Mausam, (1987), 38, 2, 241-244

551.5 : 633 : 551.577

An agroclimatic study for potential productivity evaluation under rainfed condition of Nadia district in West Bengal

S. A. KHAN

State Water Investigation Directorate, Calcutta

and

B. N. CHATTERJEE

Bidhan Chandra Krishi Viswavidyalaya, Kalyan

(*Received 24 October 1985*)

सार — साप्ताहिक वर्षण (R) के संभाव्यता अनुमान तथा वाष्पोत्सर्जन विभव (PET) के रिकार्ड वर्षा की निरंतरता के अध्ययन के लिये बहुत उपयोगी सिद्ध हुए हैं। पश्चिमी बंगाल के नादिया जिले में वर्षा के निरंतर बने रहने की संभावना 19वें सप्ताह (7 से 13 मई) के पश्चात् काफी होती है और वर्षा से पोषित होने वाली जो फसलें इसके पश्चात् बोई गई, उन फसलों की बढ़वार के लिए मानसून आगमन से पहले पानी की जो कमी रहती है उसका बहुत कम खतरा रहता है।

जब उपलब्ध जल भंडार का निर्धारण जल संतुलन के द्वारा वर्षा के साथ किया जाता है तो विभिन्न प्रकार की मिट्टियों में फसल की ढ़वार की अवधियों में काफी वृद्धि हो जाती है जो मई (19वें सप्ताह) से फरवरी (7वें सप्ताह) तक होती है। पानी के उपलब्ध होने की सबसे लम्बी अवधि चिकनी मिट्टी में 300 मि० मी० AWC तथा कम, दोमट मिट्टी में (250 मि० मी AWC) तथा सबसे कम, रेतीली दोमट मिट्टी में (200 मि० मी० AWC) पाई गई। विभिन्न प्रकार की मिट्टियों के लिए पानी की उपलब्धता की अवधियों की गणना करके उनकी तुलना 100 तथा 33 प्रतिशत के स्तरों पर, वाष्पोत्सर्जन विभव, पौध से लगाए गए धान तथा जूट के वाष्पोत्सर्जन तथा ऊपरीभूमि पर धान की बोआई के समय पानी की आवश्यकता से की गई है। जूट तथा धान आधारित फसल उगाने की प्रणालियों के लिये पानी की उपलब्धता की अवधियों की पहचान की गई है। यह पहचान विभिन्न प्रकार की AWC वर्षा पोषित मिट्टियों के लिए की गई हैं।

ABSTRACT. The probability estimates of historical weekly rainfall (R) and potential evapotranspiration (PET) records appeared to be a quite useful tool for studying the continuity of rainfall receipts. In the district of Nadia in West Bengal, the probability of continuance of rain is fairly dependable after 19th week (7 to 13 May) and rainfed crops sown after this period will escape maximum risks of water deficits occurring in the early stage of crop growth before the onset of monsoon. When available-water storage is considred with rainfall through water balance approach the crop growth periods in different soils are augmented considerably, lying in the range of May (19th week) to February (7th week). The longest water availability duration was recorded in clay soil with 300 mm AWC, followed by in loam (250 mm AWC) and in sandy loam (200 mm AWC). Water availability periods thus computed for different soils were compared with water requirement of transplanted rice, evapotranspirations of jute and upland direct seeded rice and PET at 100 and 33% levels. Water availability periods for jute and rice-based cropping systems, have thus been identified, for soils of different AWCs under rainfed condition.

1. Introduction

In the district of Nadia, a bulk of net sown area (64%) is still rainfed. The success of rainfed crop production is dependent upon rainfall and/or stored soil moisture in the root profile. During monsoon season (June to September) due to high rainfall receipts crops are not likely to undergo moisture stress but during pre and post-monsoon seasons crops usually experience water stress owing to scanty, variable and unpredictable rainfall receipts. There is thus great scope of study the agroclimatic environment of the district by taking into accout the historical and current weather data and to identify the water availability period and thereby to evaluate the feasibility of increasing cropping intensity under rainfed condition.

Following the procedure of Cocheme and Franquin (1967), an exhaustive study for finding out water availability period was carried out by India Meteorological Department using mean monthly values of rainfall and potential evapotranspiration (Raman and Srinivasamurthy 1971). Of late, the duration of crop growth period in dry farming tract of the counrty has been indicated based on the concepts of moisture availability index and assured rainfall (Sarker and Biswas 1980 and Sarker *et al.* 1982). In the paper reported hereunder an effort has been made to identify water availability periods and thereby to find out production potential under rainfed condition in different types of soils of Nadia district in West Bengal, by taking into account the probability estimates of weekly rainfall and evapotranspiration and water balance for including rainfall and available stored water in soil during a given week.

2. Materials and methods

The study was conducted for Nadia district which is situated between. Lat. 22° 53′ & 24° 07′ N and Long. 88° 10′ & 88° 45′ E. Major crops grown under rainfed conditions in the district are jute, paddy, wheat, grain legumes, and oilseeds. This district broadly has 49.4% sandy loam, 16.7% loam, 25.5% clay loam and 8.4% clay soil. In respect of land situation, there are 3.2% upland, 88.7% medium land and 8.1% lowland (Anon. 1984-85).

To represent the entire agro-climatic environment of the district, the daily rainfall data of 45-year period (1940-1984) and mean potential evapotranspiration (Penman) of Krishnagar have been collected from India Meteorological Department. Rainfall on standard week basis was calculated from 1 January. Weekly rainfall data calculated on standard week basis over the entire 45-year period were used to obtain mean weekly rainfall.

Under rainfed condition the crop water use or evapotranspiration(ET) is met by rainfall and available stored water in the root profile. Hargreaves (1975) has shown that a rainfall/potential evapotranspiration (R/PET) value of atleast 0.34 is required to meet water requirement of dryland crops. He, further, held the opinion that a dependable event of rainfall based on long-term data is one where the rainfall occurs with a probability of $\geqslant$0.75 (75%). Sivakumar and Virmani (1979) conceptualised that at most stages of crop growth the ratio of actual evapotranspiration (AE)/PET has to be atleast 0.33 to meet the minimum crop water demand. Assuming that AE demands could be met by rainfall they had chosen a ratio of rainfall/PET of 0.33 for their agroclimatic analysis for crop planning. In this study of water availability to crops the ratio of 0.33 of R (weekly rainfall) and PET (potential evapotranspiration) has also been used.

The length of the water availability period without considering the soil water storage at various probability levels either for that amount of weelkly rainfall $R \geqslant$ PET or that which meets up one-thirds of PET, *i. e.*, R/PET $\geqslant 0.33$ has been computed. The soils of Nadia district being mostly light in texture and flat in topography, the runoff is usually low. However, during rains of high intensity some runoff will occur. In this study, runoff has been assumed to be $\frac{1}{4}$ of rainfall; this has been deducted from the analysis of water availability for crop production.

The water balance equation is written as R—PET $+ W_1 =$ RO $+ W_2$, where R is mean weekly rainfall, PET is mean weekly potential evapotranspiration, RO is runoff and deep drainage and W_1 and W_2 are the available-water storage at the beginning and at the end of the week, respectively. If R exceeds PET, the soil water is recharged and when $R -$ PET $+ W_1$ exceeds available-water storage capacity (AWC), it is assumed that W_2=AWC and RO=R—PET $+ W_1 -$ AWC.

On the other hand, when R—PET$+W_1$ does not exceed AWC, *i.e.,* when $R <$ PET, the profile stored water is used for meeting ET. Then the water balance equation is written as $W_2 = R -$ PET$+ W_1$. Under very limited supply of moisture, even to the extent of $\frac{1}{3}$ of PET, the consensus of opinion is that the plants will survive. The values of available-water storage capacity (AWC) as have been determined by Water Management Project of the Department of Agriculture, West Bengal (Anon. 1974-75) have been used in the computation of water balance. The AWCs per metre depth of soil assumed for the analyses were 200 mm for sandy loam, 250 mm for loam and 300 mm for clay loam and clay soils.

Following the above mentioned water balance methodology, the week to week changes in soil water storage have been calculated from 14th to 13th week. The crop available water (WA) including storage and rainfall/metre depth of soil from 14th to 13th week was computed by summing up the soil water storage at the end of the previous week and rainfall received during the given week for soils with 200, 250 and 300 mm AWC. The water availabilities for different soils thus computed were compared with (*i*) evapotranspiration and water requirement of crops, *viz.*, direct seeded upland and transplanted rices & jute and (*ii*) with PET and 0.33 PET through curves and the dates corresponding to intersections of different water availability curves with each of other curves were interpolated to the nearest day. With the help of the water availability diagram it is possible to calculate the water availability periods of transplanted rice, upland rice, jute and other upland crops whose demands for water lie in the range of PET and 0.33 PET. The estimated values of water requirement of transplanted rice as have been reported by Mittra *et al.* (1978) have been used. Sen (1977) in his studies on determinaton of evapotranspiration of crops reported that ratios of AE and PET at different growth stages of jute and upland direct seeded rice grown in *kharif* season do not vary widely. Ratios of 0.79 and 0.89 of AE and PET during the entire growth period of jute and upland direct seeded rice, respectively, were found to be quite sufficient to provide potential yield of the crops grown under a set of crop management practices. On that basis the values of 0.79 and 0.89 have been used to multiply the PET to obtain the actual evapotranspiration of jute and upland direct seeded rice, respectively.

3. Discussion

The plots of initial probabilities of the amounts of the rainfall to meet one-third of the potential demand, *i.e.,* R/PET $\geqslant 0.33$ and $R \geqslant$ PET at Krishnagar are presented in Fig. 1. It is seen from figure that the length of the water availability period at 75% probability level when R/PET $\geqslant 0.33$ is 111 days extending from 1 June to 19 September; at $R \geqslant$ PET, the water availability period comes down to 59 days only ranging from 24 June to 21 August. Since this methodology of rainfall probability analysis does not include the stored water in the root profile, the crop growth period, thus, computed might be shorter than the actual. These results can be useful for assessing the risks associated with the sowing done in dry soils before rainfall receipts. It will also be useful to predict as to whether the standing crop in the field sown on receipt of rain will experience water stress or not in the pre-monsoon season. In the opinion of the experienced people, on receipt of a good (20-30 mm) nor'wester shower, the cropping season of this district can start. Monsoon rains usually commence in the second week of June. When nor' wester showers are delayed, farmers keep themselves ready to utilize the first good showers in germinating the crop seeds of upland direct seeded rice, pigeon pea, etc by resorting to dry sowing ahead of rainfall receipt. But owing to improper choice of time in most cases crops sown through dry sowing fail. The results depicted in Fig. 1 show that the probability of continuance of rain is fairly dependable after 19th week and, therefore, the period from 19th to 21st week offers an excellent time for dry sowing, because in subsequent 22nd week onwards there is a probability of getting a rainfall amount of one-third of PET demand in 15 years out of 20 years. Thus, although the probabiltiy analysis is not useful for identifying water availability period for crop production, it appears to be a quite useful and realistic method for evaluating the appropriate time for dry sowing in the years of delayed nor'wester shower.

When the stored soil moisture is considered with rainfall the length of the crop growing period is augmented considerably. It appears from Fig. 2 that when rainfall and soil water are considered together, the water availability period exceeds the value of water requirement of transplanted rice from 25th June to 13th December in 200 mm AWC soil, upto 2nd January in 250 mm AWC soil and to 9th January in 300 mm AWC soil, and thus, the water availability periods of transplanted rice for soils of different AWCs are estimated to be 172, 192 and 199 days, respectively. When the actual ET of jute and upland direct seeded rice are compared with water availability (WA) curves it is seen that jute and upland rice sowing can be possible after 22nd week (28 May-3 June) and when sown in this period the crops can be ready for harvest in 40th week (1-7 October) during which a good yields of jute and rice can be obtained. The points of intersections of WA curves with each of PET and 0.33 PET help us delineate the upper and lower limits of water availability of upland crops. The duration of water availability periods at two levels of PET, ET and water requirement of crops have been presented in Table 1. This shows that even after growing jute and medium duration (110-120 days) rice varieties there is scope to grow another crop.

3.1. *Crop planning*

Matching or adjustment of water availability duration with the water demand of a crop gives an idea of the suitability of the sequential or simultaneous cropping of 2 or more crops in a given soil-climate system. From Table 1 it is further apparent that crop growth period is longer in the soil with 300 mm AWC than others with 250 and 200 mm AWCs. Higher the AWC, the longer is the water availability period at the same rainfall regime. Thus, the consideration of AWC of soil for crop planning is very important.

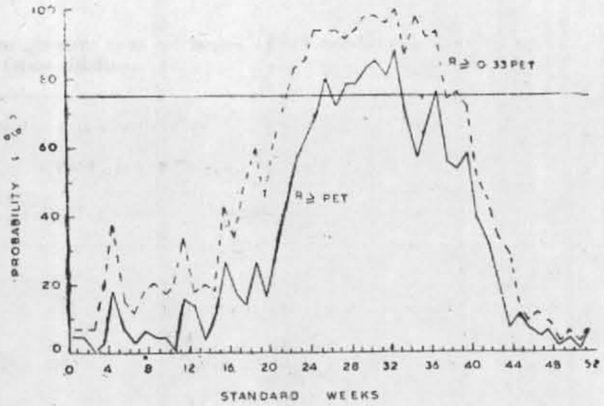

Fig. 1. Probabilities of $R \geq$ PET (— — — — —) and $R \geq 0.33$ PET (............) of Krishnagar.

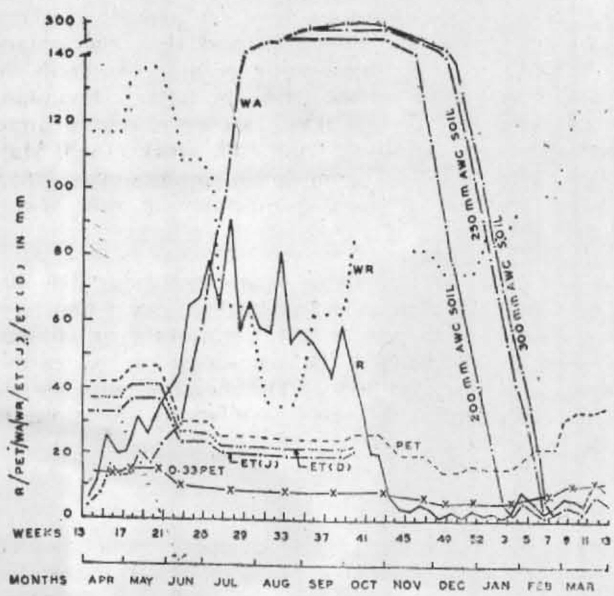

Fig. 2. Water availability diagram of Krishnagar

(R = Rainfall; PET = Potential evapotranspiration;

WA = Water availability of 200, 250 and 300 mm AWC soils;

WR = Water requirement of transplanted rice;

ET(J) = Evapotranspiration of jute; ET(D) = Evapotranspiration of upland direct seeded rice).

In Nadia district there are 3 types of land situations, *viz.*, upland, medium land and low land. To ensure the best possible utilization of natural endowments of rainfall and stored moisture, appropriate crop planning should be done for each soil and land situation.

TABLE 1

Length of water availability (WA) period for crop growing under rainfed condition in three soil textural groups having different available-water storage capacity (AWC)

Particulars	Available-water storage capacity per metre depth with soil types					
	Sandy loam (200 mm AWC)		Loam (250 mm AWC)		Clay (300 mm AWC)	
	Period	Days	Period	Days	Period	Days
WA⩾PET	2 Jun to 5 Jan	218	2 Jun to 6 Feb	250	2 Jun to 9 Feb	253
WA⩾0.33 PET	12 May to 10 Jan	244	12 May to 13 Feb	278	12 May to 15 Feb	280
WA⩾WR	25 Jun to 13 Dec	172	25 Jun to 2 Jan	192	25 Jun to 9 Jan	199
WA⩾ET (J)	3 Jun to 30 Sep	120*	3 Jun to 30 Sep	120*	3 Jun to 30 Sep	120*
WA⩾ET (D)	5 Jun to 2 Oct	120*	5 Jun to 2 Oct	120*	5 Jun to 2 Oct	120*

WA=Water availability including rainfall and storage; PET=Potential evapotranspiration;
WR=Water requirement of transplanted rice; ET(J)=Evapotranspiration of jute;
ET(D)=Evapotranspiration of upland direct seeded rice.
*Maximum duration of jute and upland direct seeded rice; there can be still varieties of shorter duration.

A low land or a medium land can provide available water to crops for a longer period than the upland situation due to accummulation of more water in the former after being carried from the latter. In upland situation having 226 mm AWC, a crop of jute or direct seeded rice may be raised from 20th week (14-20 May) followed by a suitable crop (grain legumes-peas, lentil; oilseeds-mustard, linseed, sunflower) in *rabi* season (Khan and Chatterjee 1985).

In medium and lowland situations having 216 mm AWC, double croppings of transplanted rice in the *kharif* season followed by peas or lentil or mustard or linseed or sunflower or barley in the *rabi* season can be feasible (Khan and Chatterjee 1986). The choice of crops should be in agreement with water availability durations in different soils.

4. Conclusion

It is concluded that double croppings under rainfed condition can be possible in Nadia district. If the rainfed crops are sown by 20th week they will face minimum risks of water deficits occurring during their growth period.

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