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Assessment of climate change effect on crop water requirement for chickpea in Vijayapura Karnataka using CROPWAT model

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Abstract

Chickpea is one of the major protein rich legume crops predominantly cultivated in Vijayapura region. This study estimated the crop reference evapotranspiration (ET_0), actual evapotranspiration (ET_c) and the crop water requirements of chickpea (variety BGD- 11) using CROPWAT model. This will then enable efficient use of water and better irrigation practices like scheduling in such areas like supply of water through rainfall is limited. The simulations were done by run the CROPWAT model under different environmental conditions like baseline climate condition (2006-2020) and projected climate RCP 4.5 scenario (2040-2084). Across four sowing windows of early sowing (September II fortnight), optimum sowing (I and II fortnight October) and late sowing I fortnight of November). The analyzed climate, crop and soil data were collected from Experiment conducted at Regional agricultural research station, Vijayapura. The average crop evapotranspiration (ET_c), effective rainfall (ER) and irrigation requirement (IR) under baseline climate (2006-2020) for Vijayapura were 256.9, 57.1 and 218.4 mm. respectively, there is increase of ER 72.4 mm and decrease in IR 207.2 mm and no change in ET_c were observed under projected climate (2040-2054), increase in ET_c i.e., 261.7 mm and increase of, 67.6 mm in ER and decrease in IR 215.0 mm were observed under projected climate (2070-2084). Sowing on II fortnight of September under both the projected climate (2020-2054) and (2070-2084) simulated the lowest water requirement 194.3 and 194.1mm respectively, followed by I and II fortnight of October i.e., 196.2 mm and 194.7 mm. whereas delayed sowing I fortnight of November showed highest water requirement for chickpea crop in Vijayapura district.

Keywords: Baseline climate, crop evapotranspiration, CROPWAT, effective rainfall, irrigation requirement, projected climate

Introduction

Agriculture is the largest (81%) consumer of water in India and hence more efficient use of water in agriculture needs to be top most. Water is an important input for agriculture so that this valuable resource is designed properly and deliverable. It is vital to have an understanding of crop water requirements (CWR) of crops grown especially in arid and semi-arid regions. This will then enable efficient use of water and better irrigation practices like scheduling in such areas as the supply of water through rainfall is limited. Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops grown in India. Where Karnataka ranks 3rd in the cultivation of chickpea with an area of 20.9 lakh ha, 12.4 lakh tonnes of production and 0.6 tonnes/ha of productivity. Followed by Madhya Pradesh, Maharashtra. In Karnataka, Bijapur, occupies the second position in chickpea with area (1.19 lakh ha), production (0.65 lakh tonnes) and productivity (0.57 tonnes/ha). (Anonymous, 2021) ^[2] Vijayapura is city located at 16.83 °N and 75.71 °E with an area 102.38 km² and elevation 592.23 m above mean sea level. Receives average annual rainfall of 590 mm with 38 rainy days. Where chickpea is mainly grown as rainfed crop during rabi season (September - November). It requires 120 -210 mm of water in whole growing period, due to its better adaption with low water supply and meets its water requirement from conserved moisture in deep soils, cropping area of chickpea is increasing in this region from 0.35 lakh ha in (2000-01) to 1.19 lakh ha in (2019-20). This paper aims to estimate crop water requirement of chickpea variety BGD-11 by using CROPWAT Model. Past

climate (2006-2020) taken as baseline and projected climate emission scenarios RCP 4.5 (2040-2054) and (2070-2084) The analysed climate, crop and soil data were collected from Experiment conducted at Regional agricultural research station, Vijayapura. The model was run under different growing conditions like sowing windows: early sowing (September 2nd fortnight), optimum sowing (1st and 2nd fortnight October) and late sowing (1st fortnight of November)

Materials and Methodology

The study was conducted at Regional Agricultural Research Station Vijayapura is located at 16.83 °N and 75.71 °E with area of 102.38 km² and elevation 592.23 m above mean sea level. Receives average annual rainfall of 590 mm with 38 rainy days. the experimental field comes under managolies soil type. with 150 -200 mm available soil moisture upto 60 cm. CROPWAT 8.0 is a software for the calculation of crop water requirements based on soil, climate and crop data and existing or new irrigation climate data and crop needs. In addition, the program allows the development of irrigation schedules for different management conditions and the calculation of the supply system of the variety of cropping patterns. The effect of the weather variable on the water demand of the crop can be analysed by the CROPWAT model which was developed by the FAO-Land and Water Development Division (Allen *et al.*, 1998) ^[1].

Baseline weather data (2006-2020) i.e., rainfall, minimum and maximum temperature, for Vijayapura district (Fig 1) the soil data on total available soil moisture content (SMC), initial soil moisture depletion, maximum rooting depth and maximum rain infiltration rate for black clay and red sandy loam soils for vijayapura was collected from regional agricultural research station Vijayapura. The projected data for the period of coming 30 years from 2040-2084 was collected from Copernicus Climate Change Service (IPSL-CM5A model) (<https://climate.copernicus.eu>). According to RCP 4.5 scenario, there would be an increase around 1.0 °C both day and night temperature during the chickpea cropping period (Sep-Dec) under the projected climates (2040-2084) compared to baseline climates (2006-2020). The field experiment was conducted at regional agricultural research station Vijayapura in rabi seasons of 2020-21. The phenological data for initial, mid and late growth stages of chickpea variety BGD-11 collected from the field experiment were used in the model. The salient details of chickpea crop required for the study i.e., crop coefficients (Kc), phenological days, critical depletion fraction (p), yield response factor (Ky) were also taken from the available 18 published data of FAO (Allen,1998) ^[1]

Results and Discussion

Crop evapotranspiration (ETc): The model simulated the average ETc (256.9 mm) in Vijayapur district for the baseline climate (2006-2020) across four different dates of sowing (DOS). (Table 1). Among different DOS the model simulated highest average ETc (261.9 mm) for the crop sown on delayed sowing i.e., I fortnight of November, followed by II fortnight of September (259.6mm). This was because of the highest average temperature recorded and average ETo simulated in the cropping season. Where as the model simulated lowest ETc (246.8 mm) for the crop sown on II fortnight of October. The model simulated the average ETc (256.9 mm) in Vijayapur district for the projected climate RCP 4.5 scenario (2040-2054) across four different dates of sowing (DOS). Highest average ETc was simulated for the crop sown on II fortnight of September (265.8 mm) followed by I fortnight of October (252.5 mm) and the

lowest was for DOS II fortnight of October (245.8 mm). The model simulated the average ETc (261.7 mm) in Vijayapur district for the projected climate RCP 4.5 scenario (2070-2084) across four different dates of sowing (DOS. the highest ETc was simulated for the crop sown on II fortnight of September (270.0 mm) followed by I fortnight of November (266.4 mm) and the lowest was for DOS II fortnight of October (252.9 mm), followed by DOS I fortnight of October (252.5 mm). (Table 1). Simulated outputs across dates of sowing suggest that ETc increased with delay in sowing. Simulated outputs across dates of sowing suggest that ETc increased with delay in sowing in Vijayapura districts under baseline climates This is due to increase in average ETo and decreased rainfall with delay in sowing i.e., October sowing received more rainfall than November sowing. In case of projected climates there was no significant change in ETc with delay in sowing. However, the highest ETc was for Nov-09 sowing because of minimum rainfall during second fortnight of November. similar findings was reported Thimmareddy *et al* (2021) ^[4].

Effective Rainfall (ER): The model simulated the average ER (218.4 mm) in Vijayapur district for the baseline climate (2006-2020) across four different dates of sowing (DOS). In the projected climates RCP 4.5 (2040- 2054) the highest ER was simulated for the crop sown on II fortnight of September (94.6 mm) followed by I fortnight of October (85.7 mm) and the lowest was for DOS II fortnight of November (32.5 mm), followed by II fortnight of October (76.9 mm). In the projected climates RCP 4.5 (2070- 2084) the highest ER was simulated for the crop sown on II fortnight of September (110.0 mm) followed by I fortnight of October (69.0 mm) and the lowest was for II fortnight of November (30.0 mm), followed by DOS II fortnight of October (61.5 mm). Simulated outputs across dates of sowing suggest that ER increased with Earlier in sowing. ER for chickpea crop significantly increased by 26.9 and 18.5 per cent, respectively in (2040-2054), (2070-2084) (RCP 4.5 scenario) compared to baseline period (2006-2020). The increase in ER is proportional to their respective increase in rainfall in chickpea cropping period projected climates. The CROPWAT simulated decline in ER with delay in sowing in both past and projected climates this can be explained by higher North-East monsoon rainfall in the early months (October) and rainfall dissipation of rainfall towards December month. (Table 1). similar findings was reported Thimmareddy *et al* (2021) ^[4].

Irrigation requirement (IR): The model simulated average Irrigation requirement (IR) Among all the DOS in Vijayapur district in base climate (2006-2020) 218.4 mm. among different date of sowing crop sown on II Fortnight of September showed lowest IWR 200.8 mm. followed by crop sown on I fortnight of October 208.6 mm. highest IWR showed on I fortnight of November this is mainly due to low rainfall during cropping period. The model simulated average Irrigation requirement (IR) Among all the DOS in Vijayapur district in projected climate RCP 4.5 scenario (2040-2054) 207.2 mm. among different date of sowing crop sown on II Fortnight of September showed lowest IWR 194.3 mm. followed by crop sown on II fortnight of October 194.7 mm. highest IWR showed on I fortnight of November. The model simulated average Irrigation requirement (IR) among all the DOS in Vijayapur district in projected climate RCP 4.5 scenario (2070-2084) 215.0 mm. among different date of sowing crop sown on II Fortnight of September showed lowest IWR 194.1 mm. followed by crop sown on II fortnight of October 194.7 mm. highest IWR showed on I

fortnight of November. The decrease in IR was simulated directly proportional respective decrease in ETc and inversely to increased ER. The IR increased with delay in sowing in both past and projected climates in Vijayapura because of decreased

ER and increased ETc during the cropping period Early sowing (October) receives more rainfall due to North-East monsoon onset which dissipates towards December. (Table 1) similar findings was reported Thimmareddy *et al* (2021)^[4].

Table 1: Average Crop evapotranspiration (ETc), Effective Rainfall (ER) and Irrigation Requirement (IR) for the Base line climate (2006- 2020), Projected climate (2040-2054) and (2070-2084)

Date of sowing		ETc (mm)	ER (mm)	IR (mm)
II fortnight Sep	Baseline climate (2006-2020)	259.6	95.1	200.8
I fortnight Oct		259.4	78.5	208.6
II fortnight Oct		246.8	38.3	217.4
I fortnight Nov		261.9	16.4	246.7
Average		256.9	57.0	218.3
II fortnight Sep	Projected climate (2040-2054)	265.8	94.6	194.3
I fortnight Oct		252.5	85.7	196.2
II fortnight Oct		245.3	76.9	194.7
I fortnight Nov		261.0	32.5	243.4
Average		256.1	72.42	207.1
II fortnight Sep	Projected climate (2070-2084)	270.0	110.0	194.1
I fortnight Oct		257.6	69.0	211.7
II fortnight Oct		252.9	61.5	209.5
I fortnight Nov		266.4	30.0	244.7
Average		261.7	67.6	215.0

Conclusion

The main findings of this simulation study was that the average crop evapotranspiration (ETc), effective rainfall (ER) and irrigation requirement (IR) under baseline climate (2006-2020) for Vijayapura were 256.9, 57.1 and 218.4 mm. respectively, among different date of sowing sowing under II fortnight of September under baseline climate (2006-2020), projected climate (2020-2054) and (2070-2084) simulated the lowest water requirement 200.8 194.3 and 194.1 mm respectively, followed by I and II fortnight of October i.e., 208.4, 196.2 mm and 194.7 mm. under projected climate early sowing of chickpea seems to be effective for reduced irrigation water requirement. Whereas delayed sowing I fortnight of November showed highest water requirement for chickpea crop in Vijayapura district. However further research need to be taken up on adaptability

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