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Research Article

Water Deficit Patterns for Cultivation of Rainfed Rice in the Lower Gangetic Plains of West Bengal

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ABSTRACT

To determine the water deficit pattern in the lower Gangetic plains of West Bengal historical rainfall data for about fifteen years was collected from thirty meteorological stations located within the study area. Rainfall data was analyzed for calculation of probability of receiving critical amount of rainfall for rice transplanting. It was observed that an assured amount of 50 mm rainfall can be received in all over the study area in 28th SMW (standard meteorological week). The water deficit for all the stations was calculated separately considering different transplanting dates based on rainfall probability and historical mean rainfall data. The GIS maps were then prepared showing the variation of water deficit based on 29th, 31st and 33rd SMW as transplanting week. From this GIS maps, high, moderate and low water deficit zones were identified and pertinent zone specific recommendations were prepared.

Key words: Rainfall deficit pattern, Incomplete Gamma Distribution, Forward and backward accumulation, Rainfed rice, GIS

Introduction

Lower Gangetic plains of West Bengal, which comprises of six districts, is one of the potential zone for crop cultivation due to its high soil fertility as well as availability of water. The main crops of this zone are jute and rice (both *kharif* and *boro*). With the help of monsoon rains, transplanted rice is cultivated predominantly in *kharif* season. High spatial and temporal variabilities are the basic characteristics of rainfall in the monsoon season of the region. Moreover in recent years, an increasing trend of yearly rainfall and shifting pattern of rainfall has been observed (Banerjee and Khan, 2010). In case of *kharif* rice which is grown rainfed, a high risk is usually involved due to midseason monsoon break and late season cessation of rains.

Several studies on risk analysis have been carried for this zone with the help of incomplete gamma distribution as well as Markov chain methods but mostly for discrete locations (Chakraborty and Chakraborty, 1991; Chakraborty *et al.*, 1990). In this paper a comprehensive study has been presented to characterize this zone as a whole. To represent the actual water availability status for a region, GIS tools were also used successfully (Dey, 2008).

In case of transplanted rice, water requirement for the crop is high as it is cultivated in standing

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water. It has been observed that 3.5 mm evapotranspiration per day and 3.5 mm percolation per day are optimum. So the water requirement per day is about 7 mm and per week is 49 mm which is rounded to 50 mm (Singh and Singh, 2000). The present study therefore investigates the water deficit pattern for rainfed rice in the lower Gangetic Plains of West Bengal based on this water requirement.

Materials and Methods

Study Area

The study was conducted for thirty meteorological stations situated in six districts (Nadia, Murshidabad, Howrah, Hoogli, North 24-Parganas and South 24-Parganas) of lower gangetic plain of West Bengal (Figure 1). The main *kharif* crop of this area is transplanted rice. The water deficit scenario has been studied using statistical analysis. The daily rainfall data of 60 years from 1985 to 2000 was collected for all the 30 stations and aggregated to weekly values according to standard meteorological weeks (SMW).

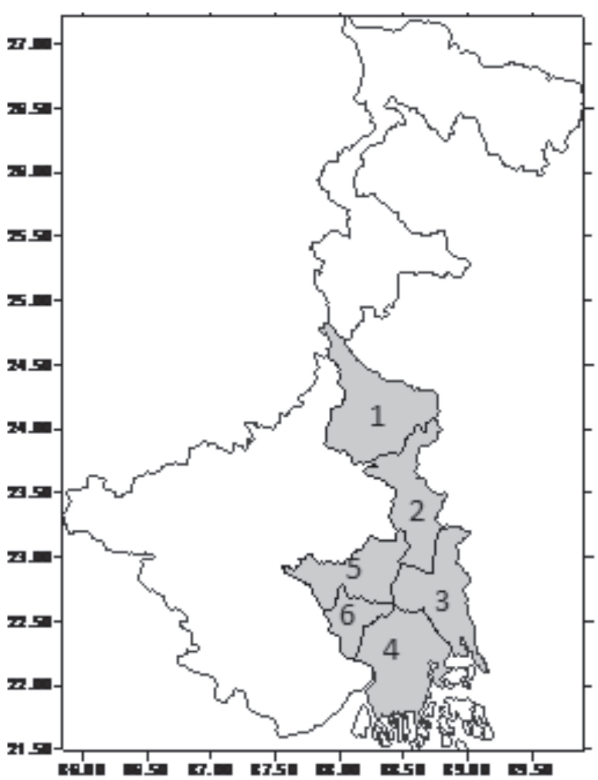

Fig. 1. Study area (The shaded portion, 1= Murshidabad, 2= Nadia, 3= North 24 Parganas, 4= South 24 Parganas, 5= Hoogli, 6= Howrah)

Incomplete Gamma Distribution

Incomplete gamma distribution (Thom, 1966) was fitted to the weekly rainfall to compute the assured rainfall (50 mm) at 50% probability level. The 50 mm weekly rainfall is optimum for transplanted rice cultivation and below which deficit occurs. 16 year average of weekly rainfall is computed for these 30 stations.

Forward and Backward Accumulation

Forward and backward accumulation is fitted with the weekly rainfall data of 16-year observations and accumulation of 200 mm of rainfall from onset of monsoon is calculated. The accumulated rainfall when reached 200 mm was considered the transplanting week for *kharif* rice.

Water Deficit Scenario

Three different sowing weeks were considered to evaluate water availability as well as deficit scenario of the study area and in turn is used for delineation of water deficit zone through accumulated value over the growing period.

GIS Mapping

The delineation was carried out in a GIS environment (Map-Info Version 6.5) to identify high, medium and low water deficit rice growing zone with respect to different dates of sowing.

Results and Discussion

Incomplete Gamma Distribution

By fitting incomplete gamma distribution using the historical rainfall data as stated earlier, it was observed that almost all the locations received more than 50 mm weekly rainfall within 28th SMW (Figure 2). Due to varied rainfall pattern across the region, the probability of occurrence of particular amount of rainfall was observed earlier in some areas and later in some other areas. Western part of North 24 Paraganas receives greater than 50 mm rainfall in 25th SMW

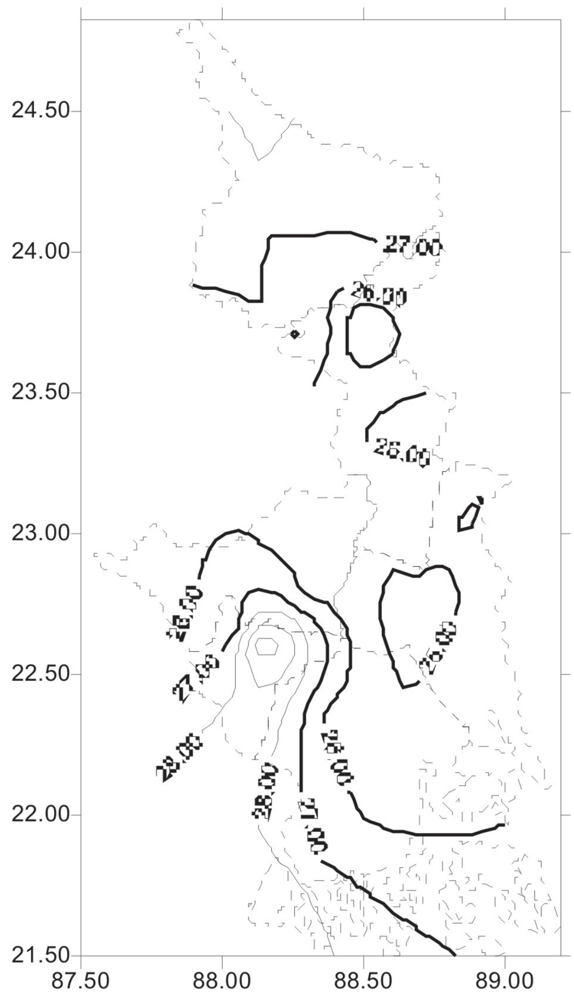

Fig. 2. Variation of starting week of receiving 50 mm rainfall or more (50% probability level by incomplete gamma distribution)

and it is the earliest period to get 50 mm rainfall at 50% probability level. In most of the area of Nadia, North and South 24 Paraganas districts, the required rainfall amount is usually received in 26th SMW. However, Murshidabad district receives the stipulated amount of rainfall in 27th SMW. The rest of the study locations receive 50 mm or above rainfall between 25th and 27th SMW. It is observed that in Murshidabad district, which is away from the coast, received the 50 mm accumulated weekly rainfall late in the season. In 27th SMW, the required rainfall probability (i.e. 50 mm) is received throughout the study area, so the transplanting of rice can therefore be done in 28th SMW considering one week gap for land preparation. The cultivators of the study area get adequate amount of rainfall at the start of the season to transplant rainfed rice.

Forward and Backward Accumulation

The calculations of forward and backward accumulation of rainfall for different locations in the study area using methods proposed by Morris and Zandstra (1979) showed similar results. Onset of crop growing season for different stations was found to occur within 25th to 27th SMW as shown in Table1. The 200 mm accumulated rainfall is best suitable for puddling of fields for rice

Table 1. Forward and backward accumulation showing starting week of 200 mm accumulated rainfall and end of season crop growing season when 50 mm of rain is yet to receive (at 50 % Probability level)

District	Block Name	Starting Week	Ending Week
Murshidabad	Berhampur	25	42
Murshidabad	Kandi	26	41
Murshidabad	Bharatpur-I & II	26	41
Murshidabad	Sagardighi	27	42
Murshidabad	Nabagram	26	42
Nadia	Kaliganj	26	42
Nadia	Nakashipara	26	42
Nadia	Karimpur-I & II	25	41
Nadia	Tehatta-I & II	24	43
Nadia	Hanskhali	26	43
Hooghly	Dhaniakhali	26	42
Hooghly	Balagarh	26	43
Hooghly	Singur	26	42
Hooghly	Arambagh	26	42
Hooghly	Pursura	27	41
HOWRAH	Jagatballavpur	26	42
HOWRAH	Uluberia-I & II	26	43
HOWRAH	Shyampur-I & II	26	43
HOWRAH	Bagnan-I & II	26	42
HOWRAH	Udaynarayanpur	27	43
24PGS(N)	Habra-I & II	26	43
24PGS(N)	Deganga	26	43
24PGS(N)	Bagdha	25	42
24PGS(N)	Bangaon	26	43
24PGS(N)	Basirhat-I & II	26	43
24PGS(S)	Baruipur	25	44
24PGS(S)	Bishnupur-I & II	25	42
24PGS(S)	Kakdwip	25	43
24PGS(S)	Sagar	25	44
24PGS(S)	Mathurapur-I & II	25	44

transplanting. It is found in the early part of the rainy season, particularly in the southern part of the study area, is suitable for the early varieties of the rainfed transplanted rice. End of the rainy season is considered when 50 mm of rainfall is still to be received in the winter season (Table 1). It is required for selection of crop varieties depending on its crop growth.

Accumulated Water Deficit

Deficit pattern in case of 29th SMW sowing week: Based on the deficit of weekly rainfall compared with the critical value (here 50mm), it has been observed that the accumulated value of rainfall-deficit varies from 35 mm to 75 mm (Figure 3). Only 35 mm rainfall deficit is observed in very small part of Nadia and Hoogly district. The western part of Hoogly and Howrah and eastern part of Murshidabad experience more than 75 mm deficit when sown in 29th SMW. Thus three distinct zones can be delineated on the basis of rainfall deficit considering 29th SMW as transplanting week. The three zones are as follows:

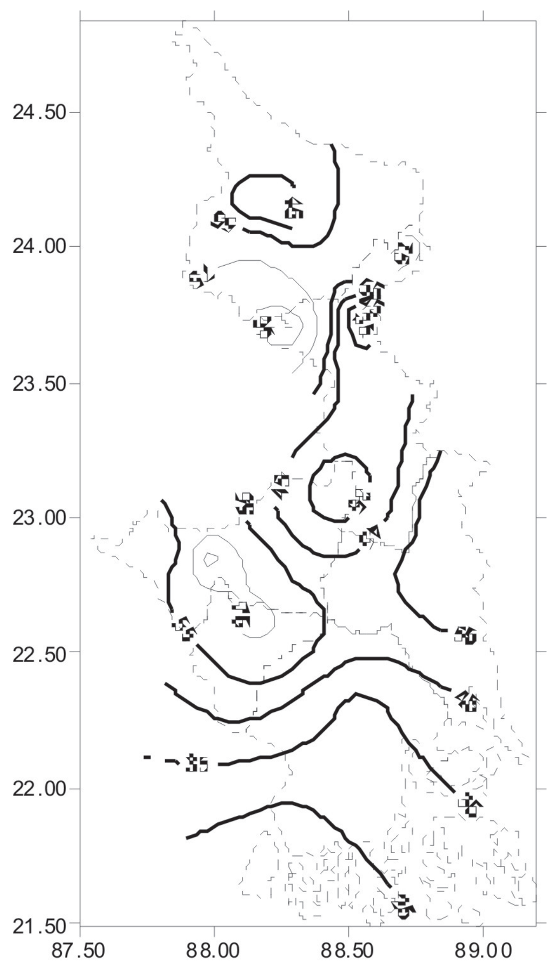

Fig. 3. Map showing water deficit pattern (mm) considering 29th SMW as transplanting week

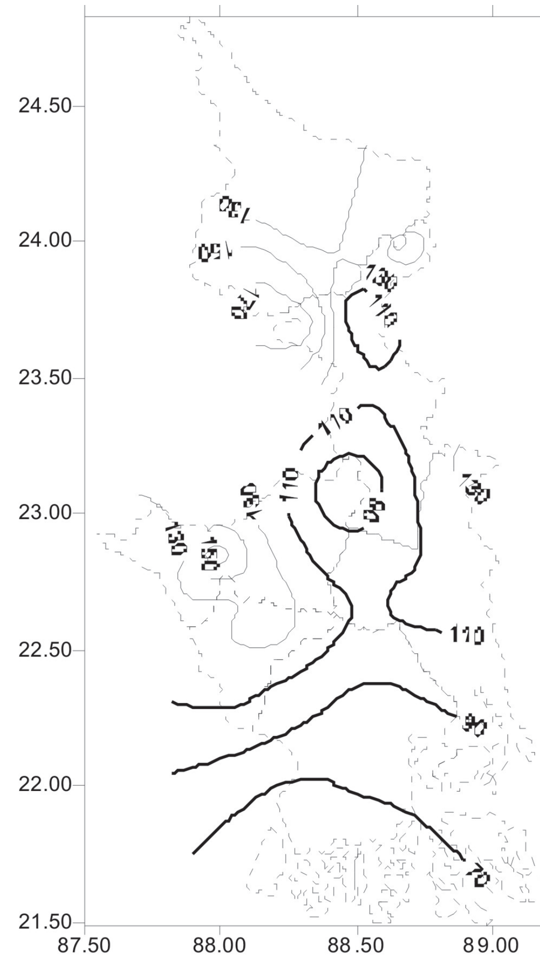

Fig. 4. Map showing water deficit pattern (mm) considering 31st SMW as transplanting week

Zone I: Low deficit (45 mm or less accumulated deficit)

Zone II: Medium deficit (45 to 75 mm accumulated deficit)

Zone III: High deficit (greater than 75 mm accumulated deficit)

Deficit pattern in case of 31st SMW as sowing week: In Zone I as demarcated in the figure 3,

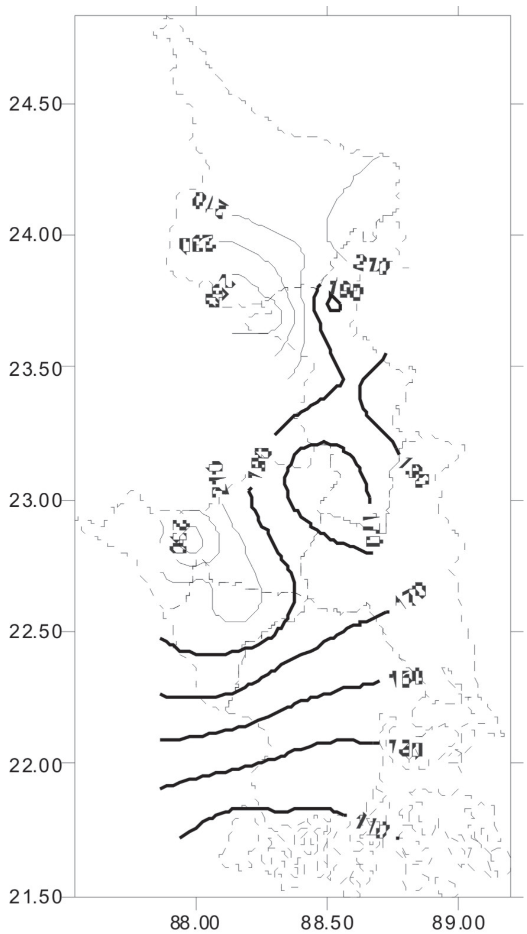

Fig. 5. Map showing water deficit pattern (mm) considering 33rd SMW as transplanting week

farmers can chose long duration varieties where as in case of Zone III farmers should opt for short duration crops. When 31st SMW is considered as start of sowing period, it is observed that in Nadia, North and South 24 Paraganas and eastern part of Hoogli, the water deficit is comparatively low (to the tune of 70 to 110 mm) where as in some parts of Nadia and Hoogli and in major portion of Murshidabad, the water deficit is comparatively high i.e. 110 to 170 mm.

Deficit pattern in case of 33rd SMW as sowing week: In this case, the sowing week is considered from 33rd SMW. Only south 24 Paraganas showed water deficit within 110 to 170 mm range but in rest of the study locations the deficit was more than 170 mm and indicates that if rice is transplanted beyond 31st SMW a supplementary any irrigation must be given to get a better harvest. It is advisable to the farmers that 29th SMW is a best time for transplanting and beyond which the water deficit becomes high.

Conclusions

It can be concluded that second fortnight of July is the most suitable time for transplanting rainfed rice. The study will be helpful to farmers in the region for selecting optimum sowing window as well as useful to the planners for recommending suitable varieties as per their crop growth duration.

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