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Characterisation of rice fallow period for increasing cropping intensity in Khordha district of Odisha

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ABSTRACT

The possibility of increasing the cropping intensity in Khordha district was assessed by block-wise characterisation of rainfall, soil texture, available water holding capacity of soil and district level temperature during the rice fallow period as well as deciding the appropriate sowing window for both *kharif* and *rabi* crops. More than 50% chances of occurrence of wet weeks at the beginning of the *kharif* season (20-22 SMW) indicated that the summer ploughing and initial seed bed preparation could be taken up during the period followed by sowing of rice from 23 SMW. The 42-43 SMW with greater than 30% initial probability of wet week at 20 mm threshold limit. Considering the length of growing period (LGP) available, the adjustment of rice variety duration by 10-15 days in medium land and advancement of pulse sowing almost by 15 days before harvest of the rice crop (Pira crop) in low land was registered as the best suitable option for *rabi* pulses to ensure better utilisation of rice fallow. In addition to these, harvesting surplus water during *kharif* and storing in farm ponds for judicious utilisation during *rabi* season further enhanced the possibility of utilisation of rice fallow and increasing the cropping intensity. In the event of delayed monsoon the rice duration has to be adjusted accordingly not to sacrifice the designated suitable period for *rabi* pulses

Keywords: Rice fallow, rainfall probability, effective rainfall, LGP, sowing window

Rice fallows basically refers to those medium and low lands *kharif* sown rice areas which remain uncropped during *rabi* (winter) season due to various reasons. Characterisation of rice fallow period involves studying the climatic and soil characteristics superimposed on Length of growing period (moisture availability period) and cropping system in order to bring out the agricultural potential of the concerned region. Rice is the major crop, grown over an area of more than 18 mha in Eastern states comprising Assam, Bihar, Chhattisgarh, Jharkhand, Odisha and West Bengal. Due to various reasons such as cultivation of long duration paddy varieties, excessive and lack of moisture in rice field at the time of planting of winter crops, lack of irrigation, non availability of seeds of short duration varieties of rabi crops more specifically the short duration cold tolerant pulse varieties and other socio-economic problems like stray cattle and blue bulls etc, an estimated area of more than 8mha remain fallow after harvest of paddy during *rabi* in these states. Odisha has a cultivated area of 61.80 lakh hectares of which 29.14, 17.55 and 15.11 lakh ha are high, medium and low land, respectively. Paddy is also the dominant crop of the state covering about 38.80 lakh hectares in *kharif* and 3 lakh hectares during *rabi*. Rice fallow is estimated to12.20 lakh hectares in the state and 30 thousand hectares in Khordha district. After rice harvest, *rabi* crops are grown on residual soil moisture in the rice fallow. So, a good rainfall towards the end of the kharif crop growing season provides sufficient moisture for germination and establishment of the next crop. Critical observation of the rainfall pattern of the state clearly indicated that though there was not much variation in quantum of rainfall during the recent past decade but the number of intermittent dry spells and intense rainy days has increased significantly alongwith decrease in number of total rainy days per year. Besides, the occurrence of rainfall during post-monsoon is completely uncertain. This situation necessitates the conservation of surplus rain water during *kharif* season and its effective utilisation during the lean period. In this context 12.20 lakh hectares of rice fallow is the most suitable area for increasing the production to meet the demands of growing population. Inclusion of short duration low water requiring pulses (green gram/ blackgram/ gram) offered excellent opportunity to utilize carry-over residual soil moisture in rice fallow (Rahmiaanna *et al*., 2000; Kar *et al.,* 2004).

Table 1: Block-wise soil texture, soil type and AWHC of Khordha district

Sl. No.	Blocks	Sand %	Silt %	Clay %	Soil Type	AWHC (mm)
1.	Balianta	73.7	9.3	17.0	Sandy loam	128
2.	Balipatna	74.1	12.0	13.9	Loamy sand	135
3.	Banapur	61.2	18.7	20.1	Sandy clay loam	145
4.	Begunia	80.8	6.5	12.7	Loamy sand	126
5.	Bhubaneswar	85.8	5.2	9.0	Sandy	106
6.	Bolagarh	79.4	7.8	12.8	Loamy sand	128
7.	Chilika	65.4	14.5	20.1	Sandy clay loam	137
8.	Jatani	81.5	8.3	10.2	Loamy sand	110
9.	Khordha	77.2	10.0	12.8	Loamy sand	112
10.	Tangi	77.5	9.8	12.7	Sandy	112

MATERIALS AND METHODS

The study was conducted for Khordha district of Odisha which lies between 19°55'-20°25'N Latitude and 84°55'-86°5'E Longitude on pilot basis for possible utilisation of rice fallow. Khordha has average rainfall of 1408 mm (1993-2017) with maximum and minimum temperature of 42.2 and 11.1 °C, respectively. The district comprises of 10 blocks namely Balianta, Balipatna, Banapur, Begunia, Bhubaneswar, Bolagarh, Chilika, Jatani, Khordha & Tangi. All the weather data including maximum temperature (T_{max}), minimum temperature (T_{min}), and evaporation (E) has been collected from the Department of Agricultural Meteorology, OUAT, Bhubaneswar for the period 1993-2017 (25 years). Block wise rainfall data of Khordha district has been obtained from SRC site of Govt. of Odisha for the same period.

Probability analysis of rainfall

Incomplete gamma distribution model has been used to determine the amount of rainfall at three different probability levels (90%, 75%, and 50%). Markov Chain probability model has been used for calculating the initial and conditional probability of dry spells using weekly rainfall data. Rainfall probability of the district was estimated by averaging the values of all the blocks. Twenty mm of rainfall per week is adequate for all the growth stages of crops. So, it has been taken as the threshold limit (Ramdurg *et al*., 2015) for designating a week as dry or wet and have calculated respective probability by Markov Chain Model procedure (Pandarinath, 1991; Kar *et al.,* 2014; Vijaya Kumar *et al.,* 2019).

Soil analysis

Soil physical properties of the ten blocks of Khordha district were characterised on the basis of their soil texture using 'Bouyoucos Hydrometer' method and soil type was decided using soil textural triangle. The available water holding capacity of the soil was calculated using pedo- transfer function Table 1.

Length of growing period (LGP)

LGP is considered as the period with sufficient soil moisture storage which can support any crop growth that includes the period from onset to cessation of rainfall during rainy season, the post monsoon rainfall and the available water holding capacity (AWHC) of the soil. Based on the formula given by Sattar *et al.*, (2013) the length of growing period was calculated. It was calculated for 10 different blocks of the district using the following formula:

LGP = Duration of rainy season in days + [{Post monsoon rainfall (mm) + AWHC (mm)} / average evaporative demand of atmosphere during post monsoon period]

Forward and backward accumulation methods as suggested by Dash and Senapati (1992)were used for calculating mean onset and cessation of rainy season.

Deciding of sowing window for kharif and rabi crops

The sowing window for *kharif* and *rabi* crops have been decided by using the initial and conditional probability analysis of rainfall during monsoon period using Markov chain model and considering the LGP that has been estimated using the formula given by Sattar *et al*., (2013). The initial

Table 2: Annual and weekly rainfall probability of Khordha district

Week	Probability levels			Mean(mm)
	90%	75%	50%	
19	0.6	3.6	14.5	28.7
20	0.8	3.5	12.3	21.7
21	1.1	4.4	14.2	24.1
22	1.1	3.3	8.8	12.6
23	3.5	8.3	18.2	27
24	4.5	13	32.9	47.9
25	9.9	20.3	39.3	48.5
26	17.2	29.1	47.9	54.4
27	14	30.2	60.5	77.1
28	7	19.3	46.8	66.9
29	25.8	41.3	65	72.5
30	23	36.2	56.4	62.4
31	28.7	46.7	74.6	84
32	17.5	31.3	54.1	63.1
33	21.6	39.4	69.3	81.9
34	22.3	36.3	57.9	64.9
35	9.3	47.6	76.1	85.6
36	22.5	35.7	55.7	61.7
37	13	24.6	44.5	53.1
38	25.8	41.5	65.7	73.5
39	6.2	15.2	33.5	44.9
40	6.8	17.5	40.4	55.8
41	1.5	6.7	22.7	40.1
42	1.3	5.7	19.8	35.5
43	0.3	2.2	11.9	28.7
44	0.2	1.9	10.4	25.1
45	0.2	1.4	6	11.9
Annual	**1092.6**	**1238.7**	**1415.9**	**1432.6**

probability of wet weeks should be more than 50% for sowing of *kharif* rice and more than 30% for sowing of *rabi* crop in rainfed areas (Ray *et al*., 2018).

Effective rainfall

Estimation of effective rainfall will give us the idea for surplus water available for run off. The monthly effective rainfall was calculated following USDA Soil Conservation Service method Sharma *et al.,* (2010).

$P_e = P_t /125 (125-0.2P_t)$ (when $P_t<250$ mm)

$P_e = 125 + 0.1P_t$ (when $P_t>250$ mm)

Where, P_e = monthly effective rainfall (mm) and P_t = total monthly rainfall (mm).

Table 3: Block-wise monsoon and post monsoon rainfall (mm) of Khordha district at three probability level

Monsoon rainfall (mm)			
Block	**50%**	**75%**	**90%**
Balianta	949.9	434.7	191.3
Balipatna	657.4	289	120
Banapur	815.4	372	165.2
Begunia	766.5	323.6	129.9
Bhubaneswar	999.7	467.9	208.7
Bolagarh	716.5	304	121.3
Chilika	828.8	331.8	166.4
Jatani	966.6	435.2	210.2
Khordha	870.1	393.2	167.3
Tangi	878.5	413.9	185.9
Post monsoon rainfall (mm)			
Balianta	61.3	14.4	4.8
Balipatna	50	13.8	4.7
Banapur	64.5	15.6	4.2
Begunia	51.5	13.6	4.2
Bhubaneswar	65.1	16.1	4.2
Bolagarh	53.5	12.4	3.1
Chilika	65.2	16.3	4.3
Jatani	63.2	16.1	4.1
Khordha	57	13.9	3.7
Tangi	63.7	16.2	4.4

RESULTS AND DISCUSSION

Probability analysis of rainfall

The expected amount of annual rainfall for the district (average of all the blocks) at 90%, 75% and 50% are 1092.6 mm, 1238.7 mm and 1415.9 mm, respectively (Table 2). After the onset of monsoon, i.e. from 23 SMW till 40 SMW the rainfall amount is very high at 75% probability level which is

Table 4: Block-wise length of growing period (LGP) of Khordha district

Blocks	SW Monsoon Period (days)	Post monsoon rainfall (mm) (cessation of monsoon-Jan)	AWHC (mm)	Average evaporation during post monsoon period (mm/day)	LGP (days)
Balianta	120	154.9	128	3.5	201
Balipatna	117	109.4	135	3.5	187
Banapur	118	134.2	145	3.5	198
Begunia	120	99.3	126	3.5	184
Bhubaneswar	122	132.9	106	3.5	190
Bolagarh	118	118.6	128	3.5	189
Chilika	117	141.7	137	3.5	204
Jatani	121	129.9	110	3.5	190
Khordha	121	114.5	112	3.5	186
Tangi	118	136.7	112	3.5	189
District	**121**	**138.9**	**124**	**3.5**	**196**

Table 5: Block-wise rice fallow period characterization of Khordha district

Blocks	Period (SMW)	Amount of rainfall (mm)	Initial Probability of wet weeks (%)	Conditional Probability of wet/wet weeks (%)	LGP available for rabi crop (days)
Balianta	43	37.0	32	55	72
Balipatna	42	28.1	36	67	68
Banapur	42	42.7	44	64	79
Begunia	42	27.9	40	45	63
Bhubaneswar	42	40.1	36	55	67
Bolagarh	42	29.4	32	58	70
Chilika	42	40.0	44	67	85
Jatani	42	32.4	48	50	68
Khordha	42	29.2	36	50	64
Tangi	43	36.3	30	50	62

the most suitable period for growing of *kharif* rice. The amount of rainfall again decreases gradually after 40 SMW (during cessation of monsoon) and so water stress condition prevails during that period for *rabi* season crops. Available water holding capacity of soil satisfies the water requirement of the pulses.

Among the blocks of the district, Bhubaneswar block received highest amount of dependable rainfall (467.9 mm) during monsoon period and Balipatna block received lowest (289 mm) amount of rainfall **(**Table 3**)**, whereas, during post monsoon period Chilika received maximum rainfall (16.3 mm) and Bolagarh received the least (12.4 mm)**(**Table 3**)**. The analysis indicated that good amount of residual soil moisture is required for the blocks receiving less amount of rainfall for growing of *rabi* pulses.

Length of growing period

The growing period starts with the beginning of monsoon. The soil type plays an important role on the variability of sowing of crops due to its water holding capacity with the difference in depth. The growing season determines the period that the land can be utilised and accordingly the crops and or varieties can be selected for judicious utilisation

Table 6: Block wise sowing window for *kharif* and *rabi* crops

Blocks	LGP (days)	Sowing window for *kharif* rice (SMW)	Duration of rice crop (days)		Sowing window for *rabi* crops (SMW)	Rabi crops
			Medium land	Low land		
Balianta	201	24	135	150	42-43	Black gram/ Green gram/ Horse gram/ Lathyrus as sole or paira crop under residual soil moisture condition. Linseed and chickpea may be new introduction in the area with high soil moisture storage of almost 150mm
Balipatna	187	24	120	145	42	
Banapur	198	24	135	155	42-44	
Begunia	184	24	120	145	42	
Bhubaneswar	196	23	120	150	42	
Bolagarh	189	24	120	150	42	
Chilika	204	24	135	155	42-44	
Jatani	195	23	120	150	42	
Khordha	192	24	135	145	42-43	
Tangi	195	24	135	145	42-43	

Table 7: Block wise effective rainfall of Khordha district

Blocks	Annual Rainfall (mm)	Effective Rainfall (mm)	Contribution (%)	Amount of water lost (mm)	Contribution (%)
Balianta	1607.5	913.7	57.0	693.7	43.0
Balipatna	1110.9	769.1	69.2	341.7	30.8
Banapur	1423.0	902.7	63.4	520.2	36.6
Begunia	1335.9	849.4	63.6	486.4	36.4
Bhubaneswar	1655.2	943.9	57.0	711.2	43.0
Bolagarh	1240.4	815.5	65.7	424.8	34.3
Chilika	1445.3	894.4	61.9	550.8	38.1
Jatani	1624.7	940.9	57.9	683.7	42.1
Khordha	1429.7	868.1	60.7	561.6	39.3
Tangi	1452.2	900.8	62.0	551.3	38.0
District	1532.8	936.2	61.1	596.5	38.9

of land. The LGP of different blocks has been mentioned in Table 4.

The total length of growing period in a year has been calculated for all the ten blocks by using LGP formula used by Sattar *et al*., (2013). The total average number of LGP for Khordha district is 196 days **(**Table 4**)**. Chilika has the highest number of LGP (204 days) and Begunia has the lowest number of LGP (184 days).

Characterisation of rice fallow period

Characterisation of the fallow land immediately following the rice crop is important for utilising it with *rabi* crops. Both medium and low lands are suitable for growing *rabi* season crops instead of keeping the field fallow after rice. In medium lands farmers mostly grow medium duration (120-135 days) variety and in low lands mid late varieties (145-150 days) during *kharif*.

Initial probability of wet weeks for sowing of *rabi* crops should be >30% and conditional probability of wet weeks followed by wet weeks should be average (>50%) which is available during 42-43 SMW in all the blocks excepting the Begunia block where the conditional probability is <50 % (45 %). The days available with proper soil moisture for production of *rabi* crops is highest in Chilika (85 days) block whereas lowest in Begunia block with 63 days **(**Table 5**)**.

Deciding of sowing window

Deciding of sowing window for *kharif* rice depends on the initial and conditional probability of rainfall during the monsoon period. Chances of occurrence of wet week more than 50 % at the beginning of *Kharif* season indicates that summer ploughing and initial seed bed preparations shall be taken up in the 20-22 SMW and sowing operations can be taken up since 23 SMW. Similarly, for *rabi* pulses 42-43 SMW has been found suitable for sowing as the initial probability of wet weeks is more than 30 % and the conditional probability of wet week followed by wet week is average (around 50 %). The optimum temperature required for sowing of pulses is also available in these weeks. Available LGP for *rabi* crops is also sufficient to grow a pulse crop successfully without any water stress.

Depending upon the LGP available for cropping in different blocks of Khordha district rice varieties of specific duration have been selected for medium and low lands. Mostly rice varieties of 120-135 days were selected for medium lands and of 145-155 days for low lands to accommodate the *rabi* crop after harvesting of rice in medium land and before harvesting as Paira crop mostly in low lands (Table 6).

Effective rainfall

Total annual effective rainfall (ER) of Khordha district is 936.2 mm which is 61 percent of the total annual rainfall **(**Table 7**)**. Therefore, almost 39 % of rainfall water is lost in the form of surface runoff, deep percolation and evaporation which necessitates the kind attention for reducing the losses and strategies for conservation of rain water.

Balipatna block has the highest annual effective rainfall (69.2 %) than any other blocks whereas Balianta and Bhubaneswar have the lowest utilisation of rain water annually (57 % each). Excess of water which is lost in the form of runoff, seepage and percolation needs to be harvested in water storage structures for utilisation of water during water stress conditions. Harvesting and storing of rain water in lined farm pond and other water harvesting structures are strategic approach for conservation of rain water. Judicious utilisation of this stored water can not only take care of the *kharif* crop during the intermittent dry spells but also increase the possibility of taking second crop. Almost 57-69 % of the total annual rainfall in all the blocks of Khordha district of Odisha is effective and rest is simply go as waste through run off and deep percolation. It is suggested to save at least 10-20 % of rain water which comes to the tune of 70 to 140 mm by which the availability of water to *rabi* crop can be increased by at least 15 to 30 days so that a rabi crop can be grown successfully without water stress. Thus, the cropping intensity of different blocks can be increased remarkably and the productivity of *rabi* crop can also be enhanced.

CONCLUSION

Characterisation of rice fallow period is highly essential to have judicious utilisation of rice fallow by growing suitable short duration *rabi* crops for increasing the cropping intensity and production. The characterisation clearly illustrates that the sowing window for *kharif* crop is almost in 24-25 SMW and that of *rabi* crops is in 42-43 SMW as determined from the initial probability of wet weeks. Depending upon the LGP available, the rice variety has to be chosen based on its duration. Further, the type of *rabi* crops and its methods of establishment (normal sowing/ Paira cropping) has to be decided either to advance the *rabi* crop sowing or to sow in the standing rice crop for better utilisation of residual soil moisture. The productivity enhancement of *rabi* crops can also be ensured by effective harvesting of rainwater and its judicious utilisation by providing only supplemental irrigation at critical growth stages of the crop.

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