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Crop Planning based on Rainfall Probability for Cuttack District of Odisha

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A B S T R A C T

The knowledge and information on the rainfall dynamics and its distribution over the cropping season are very important for selection of crop varieties and choice of cropping pattern. Block wise historical rainfall data of 24 years (1995 to 2018) of Cuttack District were collected and processed by using Weather cock software to estimate annual, seasonal and monthly rainfall. The analysis of rainfall revealed that the total mean annual rainfall of the district is 1597 mm. Cuttack receives almost 77% of mean annual rainfall during south-west monsoon which is about 1216 mm and it receives 207 mm rainfall during post monsoon season. The initial rainfall probability {P (W)} of getting 20 mm rainfall per week was >30% during 22 Standard meteorological week (SMW) at Cuttack district, hence, field preparation should be done during this period. The initial as well as conditional probability of wet week followed by wet week {P (W/W)} of getting 20 mm rainfall was more than 50% in 23rd SMW, this week is more suitable for sowing of crops. During 44th to 46th SMW (29th Oct. – 18th November) probability of getting 10 mm rainfall per week was more than 30 per cent. This period is suitable for land preparation and sowing of *rabi* crops. Seasonal rainfall variability varied from 72 to 112% during post-monsoon (October-December) and 123 to 198% in winter (January-February) season. It indicates that there was less dependability on rain fall during *rabi* season which was favorable for growing of *rabi* pulses and vegetables in post-monsoon as well as winter period in the rice-fallow area. Proper crop planning with suitable water conservation measures are needed to be adopted to enhance the acreage, production and productivity of *kharif* as well as *rabi* crops of the district.

Introduction

Rainfall is the single most important factor in crop production programme. Among the climatic factors, rainfall is of greatest concern to the farmers in rainfed agriculture. The variation of monsoonal and annual rainfall in space and time are well known and this inter-annual variability of monsoonal rainfall has considerable impact on agricultural production. Terminal drought is a recurring feature in Odisha. Intermittent dry spells make the crop operations delayed as 80 percent of the area in this region is under rainfed conditions. The agro ecology of the state is very much vulnerable as the

agricultural operations depend upon the moisture availability due to rainfall pattern, amount, intensity and its uses for crop production (Deka and Nath, 2000). The establishment of start, end and length of the growing season and the patterns of dry and wet spells throughout the season is suitable information for the agricultural planning and farm management processes comprising land preparation, crop planting, fertilizer and other agro-chemical applications, weeding, harvesting and post-harvest management. Odisha is always exposed to frequent floods and water logging conditions. Apart from cyclonic winds, heavy rainfall and long tides are experienced mainly during post monsoon period due to low pressure. It causes huge loss to human lives, properties and crop fields as well affecting the food security of the victims. Hence crop planning will certainly reduce the crop loss and crop failure. Detailed knowledge of rainfall pattern helps in planning the cultivation of crops, their varieties, adoption of cultural operations, designing of different storage structures (Chand *et al.*, 2011) and harvesting of excess rain water of any region (Sinhababu, 1977; Budhar *et al.*, 1987 and Kar, 2002) to meet out irrigation requirement during moisture stress period. The distribution of rainfall influences the crop yield rather than the total amount of rainfall as studied by Bhargava *et al.,* (1974). Therefore, analysis of rainfall and determination of annual maximum daily rainfall would enhance the management of water resources applications as well as the effective utilization of water resources (Subudhi, 2007). Probability and frequency analysis of rainfall data enables us to determine the expected rainfall at various chances (Manikandan *et al.,* 2017). Hence, present study has been undertaken to suggest the cropping plan for Cuttack district of Odisha considering the rainfall amount at different probability levels.

Materials and Methods

Rainfall characteristics and rainfall variability

Block wise daily rainfall data were used to calculate the rainfall characteristics. Mean annual, seasonal and monthly rainfall variability was found out by analyzing rainfall block wise over a period of 24 years. The data were processed by using Weather cock. "Rainy Day.exe" module was used to analyse the rainfall data.

The mean rainfall, standard deviation (SD) and Coefficient of variation (CV) for each data series were determined. The variability of the annual, seasonal and monthly rainfall values are indicated by standard deviation (SD) and Coefficient of variation (CV).

Initial and conditional probabilities (Markov–chain model)

Simple criterion related to sequential phenomenon like dry and wet spell was used for analyzing rainfall data to obtain specific information needed for crop planning and for carrying out agricultural operations. In this study, weekly rainfall values have been computed from daily data series and were used for estimation of initial, conditional probabilities and consecutive dry and wet spell analysis based on 'Markov chain probability model'.

In this method, 20 mm or more rainfall in a week is considered as wet week otherwise dry as the previous researchers (Joseph *et al.*, 2017; Dash and Senapati, 1992) also used 20 mm as the threshold value. Initial, conditional probabilities and consecutive dry and wet spell analysis for 52 Standard meteorological weeks (SMW) are made by using equations from 1-10.

Initial probability

$$P(D) = F(D)/N \quad \text{(Eq. 1)}$$

$$P(W) = F(W)/N \quad \text{(Eq. 2)}$$

Where,
P(D) = probability of the week being dry
F(D) = frequency of dry weeks
P(W) = probability of the week being wet
F(W) = frequency of wet weeks
N = total number of years of data being used.

Conditional probabilities

$$P(DD) = F(DD)/F(D) \quad \text{(Eq. 3)}$$

$$P(WW) = F(WW)/F(W) \quad \text{(Eq. 4)}$$

$$P(WD) = 1 - P(DD) \quad \text{(Eq. 5)}$$

$$P(DW) = 1 - P(WW) \quad \text{(Eq.6)}$$

Where,

P(DD) = probability of a week being dry preceded by another dry week

F(DD) = frequency of dry week preceded by another dry week

P(WW) = probability of a week being wet preceded by another wet week

F(WW) = frequency of a wet week preceded by another wet week

P(WD) = probability of a wet week preceded by a dry week

P(DW) = probability of a dry week preceded by a wet week.

Consecutive dry and wet week probabilities

$$P(2D) = P(DW1)\times P(DDW2) \quad \text{(Eq. 7)}$$

$$P(3D) = P(DW1)\times P(DDW2)\times P(DDW3) \quad \text{(Eq. 8)}$$

$$P(2W) = P(WW1)\times P(WWW2) \quad \text{(Eq. 9)}$$

$$P(3W) = P(WW1)\times P(WWW2)\times P(WWW3) \quad \text{(Eq. 10)}$$

where,

P(2D) = probability of 2 consecutive dry weeks starting with the week
P(DW1) = probability of the first week being dry

P(DDW2) = probability of the second week being dry, given the preceding week being dry

P(3D) = probability of 3 consecutive dry weeks starting with the week

P(DDW3) = probability of the third week being dry, given the preceding week dry

P(2W) = probability of 2 consecutive dry weeks starting with the week

P(WW1) = probability of the first week being wet

P(WWW2) = probability of the second week being wet, given the preceding week being wet

P(3W) = probability of 3 consecutive wet weeks starting with the week

P(WWW3) = probability of the third week being wet, given the preceding week wet.

Thresholds of rainfall for Deciding sowing window and other practices of kharif paddy and rabi pulses

For the district Cuttack to decide the sowing window of *kharif* paddy in the threshold limit

of 20 mm per week, the initial probability (P(W)) of rainfall for land preparation was taken in the premonsoon shower, when it is more than30%and the average weekly rainfall is 20-40 mm The sowing operation is done when the conditional probability of wet followed by wet week (P(WW)) is more than 50%. The average weekly threshold limit of CV in the rainy season should be less than 150% which means there is high dependability of rainfall in the rainy season. During *rabi* period chances of occurrence of wet week are more than 30% and consecutive wet weeks are average preferable for sowing of *rabi* pulses like green gram and black gram. The weekly CV of rainfall during the sowing period of *rabi* crop varies from 83 to 175%. During this crop season the CV is more than threshold limit of 50%. This indicates less dependability of rainfall during this period.

For the purpose of agricultural planning, we have applied Markov Chain model by choosing 10, 20, 40 and 80 mm/week as threshold limits. These threshold levels were considered as adequate for the crop activities such as land preparation (10 mm), crop planting or sowing (20 mm), and application of fertilizer and/or weeding (40 mm).

According to Reddy (2008), if a given week 'i' of a given year received more than 20 mm/week at more than 50% (W/W) threshold level, then week 'i' is the right time for planting. If weeding/fertilizer application is to be carried out in week 'i' then the week should have at least 75% (W/W) probability at 40 mm/week. If the interest is when we should not apply fertilizer/pesticides, then one can use the probability estimate at 80 mm/week. If fertilizer and/or insecticides/pesticides are applied on week 'i' then W should not exceed 25% probability level at 80 mm/week.

Results and Discussion

Rainfall characteristics and rainfall variability

Annual Rainfall and rainy days

The mean annual rainfall of the district was found to be 1597 mm (Table 1). The highest rainfall was received in the block Athagad (1979 mm) while Badamba block received the lowest amount of rainfall (1350 mm).Variability of the district annual rainfall was 18 to 34% (Figure 1). Thus blocks having CV less than 25% can be considered to be receiving rainfall that is highly dependable. The blocks coming under this category are Badamba, Narsinghpur, Nischintakoili, Salepur and Tangi-Choudwar.

The remaining eight blocks are having CV greater or equal to the threshold, indicating that there is high variability in the amount of rainfall received by these blocks over years. So, a greater part of the district has the risk in rainfed farming. Pasupalak (2015), reported that the variability of annual rainfall in Odisha was 21%. Eight districts had high variability (>23%), while 10 districts had low variability (<20%). Variability was maximum (25%) in Sonepur district and minimum (16%) in Sundargarh district. Present results confirm the results of Pasupalak (2015) for the Cuttack district.

Seasonal rainfall

In case of seasonal rainfall Cuttack receives almost 76-77% of mean annual rainfall during SW monsoon (Table 2). Two blocks namely Athagad and Banki had >1400 mm amount of monsoon rainfall (Fig. 1). Variability of rainfall during SW monsoon was 32% in the district. Kantapada block had maximum (47%) variability while Narsinghpur had the minimum (19%). That indicated that

Narasinghpur block had more dependability on rain fall due to less rainfall in rainy season as compared to other block.

Lowest (22 mm) amount of rainfall was received during winter and variability was also maximum (157%) during this period in the district. It was thus clear that SW monsoon accounts a major part of rainfall distribution out of all the seasons. During SW monsoon 3 out of 13 blocks had low variability (<30%) while other blocks had high variability of >30% (Table 2). The post monsoon rainfall was also good for almost all the blocks with minimum amount in Narsinghpur block (Fig. 2).

Rainfall variability varied from 72 to 112% during post-monsoon and 56 to 90% in summer season. It indicates that there was less dependability on rainfall during *rabi* season which was favourable for growing of *rabi* pulses and vegetables in post-monsoon period in the rice-fallow area. In the present study it is also found that monsoon season has the highest rainfall of 1216 mm and the lowest variability (32%) which contributes better condition for *kharif* rice cultivation. The CV of seasonal rainfall except South west monsoon is higher than the threshold (50% for seasonal rainfall).

The summer monsoon rainfall over northeast India showed characteristic spatial and temporal variability due to the interaction of basic monsoon flow with orography and the synoptic scale systems developing over Indian region (Mohapatra *et al.,* 2011).

In a study, Mandal *et al.,* (2013) observed that the total annual rainfall in Daspalla region was 1509.2 mm with 14.8% CV. They further reported that Southwest Monsoon, Winter season, Pre Monsoon and Post Monsoon contributes about 75.7, 3.1, 10.8 and 10.4 per cent of total annual rainfall.

Monthly rainfall

The highest mean monthly rainfall in the district was in the month of August (387 mm) (Fig. 3). It was followed by July with 335 mm and September with 298 mm. December was the month of lowest rainfall (2 mm). Monthly rainfall variability was the maximum in January and December (40%) followed by April (37%), while minimum in the month of May (12%) followed by July and October (14%). Six out of twelve months namely, May, June, July August, September and October had low variability (<20%) of monthly rainfall (Fig. 3) where as monthly rainfall variability was high (>20%) in the other months. Monthly rainfall varies from region to region and the highest rainfall giving month may be July or August.

Present result confirms the result of (Manorama *et al.,* 2007) that in the Nilgiris the coefficient of variation (CV) in percentage is an indicative of dependability of rainfall. The threshold levels for CV for any interpretation are < 25, < 50, < 100 and < 150% for annual, seasonal, monthly and weekly rainfall, respectively. If the CV is within the threshold limit of variability, it is considered that the rainfall is highly dependable and vice-versa.

Crop planning

Rice is the principal *kharif* crop sown in the district covering more than 75% area. During *rabi* season Greengram, Blackgram, Groundnut, Brinjal, Tomato and Cole crops are grown.

In Cuttack district, out of 1, 88, 000 ha of total cultivable area, 74,778 ha (40%) area under rainfed. Paddy is a important crop of the district which covers 1, 34,924 ha in *kharif*. The *kharif* and *rabi* vegetable area are 5.28% and 7.61% of the cultivable area

respectively. Rice- green gram, Rice- black gram, Rice-Vegetables are the major cropping system of the district So there is enough scope to increase pulse area through *paira* or zero till method cropping by taking 120-130 days duration rice varieties in *kharif* season.

Table.1 Blockwise mean annual rainfall of Cuttack district

Blocks	Rainfall (mm)	SD	CV
Athagad	1979	530	27
Badamba	1350	272	20
Banki	1904	647	34
Baranga	1490	426	29
Cuttack sadar	1546	458	30
Kantapada	1773	606	34
Mahanga	1765	464	26
Narasinghpur	1379	242	18
Niali	1610	403	25
Nischintakoili	1449	351	24
Salepur	1439	337	23
Tangi-choudwar	1405	336	24
Tigiria	1672	417	25
Mean	**1597**	**422**	**26**

*SD= Standard Deviation*CV= Coefficient of Variance

Table.2 Block wise mean seasonal rainfall of Cuttack district

Blocks	Monsoon			Post Monsoon			Winter			Summer		
	RF	SD	CV	RF	SD	CV	RF	SD	CV	RF	SD	CV
Athagad	1488	485	33	247	220	89	31	45	146	214	120	56
Badamba	1010	243	24	179	160	89	29	35	124	131	88	67
Banki	1493	566	38	233	260	112	18	24	135	160	124	78
Baranga	1145	358	31	174	153	88	19	36	192	152	116	76
Cuttack sadar	1224	409	33	182	164	90	16	31	198	124	106	85
Kantapada	1360	643	47	250	179	72	18	29	166	146	122	84
Mahanga	1372	513	37	216	172	80	11	20	181	165	100	60
Narasinghpur	1025	190	19	161	149	92	34	42	123	159	125	79
Niali	1192	375	31	243	212	87	26	33	129	149	130	87
Nischintakoili	1069	307	29	217	221	102	17	26	157	147	101	69
Salepur	1073	342	32	200	187	93	23	33	143	143	129	90
Tangi-choudwar	1064	342	32	190	170	89	20	36	179	131	76	59
Tigiria	1287	426	33	201	181	90	27	46	168	158	101	64
Mean	**1216**	**400**	**32**	**207**	**187**	**90**	**22**	**34**	**157**	**152**	**111**	**73**

*SD= Standard Deviation*CV= Coefficient of Variance

Table.3 Initial and conditional rainfall probability of Cuttack district

SMW	Initial probability		Conditional Probability			
	P(W)	P(D)	P(W/W)	P(D/W)	P(D/D)	P(W/D)
1	0.00	1.00	0.00	0.00	1.00	0.00
2	0.10	0.90	0.00	0.00	0.90	0.10
3	0.00	1.00	0.00	1.00	1.00	0.00
4	0.05	0.95	0.00	0.00	0.95	0.05
5	0.00	1.00	0.00	1.00	1.00	0.00
6	0.00	1.00	0.00	0.00	1.00	0.00
7	0.10	0.90	0.00	0.00	0.90	0.10
8	0.05	0.95	0.00	1.00	0.94	0.06
9	0.00	1.00	0.00	1.00	1.00	0.00
10	0.05	0.95	0.00	0.00	0.95	0.05
11	0.10	0.90	0.00	1.00	0.89	0.11
12	0.05	0.95	0.00	1.00	0.94	0.06
13	0.00	1.00	0.00	1.00	1.00	0.00
14	0.15	0.85	0.00	0.00	0.85	0.15
15	0.00	1.00	0.00	1.00	1.00	0.00
16	0.10	0.90	0.00	0.00	0.90	0.10
17	0.15	0.85	0.00	1.00	0.83	0.17
18	0.10	0.90	0.00	1.00	0.88	0.12
19	0.40	0.60	0.00	1.00	0.56	0.44
20	0.45	0.55	0.63	0.38	0.67	0.33
21	0.40	0.60	0.44	0.56	0.64	0.36
22	0.35	0.65	0.63	0.38	0.83	0.17
23	0.45	0.55	0.86	0.14	0.77	0.23
24	0.50	0.50	0.44	0.56	0.45	0.55
25	0.85	0.15	0.90	0.10	0.20	0.80
26	0.95	0.05	1.00	0.00	0.33	0.67
27	1.00	0.00	1.00	0.00	0.00	1.00
28	0.70	0.30	0.70	0.30	0.00	0.00
29	0.95	0.05	0.93	0.07	0.00	1.00
30	0.90	0.10	0.89	0.11	0.00	1.00
31	0.95	0.05	1.00	0.00	0.50	0.50
32	0.95	0.05	0.95	0.05	0.00	1.00
33	1.00	0.00	1.00	0.00	0.00	1.00
34	0.95	0.05	0.95	0.05	0.00	0.00
35	0.95	0.05	0.95	0.05	0.00	1.00
36	0.90	0.10	0.89	0.11	0.00	1.00
37	0.80	0.20	0.83	0.17	0.50	0.50
38	0.90	0.10	0.94	0.06	0.25	0.75
39	0.65	0.35	0.61	0.39	0.00	1.00

40	0.70	0.30	0.85	0.15	0.57	0.43
41	0.45	0.55	0.43	0.57	0.50	0.50
42	0.35	0.65	0.67	0.33	0.91	0.09
43	0.20	0.80	0.43	0.57	0.92	0.08
44	0.20	0.80	0.25	0.75	0.81	0.19
45	0.15	0.85	0.25	0.75	0.88	0.13
46	0.10	0.90	0.00	1.00	0.88	0.12
47	0.00	1.00	0.00	1.00	1.00	0.00
48	0.00	1.00	0.00	0.00	1.00	0.00
49	0.05	0.95	0.00	0.00	0.95	0.05
50	0.05	0.95	0.00	1.00	0.95	0.05
51	0.00	1.00	0.00	1.00	1.00	0.00
52	0.00	1.00	0.00	0.00	1.00	0.00

Fig.1 Block wise mean south-west Monsoon rainfall

Fig.2 Block wise mean Post monsoon (Oct-Dec) rainfall

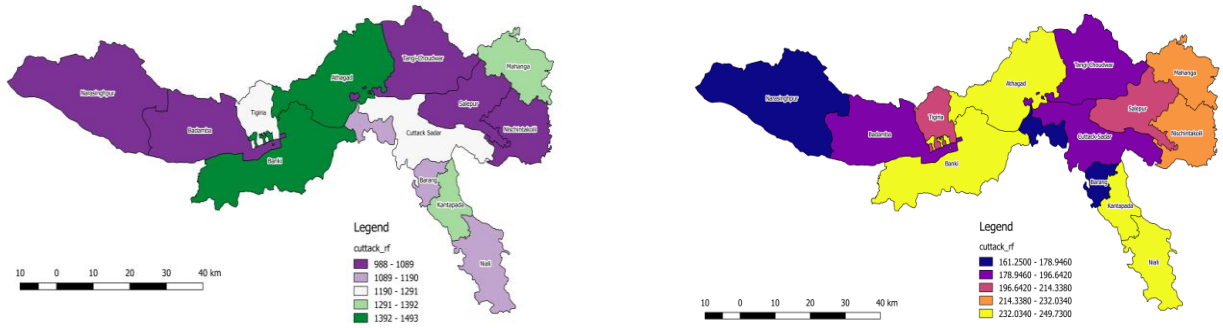
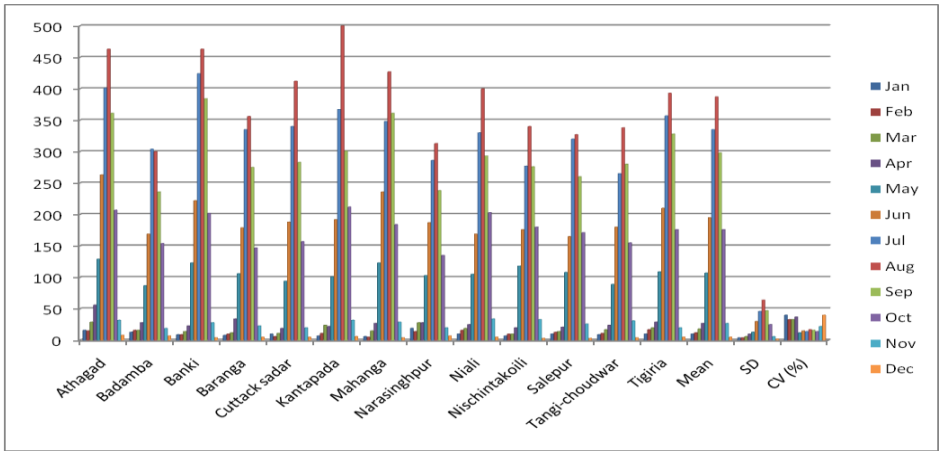


Fig.3 Block wise mean monthly rainfall of Cuttack District



Assessment of sowing window of based on Initial and Conditional Rainfall Probability

The initial rainfall probability {P (W)} of wet week getting 20 mm rainfall per week was >30% during 22 SMW (Table 3) at Cuttack district and hence, field preparation should be done during this period. The pre-monsoon rain can be utilized for summer ploughing, sowing dhaincha and seed bed preparations. The initial as well as conditional probability of wet week followed by wet week {P (W/W)} of getting 20 mm rainfall was more than 50% in 23 SMW (Table 3). Therefore, this week is more suitable for sowing of direct seeded low land rice. Nursery preparation of rice can also be planned. Further delay in sowing may cause very low productivity and even crop failure. Nurseries for transplanted paddy can be sown either in 23 and 24 SMW (4th – 17th June) with the pre-monsoon showers which seems to be sufficient to bear the normal soil moisture range and afford good germination.

The direct sown paddy and paddy nurseries will be ready for further cultural operation and transplantation with the onset of monsoon (24 to 25 SMW). The transplantation of paddy should be completed within July and 1st fortnight of August as high rainfall exists from 27 to 33 SMW.

The transplanted crop needs more water for puddling in addition to normal water requirement and the above period gets 40 mm rain at more than 50% probability. In rainfed rice based cropping system, it is preferable to grow medium duration rice varieties, provide protective life saving irrigation from harvested rain water, harvest paddy at physiological maturity stage, strengthening of field bunds, check run off and seepage loss and block drainage channel. Prepositioning of inputs for *rabi* crops should be done to complete sowing in time.

Rabi

During 44 to 46 SMW (29th Oct. – 18th November) probability of getting 10 mm rainfall per week was more than 30 % (Table 3). So, this period is the most suitable for land preparation and sowing of *rabi* crops like green gram, black gram, mustard, sesame, groundnut and vegetables like Brinjal, Tomato, cole crops, onion, and chili can also be taken up. After 46 SMW (12th – 18th November) week farmers are advised for zero till sowing of pulse and oilseeds crops requiring less water. Manikandani *et al.,* 2014 analysed that the chance of getting 25 mm weekly rainfall with 50 per cent probability was noticed from 39th to 46th standard week covering eight weeks. Drought resistant short duration pulses and sorghum can be grown within the growing Period from 39th to 46th standard weeks. After 46 (12th – 18th November) week there is remote possibility of rain as the probability of rainfall is less than 30% for all the amounts i.e. for 10 mm, 20 mm and 40 mm. Direct sowing of *rabi* crops just after harvest of *kharif* crops may also be tried to realize the advantage of residual moisture. Reddy *et al.,* (2008) studied on Markov Chain Model Probability of Dry, Wet Weeks and Statistical Analysis of Weekly Rainfall for Agricultural Planning at Bangalore. In this study Markov Chain Model has been extensively used to study spell distribution.

The data on onset and withdrawal rainy season indicated that the monsoon starts effectively from 24th SMW (11 - 17th June) and remains active up to 45th SMW (5 - 11th November). During rainy season the probability of occurrence of wet week is more than 35% except during 25th - 27th SMW and 44th - 48th SMW. During rainy season the mean weekly rainfall is found to be more than 40 mm during 36th - 41st SMW and found to be less than 20 mm during 20th SMW, 25th -

27th SMW and 44th - 48th SMW. The results through analysis have been used for agricultural planning at Bangalore region.

Crop management and planning strategies for the district

Under the ideal situation, medium to long duration rice varieties those are transplanted by the end of July will have its flowering period during the middle of October. Flowering is a critical phase with respect to water requirement, as shortage of water during this time will affect subsequent grain filling and hence yield. Therefore farmers, especially those growing rice crops in need to arrange supplemental irrigation through tube wells, dug wells and harvested rain water. The rice crop is totally dependent on rainfall for water requirement. So, it is advisable to take up early and medium duration varieties, which will complete major reproductive stage by September. In lowlands a successful rainfed crop is possible with medium to long duration varieties with timely planting by 26 SMW or by direct sowing by 1st week of June before onset of monsoon. Measures like storage of runoff water in the fields, increasing bund height to 25-30 cm needs to be adopted for a successful rainfed crop.

Even under irrigated condition, transplanting by 26 SMW is crucial to make use of all rainwater and harvest a good crop of rice and a subsequent successful *rabi* crop. Under late planting situation in farmer's field, the phenophases like maximum tillering and panicle development comes during the month of September. Since panicle development decides the number of grains in the panicle and tillering decides the number of panicles and hence capacity for higher yield, the availability of water during these periods is critical. Hence, it is important to ensure availability of irrigation water during the period. Scientific water management practices like irrigation at 3 days after disappearance of earlier ponded water instead of maintaining standing water continuously in the field can save up to 50% of irrigation water and make it available to irrigate more area. Increasing the bund height in the field up to 30 cm can also retain more rainwater in the field and increase the moisture content of the soil.

Balanced fertilizer application i.e., application of phosphorus and potash along with nitrogen (urea) can give the crop a certain extent of drought tolerance. By ensuring the release of irrigation water during the critical phases the crop failure and yield reduction can be avoided. Similarly, traditional water harvesting structures like ponds and tanks should be rejuvenated to enhance storage of runoff water and increase groundwater recharge.

It has been observed that from 2013 onwards Odisha is hit by severe cyclones in between 10-15 October and keeping that in view it is advised farmers to grow short to medium duration rice varieties so that it can be harvested before 10^{th}-15^{th} of October and thus no yield loss. The direct seeded rice is mainly sown after the first shower of monsoon, i.e. 24-25 SMW for better seed germination. The dry seed beds are prepared for nursery rising in 26-27 SMW so that rice can be transplanted during 31-33 SMW. Medium duration rice varieties in medium lands are harvested mostly after withdrawal of the monsoon at around 39-41 SMW. As variability of rainfall is much more in post monsoon and winter months, sowing of *Rabi* crops can be suitably adjusted as per medium range weather forecasting and availability of soil moisture in the fields. Brinjal, Tomato, onion, cabbage, cauliflower, okra can also be taken up after harvesting of the transplanted rice at the beginning of October. No crops are advised to take up after 46-47 SMW as there is very little chance of getting rainfall in

medium and uplands. Low lands can store moisture for a little more time than medium and uplands due to water stagnation.

In conclusion monsoon starts effectively from 24 SMW in Cuttaack district and remain active up to 41-42 SMW. Therefore, we expected good monsoon shower for about 18 weeks (24 to 42 SMW) which contributes 1216 mm monsoon rainfall in the region so medium and mid-late duration paddy (120-145 days) should be grown to avoid moisture stress during late reproductive stages. The long duration paddy varieties must be avoided as it may cause a heavy risk during drought or dry spell or cyclones during 1^{st}-2^{nd} week of October. However supplementary irrigation and moisture conservation need to be available if the crop is of long duration. The rainfall before 24 SMW should be utilized for land preparation and after 41 SMW the residual moisture should be utilized for pulses (green gram, black gram), oilseeds (Ground nut, Toria, Sesame) and various vegetables. The post monsoon rainfall is 206 mm which is sufficient for rainfed rabi crops. Rain water need to be stored in water harvesting structures for efficient utilization during water stress condition in critical stages of crop growth in Narsinghpur block mainly. Farmers should go for zero tillage practice for efficient use of soil moisture and save time for land preparation for pulses.

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