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Rainfall pattern and crop planning in two agroclimatic zones of West Bengal under rainfed rice cultivation

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ABSTRACT

Short intervals of important weather factors, specially rainfall, have their potential uses to determine the opportune time for ensuing/ planning vital cropping activities. Indeed, the determination of (a) the distribution of dry and wet spells and (b) the pattern of occurrence of rainfall in short intervals, like, 2, 4 days period and in medium-duration intervals like, 10, 16 days period are essential inputs in the preparation of cropping schedule by farmers. This paper is devoted to building up an information chart on moisture surplus and moisture stress in the five critical growth phases with respect to the rainfed rice crop cultivation in the red and laterite zone and also in the old alluvial zone of West Bengal.

Key Words: Dry spell, wet spell, probability geometric distribution crop growth phases.

Among all weather factors, rainfall is the most vital factor which influences the crop growth and its production directly. As steady or erratic rainfall governs the timing of routine agricultural operations including plant protection measures, advance knowledge of the rainfall characteristics plays an important role to a farmer in minimization of the loss in crop production. Needless to mention that rainfall-pattern can be determined with probable margins of error only through a rigorous analysis of long term historical data on rainfall. Different rainfall characteristics, viz., the distribution of dry and wet spells, the pattern of occurrence of rainfall in short intervals, like, 2, 4 days period and in medium-duration intervals, like, 10,16 days period, are the essential determinants in the preparation of an effective agricultural planning programme. Literature reveals the existence of quite a number of statistical methodologies for rainfall analysis. Saksena *et al.* (1979) studied the distribution of dry and wet spells and

also the pattern of occurrence of rainfall in short intervals, like, 5, 10 or 15 days period using a truncated geometric distribution over different crop growth phases. Ghadekar and Thakare (1991) studied the rainfall distribution over Nagpur region of Maharastra extensively. Chaudhury (1994) suggested a crop planning calendar on the basis of rainfall analysis in Bastar district of Madhya Pradesh. Chaudhury and Tomar (1991) reported the stable rainfall period during crop season through an analysis of forty years of rainfall data over 12 stations of Bastar District. The present study concerns the characterization of the distribution of dry and wet spells in intervals, like, 2, 4, 10 and 16 days by using truncated geometric distribution for rainfall occurrence in the 'aman' season (rice crop) in the red and laterite zone and also in the old alluvial zone of West Bengal.

MATERIALS AND METHODS

To derive the distributions of dry and wet spells, let p_{11} and p_{22} define the conditional probabilities that (i) a dry day will follow a dry day and (ii) a wet day will follow a wet day, respectively. Now for the estimation of p_{11} and p_{22}, each day of the period, say, seedling phase (seed sowing to four leaf stage) of rice crop consisting of a period of 28 days in Paschim Midnapore district, is classified as dry or wet on the basis of the criterion fixed according to the water requirement of the crop. Let f_{11} and f_{22} be, respectively, the frequencies of (i) a dry day followed by a dry day and (ii) a wet day followed by a wet day. If N_1 and N_2 are the number of dry and wet days, respectively, then, p_{11} and p_{22} are estimated by f_{11}/N_1 and f_{22}/N_2, respectively. Without any loss of generality, the distributions of dry and wet spells can be taken as independent and as such a positive integral valued random variable 'x', called 'the length of dry/wet spell' can be defined. If p represents either p_{11} or p_{22}, then,

$$Pr(x = n/\ n \leq s) = \{ p^{n-1}(1- p)\}/ \sum_{n=1}^{s} p^{n-1}(1-p)\}, n = 1, 2..., s;$$

where s is the length of the period under consideration crop phase, n is the length of the spell (dry/wet), the term in the denominator is due to the truncation of the distribution at s, the size of the period of crop phase.

The expected value of x is

$$E(x) = \sum_{n=1}^{s} n\, p^{n-1}(1-p\}/ \{\sum_{n=1}^{s} p^{n-1}(1-p\}, n = 1, 2, ..., s;$$

and, finally, the expected length of a

Table 1: Expected length of spells at different conditional probability levels for different sizes of the period (Crop Phase)

Prob	4 Days			10 Days			16 Days			21 Days			27 Days			28 days		
	0.000	0.004	0.008	0.000	0.004	0.008	0.000	0.004	0.008	0.000	0.004	0.008	0.000	0.004	0.008	0.000	0.004	0.008
0.02	1.020	1.024	1.028	1.020	1.024	1.029	1.020	1.024	1.029	1.020	1.024	1.029	1.020	1.025	1.029	1.020	1.025	1.029
0.05	1.052	1.057	1.061	1.053	1.057	1.061	1.053	1.057	1.061	1.053	1.057	1.062	1.053	1.057	1.062	1.053	1.507	1.062
0.10	1.110	1.115	1.120	1.111	1.116	1.121	1.111	1.116	1.121	1.111	1.116	1.121	1.111	1.116	1.121	1.111	1.116	1.121
0.15	1.174	1.179	1.185	1.176	1.182	1.188	1.176	1.182	1.188	1.176	1.182	1.188	1.176	1.182	1.188	1.176	1.182	1.188
0.20	1.243	1.249	1.255	1.250	1.256	1.263	1.250	1.256	1.263	1.250	1.256	1.263	1.250	1.256	1.263	1.250	1.256	1.263
0.25	1.317	1.323	1.329	1.333	1.340	1.348	1.333	1.340	1.348	1.333	1.340	1.348	1.333	1.340	1.348	1.333	1.340	1.348
0.30	1.395	1.402	1.408	1.428	1.437	1.445	1.428	1.437	1.445	1.429	1.437	1.445	1.429	1.437	1.445	1.429	1.437	1.445
0.35	1.477	1.484	1.490	1.538	1.548	1.557	1.538	1.548	1.558	1.538	1.548	1.558	1.538	1.548	1.558	1.538	1.548	1.558
0.40	1.561	1.568	1.575	1.666	1.677	1.688	1.666	1.678	1.689	1.667	1.678	1.690	1.667	1.678	1.690	1.667	1.678	1.690
0.45	1.647	1.654	1.660	1.815	1.828	1.841	1.818	1.831	1.845	1.818	1.831	1.845	1.818	1.832	1.845	1.818	1.832	1.845
0.50	1.733	1.740	1.747	1.990	2.005	2.021	2.000	2.016	2.032	1.999	2.016	2.033	2.000	2.016	2.033	2.000	2.016	2.033
0.55	1.819	1.826	1.833	2.197	2.215	2.233	2.221	2.241	2.261	2.222	2.242	2.262	2.222	2.242	2.262	2.222	2.242	2.262
0.60	1.904	1.911	1.917	2.440	2.460	2.481	2.495	2.520	2.545	2.499	2.525	2.550	2.500	2.525	2.551	2.500	2.525	2.551
0.65	1.987	1.994	2.001	2.721	2.745	2.770	2.841	2.872	2.904	2.855	2.887	2.921	2.857	2.890	2.924	2.857	2.890	2.924
0.70	2.069	2.075	2.082	3.043	3.070	3.098	3.280	3.320	3.361	3.332	3.365	3.410	3.332	3.376	3.422	3.334	3.377	3.423
0.75	2.147	2.154	2.161	3.403	3.434	3.464	3.838	3.888	3.940	3.95	4.010	4.070	3.989	4.052	4.117	3.991	4.055	4.120
0.80	2.224	2.231	2.236	3.797	3.830	3.863	4.536	4.599	4.662	4.805	4.906	4.967	4.935	5.027	5.123	4.946	5.040	5.127
0.85	2.298	2.304	2.309	4.215	4.249	4.284	5.383	5.457	5.532	5.951	6.057	6.165	6.327	6.463	6.603	6.368	6.508	6.652
0.90	2.368	2.374	2.379	4.647	4.681	4.716	6.361	6.443	6.526	7.420	7.550	7.683	8.333	8.523	8.717	8.454	8.653	8.857
0.95	2.435	2.441	2.446	5.079	5.113	5.147	7.422	7.509	7.595	9.153	9.301	9.448	10.983	11.211	11.453	11.263	11.513	11.765

cycle (i.e., a dry spell followed by a wet spell and vice versa) are obtained by adding the expected lengths of dry and wet spells, since both are independent. Notation ally, E(c) = E(x) + E(y), where c, x and y are the length of the cycle, the lengths of the dry and wet spells, respectively.

Daily rainfall data for 31 years (1961 to 1991) for Midnapore and Manbhum, belonging to the red and laterite zone of West Bengal, were collected from IMD, Pune and also daily rainfall data for 15 years (1976 to 1990) for Dhaniakhali, situated in the old alluvial zone of West Bengal were collected from CAPE Project, BCKV, Mohanpur. Monthly mean of evaporation data for 10 years (1976 to 1985) were collected from " Evaporation data of observatories in India (1976 to 1985)", issued by IMD, Pune. The evaporation figures were multiplied by the constant 0.845 as suggested by Ramdas (1957). These adjusted evaporation figures represent the potential evapotranspiration (PET) values. For rice crop, Doorenbos and Pruitt (1977) obtained the values of K_c (crop coefficient) for different growth stages of rice plant as 1.10, 1.05 and 0.95 corresponding to the initial , mid-season and late season stages, respectively. Finally, AET (actual evapotranspiration) or the actual crop water loss is obtained as PET x K_c.

In Table 2 a spell has been described as dry or wet, when probable rainfall, R (derived from the model) at a particular growth stage is less than or greater than or equal to AET. Thus on the basis of AET and R (rainfall), a day is classified as dry or wet in the entire crop season of rainfed (aman) rice. A day is classified as wet, if R (rainfall) $\geq$ W (water requirement), otherwise it is dry. A wet day has enough rain to meet up the water requirement of a day and conserve some moisture in the soil and a dry day just following a wet day has enough moisture for the crop which is considered as good as a wet day for all practical purposes. It is assumed that two dry days following two continuous wet days may not create any moisture stress for the crop.

RESULTS AND DISCUSSION

Applying the method described above, the expected lengths of dry/ wet spells are obtained for various durations of crop phases and at various conditional probability levels (Table 1). For example, if the conditional probability of a dry day following a dry day in a period (crop phase) of 16 days is 0.608, the expected length of dry spell is given in column no. 13 and row no. 13 of Table 1 as 2.545 days. Thus for a given pair of

Table 2: Crop growth phases and estimated lengths of dry/ wet spells at Manbhum, Midnapore and Dhaniakhali

Crop growth Phase	Duration of the phase	No. of days In that period	p_{22}	Expected length of wet spell	p_{11}	Expected length of dry spell	wet + dry spell (days)
a. Manbhum							
Seedling	2 to 29th July	28	0.456	1.838	0.633	2.725	4.563
Tillering	14th Aug. to 3rd Sept.	21	0.523	2.096	0.606	2.537	4.633
Panicle initiation	4th to 30th Sept.	27	0.483	1.934	0.718	3.543	5.477
Booting or flowering	1st to 10th Oct.	10	0.446	1.802	0.750	3.403	5.205
Milk or soft dough	11th to 24th Oct.	14	0.381	1.615	0.872	5.400	7.015
b. Midnapore							
Seedling	2 to 29th July	28	0.455	1.835	0.630	2.703	4.538
Tillering	14th Aug. to 3rd Sept.	21	0.470	1.887	0.626	2.673	4.560
Panicle initiation	4th to 30th Sept.	27	0.495	1.980	0.694	3.266	5.246
Booting or flowering	1st to 10th Oct.	10	0.489	1.949	0.721	3.190	5.139
Milk or soft Dough	11th to 24th Oct.	14	0.358	1.558	0.853	5.108	6.666
c. Dhaniakhali							
Seedling	20th June to 17th July	29	0.455	1.835	0.630	2.703	4.538
Tillering	2nd to 26th Aug.	25	0.470	1.887	0.626	2.673	4.560
Panicle initiation	27th Aug. to 25th Sept.	30	0.495	1.980	0.694	3.266	5.246
Booting or flowering	28th Sept. to 5th Oct.	11	0.489	1.949	0.721	3.190	5.139
Milk or soft dough	6th to 20th Oct.	15	0.358	1.558	0.853	5.108	6.666

conditional probabilities, p_{11} and p_{22}, the expected numbers of dry and wet days (i.e., the lengths of dry and wet cycles) in a crop phase, respectively, can be obtained.

In the red and laterite zone of West Bengal *'kharif'* season starts from the first week of July and hence short duration rice varieties (100 to 120 days) are cultivated here. Rice is, generally, sown in the first week of July and is harvested in the first week of November. In the old alluvial zone of West Bengal the season starts, normally, from the second week of June and hence long duration rice varieties (130 to 150 days) are cultivated. Thus, here, rice is sown in the second week of June and harvested in the first week of November.

Out of the five phases (Table 2), the three phases, namely, panicle initiation, booting or flowering and milk or soft dough are the most critical stages for moisture stress/ surplus. Salient features of Table 2 are as follows:

(a) The pattern of pair of values (p_{11} and p_{22}) and the corresponding pair of the lengths of dry and wet spells suggest absence of any moisture stress for the seedling. The intercultural operations or fertilizer applications can take place on the second dry day in case of Manbhum and Midnapore sites and such operations can be performed on the third dry day at Dhaniakhali site.

(b) In the tillering stage, the estimated lengths of dry and wet spells suggest an expected pattern which ensures an adequate supply of moisture to the plant in case of both long duration and short duration crops.

(c) In both long and short duration crops the lengths of dry spell are more than the corresponding lengths of wet spell in the panicle initiation stage.

(d) In milk or soft dough stage, a small amount of rainfall is beneficial to the crop. However, if the dry spell assumes a longer period, where available, protective irrigation measures may be necessary.

In conclusion, the following advices are presented briefly:

1) A short duration variety of rice is suitable for red and laterite zone of West Bengal, so that water requirements are met at the critical phases of growth.

2) A medium/ long duration variety of rice is appropriate for cultivation in the old alluvial zone of West

Bengal and the crop is to be sown in the third week of June.

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