Test of AquaCrop model in simulating yield and water use efficiency of tomato crop under varied climatic conditions at Ponnaniyar basin of Tamil Nadu

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Introduction

- Tomato (*Lycopersicum esculentum*, L.) - important vegetable.

- Global production -163.96 million metric tons, with China and India as the leading producers - 2013 (Faostat, 2014).

- In India, tomato occupies
  - fourth position in area
  - second position in production.
- Area – 865 lakh hectares
- Production of 16826 MT
- Productivity of 19.50 MT.
- Major producing states - Bihar, Karnataka, Uttar Pradesh, Orissa, Tamil Nadu Andhra Pradesh, Maharashtra, Madhya Pradesh and Assam.

- In Tamil Nadu,
  - Area - 27,000 hectares
  - Production - 580.60 MT
  - Productivity - 21.40 MT.

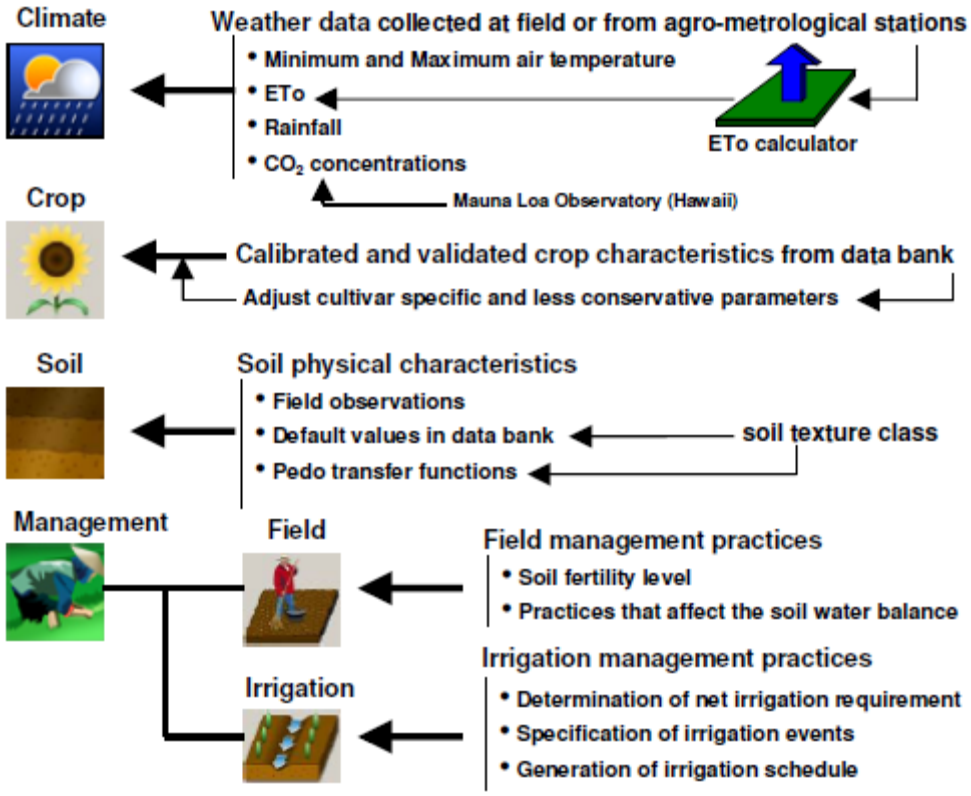
(Indian Horticulture Database, 2014).

What is AquaCrop ?

- AquaCrop is a crop water productivity model
- Developed by FAO.
- It is a menu driven program
- AquaCrop is a tool for:
    1. Predicting crop production under different water-management conditions (including rain fed and supplementary, deficit and full irrigation) under present and future climate change conditions;
    2. Investigating different management strategies, under present and future climate change conditions.

Materials and methods

Representation of AquaCrop model



Input required

Define the environment in which the crop will develop

- **Weather data**
- **Crop**
- **Irrigation**
- **Field management**
- **Soil and ground water characteristics**

AQUACROP

Impact of current climate variability on water productivity of Tomato

- To understand the impact of current variability on water productivity of Tomato- weather data at daily time steps for a period from 1980 to 2010 - **Anbil Dharmalingam Agricultural College and Research Institute (ADAC&RI), Thiruchirapalli, TNAU.**
- Climate data file - rainfall, maximum temperature, minimum temperature, sunshine hours, wind speed and relative humidity in AquaCrop model.
- The simulation was **performed for 31 years** (fruit yield, ET) and assessed the impact of climate variability on Tomato crop water productivity.

Prediction of the Tomato productivity under normal, excess and deficit rainfall situation and irrigation optimization

- Long-term weather data for the period of 31 years (1980-2010) was used to categorize the normal, surplus and drought years. Derived the **Long-term Period Average** (LPA) and computed the anomaly of each year from the long-term average.

- Based on the **India Meteorological Department (IMD) classification**,

Rainfall deviation from LPA	Category
> -59%	Scanty
<-19% to -59%	Deficit
-19% to 19%	Normal
>+19% to +59%	Excess
>+59%	Wet

Results

Prediction of Tomato Productivity And Water Use Efficiency under different rainfall conditions (Excess, Normal, Deficit)

- Tomato yield was observed to be higher under normal rainfall condition in both *Kharif* and *Rabi* seasons compared to deficit and excess condition.

- During the normal year the yield was 32.8 and 33.4 t ha^{-1} followed by 29.8 and 28.3 under deficit rainfall condition during *Kharif* and *Rabi* respectively. The low yield was noticed under excess rainfall condition which was 27.9 and 25.1 t ha^{-1} during *Kharif* and *Rabi* respectively.

Table 1. Tomato productivity and water use efficiency (WUE) under different rainfall conditions (Excess, normal, deficit) without irrigation optimisation

	***Kharif* irrigated**			***Rabi* irrigated**		
	Excess	**Normal**	**Deficit**	**Excess**	**Normal**	**Deficit**
Rainfall	288	215	140	1198	370	252
Irrigation	560	560	560	-	560	560
Total (R+I)	846	775	700	1198	932	814
Fruit yield (t ha^{-1})	27.9	32.8	26.8	25.1	33.4	28.3
WUE (Kg ha^{-1} mm^{-1})	42.8	48.3	47.5	46.6	70.4	60.5

- Water Use Efficiency also followed the same pattern of the yield under different rainfall situations. WUE was found to be more during normal rainfall years compared to deficit and excess rainfall years.

- Among the rainfall situations excess rainfall condition had less WUE during both *Kharif* and *Rabi* seasons. WUE got reduced from normal condition by 11.5 and 1.8 percent under excess and deficit rainfall condition respectively during *Kharif.*

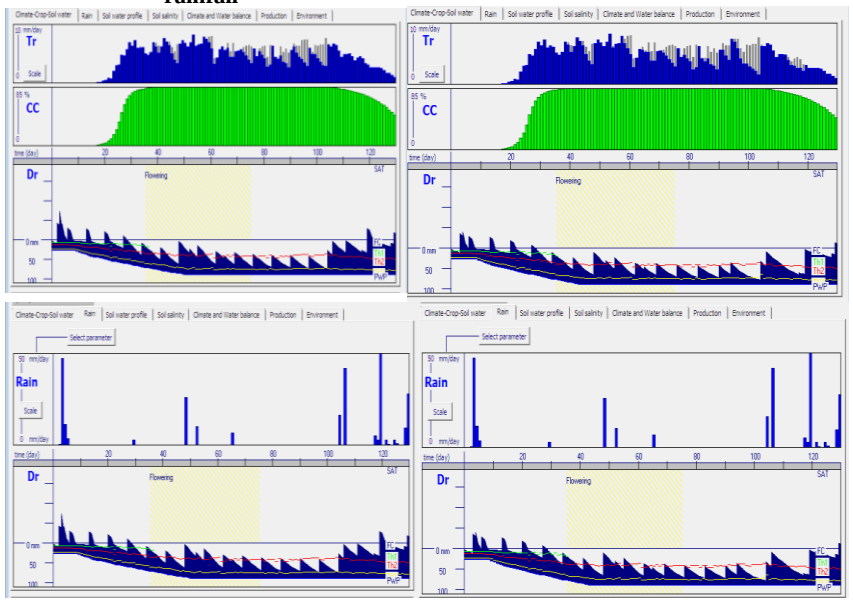
- In *Rabi* season the WUE efficiency was declined with a higher magnitude than the *Kharif* season and reduction was observed to be 33.8 and 14.1 per cent from normal condition, under excess and deficit conditions respectively.

Optimisation of Irrigation through water stress based irrigation under different rainfall conditions (Excess, Normal, Deficit)

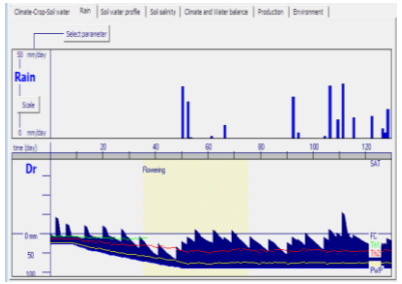
- The irrigation was withheld whenever there was rainfall of >25mm per day and irrigating the crop whenever the soil moisture is low improved the WUE

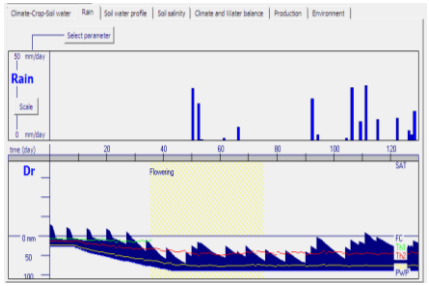
Figure 1. AquaCrop simulations on tomato under excess, deficit and normal rainfall years under full irrigation and irrigation optimisation during *Kharif* season

a) Full irrigation (560mm) -excess rainfall

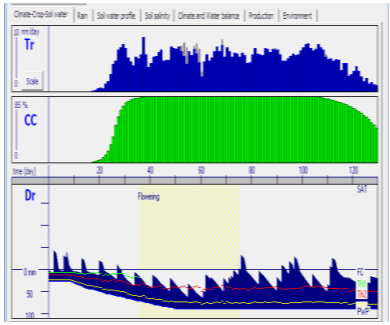


a) Irrigation based on water stress -excess rainfall

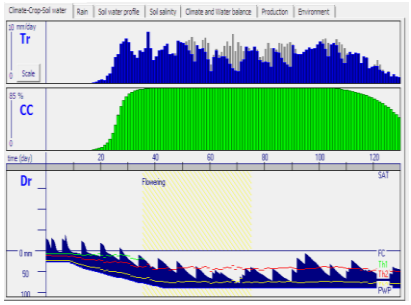




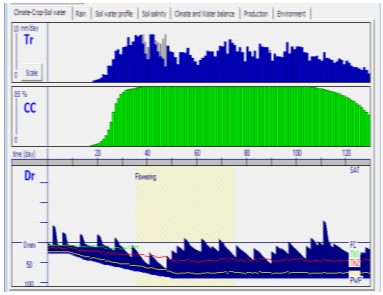
c) Full irrigation - normal rainfall



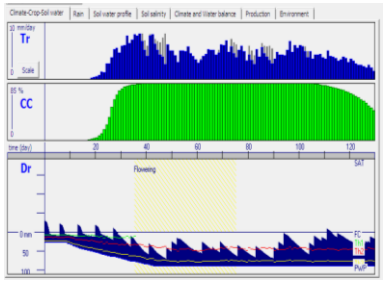
b) Irrigation based on water stress - normal rainfall

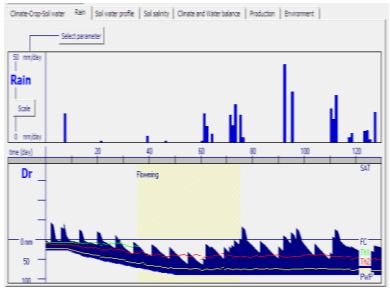


b) Full irrigation - deficit rainfall



b) Irrigation based on water stress- deficit rainfall





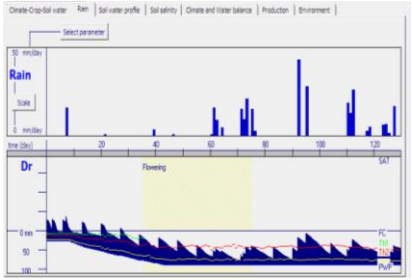
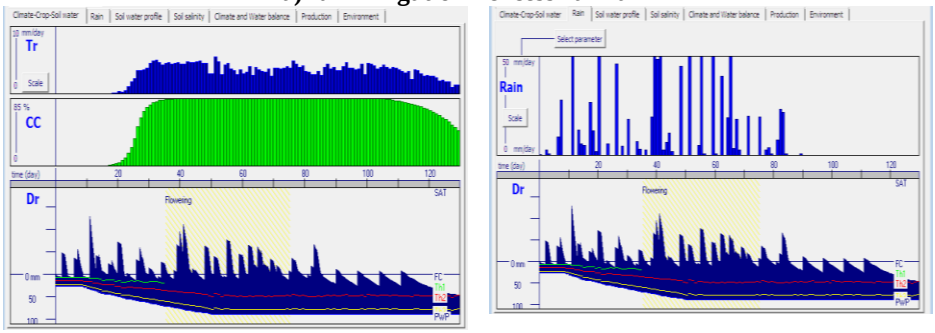
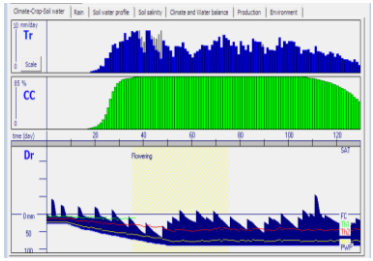


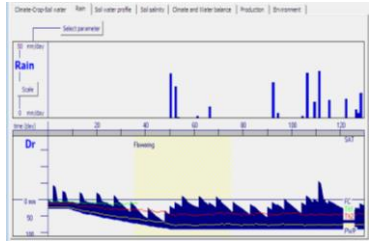
Figure 2. AquaCrop simulations on tomato under excess, deficit and normal rainfall years under full irrigation and irrigation optimisation during *Rabi* season

a)Full irrigation - excess rainfall

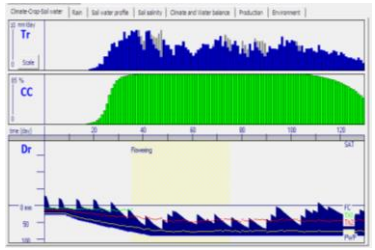


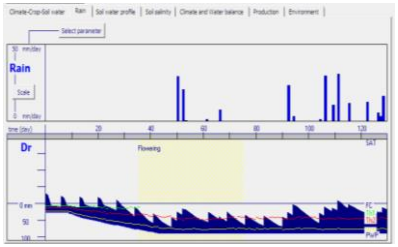
b) Full irrigation - deficit rainfall



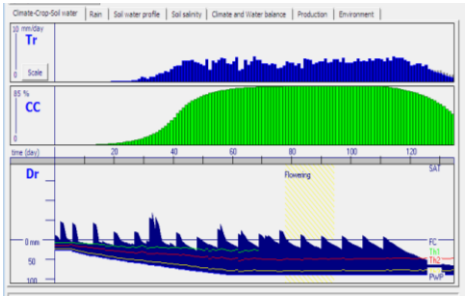


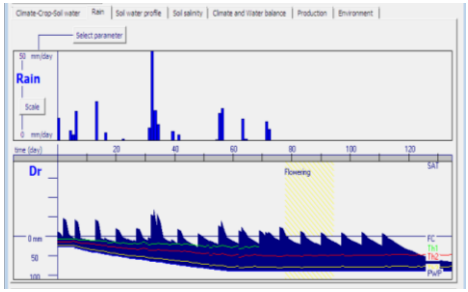
b) Irrigation based on water stress-deficit rainfall



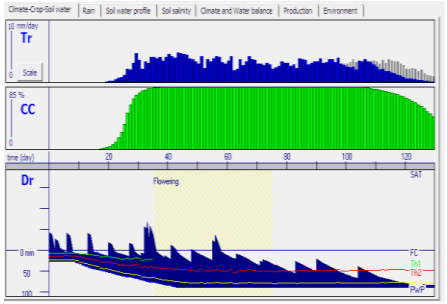


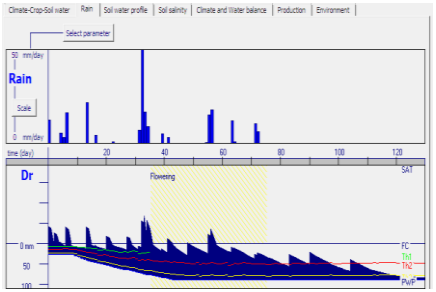
b) Full irrigation - deficit rainfall



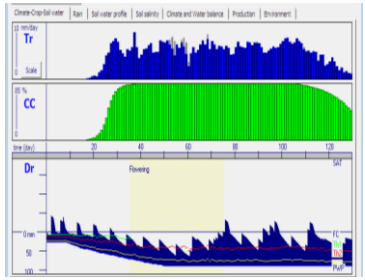


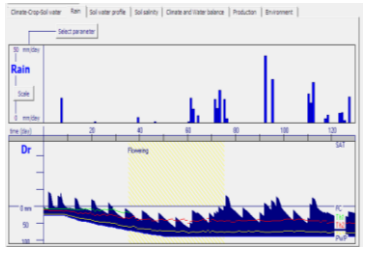
b) Irrigation based on water stress - deficit rainfall



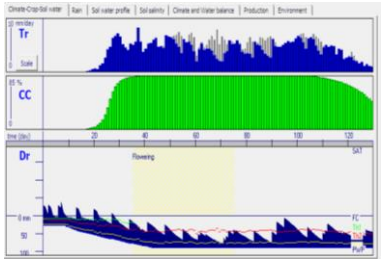


c) Full irrigation - normal rainfall





b) Irrigation based on water stress - normal rainfall



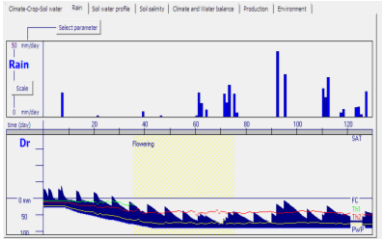


Table 2. Tomato productivity and WUE at water stress based irrigation under different rainfall conditions (Excess, normal, deficit)

	***Kharif* irrigated**			***Rabi* irrigated**		
	Excess	**Normal**	**Deficit**	**Excess**	**Normal**	**Deficit**
Rainfall	288	215	140	1198	370	252
Irrigation	260 (-53)	300 (-46)	360 (-35)	-	190 (-66)	280 (-50)
Total (R+I)	548	515	500	1198	560	532
Fruit yield ($t\ ha^{-1}$)	28.60 (2.5)	33.80 (3)	30.7 (14.6)	25.10	35.60 (6.5)	31.16 (10.1)
WUE ($Kg\ ha^{-1}\ mm^{-1}$)	51.1 (19.4)	54.45 (12.7)	61.7 (29.8)	46.6	75.49 (7.3)	71.6 (18.3)

Note: Values in the parenthesis ( ) indicate that % deficit in irrigation from the full irrigation condition, % changes tomato productivity and water use efficiency (WUE) from full irrigation

Conclusion

- Analysis on the impact of extreme rainfall events (deficit and excess) on yield and water use efficiency (WUE) of tomato productivity indicated that in excess rainfall condition tomato yield was reduced by 14.9 and 24.9 per cent and under the deficit rainfall year the yield reduction was 18.3 and 15.3 per cent during *Kharif* and *Rabi* respectively.

- Excess condition even without irrigation during *Rabi* affected much the tomato yield than the deficit and normal conditions.

- WUE was reduced in excess rainfall condition by 11.4 and 33.8 per cent and under the deficit rainfall year the yield reduction was 1.7 and 14.1 per cent during *Kharif* and *Rabi* respectively.

- Irrigation optimisation of 340 and 460 mm during *Kharif* and 190 and 313 mm in *Rabi* under normal and deficit conditions produced the maximum attainable yield (35 t ha^{-1}) of tomato.

Be weather wise; Otherwise; Not wise

- Agro Climate Research Centre, TNAU

Thank you.