rainy season of all the stations becomes same which is 32 week. For onset, both Sambalpur and Bolangir take 3 weeks to accumulate 200mm rainfall from 75mm. The duration for the same is 2 and 5 weeks at Kalahandi and Koraput respectively. At the end of rainy season all the stations of interior Orissa except Koraput takes 3 weeks to drop from an expected 300 to 100mm rainfall. For Koraput, the duration for the same is 4 weeks.

2.1. The probability of occurrence of dry week, dry week followed by dry week and two consecutive dry weeks of coastal and interior Orissa are presented in Tables 2 & 3 respectively. It is seen from Table 2 that for the initial 4 weeks of rainy season (23 to 39 SMW) the probability of occurrence a week being dry lies between 0.60 to 0.70 and 0.50 to 0.80 at Bhubaneswar and Cuttack respectively. However, at Balasore, for the first 3 weeks the values for the same varies from 0.52 to 0.72 but for the rest period of the season it is less than 0.50 at both Balasore and Bhubaneswar but at Cuttack less than 0.50 is obtained upto 37 SMW except in certain weeks after the initial 4 weeks of rainy season. At Gopalpur the probability of occurrence of dry week lies between 0.55 to 0.89 during south west monsoon period. At both Kalahandi and Koraput at the initial 3 weeks of rainy season the probability of a week being dry lies between 0.65 to 0.90 and 0.69 to 0.78 respectively (Table 3). In case of Sambalpur and Bolangir the first 4 and 5 weeks of rainy season represents the value of a week being dry is from 0.55 to 0.96 and 0.64 to 0.93 respectively. Less than 0.50 probability of a week being dry ranges from 27 to 36 SMW, 28 to 36 SMW, 26 to 37 SMW, and 26 to 38 SMW at Sambalpur, Bolangir, Kalahandi and Koraput respectively.

The probability of a week being dry followed by another dry week is less than 0.50 from 30 to 39 SMW and 28

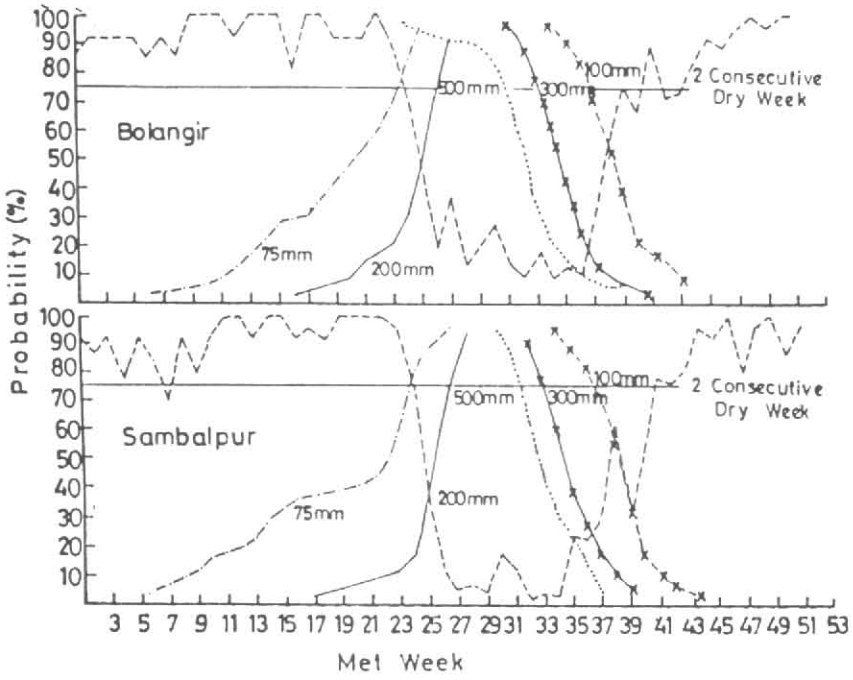

Fig.1(c). Cumulative probability of having received 75 mm & 200 mm rainfall and of still receiving 500 mm, 300 mm & 100 mm rainfall and the probability of having at least 2 (two) consecutive dry weeks

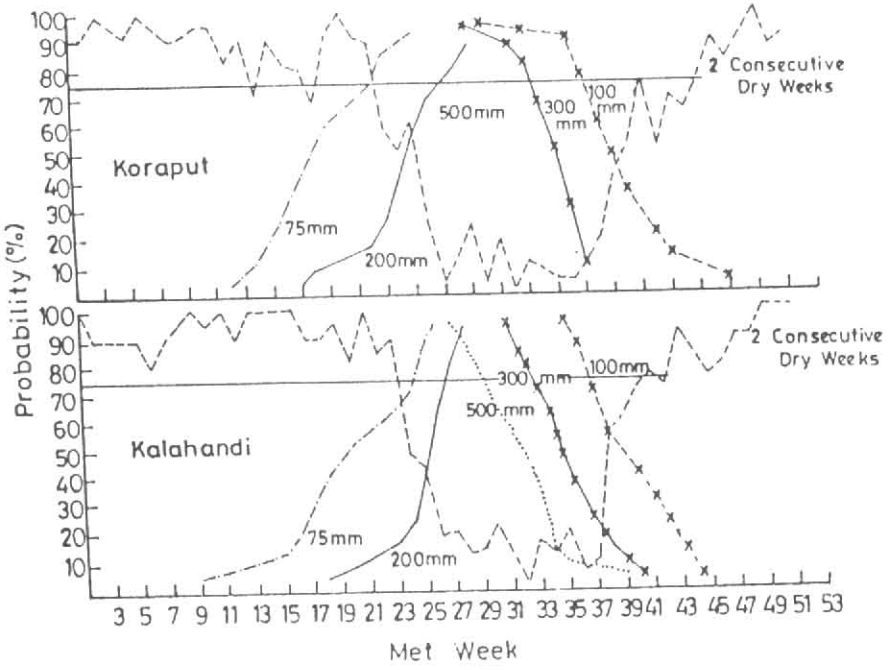

Fig.1(d). Cumulative probability of having received 75 mm & 200 mm rainfall and of still receiving 500 mm, 300 mm & 100 mm rainfall and the probability of having at least 2 (two) consecutive dry weeks.

to 37 SMW at Bhubaneswar and Cuttack respectively. While, at Balasore the value for the same lies between 26 to 38 SMW except in certain weeks. At Gopalpur, less than 0.50 value is noticed on 29 and 30 weeks. But unlike coastal Orissa the probability of a dry week followed by another dry week is highly variable during southwest monsoon among the stations of interior Orissa (Table 3).

3. It is observed from Fig.1(b) that rainy season at Balasore lasts for 23 weeks (17-39 SMW). The season with heavy rainfall sufficient to grow paddy is from 23 to 35 SMW. As the duration is short (13 weeks) cultivars like - Parijat, Subhadra, Partha and Neela that can mature within 90 day's can be grown here successfully. Moreover first

week of June (23 week) seems to be a reasonable planting date of the said cultivars as risk of two consecutive dry weeks is less during the period. So, plant will not suffer from any moisture stress if transplanted during the period. For both Cuttack and Gopalpur the duration of rainy season is 18 weeks but for Bhubaneswar the duration for the same is 20 week. However, the duration of heavy rainfall sufficient to grow paddy for all the stations are same which is about 10 weeks (26 - 35 SMW). Thus, it is obvious that this duration is short for paddy crop. However, very short duration cultivars like — Heera, Rudra and Kalinga- III can be grown here. But farmers have to wait till end of June *i.e.*, upto 26 week for planting of these cultivars as, probability of two consecutive weeks being dry is less than 25 per cent during the period. [Figs. 1(a&b)]. If planting is done during this period crop will face less risk of dry spell during growth cycle, thereby moisture stress will not be a limiting factor. This will ensure good harvest with optimum input and proper management practices. From the Figs. 1(c & d) it is seen that unlike coastal Orissa, the length of growing season of all the stations of interior Orissa is very short. At both Sambalpur and Bolangir the length of growing season is 13 weeks (24 to 36 SMW). Whereas, at Koraput and Kalahandi the duration for the same is 16 (22 to 37 SMW) and 12 (25 to 36) weeks respectively. The duration of heavy rainfall sufficient to grow paddy is 6 and 5 weeks at Kalahandi and Koraput respectively as compared to that of 7 weeks at both Sambalpur and Bolangir. So it is adviseable not to grow paddy crop at those stations under rainfed as assured water availability for such a short period will adversely affect normal growth and development of the crop resulting poor yield, leading to paddy cultivation non profitable.

The study leads to the following conclusions

(*i*) Among the stations of coastal Orissa commencement of growing season for dry seeding crop is the earliest at Balasore followed by both at Cuttack and Bhubaneswsar and Ganjam. The stations also show the similar trend for accumulation of 200 mm rainwater for initiation of puddling.

(*ii*) Over the districts of interior Orissa growing season for dry seedings crops starts first at Koraput followed by both at Sambalpur, Bolangir and Kalahandi but for initiation of puddling operations accumulation of 200 mm rainwater is same at all the stations except Koraput where the lag period for the same is one week.

(*iii*) Accumulation of higher amount is much more gradual than that of lower amount over the districts of coastal Orissa.

But among the stations of interior Orissa the onset and end of rainy season is much more variable at Koraput than that of other stations.

(*iv*) Short duration paddy cultivars like Parijat, Subhadra, Partha, Neela *etc.* may be grown successfully at Balasore and very short duration cultivars like Heera, Rudra and Kalinga-III may be cultivated as rainfed at Bhubaneswar, Cuttack and Ganjam.

(*v*) As the duration of heavy rainfall sufficient to grow paddy is very short at all the stations of interior Orissa no paddy cultivars can be grown there successfully as rainfed.

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