

Studies on water Requirement of Colored Capsicum under Protected Cultivation and Open Field by using CROPWAT 8.0 model

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Abstract- The present work was carried out by using the CROPWAT 8.0 facilitates the estimate of the crop evapotranspiration, irrigation schedule and agricultural water requirements with different cropping patterns for irrigation planning for capsicum crop in Anantapur region. Meteorological data from meteorological station, Anantapur and seasonal data from College of Agricultural Engineering, Madakasira are collected to acquire crop water requirement and irrigation schedule for capsicum crop. It was observed that the Reference evapotranspiration (ET_o) in poly house obtained (3.89 mm/day) was less than Anantapur region (6.02 mm/day). The crop evapotranspiration (ET_c) under poly house obtained was 685.9 mm per entire crop period but Anantapur region had the highest ET_c (i.e. 1128.4 mm per entire crop period). The irrigation requirement in poly house (685.9 mm per entire crop period) was much lesser than the Anantapur region (1007.3 mm per entire crop period).

This study was concluded that reference evapotranspiration, crop evapotranspiration, and actual irrigation requirement for seasonal climate data under protected cultivation are less when compared with open field of Anantapur region.

Keywords- Capsicum annum, protected cultivation, yield, Evapotranspiration, Irrigation schedule, Crop water requirement

I. INTRODUCTION

India contributes one fourth of world production of capsicum (*Capsicum annum* L) with an average annual production of 0.9 million tons from an area of 0.885 million hectare with a productivity of 1266 kg per hectare (Sreedhara et al., 2013) under protected condition cultivation. In *Capsicum annum* is not known in a wild state and species commonly cultivated are capsicum annum known as sweet pepper, bell pepper, cherry pepper and green pepper. Andhra Pradesh (unified) stands first in area under cultivation of capsicum crop i.e. 236.5 thousand ha with a production of 748.5 thousand tons and followed by Karnataka in area (76 thousand ha) with a production of about 131 thousand tons.

The cost of establishment of capsicum production under protected condition was Rs. 24, 80, 956 per ha.

Most capsicum varieties are hybrids. Varieties have a primary mature color that is usually green, but may be yellow or purple. Capsicum varieties have a secondary mature color that is usually red, but may be orange or yellow or other colors. Colored capsicum is one of the important high value vegetable crops cultivated in milder climatic regions like Bangalore, Pune etc. It is rich in vitamin-A, C and minerals. Capsicum cultivation is very popular in Peri-Urban production systems because of easy access to urban markets like Bangalore, Hyderabad, and Pune etc. The traditionally grown green capsicum, depending upon variety and season, usually yields 20-40 tons per hectare in about 4-5 months. In greenhouse, the crop duration of green and colored capsicums is about 7-10 months and yields about 80-100 tons per hectare. Capsicum is basically a cool season crop and optimum temperatures for fruit setting are between 16°C and 21°C. For good fruit development, night temperatures of 15–17°C and day temperatures of 20–24°C are best (Amrik Singh Sidhu 2011).

CROPWAT 8.0 MODEL

CROPWAT for Windows uses the FAO Penman-Monteith method for calculation of reference crop evapotranspiration (Allen et al., 1998). The development of irrigation schedules and evaluation of rainfed and irrigation practices are based on a daily soil-moisture balance using various options for water supply and irrigation management conditions. Studies have shown that the Penman-Monteith method is more reliable than methods that use less climatic data (Jensen et al., 1990). In Anantapur region no research has been done for crop water requirement of the colored capsicum crop. Keeping the above views an attempt was made to estimate crop water requirements of colored capsicum crop in protected cultivation and open field condition by using CROPWAT 8.0 model.

II. MATERIALS AND METHODS

Study Area

Geographical position of experiment area is located at latitude of $13^{\circ} 56' 13''\text{N}$, longitude of $77^{\circ} 16' 10''\text{E}$ and

elevation of 636 m above the mean sea level at College of Agricultural Engineering, Madakasira was shown in Fig 1.

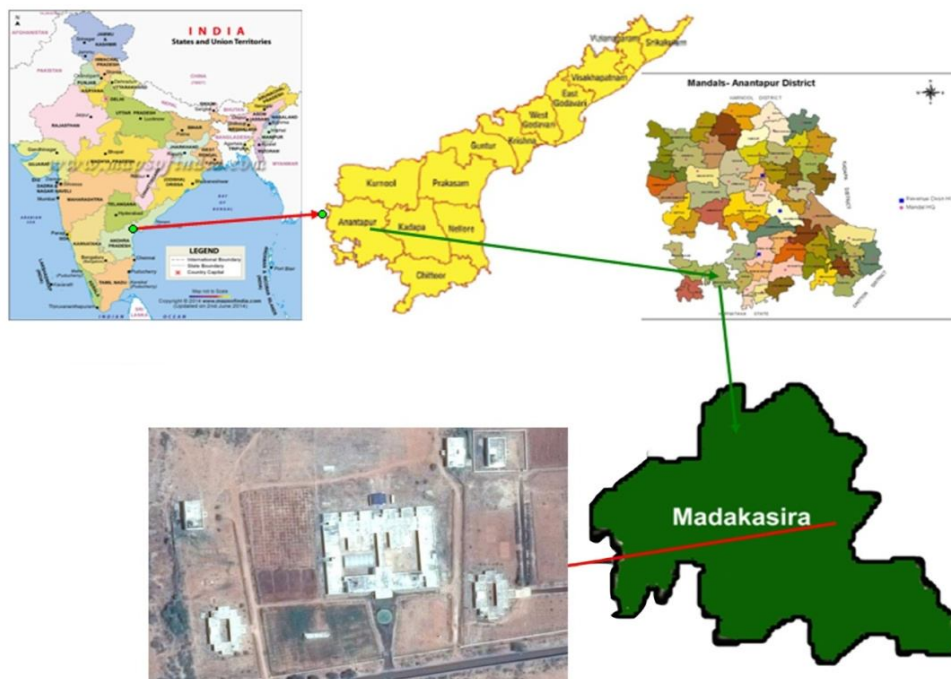


Fig 1. Location of experimental plot

III. EXPERIMENT PROCEDURE

Construction details of naturally ventilated poly house

The present investigation was carried out to study the performance of hybrid colored capsicum (*capsicum annum L*)

grown an area of 12 m x 24 m (288 m²) under protected cultivation as shown in Fig 2 and Table 1 with inline drip irrigation at College of Agricultural Engineering, Madakasira.



Fig 2. Naturally Ventilated Gothic type of Poly house

Table 1. Technical Specifications Gothic type of Poly house

| | |
|--------------------|------------------------------|
| Type of Poly house | Gothic type poly house |
| Area | 12 m×24 m=288 m ² |
| Side height | 4 m |
| Ridge height | 6.297 m |
| Number of beds | 23 |
| Each bed length | 8 m |
| Type of pillar | D60 |
| Door | 1.2 m × 2 m |
| Front covering | 200μ poly film |
| Side covering | 200 μ poly film |
| Roof covering | 200 μ poly film |

Land preparation in Poly house

Well decomposed organic manure at the rate of 20-25 kg per m² is mixed with soil. One application is sufficient to grow three capsicum crops successively. Raised beds are formed after bringing soil to fine tilth. The size of the bed is 0.5 m wide, 8 m length and 0.3 m height. The spacing between the beds 0.45 m is provided for easy to picking the fruits and other cultural operations.

Irrigation in Poly house

Irrigation is to provide within line drip 2-4 liters of water per square meter per day depending on the season for capsicum crop under the naturally ventilated poly house (IIHR, Bangalore, Technical bulletin no 22, 2011). Inline drip lateral of 16 mm size was placed at each row along the plant capsicum rows. Run the drip system to check each emitting point for uniform discharge as shown in Fig 3.



Fig 3. Drip Line Irrigation in Poly House

Estimation of CROPWAT 8.0 requirement for capsicum crop

The estimation of crop water requirement for capsicum crop in Anantapur region for different by using CROPWAT 8.0 software. Mean 15 years meteorological data of Anantapur region collected from Agricultural Research station, Anantapur.

Data required for generation of CROPWAT 8.0 model

The initial data that are needed for the model in order to get the irrigation crop water requirements are summarized as the following

- Climate data
- Rain data
- Crop data
- Soil data
- Cropping pattern

Climate Data Collection

The weather data was recorded by using digital temperature recorder and Psychrometer every day under the poly house and open field for crop growing period. The 15 years mean climatic data have been collected from Agricultural Research Station, Anantapur Fig 4 and Fig. 5. The sources of data are as shown in below.

Temperature: CAE, Madakasira

Humidity: CAE, Madakasira

Sunshine hours: ARS, Pavagada

Average meteorological data: Anantapur

| Month | Min Temp °C | Max Temp °C | Humidity % | Wind m/s | Sun hours | Rad MJ/m ² /day | ETo mm/day |
|----------------|----------------|----------------|---------------|-------------|--------------|-------------------------------|---------------|
| January | 23.0 | 34.0 | 58 | 0.0 | 8.9 | 19.4 | 3.43 |
| February | 20.0 | 37.0 | 57 | 0.0 | 8.5 | 20.4 | 3.78 |
| March | 21.0 | 38.0 | 43 | 0.0 | 8.9 | 22.5 | 4.15 |
| April | 24.0 | 30.0 | 41 | 0.0 | 8.4 | 22.5 | 3.87 |
| May | 27.0 | 40.0 | 40 | 0.0 | 8.6 | 22.6 | 4.41 |
| June | 24.0 | 35.0 | 45 | 0.0 | 8.6 | 22.3 | 4.40 |
| July | 20.0 | 30.0 | 54 | 0.0 | 8.9 | 22.8 | 4.18 |
| August | 21.0 | 29.0 | 60 | 0.0 | 8.4 | 22.3 | 4.03 |
| September | 22.0 | 31.0 | 61 | 0.0 | 8.7 | 22.3 | 4.08 |
| October | 23.0 | 34.0 | 58 | 0.0 | 8.4 | 20.6 | 3.83 |
| November | 22.0 | 34.0 | 53 | 0.0 | 8.9 | 19.7 | 3.44 |
| December | 20.0 | 34.0 | 57 | 0.0 | 8.3 | 18.0 | 3.07 |
| Average | 22.3 | 33.8 | 52 | 0.0 | 8.6 | 21.3 | 3.89 |

Fig 4: Weather data in Poly house

| Month | Min Temp °C | Max Temp °C | Humidity % | Wind km/day | Sun hours | Rad MJ/m ² /day | ETo mm/day |
|----------------|----------------|----------------|---------------|----------------|--------------|-------------------------------|---------------|
| January | 16.8 | 31.7 | 57 | 168 | 9.3 | 19.9 | 4.64 |
| February | 19.1 | 34.8 | 51 | 180 | 9.7 | 22.1 | 5.65 |
| March | 22.1 | 37.5 | 43 | 176 | 9.8 | 23.9 | 6.58 |
| April | 25.7 | 38.9 | 38 | 206 | 9.6 | 24.3 | 7.58 |
| May | 25.7 | 38.1 | 41 | 293 | 9.1 | 23.4 | 8.36 |
| June | 24.4 | 35.3 | 49 | 377 | 7.2 | 20.2 | 7.77 |
| July | 23.6 | 33.6 | 54 | 364 | 5.6 | 17.9 | 6.72 |
| August | 23.0 | 33.5 | 59 | 339 | 5.6 | 18.0 | 6.20 |
| September | 22.7 | 32.2 | 60 | 259 | 6.5 | 19.0 | 5.60 |
| October | 21.6 | 32.4 | 61 | 157 | 7.0 | 18.6 | 4.75 |
| November | 19.4 | 31.5 | 63 | 140 | 7.9 | 18.3 | 4.32 |
| December | 15.4 | 30.7 | 63 | 149 | 8.0 | 17.7 | 4.03 |
| Average | 21.6 | 34.2 | 53 | 234 | 7.9 | 20.3 | 6.02 |

Fig 5. Average climate data of 15 years in Anantapur region

3.4.3 Rain fall data

The rainfall contributes to a greater or lesser extent in satisfying CWR, depending on the location. The precipitation data required for CROPWAT 8.0 can be daily, decade or monthly rainfall, commonly available from many climatic stations.

Monthly rainfall data was calculated from the data procure from Agricultural Research station, Anantapur and shown in the Fig 6 and Fig 7.

| | Rain | Eff rain |
|--------------|------------|------------|
| | mm | mm |
| January | 0.0 | 0.0 |
| February | 0.0 | 0.0 |
| March | 0.0 | 0.0 |
| April | 0.0 | 0.0 |
| May | 0.0 | 0.0 |
| June | 0.0 | 0.0 |
| July | 0.0 | 0.0 |
| August | 0.0 | 0.0 |
| September | 0.0 | 0.0 |
| October | 0.0 | 0.0 |
| November | 0.0 | 0.0 |
| December | 0.0 | 0.0 |
| Total | 0.0 | 0.0 |

Fig 6. Rainfall data in poly house

| | Rain | Eff rain |
|--------------|--------------|--------------|
| | mm | mm |
| January | 2.0 | 2.0 |
| February | 0.3 | 0.3 |
| March | 6.2 | 6.1 |
| April | 18.7 | 18.1 |
| May | 49.4 | 45.5 |
| June | 64.6 | 57.9 |
| July | 96.4 | 81.5 |
| August | 109.4 | 90.3 |
| September | 127.9 | 101.7 |
| October | 100.1 | 84.1 |
| November | 34.5 | 32.6 |
| December | 5.9 | 5.8 |
| Total | 615.4 | 526.0 |

Fig 7. Average rain fall data of 15 years in Anantapur region

3.4.4 Crop data

The required crop data was collected from FAO, Rome, Italy, and Paper No 24 as shown in Fig 8.

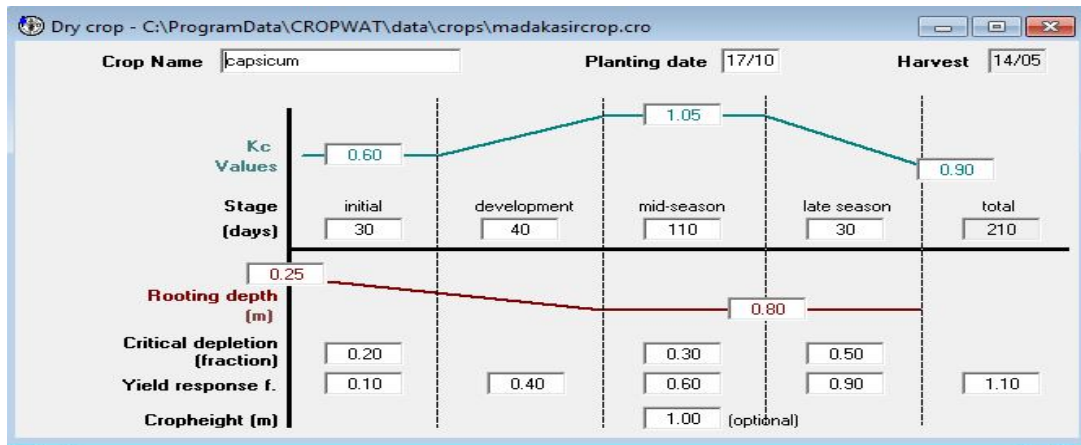


Fig 8. Crop data for capsicum crop

3.4.5 Different types of soil data

The soil details which are used in the CROPWAT 8.0 are taken from FAO, Rome, Italy, and Paper No 24 and shown in Table 2.

Table 2. Different types of soil data

| S. No | Soil description | Black clay | Red loam sandy | Red sandy | Red loam |
|-------|---|------------|----------------|-----------|----------|
| 1 | Total available soil moisture (FC-WP), mm/m | 200 | 100 | 100 | 180 |
| 2 | Maximum rain infiltration rate, mm/day | 30 | 30 | 30 | 30 |
| 3 | Maximum rooting depth, cm | 900 | 900 | 900 | 900 |
| 4 | Initial soil moisture depletion (as % TAM), % | 50 | 0 | 0 | 0 |
| 5 | Initial available soil moisture, mm/m | 100 | 100 | 100 | 180 |

Source: FAO Irrigation drainage paper No.24

IV. RESULTS AND DISCUSSION

Reference evapotranspiration can be calculated from poly house by using climate data. The maximum ETo was observed in the month of May as 4.41 mm/day due to high mean temperatures and minimum in month of December as 3.07 mm/day due to minimum mean temperatures. The average annual ETo was estimated for climate data of poly house as 3.89 mm/day.

Estimation of Crop Water Requirement for Capsicum Crop in red loam soil under protected cultivation:

Crop water requirement can be calculated from climatic data and by integrating directly the crop resistance, albedo and air resistance factors in the Penman-Monteith approach. The maximum ETc was observed in the month of March, 3 decade as 44.1 mm/dec due to the high mean temperature and minimum ETc during the month of October 2 decade as 9.2 mm/dec due to the minimum mean temperature.

The total annual ETc estimated for the capsicum crop in poly house climate data was 685.9 mm per crop period and irrigation requirement as 685.9 mm per crop period respectively.

Irrigation Schedule for Capsicum Crop in red loam soil under protected cultivation

The irrigation schedule for capsicum crop in red loam soil under poly house was obtained as the gross irrigation 964.5 mm and total net irrigation 675.2 mm, actual water use by crop 682.3 mm, potential water use by crop 682.3 mm, efficiency irrigation schedule 100%, moist deficit at harvest 7.1 mm, actual irrigation requirement 682.3 mm.

Estimation of Crop Water Requirement of Capsicum Crop for Different Soils in Anantapur Region

The maximum ETc was observed in the month of March, 3 decade as 80.3 mm/dec due to the high mean temperature and minimum ETc during the month of October 2

decade as 11.4 mm/dec due to the minimum mean temperature. The total annual ETc estimated for the capsicum crop in the Anantapur region for 15 years climate data was 1128.4 mm per crop period and effective rain fall and irrigation requirement as 119.3 mm per crop period, 1007.30 mm per crop period respectively.

Irrigation Schedule

The irrigation schedule for capsicum crop in Anantapur region for black clay soils from last average 15 years climate data as the gross irrigation 1464.3 mm and total net irrigation 1025 mm, actual water use by crop 1120.6 mm, potential water use by crop 1120.6 mm, efficiency irrigation schedule 100 %, total rain fall 135 mm, effective rain fall 128.5 mm, total rain loss 6.5 mm, moist deficit at harvest 47.1 mm, actual irrigation requirement 992.1 mm, efficiency rainfall 95.2 %.

The irrigation schedule for capsicum crop in Anantapur region for red sandy loam soils from last average 15 years climate data as the gross irrigation 1454.1 mm and total net irrigation 1017.9 mm, actual water use by crop 1120.6 mm, potential water use by crop 1120.6 mm, efficiency irrigation schedule 100 %, total rain fall 135 mm, effective rain fall 87.9 mm, total rain loss 47.1 mm, moist deficit at harvest 14.8 mm, actual irrigation requirement 1032.7 mm, efficiency rainfall 65.1%.

The irrigation schedule for capsicum crop in Anantapur region for red sandy soils from last average 15 years climate data as the gross irrigation 1466 mm and total net irrigation 1026.2 mm, actual water use by crop 1120.6 mm, potential water use by crop 1120.6 mm, efficiency irrigation schedule 100%, total rain fall 135 mm, effective rain

fall 64.0 mm, total rain loss 71.1 mm, moist deficit at harvest 30.4 mm, actual irrigation requirement 1056.6 mm, efficiency rainfall 47.4%.

The irrigation schedule for capsicum crop in Anantapur region for red loamy soils from last average 15 years climate data as the gross irrigation 1443.4 mm and total net irrigation 1010.4 mm, actual water use by crop 1120.6 mm, potential water use by crop 1120.6 mm, efficiency irrigation schedule 100 %, total rain fall 135 mm, effective rain fall 87.6 mm, total rain loss 47.4 mm, moist deficit at harvest 22.6 mm, actual irrigation requirement 1033 mm, efficiency rainfall 64.9%.

Estimation of Evapotranspiration for open filed (Anantapur region for different soils)

Mean climate data of Anantapur region of 15 years was given to CROPWAT model. The maximum ETo was observed in the month of May as 8.36 mm/day due to high mean temperatures and minimum in month of December as 4.03 mm/day due to minimum mean temperatures. The average annual ETo was estimated for last 15 years climate data of Anantapur region as 6.02 mm/day.

Estimation of Evapotranspiration for unprotected cultivation

Reference evapotranspiration (ETo) in poly house obtained (3.89 mm/day) was less than Anantapur region (6.02 mm/day). The crop evapotranspiration (ETc) under poly house obtained was 685.9 mm/dec but Anantapur region had the highest ETc (i.e. 1128.3 mm/dec). The irrigation requirement in poly house (685.9 mm/dec) was much lesser than the Anantapur region (1007.06 mm/dec) due to the high temperatures, less humidity and direct sunlight at open filed.

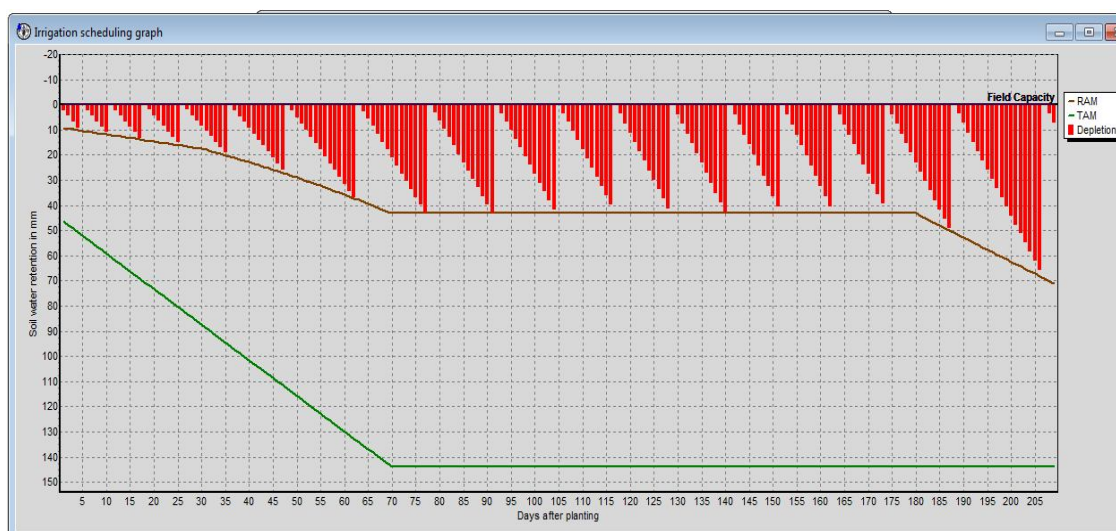


Fig 9. Irrigation Schedule of Capsicum Crop in poly house Red loam soil

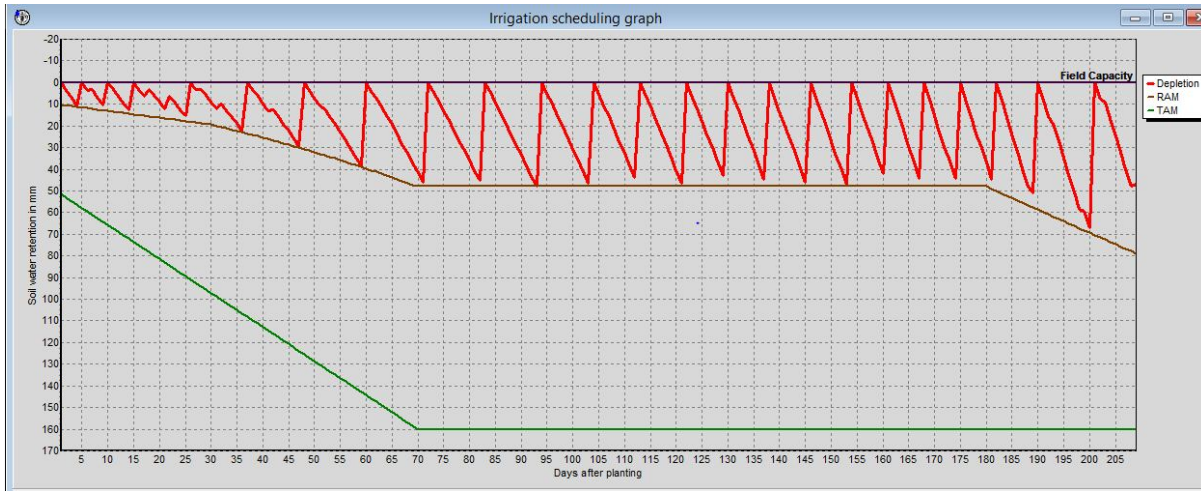


Fig 10. Irrigation Schedule of Capsicum Crop in Anantapur Region for Black Clay Soils

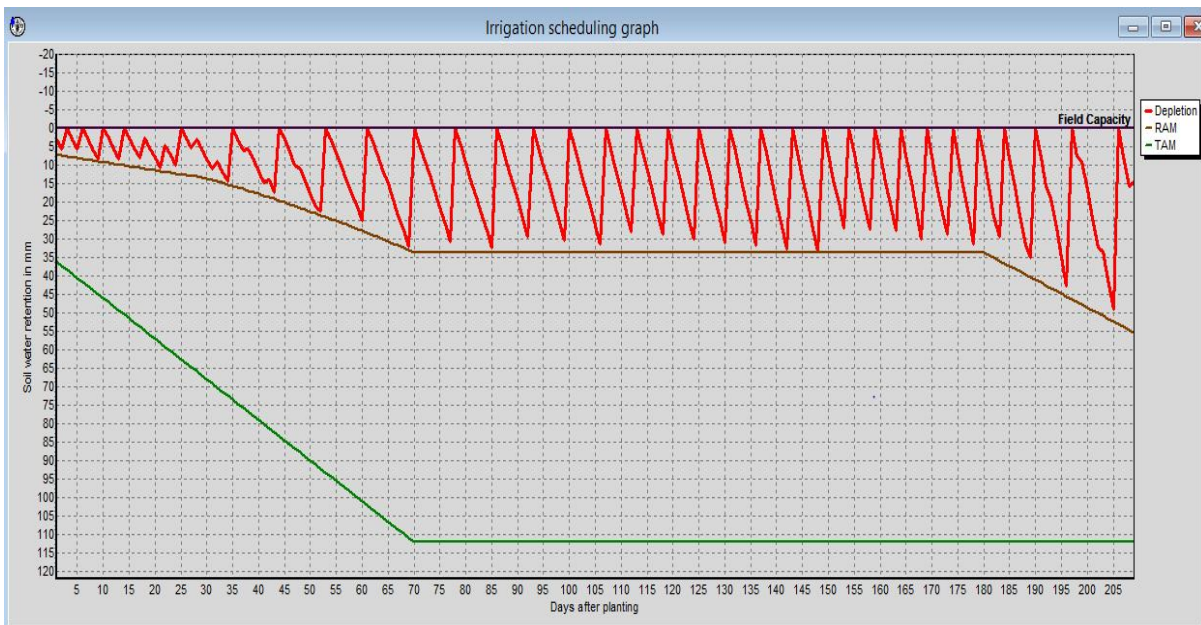


Fig 11. Irrigation scheduling of capsicum crop in Anantapur region for red sandy loam soils

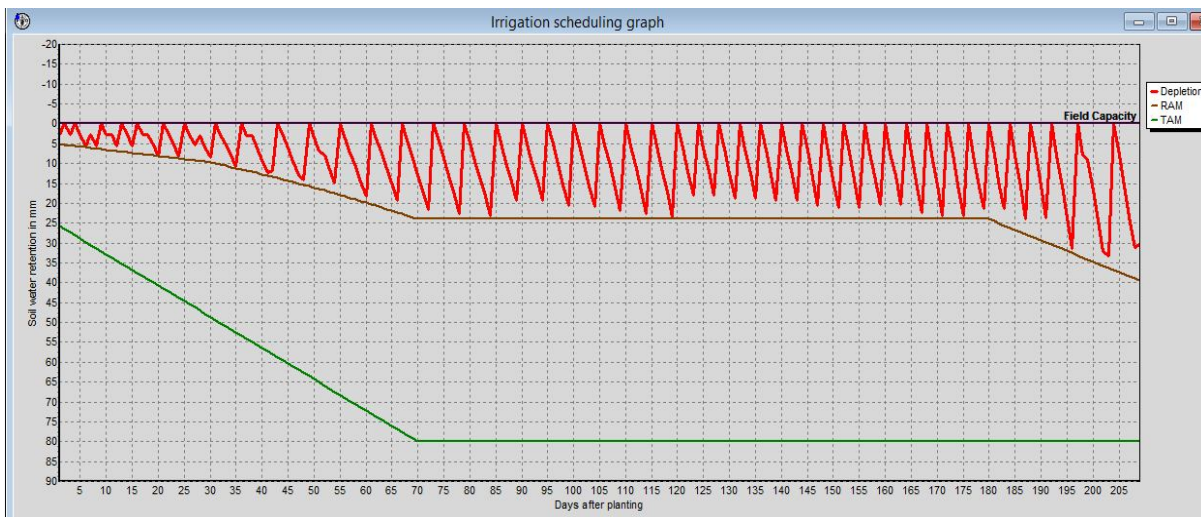


Fig 12. Irrigation Schedule of Capsicum Crop in Anantapur Region for Red Sandy Soils

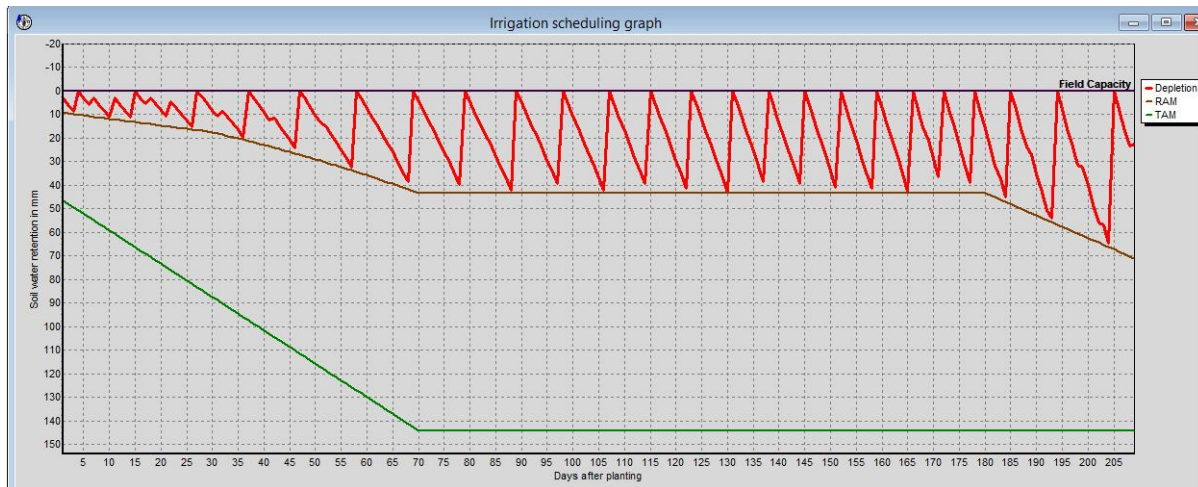


Fig 13.Irrigation Schedule for capsicum crop in Anantapur region for red loamy soils

V. CONCLUSIONS

- The total annual ETc estimated for the capsicum crop in the Anantapur region for 15 years climate data was 1128.4 mm per crop period and effective rain fall and irrigation requirement as 119.3 mm per crop period, 1007.30 mm per crop period respectively.
- The irrigation required for colored capsicum in Anantapur region is same for different soils but the irrigation schedule is varying one soil to other soils.
- The Reference evapotranspiration (ETo) in poly house obtained (3.89 mm/day) was less than Anantapur region (6.02 mm/day). The crop evapotranspiration (ETc) under poly house obtained was 685.9 mm per entire crop period but Anantapur region had the highest ETc (i.e. 1128.4 mm per entire crop period). The irrigation requirement in poly house (685.9 mm per entire crop period) was much lesser than the Anantapur region (1007.3 mm per entire crop period) due to the high temperatures, less humidity and direct sunlight at outside the poly house.
- The irrigation required for colored capsicum in Anantapur region is same for different soils but the irrigation schedule is varying one soil to other soils.

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