

Climate Change Impact on Crop Water Requirement in Ganga River Basin, West Bengal, India

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Abstract. The threat of climate change is affecting and will affect the important natural resources including water. Considering this, a study was carried out to assess the impact of climate change on crop water requirement. In this study, potato was taken as the reference crop for its growing period and its high response to irrigation. The ET values from the potato field were measured using field water balance method and the data was used to validate the CROPWAT model. After proper validation of CROPWAT model, the model was used to determine the irrigation requirement of potato using current and future (prediction years: 2020 and 2050) weather data. It was observed that irrigation water requirement will be increased by 7 to 8% during 2020, while it may increase about 14 to 15% during 2050.

Keywords: Evapotranspiration, Irrigation requirement, CROPWAT, Potato, Climate change

1. Introduction

The population growth along with increased urbanization and high level of consumption has focused on the demand for food and water on a global basis. The comprehensive assessment of water management in agriculture revealed that one in three people are already facing water shortage due to climate change. Water scarcity is expected to become the most prominent problem under the projected climatic scenario. Due to climate change the spatial and temporal distribution of rainfall will vary a lot (Oki, 2006). Moreover, the rate of evaporation may change which will lead to variation in water availability and ground water recharge (Huntington, 2005). Hence there is a need of assessing future water requirement for different sectors including agriculture.

Potato is one of the most important *Rabi* crop with high irrigation requirement. The lower Gangetic plain is the major potato growing area in West Bengal. Like all other crops, potato is influenced by a complexity of environmental factors. Presently the threat of climate change compels us to rethink about the impact of climatic variables on crop growth. Moreover, the water available for irrigation may be scanty due to probable climate change. Considering this view, an investigation was carried out to determine the variation of crop evaporation from the potato field and to work out the change detection of its irrigation requirement.

2. Materials and Methods

2.1. Study Area and Field Data Collection

The field experiment was conducted in the Gangetic West Bengal and the meteorological data were collected from the Kalyani observatory (Latitude: 23°N, Longitude: 89°E). Maximum temperature, minimum

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temperature, humidity, wind speed, bright sunshine hour and rainfall data on daily basis were collected from the said observatory.

The data on soil texture was based on the analysis of the representative soil samples, collected from the potato field around Kalyani observatory. Other required properties like total available soil moisture, maximum rain infiltration rate, maximum rooting depth, initial soil moisture depletion, initial available soil moisture were also measured using standard procedure.

2.2. Evapotranspiration (ET) Calculation by Field Water Balance Method

To estimate evapotranspiration using field water balance (FWB) method, first the soil moisture content of the field and depth of rainfall or irrigation applied in the field were measured. To get the deep percolation away from the root zone the difference of soil moisture in the last layer of vadose zone were considered. Then the evapotranspiration of potato for that field were calculated using following equation:

$$ET = P+I-S-C-R \dots\dots\dots (1)$$

Where, P= Precipitation; I= Irrigation; S= Difference of soil moisture contents C= Deep percolation; R= Runoff (here, negligible due to field-bund) [all units were in mm].

2.3. ET and Irrigation Requirement Calculation by CROPWAT Model

The ET and irrigation requirement of the said crop was determined using CROPWAT 8.0, developed by Food and Agriculture Organization (FAO), Italy. This decision support system (Model) works out the reference evapotranspiration, crop water requirement, and irrigation requirement (FAO, 1992). CROPWAT 8.0 uses the FAO Penman-Monteith method for calculation of reference crop evapotranspiration (Allen *et al.*, 1998).

2.4. Statistical Analysis

Correlation coefficient (r-value), standard error (SE) and root mean square error (RMSE) were estimated to find out performance of CROPWAT model.

2.5. Climate Prediction using PRECIS Model

PRECIS model is based on the Hadley Centre's regional climate modeling system to generate high-resolution climate change information. PRECIS output was generated for the years 2020 and 2050 for Ganga River Basin.

3. Results

The field experimental data (mainly change in soil moisture contain, deep percolation, and irrigation amount) were used to find out the evapotranspiration by field water balance (FWB) method. The different components of FWB are shown in Table 1. Table 2 shows the comparison between ET calculated by field water balance (FWB) and CROPWAT 8.0 model. Here the ET values are calculated are on daily basis. On the basis of FWB method, ET varied from 1.86 to 2.35 mm/day, while model output shows, it varied from 1.88 to 2.46 mm/day. The average values of daily ET estimated through both the methods are very close to each other.

After validation of the CROPWAT8.0 model for the study location, the crop evapotranspiration were determined for 2010 (using actual weather data) and for 2020 & 2050 (using PRECIS output) as shown in figure 1. The seasonal ET values from potato field are in the tune of 206 mm in 2010, 222 mm in 2020, and 236 mm in 2050. The figure 2 shows the irrigation requirement of potato for 2010, 2020, and 2050.

4. Discussion

It was observed that among thirteen (13) treatments the field ET varied from 141.9 mm/season (Treatment Y1D5) to 216.2 mm/season (Treatment Y3D1). The average seasonal ET is 183.8mm. The ET calculated by FWB method (on daily basis) was compared with the ET calculated by CROPWAT 8.0 model. It was observed that ET calculated by those two methods were significantly correlated and the RMSE value was very low. The low RMSE value signifies that the CROPWAT model can be used safely for ET calculation as well determination of irrigation requirement.

Once the CROPWAT model is validated for the Gangetic West Bengal, it was used to determine the irrigation requirement of potato. It was observed that after a decade, irrigation water requirement will increase by 7 to 8%, while during 2050, it may increase about 14 to 15%. Hence, scientist may concentrate on evolving such varieties which will require less water and must opt for better water scheduling.

5. Acknowledgements

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6. References

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Table 1: Seasonal water balance in the potato field for various treatments during study period

| Treatments | Date of planting | P+I (mm) | S (mm) | D (mm) | ET (mm) |
|------------|------------------|----------|--------|--------|---------|
| Y1D1 | 13.11.07 | 194.4 | 0.7 | 0.6 | 193.1 |
| Y1D2 | 20.11.07 | 188.3 | -0.1 | 2.2 | 186.2 |
| Y1D3 | 27.11.07 | 208.3 | 10.1 | 6.3 | 191.9 |
| Y1D4 | 04.12.07 | 208.3 | 6.2 | -1.7 | 203.8 |
| Y1D5 | 11.12.07 | 178.3 | -28.5 | -9.4 | 216.2 |
| Y2D1 | 13.11.08 | 270.0 | 75.7 | 11.6 | 182.7 |
| Y2D2 | 20.11.08 | 270.0 | 52.1 | 4.5 | 213.4 |
| Y2D3 | 27.11.08 | 240.0 | 42.5 | 5.0 | 192.5 |
| Y2D4 | 04.12.08 | 210.0 | 8.2 | 1.2 | 200.6 |
| Y2D5 | 11.12.08 | 210.0 | 47.6 | 5.2 | 157.2 |
| Y3D1 | 11.11.09 | 200.0 | 45.7 | 12.3 | 141.9 |
| Y3D2 | 20.11.09 | 150.0 | 0.6 | 2.0 | 147.4 |
| Y3D3 | 29.11.09 | 207.2 | 40.7 | 4.0 | 162.5 |

(Y = Year of planting, D = Date of planting)

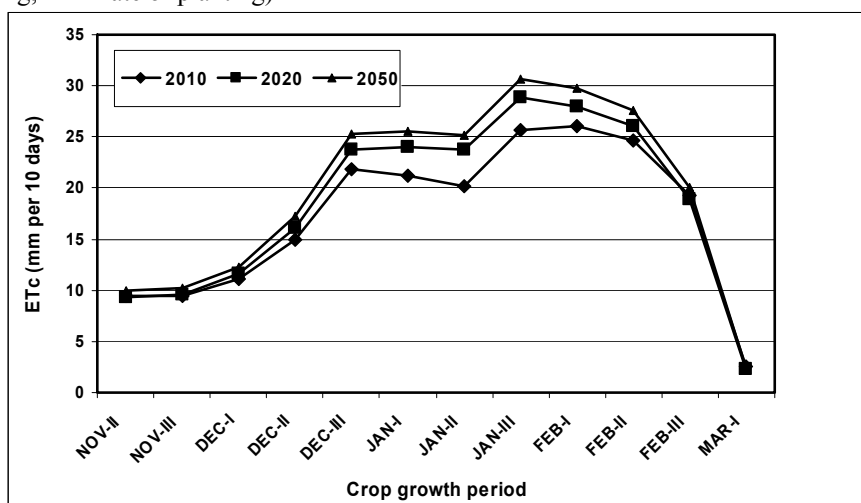


Fig. 1: Crop ET from the potato field (on the basis of 10 days cumulative ET) under present and future climatic scenario

Table 2: Comparison between ET calculated by field water balance (FWB) and CROPWAT 8.0 model

| ET calculated by FWB (mm/day) | ET calculated from CROPWAT (mm/day) |
|----------------------------------|--|
| 2.08 | 1.93 |
| 1.92 | 1.91 |
| 2.06 | 2.02 |
| 2.26 | 2.16 |
| 2.51 | 2.26 |
| 1.86 | 2.04 |
| 2.35 | 2.04 |
| 2.29 | 2.18 |
| 2.61 | 2.33 |
| 2.25 | 2.46 |
| 1.87 | 1.88 |
| 1.91 | 1.92 |
| 1.87 | 2.07 |
| SE | 0.13 |
| RMSE | 0.18 |
| r-value | 0.73** |

(** Significant at 1% level)

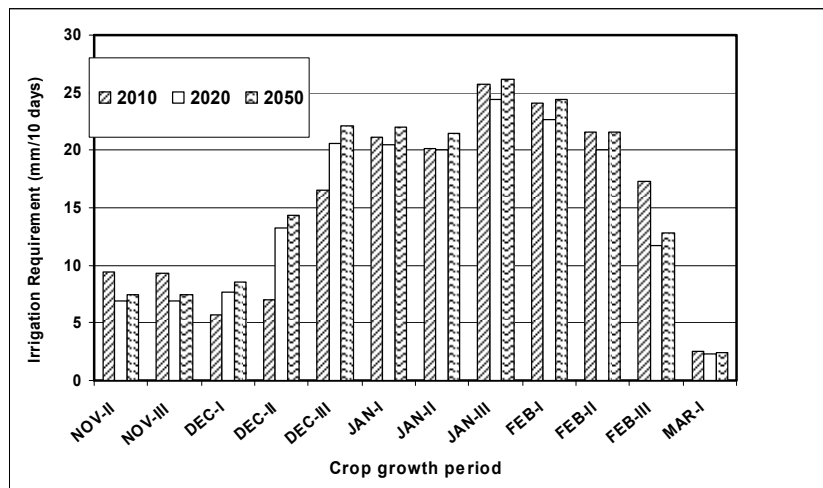


Fig. 2: Irrigation requirement of potato under present and future climatic scenario