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Cropping potential of the red-laterite-gravelly belt of West Bengal based on moisture availability index and soil characteristics

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सार — पश्चिम बंगाल की लाल लैटराइट मिट्टी के संबंध में विस्तार से जानकारी के साथ नमी उपलब्धता सूचकांक (एम. ए. आई.) का प्रयोग करते हुए इसकी बजरीली पट्टी में फसल उगाने की सम्भावना के बारे में इस लेख में बताया गया है। नमी उपलब्धता सूचकांक से पता चलता है कि इस मिट्टी की पट्टी में फसल उगाने की 15 सप्ताह की अवधि की फसल की 80 प्रतिशत, 18 से 20 सप्ताह की अवधि की फसल की 50 प्रतिशत तथा 22 से 24 सप्ताह की अवधि की फसल की 30 प्रतिशत तक सम्भावना है। इस मिट्टी की चावल उगाने वाली पट्टी में पानी की कमी वाले समय को सम्मिलित करते हुए भी प्रत्येक दस वर्ष की अवधि में अधिकांश स्थानों में आठ फसलें उगाई जा सकती हैं। चावल के उपरांत मिट्टी की अवशिष्ट नमी के आधार पर चना, तुअर तथा मसूर जैसी दालें और रेपसीड तथा सरसों जैसी तेलहन फसलें लगाई जा सकती हैं। कम वर्षा वाले वर्षों में खरीफ में चावल के स्थान पर ज्वार, मूंगफली और मक्का उगायी जा सकती है। कृषि उत्पादन में वृद्धि और स्थिरता के लिए वन संबंधी तथा उद्यान वाली फसलों के उगाने पर भी बल दिया जाना चाहिए।

ABSTRACT. Crop potential has been brought out over the red-laterite-gravelly belt of West Bengal using Moisture Availability Index (MAI) and broad soil information. MAI indicates that a crop of 15, 18-20 and 22-24 weeks' duration at 80%, 50% and 30% probability levels respectively may be raised from this belt. In most of the stations of the belt, rice could be raised in eight out of every ten years without encountering much water-stress period. At lower probability levels, after rice, pulses like gram, tur and lentil and oilseeds like rapeseed and mustard may be raised based on residual soil moisture. In low rainfall years sorghum, groundnut, maize could be introduced in place of rice in the kharif season. Emphasis should also be given on agro-forestry and horticultural crops for increasing and stabilizing agricultural production.

Key words — Moisture availability index (MAI), Potential evapotranspiration (PET), Accumulated assured rainfall (AAR), Crop potential, Red-laterite-gravelly soil.

1. Introduction

The red-laterite-gravelly belt of West Bengal comprises of four districts, *viz.*, Birbhum, Bankura, Purulia and Midnapore. This region is undulated with ridges and valleys which represent the eastern fringe of Vindhya ranges and are characterized by the presence of low hills like Ayodhya, Susunia and others. The altitude varies from 60 to 600 m above mean sea level. Seasonal rivers, namely, Kangsabati, Ajoy, Damodar, Silabati, Mayurakshi flow through this region towards southeast and ultimately discharge into the river Ganges. The climate of this region is broadly sub-humid. Average annual rainfall over the belt ranges from 1100 to 1300 mm; maximum temperature during summer may exceed 40°C and minimum temperature during winter could be as low as 7-9°C. This belt receives rainfall mainly from southwest monsoon.

Mainly red, laterite and gravelly types of soils are prevalent in this belt. Although variation of climate is less but crop practices differ due to variations of soil.

In this belt farmers traditionally cultivate rice as their main crop. Water requirement of rice is quite high, during the low rainfall years, rice yield suffers severe set back. This problem could be overcome by cultivating suitable crops based on available moisture status and taking soil factors into consideration.

The main objective of this study is to suggest sustainable crops for the area on the basis of moisture availability index (MAI) which is defined as the ratio of weekly assured rainfall and potential evapotranspiration of the corresponding period and broad soil information. This will help in increasing agricultural production in this region.

2. Soils

Three types of soil are usually found over this region. A brief description of each type of soil is as follows :

TABLE 1

Moisture Availability Index (MAI), Potential Evapotranspiration (PET) and Accumulated Assured Rainfall (AAR) over the red-laterite-gravelly belt of West Bengal

Station	ABR	At 30% probability level				At 50% probability level				At 70% probability level				At 80% probability level			
		Number of weeks with MAI		AAR (mm)	PET (mm)	Number of weeks with MAI		AAR (mm)	PET (mm)	Number of weeks with MAI		AAR (mm)	PET (mm)	Number of weeks with MAI		AAR (mm)	PET (mm)
		⩾0.3	⩾0.7			⩾0.3	⩾0.7			⩾0.3	⩾0.7			⩾0.3	⩾0.7		
Birbhum																	
Suri	SRI	22	21	1475	659	21	18	915	635	17	13	513	488	15	11	447	424
Rampurhat	RPT	23	22	1515	672	21	18	920	622	16	13	476	450	15	11	417	391
Bolpur	BLP	22	21	1318	658	19	16	757	561	16	11	399	466	14	10	308	407
Murarai	MRR	22	21	1537	648	21	16	897	622	16	12	456	453	14	11	391	396
Labpur	LBP	22	20	1285	653	19	17	738	558	14	11	365	401	13	10	329	376
Bankura																	
Bankura	BNK	22	21	1458	610	20	18	874	543	17	13	481	454	15	12	333	394
Vishnupur	VSP	23	21	1444	648	20	18	884	573	17	13	497	459	15	12	345	399
Khatra	KHT	22	21	1384	592	19	18	832	502	16	13	453	415	14	12	320	355
Indus	IDS	22	22	1357	647	21	17	828	621	17	12	454	487	15	11	361	427
Kotalpur	KTP	22	22	1450	601	21	17	860	576	17	14	456	447	15	12	304	387
Onda	OND	22	20	1188	622	20	17	707	555	15	11	365	405	13	10	321	344
Gangajal-ghati	GJD	22	19	1387	626	18	17	835	494	16	13	482	442	14	12	327	380
Sonamukhi	SMK	22	22	1366	643	19	17	814	565	17	12	451	484	15	11	361	422
Taldangra	TLD	23	20	1581	637	20	17	914	546	16	14	479	422	14	12	328	372
Midnapore																	
Midnapore	MDP	23	22	1579	639	21	18	981	590	18	14	560	482	17	13	405	442
Tamluk	TMK	22	22	1687	632	20	19	990	564	18	15	529	499	16	14	415	468
Ghatal	GHL	22	21	1478	622	20	18	887	572	18	13	479	492	16	12	417	467
Kukrahati	KKH	23	22	1707	657	20	18	983	563	17	15	521	459	16	13	404	433
Panskura	PNK	24	23	1551	672	21	18	916	600	17	13	499	466	16	12	434	436
Pachet	PCT	22	21	1670	606	20	20	964	538	18	14	489	472	17	12	398	448
Bhagwanpur	BWP	23	22	1556	668	21	18	928	617	18	14	506	503	17	12	436	466
Kesiary Kaltikri	KKT	24	24	1670	651	20	18	961	558	18	14	507	472	17	12	406	445
Sildabel-pahari	SLB	22	21	1513	590	20	18	937	522	18	14	546	458	17	12	417	432
Amlagora	AMG	22	21	1589	621	20	18	978	570	17	14	548	464	16	12	416	442
Purulia																	
Purulia	PRL	22	20	1479	599	19	17	913	507	16	13	525	407	15	12	344	373
Raghunath-pur	RGP	22	20	1340	597	20	17	795	481	17	13	437	381	15	11	328	347
Barabazar	BRB	22	21	1478	590	19	17	890	499	16	12	485	399	15	11	330	363
Jhalda	JLD	21	20	1562	603	18	16	949	509	16	12	553	444	15	11	370	406

2.1. *Red soil*

This soil is found over the parts of Midnapore, Bankura and Birbhum districts. Soil depth is variable, texture is coarse to medium, soil reaction is mildly acidic (pH 5.4-6.6). Lime, ferro-manganese concretions are sometimes present in the profiles. The lands are terraced and well drained. This soil is poor in organic matter, calcium and nitrogen. Available phosphorus and potash are medium and low to medium respectively.

2.2. *Laterite and lateritic soil*

This soil is found over eastern part of Bankura and western part of Birbhum and Midnapore districts. It is coarse textured and well drained. Soil depth is variable, water holding capacity is low. This soil is moderate to strongly acidic in reaction (pH 4.5-6.5). Iron concretions are dispersed on the surface and hard honey-comb structures of iron and aluminium are present in the sub-surface or exposed in some eroded area. This soil is poor in organic matter, lime and nitrogen and low to medium in available-phosphorus and potash. Phosphate fixation capacity is high. Deficiencies of secondary nutrients are also observed in certain places. Upland soils are very deficient in available plant nutrients, whereas the lowlying lands, locally known as 'Shale' or 'Bahal', are fertile.

2.3. *Gravelly soil*

This soil is mainly found over the entire Purulia district and western part of Bankura district. It has low water holding capacity. Soil reaction is mildly acidic (pH 6.5-7.0), coarse textured soil. This soil contains large amount of coarse sand and gravel of different sizes. Organic matter content is very low. Upland soils are highly susceptible to erosion hazards.

3. Data and methodology

Weekly rainfall data of 28 stations spread in the red-laterite-gravelly belt available for 85 years (1901-85) have been utilized in this study. Weekly PET values have been obtained from the publication of Khambate and Biswas (1992) and broad soil type has been extracted from 'Soils of India and their Management' (FAI 1985).

Biswas (1982) and Sarker & Biswas (1988) developed a methodology based on MAI to evaluate crop potential of an area. The same method has been used here to find out crop potential of the red-laterite-gravelly belt. Attempts have been made to explore the possibilities of raising post-rainy crops on the basis of residual soil moisture.

4. Discussions

4.1. *Moisture Availability Index (MAI)*

Table 1 presents the duration of MAI and amount of AAR and PET at different probability levels over the red-laterite-gravelly belt of West Bengal.

Perusal of the data in Table 1 indicates that during southwest monsoon period MAI is $\geqslant 0.3$ for a period of about 22-24, 18-21 and 16-18 weeks at 30%, 50% and 70% probability levels respectively. Even at 80% probability level MAI is $\geqslant 0.3$ and $\geqslant 0.7$ for a period of about 15-16 and 11-12 weeks respectively. This indicates that moisture environment is adequate for growing a crop of atleast 15 weeks' duration in 8 out of every 10 years.

AAR over the belt varies from about 1200-1700, 700-950 and 450-550 mm at 30%, 50% and 70% probability levels respectively. At 80% probability level, average AAR is about 370 mm which is less than the average PET, so crops may not get residual moisture after cessation of rainy season. But at lower probability levels, say at 30%, AAR is more than double of PET, so a long duration crop could be grown at this level based on the residual soil moisture even after the cessation of rainy season.

4.2. *Existing and suggested cropping system*

This investigation shows that MAI is more or less similar over the four districts of this belt, hence cropping potential depends on soil type, depth and texture of the soils.

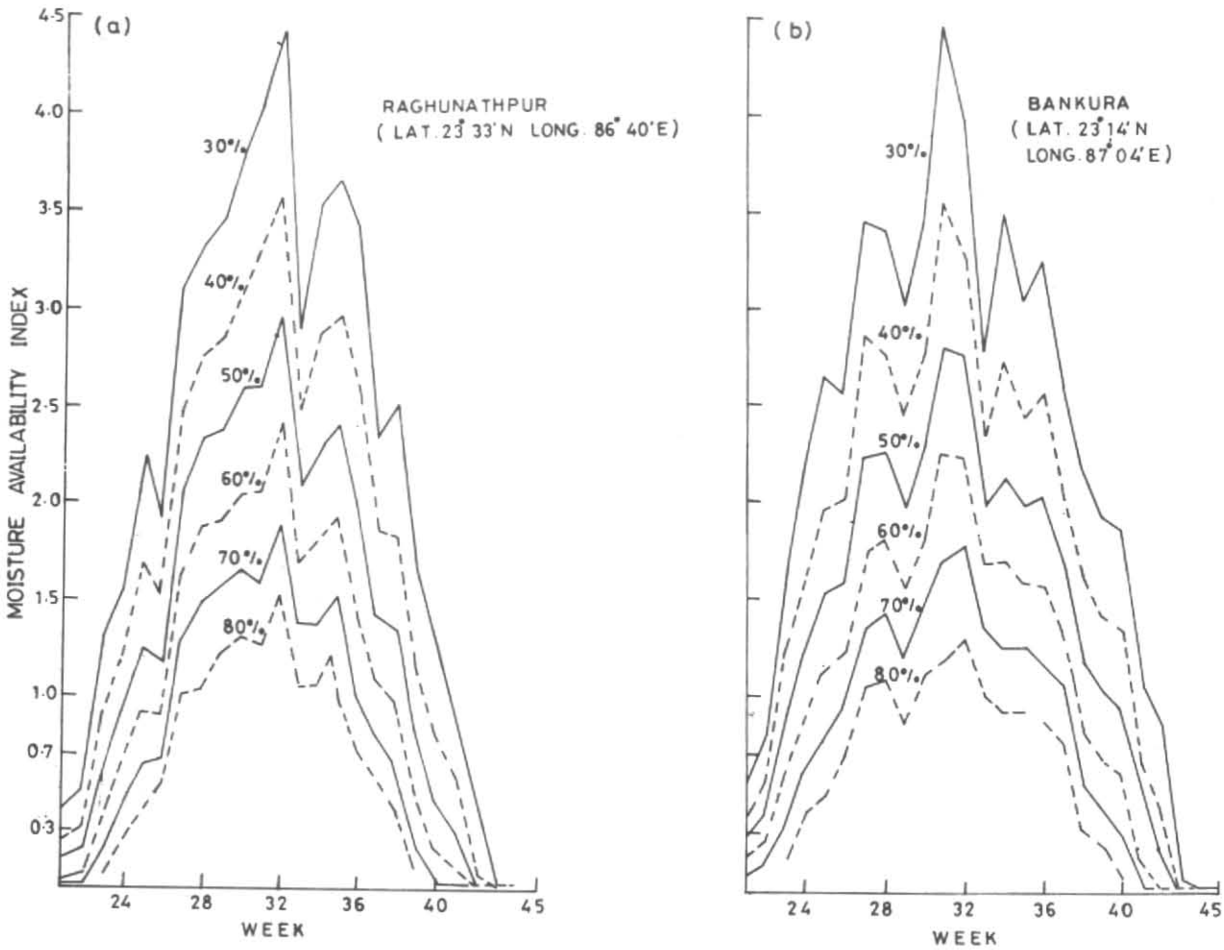
Cropping potential has been discussed under rainfed conditions for each type of soil, in the following paragraphs :—

4.2.1. *Red soil*

Rice is the main crop (water requirement about 100 cm) with 80 to 90% of the cropped area. At 80% level MAI is $\geqslant 0.3$ for a period of about 15 weeks which indicates that rice can be raised in 8 out of every 10 years. Other two years, crops like maize or sorghum which require comparatively less water, 60 and 50 cm respectively, may be raised during kharif season. Fibre crop like sunhemp may be introduced in this area. At low probability levels after kharif rice, pulses like gram, tur, lentil and oilseeds like mustard and soyabean may be followed. Low water requirement of pulses (about 20 cm) and oilseeds (about 40-45 cm) makes them most suitable crops during low rainfall years.

4.2.2. *Laterite and lateritic soil*

Rice is the main crop and is rotated with wheat, potato, pulses and rape & mustard. Sometimes,



Figs. 1 (a & b). Moisture Availability Index (MAI) at different probability levels

vegetables like cucurbits are also grown. MAI values presented in Table 1 indicates that in two years out of every ten years rice may encounter water stress, hence, maize and groundnut whose water requirement is comparatively less (about 60 and 45 cm respectively) may be introduced in the cropping pattern of this area. Inclusion of these crops in the cropping pattern would make crop production more sustainable during the low rainfall years. At lower probability levels mung bean and sesamum whose water requirement is about 20 and 40 cm respectively, could be successfully raised based on the residual soil moisture during rabi season. Horticultural crops like guava, ber etc. may be introduced.

4.2.3. *Gravelly soil*

Existing crops are rice, maize, blackgram. MAI shows that the present practice of taking rice, maize and blackgram may be continued. Rape seed & mustard and green gram whose water requirement is about 40-45 and 20 cm respectively also could be successfully raised by using residual moisture after cessation of rainy season. In the upland areas, where rice is grown extensively, the productivity is very low because of its high water requirement (about 100 cm). In the same situations agricultural productivity could be increased by reducing the area under rice and cultivating maize, sorghum, millets with proper package of practices; even yield could be increased in upland region through intercropping with legumes. In low land areas, rice in kharif or lathyrus (fodder) in rabi could be more profitable. Emphasis should also be placed on planting teakwood and increasing area under agroforestry by introducing suitable trees.

4.3. *Cropping systems of two representative stations*

Details of MAI, soil, cropping system and crop potential have been discussed for two individual stations, namely Raghunathpur and Bankura so that it can serve as a guideline for changing the existing cropping system to increase production. These are discussed below :

4.3.1. *Raghunathpur* (*Lat. 23°33'N, Long. 86° 40'E*)

Existing crops at this station, mainly, are rice, wheat, blackgram, maize etc. Fig. 1 (a) depicts MAI at various probability levels at this station. It can be seen that at this station at 80% probability level MAI is more than 0.3 and 0.7 for a period of 15 weeks and 11 weeks respectively, of which periods, the MAI is more than one for a period of 9 weeks (27th week to 35th week). Accumulated assured rainfall and PET during these 15 weeks, is 328 and 364 mm. respectively. As PET is more than AAR during this period, so there may not be any stored soil moisture after cessation of rainy season. A crop of 15 weeks' duration, however, may be raised from this station. At 50% probability level MAI is greater than 0.3 and 0.7 for about 20 and 17 weeks respectively and for about 15 weeks MAI is more than 1. At this level, AAR exceeds PET by about 300 mm. Hence, adequate amount of stored moisture is available which crops can use after monsoon season. At 30% level, the periods during which MAI is more than 0.3 and 0.7 are 22 and 20 weeks respectively and 18 weeks when MAI is more than 1. AAR is more than double of PET. One long duration crop or two short duration crops may be raised at this station.

Critical analysis of MAI shows that during kharif season in 80% of the years crops could get sufficient moisture for a period of about 15 weeks, so emphasis should be given on short duration cultivars of predominently grown crops whose growing cycle fits in with the water availability period. In upland areas rice should not be grown extensively, instead emphasis should be given on such crops as maize, sorghum and millets whose water requirement is much lower than rice, hence more yield could be expected from these crops. At lower probability levels pulses like gram, horsegram, greengram and oilseeds like mustard could be raised based on residual soil moisture. This area is suitable for forestry, especially for the teakwood. Planting suitable trees and increasing area under agroforestry may be emphasized.

4.3.2. *Bankura* (*Lat. 23°14'N, Long. 87°04'E*)

Existing crops at this station mainly are rice, wheat, lentil, rapeseed and mustard, potato, arhar etc.

Fig. 1 (b) depicts MAI at various probability levels at this station. It can be observed that at this station at 80% probability level MAI is more 0.3 and 0.7 for about 15 and 12 weeks respectively of which MAI is more than one for about 5 weeks. Accumulated assured rainfall during these 15 weeks is less than the PET which indicates that after cessation of rainy season crops may not get any stored soil moisture. However, a crop of 15 weeks' duration can be successfully raised. At 50% probability level MAI is greater than 0.3 and 0.7 for about 20 and 18 weeks respectively and MAI is more than one for about 16 weeks. At this probability level AAR exceeds PET by about 330 mm which indicates that adequate amount of stored moisture is available that can be used even after cessation of rainy season. At 30% probability level MAI is more than 0.3 and 0.7 for about 22 and 20 weeks respectively and for about 19 weeks MAI is greater than 1. At this probability level AAR is more than double of the PET which indicates that stored moisture and ground water recharge occur at this level. A crop of about 22 weeks could be grown successfully at this level.

MAI analysis reveals that in 8 out of every 10 years a rice crop of about 15 weeks' duration can be successfully raised without much moisture-stress condition; in other 2 years crops of less water requirement, *viz.,* millets, pulses, oilseeds etc. should be favoured. With the increase in the price of oilseeds farmers should put more of fertilizer and irrigation resources to this crop. Sugarcane and potato could also be included in the cropping pattern which could give more remuneration. Sesame could also be profitable. It could be sown in dry season (January-February) after the harvest of late rice in the low lying areas or after the harvest of early potato. Linseed in rabi could be emphasized in rice fallows and in upland areas groundnut in kharif should be introduced.

5. Prospects of new crops

In the low rainfall years, rice normally gives very low yield due to moisture stress. Under the same moisture condition crops like sorghum, millet, maize, groundnut etc. can sustain and give optimum yield under proper management. So, total productivity will increase due to the introduction of these crops, hence, the economy of the farmers.

Opening of agro-industries and other small scale industries in rural areas, for example, (a) maize crop based industries (starch, animal feed mills and other corn product based manufacturing units); (b) special oil extraction mills for extraction of groundnut oil and (c) soyabean oil and defatted soyabean material processing units also can go a long way to boost the economy of the farmers of the red-laterite-gravelly belt where rice is the main crop grown for subsistence.

6. Conclusions

The following conclusions emerge from this study :—

(*i*) Rice could be successfully raised from the red-laterite-gravelly belt of West Bengal in eight out of every ten years, in the remaining two low rainfall years, maize and sorghum may be introduced in place of rice.

(*ii*) In uplands, area under rice cultivation should be progressively reduced and crops such as maize, sorghum, millets could be chosen to replace rice.

(*iii*) At 50% and other low probability levels adequate amount of stored moisture can be available at the end of rainy season. A long duration kharif crop or double cropping could be introduced at these levels.

(*iv*) Large amount of ground water recharge takes place at 50% and other low probability levels. This can be used for scheduling life saving irrigation.

(*v*) At low probability levels residual moisture is available after the cessation of rainy season which could be utilised for raising pulses like gram, tur and lentil and oilseed like rapeseed and mustard after rice.

(*vi*) Emphasis should be placed on planting teakwood and increasing area under agroforestry and horticultural crops.

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