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An assessment of climatic risk involved in growing rainfed *rabi* crops in different agroclimatic zones of West Bengal

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ABSTRACT

With the objective of studying rainfed crop potential during *rabi* season through climatic water balance approach, historical rainfall data for 50-90 years were collected from six stations representing six different agroclimatic zones of West Bengal. Weekly rainfall data generated at 50% probability level were subjected to climatic water balance analysis. Period of availability of optimum moisture adequacy index (MAI) and accumulated minimum expected actual evapotranspiration were analysed to suggest possibility for fitting of crops of different duration. For a 17-week crop sowing can be advanced by 4 weeks. Accumulated AET up to 200 mm and 227 mm can be expected for medium and fine textured soil respectively

Key words: Climatic risk, water balance, *rabi* crops

Availability of moisture in the soil profile is the main determinant for the choice of crops during post-rainy season especially under rainfed conditions as in West Bengal. Amount of soil moisture present at the time of sowing as well as its duration of availability over the crop growing period are equally important in characterising the crop growing environment under this situation. In West Bengal, post-rainy season rainfed crops are mostly grown in the rice-fallows and the sowing time of these crops is subject to large variation depending on the time of harvesting of *kharif* rice. Depending upon the extent of delay in sowing of these rainfed crops and the magnitude of water holding capacity of these soils, post rainy season crops are most often exposed to various degrees of moisture stress during different stages of their growth in general and during reproductive and post-reproductive stages in particular. So critical analysis of the soil moisture environment during different times of the post-rainy season in soils of different water holding capacity is helpful for selection of crops under this condition in order to avoid or escape the likely moisture stress during critical period of their growth. Water budgeting facilitates the determination of the length of crop growing season, identification of suitable crops and cropping systems,

forecasting of yield and monitoring droughts (Vijay Kumar, 1992). In the present work, an attempt has been made to study the feasibility of fitting a 13-week/17-week *rabi* crop under rainfed condition of West Bengal considering soil moisture dynamics, textural variations, estimated actual as well as potential evapotranspiration of the concerned regions. Rainfall availability has been considered at 50% probability level as it was adopted for crop planning by some early workers such as Sarker and Biswas(1982).

MATERIALS AND METHODS

The study was conducted for six stations of West Bengal, viz, Darjeeling, Coochbehar, Malda, Krishnanagar, Purulia and Contai representing six agroclimatic zones of West Bengal, viz, Hill, Terai, Old alluvial, New alluvial, Red & laterite and Coastal saline zone, respectively. Daily rainfall data for these stations for 50-90 years were collected from India Meteorological Department which were further processed on standard meteorological weeks (SMW) basis. Normal weekly PET values corresponding to different centres were collected from AICRP on Agrometeorology, BCKV Centre. Expected rainfall at 50% probability levels were computed following incomplete gamma distribution technique as developed by Thom (1958) and adopted by Sarker (1988). Weekly rainfall at 50% probability level and normal PET data were subjected to popular book keeping method of water balance developed by Thornthwaite and Mather(1955) and as adopted by Krishnan *et al.* (1980) for estimating weekly soil moisture storage, actual evapotranspiration and moisture adequacy index. Two different textural types of soil viz, medium (AWHC = 140 mm/m depth) and fine (AWHC = 200 mm/m depth) were considered for this study. Standard values of AWHC for these soils were collected from Doorenbos and Pruitt (1977). All the water balance parameters were estimated at 50% probability level, which is a justified level for rainfed crop planning.

RESULTS AND DISCUSSION

Temporal variability of soil moisture during rabi season

Data presented in Table 1 reveals that there is little variation in time during *rabi* season among different agroclimatic zones up to which soil moisture would remain to its fullest capacity irrespective of textural variation. However, when available soil moisture was considered at 50% and 33% level, duration of these periods varied to a great extent across the textural classes as well as agroclimatic

Table 1: Latest week number (Standard Meteorological week) in the *rabi* season with different levels of profile soil moisture (at 50% probability level) at different agroclimatic zones of West Bengal.

Zones	Full AWHC		½ AWHC			1/3 AWHC		
	Medium textured soil	Fine textured soil	Medium textured soil	Fine textured soil	Diff. between them	Medium textured soil	Fine textured soil	Diff between them
Hill	41	41	4	13	9	13*	13*	
Terai	41	41	47	50	3	51	6	7
Old Alluvial	40	40	45	48	3	49	2	5
New Alluvial	40	40	48	52	4	2	9	7
Red & laterite	40	40	48	52	4	2	8	6
Coastal Saline	40	40	46	48	2	49	1	4

* considered limit for rabi crops.

zones of the state. Except in the hill zone, available soil moisture to the extent of at least 50% exists upto 45th. to 48th. SMW in medium textured soil and 48th. to 52nd. SMW in fine textured soil. So duration of these period can be extended upto 2-4 weeks due to increase n the AWHC of soil to the tune of 60 mm/m depth (medium to fine). This duration is, however, much larger in the hill zone of the state. AWHC at 33%, which may be considered fairly suitable for maturity stages of *rabi* crops extends upto 49th to 2nd SMW in medium and 1st. to 9th SMW in fine textured soil indicating higher zonal variation in fine textured type of soil. Zonal analysis showed that the time of sowing of rainfed *rabi* crops can be delayed much more (48th to 52nd SMW) in both new alluvial and red & laterite zones than in other soils with AWHC ranging between 140-200 mm/m depth. Duration of time, the water storage of the soil is at 50% of its capacity or above reflect the potential that exists for cropping under rainfed condition (Sivakumar and Gnoumou, 1987).

Table 2: Latest standard meteorological week number for accommodating a 13-week and a 17-week rainfed *rabi* crop (at 50% probability level) in different agroclimatic zones of West Bengal.

Zones	Medium textured soil				Fine textured soil				Extension of sowing in fine over medium (total number of weeks)	
	13-week crop		17-week crop		13-week crop		17-week crop			
	S	H	S	H	S	H	S	H	13-week crop	17-week crop
Hill	1	13	49	13	1	13	49	13	-	-
Terai	48	8	44	8	1	3	49	13	5	5
Old alluvial	45	5	41	5	47	7	43	7	2	2
Newalluvial	49	9	47	11	1	13	49	13	4	2
Red & Laterite	-	-	-	-	46	6	42	6	-	-
Coastalsaline	49	9	45	9	1	13	49	13	4	4

S : Sowing, H : Harvesting

Latest meteorological week for fitting different rabi crops

Under rainfed condition during *rabi* season two types of field crops can be considered under West Bengal condition. One is of short duration (maturity within 13 weeks) like toria, rape etc. Second type (maturity duration around 17 weeks) includes wheat, lentil, mustard, pea, lathyrus, sunflower etc. Several workers (Krishnan *et al.*, 1980; Khan & Saha, 1993) used MAI value for selecting crops under rainfed condition considering a value of index 0.5 for start and 0.33 for end of the season. Weekly data on MAI during October to March at 50% probability levels (Fig.1) has been used to find out latest period of sowing a 13-week or a 17-week crop in both medium and fine textured soil across different agroclimatic zones of the state and presented in Table 2. Data shows that even a 13-week *rabi* crop cannot be fitted in the medium textured soil of red & laterite zone. However, in other zones except Darjeeling, chance of sowing (once in two years) extends upto 45th. to 49th SMW in such soil with the earliest, in old alluvial zone and latest in new alluvial and coastal zone. In red and

Table 3: Accumulated expected AET at 50% probability of rainfed *rabi* crops sown in different weeks for crop duration of 13 weeks

SMW	Hill		Terai		Old alluvial		New Alluvial		Red & laterite		Coastal saline	
	M*	F**	M	F	M	F	M	F	M	F	M	F
40	126.6	131.5	180.3	195.5	177.2	196.5	155.7	167.3	167.0	186.2	207.5	228.1
41	117.5	122.9	162.0	178.6	157.4	178.2	142.8	155.7	150.0	170.8	186.8	209.3
42	108.1	114.3	143.3	161.3	137.7	160.1	130.0	144.0	133.0	155.3	165.4	189.9
43	100.2	106.1	124.5	143.7	119.1	142.4	116.6	131.8	117.2	140.5	144.9	171.0
44	92.5	98.3	107.3	127.3	103.3	126.8	104.3	120.2	103.7	127.2	125.3	152.5
45	81.5	91.9	94.0	114.1	90.6	13.8	94.1	110.4	93.6	116.9	109.3	137.0
46	84.3	88.0	83.9	104.0	81.3	104.1	88.1	104.4	87.9	110.7	98.2	125.8
47	83.2	86.1	77.4	97.2	76.0	98.2	85.7	101.7	81.8	104.5	88.8	116.1
48	82.0	86.0	74.3	93.8	74.0	95.7	84.1	100.1	7.7	100.1	83.5	110.5
49	82.8	86.1	71.2	90.9	69.9	91.5	81.6	98.0	74.9	97.2	78.9	105.8
50	84.8	87.8	69.8	89.7	68.5	90.1	81.2	98.0	72.4	94.8	74.9	101.3
51	90.1	90.8	69.0	89.4	66.6	88.6	81.1	98.6	71.3	93.8	72.2	98.4
52	97.2	96.6	72.4	93.1	66.7	88.9	83.0	101.2	72.2	94.7	71.9	97.9
1	101.4	104.3	80.1	101.0	66.2	89.1	84.9	104.2	72.7	95.7	71.4	97.4

* Medium textured soil **Fine textured soil

Table 4: Accumulated expected AET at 50% probability of rainfed *rabi* crops sown in different weeks for crop duration of 17 weeks.

SMW	Hill		Terai		Old alluvial		New Alluvial		Red & laterite		Coastal saline	
	M*	F**	M	F	M	F	M	F	M	F	M	F
40	147.0	153.7	198.5	219.1	196.2	221.3	175.7	192.2	186.8	212.3	228.0	256.4
41	138.1	145.8	180.1	202.4	117.1	203.7	163.6	181.3	171.4	198.4	207.5	237.8
42	129.7	139.5	162.6	186.1	158.0	186.2	152.9	171.7	158.1	186.4	188.0	220.2
43	123.2	133.9	145.3	170.3	141.1	170.4	143.9	163.6	143.0	172.7	168.3	202.2
44	117.9	129.4	131.0	157.1	128.1	157.8	135.2	155.8	129.8	160.1	150.9	186.0
45	114.0	124.8	118.1	144.9	114.5	144.4	125.4	146.9	118.8	149.3	134.4	170.2
46	110.0	122.0	108.4	135.9	105.0	130.8	118.7	140.8	108.8	139.5	120.7	156.6
47	108.5	121.2	101.6	128.9	97.4	127.2	113.5	136.3	102.3	132.9	110.2	145.9
48	108.6	123.9	100.1	127.4	92.6	122.5	110.9	134.4	98.7	129.0	103.6	138.9
49	112.4	129.1	103.8	131.0	88.3	118.4	109.5	133.9	96.1	126.4	98.8	133.6

* Medium textured soil **Fine textured soil

laterite zone, however, rainfed crops can be taken in a fine textured soil where sowing of a 13-week crop can be extended upto 40th SMW. In other zones except old alluvial, this period can be extended upto 1st SMW considering optimum MAI value (at 50% probability) of 0.5 during sowing and initial period as well as 0.33 in the maturity period. A 17-week crop can be fitted at least 4 weeks ahead of these times. Except in hill and red and laterite zones, sowing of rainfed crops can be delayed upto 2-5 weeks in fine textured soil as compared to medium textured one.

Accumulated expected actual evapotranspiration(AET) for the rabi crops of different duration

Data presented in Table 3 reveals that if a rainfed crop of 13-week duration is sown in the 40th SMW, i.e., 1st week of October 127-208 mm of water use per metre depth of soil can be expected in medium textured soil once in two years in the state of West Bengal. In fine textured soil this value ranged between 131-288 mm. With subsequent delay in sowing beyond this period water availability / water use of the rainfed crops will gradually be reduced. However, in the hill and terai zone there is an increase in accumulated AET for the crops sown from 50th to 1st SMW, which is due to occurrence of rainfall during the month of March in these zones. It is interesting to note that even if the amount of rainfall is higher in hill and *terai* region as compared to others, the accumulated AET is substantially low. This is due to lower atmospheric water demand (as indicated by PET) of these two regions, a limit that AET cannot exceed in any particular time period according to this soil water accounting system. Change in soil texture from medium to fine can add 5-15 mm more water use in a crop's life period (13 weeks) across different agroclimatic zones of the state.

For a 17-week *rabi* crop (Table 4) accumulated AET ranges between 147-228 mm in medium textured soil and 153-256 mm in fine textured soil. Advantage of water use in fine textured soil over medium is to the tune of 7-35 mm.

Taking into consideration the value of optimum MAI for sowing and harvesting in different agrocimatic zones of the state (Fig. 1) expected moisture use corresponding to the sowing periods can be estimated following (Tables 3 and 4). This can help in selecting a 13-week *rabi* crop like toria and rapeseed, or a 17-week *rabi* crop like wheat lentil, pea, lathyrus, mustard etc. in different zones of the state after proper assessment of soil texture, profile soil moisture, moisture adequacy indices as well as

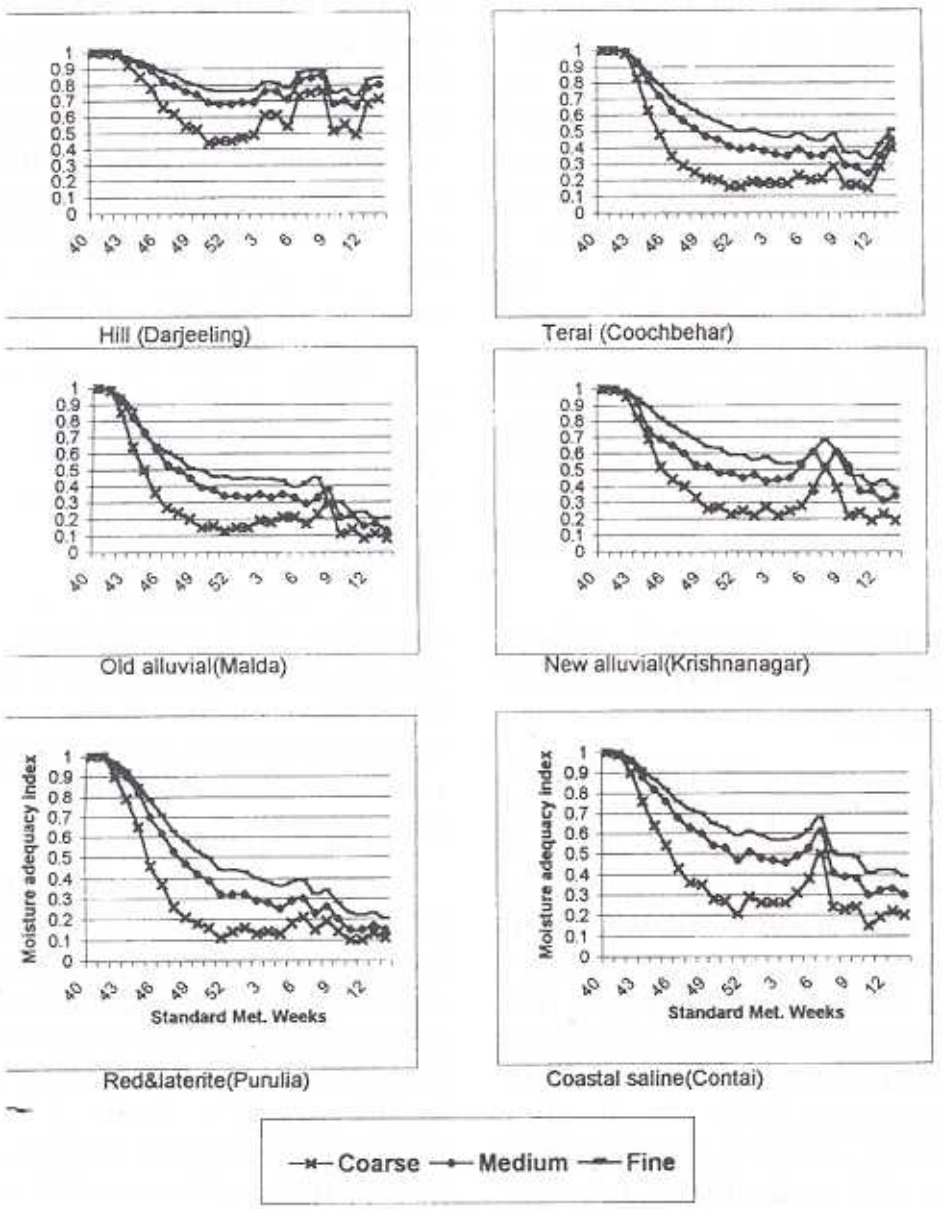

Fig. 1: Moisture adequacy index (MAI) during *rabi* season in soils of different texture in West Bengal

estimated water use at a probability level optimum for crop planning in West Bengal. At 50% rainfall probability which is an affordable risk for farmers and planners sowing of a 13-week rainfed *rabi* crop can be extended upto 45th to 49th week in medium textured and upto 47th to 52nd week in fine textured soil depending upon amount of rainfall and agroclimatic zone of the state. For a 17-week crop, however, sowing can be advanced by 4 weeks in each case.

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