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Research Article

# ESTIMATION OF CROP WATER REQUIREMENT USING CROPWAT SOFTWARE IN APPAPURAM CHANNEL COMMAND UNDER KRISHNA WESTERN DELTA

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**Abstract-** Crop water requirements of crops in Appapuram Channel Command under Krishna Western Delta were computed with CROPWAT using the meteorological parameters. The major cultivated crops are rice and maize. The total water requirement for these crops has been computed. The CROPWAT a computer simulation model was used to estimate crop water requirement in Appapuram Channel Command under Krishna Western Delta in Andhra Pradesh for the years 2000 to 2010. The Penman – Monteith method was used for evapotranspiration calculation in the model. It was estimated that the gross water requirement for Appapuram Channel Command area to irrigate 8880 ha was registered and 4000 ha unregistered ayacut during kharif season and maize 4000 ha during Rabi to be 124.39 M.cum. The canal operation plan was prepared for estimated gross water requirement.

**Keywords**- Evapotranspiration, Crop coefficients, CROPWAT, Potential evapotranspiration.

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## Introduction

Acute water shortages are observed in many countries particularly in India and other countries and there is no life without water. Earth is the only plant, so far known to have water and this makes it fit for human living. Agriculture is the largest consumer of water in India and hence more efficient use of water in agriculture needs to be top most priority. It is important that the water requirements of crops are known at different management levels within the irrigated area to accomplish effective irrigation management. The crop water requirements are met from the effective rainfall, irrigation water applied and the available soil moisture. The potential evapotranspiration ($ET_p$) of a crop is the volume of water required to meet crop evapotranspiration requirements. The crop irrigation water requirement is a difference between potential evapotranspiration ($ET_p$) and effective precipitation. Therefore, it is important that crop water requirement is obtained using combination of climate, soil and plant factors to distribute water resource and to improve water use efficiency.

Irrigation is a costly and scarce input in agriculture and plays an important role in increasing food production. In Andhra Pradesh, most of the irrigated areas are commanded by the major irrigation projects. Out of the 57 lakh hectares of irrigated area, about 22 lakh hectares of land is irrigated by canals of major irrigation projects. As rainfall is highly stochastic in nature, irrigation has to be planned efficiently. In order to apply irrigation water efficiently, the water requirement of the crops is to be estimated accurately. Several computer models are now available to estimate the crop water requirements. CROPWAT, a computer program developed at the Netherlands, calculates the summarized irrigation water requirements of a complex scenario.

It was reported that the cost of creating irrigation potential for one hectare of land through irrigation projects works out to be Rs 97033/- per acre (Ninth Plan). When such huge investments are made on creating source of irrigation, there is every need to estimate the crop water requirements accurately and apply irrigation water judiciously to avoid under or over irrigation.

## Materials and Methods

### Study area

The study area falls under Krishna western delta in Guntur district of Andhra Pradesh and is located at 16° 04' N latitude and 80 34' E longitudes. The command area of Appapuram channel, which branches form Commamuru branch canal of Krishna Western main canal near Sangam Jagarlamudi lock is selected as the study area.

### Climatic conditions

The Appapuram channel is considered one of the humid areas with low precipitation and high evaporative demand. The average air temperature is 28.42 °C, whereas the maximum air temperature is 47.2 °C and the minimum air temperature is 11.5 °C. The average minimum relative humidity is 57%, and the average maximum relative humidity is 83%. The average wind speed is equal to 6.28 km/hr while the annual precipitation ranges from 574 to 1500 mm

### Soil description

The Most of study area is characterized by black clay soil texture with two soil layers. A total effective soil depth is in average about 180 cm while the depth of the top layer is about 40-50 cm representing about one-third of the whole soil profile.

### Irrigation water source and quality

The water which is used for irrigation in the Appapuram channel command area is fresh water that comes from Prakasam barrage.

### CROPWAT – A Simulation Program on Crop Water Requirement

CROPWAT is a program that uses the Smith (1992) Penman-Monteith methods

for calculating reference crop evapotranspiration. These estimates are used in crop water requirements and irrigation scheduling calculations. CROPWAT calculates the irrigation water requirements (either per month or per week period or as required) of a cropping pattern in an irrigated area, for various stages of crop development throughout the crops' growing season.

**Data entry**

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

- General data
- Crop data,
- Soil data,
- Reference evapotranspiration data,
- Weather data (Effective rainfall, minimum relative humidity, Wind speed data),
- Irrigation option data,

**General Data**

General data file for CROPWAT

| S. No. | Particulars | Value |
|---|---|---|
| 1. | Country | India |
| 2. | Name of region or project | Andhra Pradesh |
| 3. | Description of irrigated area | Appapuram channel Command under KWD |
| 4. | Hemisphere | North |
| 5. | Latitude | 16. 14 |
| 6. | Altitude | +5.5 m |
| 7. | Size of irrigable area | 8880 ha |
| 8. | Calculation period (month/7 days) | month/ 7 days |
| 9. | Mean depth of water application | 75 mm per Application |
| 10. | Interval between applications | 7 days |

**Meteorological data**

Meteorological data for the Appapuram canal command area have been obtained from the Regional Agricultural Research Station, Lam, and Guntur for the 2000-2010 period. The following parameters have been collected on a daily basis for 10 years period of (2000-2010):

Average minimum and maximum air temperature in ° C,

Average minimum and maximum relative humidity in %,

Incoming solar radiation in W/m$^2$,

Total precipitation in mm,

Average wind speed in m/s

**Crop data**

The collected data for each crop:

- Duration of four main crop growth stages (initial, development, mid-season and late season;
- Root depth growth (initial and maximum);
- Crop coefficient ($K_c$) values depending on the crop growth stages
- Maximum crop height;
- Yield reduction coefficient ($K_y$) and.
- Typical cropping pattern followed in Appapuram Channel Command area [Table-1]. Paddy – Maize – Fallow

**Table-1** *Cropping pattern of the Appapuram command area*

| S.No | Crop | Registered command Area (ha) | Transplanting date | Harvesting date |
|---|---|---|---|---|
| 1 | RICE | 1223.3 | 23-Jul | 25-Nov |
| 2 | RICE | 729.1 | 25-Jul | 27-Nov |
| 3 | RICE | 1002.3 | 27-Jul | 29-Nov |
| 4 | RICE | 1120.3 | 29-Jul | 01-Dec |
| 5 | RICE | 844.7 | 31-Jul | 03-Dec |
| 6 | RICE | 826.2 | 02-Aug | 05-Dec |
| 7 | RICE | 848.8 | 04-Aug | 07-Dec |
| 8 | RICE | 763.7 | 06-Aug | 09-Dec |
| 9 | RICE | 830.9 | 08-Aug | 11-Dec |
| 10 | RICE | 690.4 | 10-Aug | 13-Dec |
| 11 | MAIZE | 831.1 | 12-Dec | 11-Apr |
| 12 | MAIZE | 571.0 | 14-Dec | 13-Apr |
| 13 | MAIZE | 591.6 | 16-Dec | 15-Apr |
| 14 | MAIZE | 765.6 | 18-Dec | 17-Apr |
| 15 | MAIZE | 373.4 | 20-Dec | 19-Apr |
| 16 | MAIZE | 814.6 | 22-Dec | 21-Apr |
| 17 | MAIZE | 776.2 | 24-Dec | 23-Apr |

**Results and Discussion**

**Crop water requirement**

Estimation of the CWR was carried out by calling up successively the appropriate climate and rainfall data sets, together with soil and crop data files and the corresponding planting dates. Based on the climate data, rainfall data, crop data, cropping pattern data and soil data fed to the CROPWAT model, the crop water requirements were estimated for Appapuram channel command area. The crop water requirements were presented in [Table-2].

**Table-2** *Crop water requirements of Appapuram command area*

| Date | ETo (mm/period) | Planted Area (%) | Crop Kc | CWR (ETm) (mm/period) | Total Rain (mm/period) | Effect. Rain (mm/period) | Irr. Req. (mm/period) | FWS (l/s/ha) |
|---|---|---|---|---|---|---|---|---|
| 23/7 | 37.51 | 22.86 | 0.25 | 9.39 | 9.50 | 6.74 | 2.65 | 0.07 |
| 30/7 | 36.19 | 57.14 | 0.63 | 22.70 | 24.60 | 17.28 | 5.43 | 0.15 |
| 6/8 | 34.83 | 91.43 | 1.01 | 34.99 | 40.38 | 28.17 | 6.82 | 0.19 |
| 13/8 | 33.45 | 100.00 | 1.10 | 36.83 | 44.78 | 31.14 | 5.69 | 0.16 |
| 20/8 | 32.07 | 100.00 | 1.10 | 35.43 | 44.85 | 31.19 | 4.24 | 0.12 |
| 27/8 | 30.70 | 100.00 | 1.11 | 34.12 | 44.32 | 30.95 | 3.16 | 0.09 |
| 3/9 | 29.37 | 100.00 | 1.12 | 32.86 | 43.22 | 30.41 | 2.45 | 0.07 |
| 10/9 | 28.07 | 100.00 | 1.13 | 31.63 | 41.55 | 29.56 | 2.07 | 0.06 |
| 17/9 | 26.84 | 100.00 | 1.13 | 30.45 | 39.37 | 28.43 | 2.02 | 0.06 |
| 24/9 | 25.68 | 100.00 | 1.14 | 29.33 | 36.74 | 27.02 | 2.30 | 0.06 |
| 1/10 | 24.61 | 100.00 | 1.15 | 28.23 | 33.74 | 25.58 | 2.86 | 0.08 |
| 8/10 | 23.64 | 100.00 | 1.15 | 27.18 | 30.48 | 23.53 | 3.65 | 0.10 |
| 15/10 | 22.78 | 100.00 | 1.15 | 26.19 | 27.05 | 21.52 | 4.68 | 0.13 |
| 22/10 | 22.03 | 100.00 | 1.15 | 25.34 | 23.58 | 19.40 | 5.94 | 0.16 |
| 29/10 | 21.42 | 100.00 | 1.15 | 24.56 | 20.18 | 17.21 | 7.35 | 0.20 |
| 5/11 | 20.93 | 100.00 | 1.12 | 23.51 | 16.95 | 15.07 | 8.51 | 0.23 |
| 12/11 | 20.58 | 100.00 | 1.08 | 22.17 | 13.98 | 12.88 | 9.29 | 0.26 |
| 19/11 | 20.37 | 98.57 | 1.00 | 20.31 | 11.21 | 10.67 | 9.64 | 0.27 |
| 26/11 | 20.29 | 72.86 | 0.71 | 14.32 | 6.70 | 6.52 | 7.79 | 0.21 |
| 3/12 | 20.34 | 37.14 | 0.35 | 7.06 | 2.74 | 2.68 | 4.38 | 0.12 |
| 10/12 | 20.52 | 14.71 | 0.08 | 1.62 | 0.84 | 0.08 | 0.81 | 0.02 |
| 17/12 | 20.80 | 33.00 | 0.10 | 2.06 | 1.41 | 1.29 | 0.78 | 0.02 |
| 24/12 | 21.19 | 49.00 | 0.15 | 3.11 | 1.48 | 1.28 | 1.84 | 0.05 |
| 31/12 | 3.06 | 49.00 | 0.15 | 0.45 | 0.15 | 0.13 | 0.32 | 0.06 |
| 1/1 | 22.20 | 49.00 | 0.15 | 3.28 | 0.50 | 0.44 | 2.84 | 0.08 |
| 8/1 | 24.01 | 49.00 | 0.17 | 4.20 | 0.00 | 0.00 | 4.20 | 0.12 |
| 15/1 | 25.89 | 49.00 | 0.25 | 6.51 | 0.00 | 0.00 | 6.51 | 0.18 |
| 22/1 | 27.81 | 49.00 | 0.35 | 9.83 | 0.20 | 0.20 | 9.62 | 0.27 |
| 29/1 | 29.72 | 49.00 | 0.46 | 13.56 | 1.13 | 1.13 | 12.43 | 0.34 |
| 5/2 | 31.61 | 49.00 | 0.54 | 17.20 | 1.69 | 1.69 | 15.50 | 0.43 |
| 12/2 | 33.46 | 49.00 | 0.58 | 19.54 | 1.95 | 1.90 | 17.64 | 0.49 |
| 19/2 | 35.22 | 49.00 | 0.59 | 20.71 | 2.03 | 1.91 | 18.81 | 0.52 |
| 26/2 | 36.90 | 49.00 | 0.59 | 21.70 | 2.02 | 1.87 | 19.83 | 0.55 |
| 5/3 | 38.46 | 49.00 | 0.59 | 22.62 | 1.99 | 1.86 | 20.75 | 0.57 |
| 12/3 | 39.90 | 49.00 | 0.58 | 22.99 | 1.98 | 1.93 | 21.07 | 0.58 |
| 19/3 | 41.20 | 49.00 | 0.53 | 21.74 | 1.96 | 1.96 | 19.78 | 0.55 |
| 26/3 | 42.34 | 49.00 | 0.45 | 19.08 | 1.85 | 1.85 | 17.23 | 0.47 |
| 2/4 | 43.33 | 49.00 | 0.37 | 16.06 | 0.93 | 0.92 | 15.13 | 0.42 |
| 9/4 | 44.15 | 40.00 | 0.25 | 11.06 | 0.00 | 0.00 | 11.06 | 0.30 |
| 16/4 | 44.80 | 16.00 | 0.09 | 3.98 | 0.00 | 0.00 | 3.93 | 0.11 |
| 23/4 | 45.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 30/4 | 45.57 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 7/5 | 45.69 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 14/5 | 45.65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 21/5 | 45.44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 28/5 | 45.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 4/6 | 44.54 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 11/6 | 43.87 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 18/6 | 43.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 25/6 | 42.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 2/7 | 41.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 9/7 | 39.99 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 16/7 | 38.79 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |

**Irrigation scheduling and canal operation plan of Appapuram command area**

Based on the crop water requirements, canal operation plan for Appapuram command area of 8880 ha of registered ayacut and 4000 ha of unregistered ayacut for Kharif and 8880 ha of registered ayacut and 400 ha of unregistered ayacut Rabi seasons was prepared. In the preparation of canal operation plan, water requirement for nursery and land preparation, effective rainfall and seepage losses from Appapuram command area were considered. For land preparation and nursery based on the experiments conducted at A.P. Water Management Project, Bapatla, a depth of 205 mm per 21 days was assumed and considered for estimation purpose. Using this data an attempt was made to prepare canal operation plan [Fig-1] with an objective of matching supply versus demand. Essentially canal operation plan has been the process of realising; conveying and dividing the water in the canal system to ensure predetermine flows at prescribed time for specified durations at demarcated points at delivery. Initially allocation rules have been laid down as per practice and supplies were assured to meet peak crop water demand. Further, an attempt was made to prepare canal operation plan on weekly duration basis on Appapuram channel command area. Irrigation supplies were matched as closely as possible to meet crop water demand. It was observed from the [Table-4] that for an average meteorological and rainfall for the decade 2000 to 2010, the estimated crop water demand at system level inclusive of multiple uses and losses to be 60.99 M. cum. Irrigation supplies from Appapuram channel was planning to meet the demand with supply level 65.37 M. cum. Further, for easy understanding of operation plan to the luskers and work inspectors pictorial representation of canal operation was prepared and presented in the [Fig-1].

**Water releases from Appapuram main channel**

The water releases from Appapuram main channel during the period 1999 to 2010 was collected from Irrigation Department, Bapatla and presented in [Table-3].

**Table-3 Water Releases from Appapuram Main Channel**

| Year | Actual Releases (M.cum) | Average Releases (M.cum) | Excess/ deficit Water Releases | % Excess/deficit water |
|---|---|---|---|---|
| 1999-2000 | 131.08 | 65.37 | 65.71 | 101 |
| 2000-2001 | 22.74 | 65.37 | -42.63 | -65 |
| 2001-2002 | 25.31 | 65.37 | -40.06 | -61 |
| 2002-2003 | 108.81 | 65.37 | 43.44 | 66 |
| 2003-2004 | 38.82 | 65.37 | -26.55 | -41 |
| 2004-2005 | 86.42 | 65.37 | 21.05 | 32 |
| 2005-2006 | 98.03 | 65.37 | 32.66 | 50 |
| 2006-2007 | 105.23 | 65.37 | 39.86 | 61 |
| 2007-2008 | 120.74 | 65.37 | 55.37 | 85 |
| 2008-2009 | 149.23 | 65.37 | 83.86 | 128 |
| 2009-2010 | 92.02 | 65.37 | 26.65 | 41 |

It was observed from table 3 the percentage of excess water released from 32 to 101%

**Conclusions**

1. Gross Water Requirement (GWR) and Gross Irrigation Requirement (GIR) was effectively calculated using Penman-Monteith method using CROPWAT simulation programme and could be adopted for large scale implementation under large canal network systems. Accuracy of estimation of GWR and GIR at command level greatly depends on the cropping pattern followed and staggering of crops sown in the command area.
2. Estimation of seepage losses in the canal network system greatly influences accuracy of the estimation of GWR/GIR.
3. Gross Water Requirement (GWR) under Appapuram Channel Command was estimated to be 124.39 M.cum. The contribution of effective rainfall towards GWR to be 63.40 M.Cum indicating the fact that almost 50.97% of GWR was met from the effective rainfall itself.
4. The major findings of the present research paper had clearly demonstrated that the average percentage of excess water released was estimated 32 to 101 % and there was considerable scope to improve the match between irrigation demand and canal supply. To match the irrigation supply vs demand, irrigation water measurements should be made mandatory at head regulator and at branch canals and distributories. The modernization works of Appapuram Channel should therefore be focused on addressing these issues.

**Conflict of Interest: None declared**

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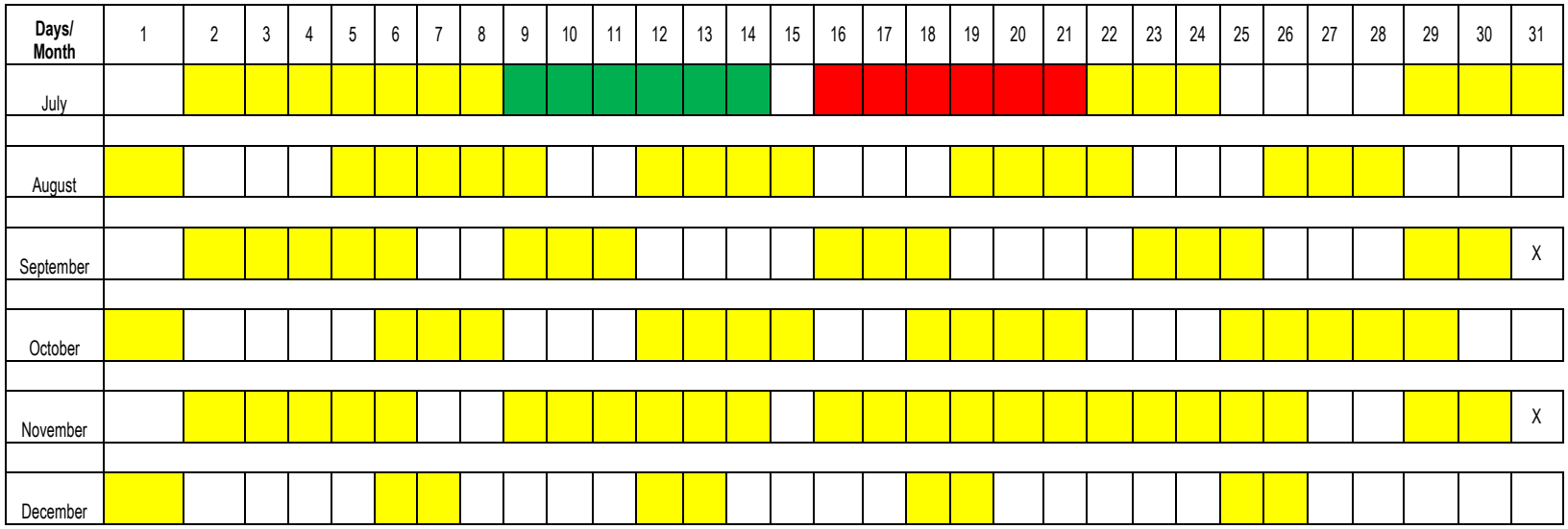
**Table-4** *Irrigation scheduling and canal operation plan for Appapuram distributory of Krishna Western Delta main Canal*

| | Cusecs | Cumecs | MODE | 1 Day | 2 Day | 3 Day | 4 Day | 5 Day | 6 Day | 7 Day | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Full** | 368 | 10.4205 | F | 0.9003 | 1.8007 | 2.7010 | 3.6013 | 4.5017 | 5.4020 | 6.2509 | | | | | | | |
| **3/4th** | 276 | 7.8154 | T | 0.6752 | 1.3505 | 2.0257 | 2.7010 | 3.3762 | 4.0515 | 4.6882 | | | | | | | |
| **Half** | 184 | 5.2103 | H | 0.4502 | 0.9003 | 1.3505 | 1.8007 | 2.2508 | 2.7010 | 3.1255 | | | | | | | |
| **40%** | 147 | 4.1625 | P | 0.3596 | 0.7193 | 1.0789 | 1.4386 | 1.7982 | 2.1579 | 2.5004 | | | | | | | |
| **CA** | **Month** | **Total Cropped Area** | **UCA** | **N and LP** | **C W D at FL (m3)** | | **E R** | **I R at FL** | **I R at FL** | **SL I in Main canals** | **W A at DL per period** | **G W A at D incl. MUS per period** | **Irrigation supply** | | **ISM and FC** | | |
| | | **Ha** | **Ha** | **mm** | **mm** | **total** | **mm** | **mm** | **M cum** | **M cum** | **M Cum** | **M. Cum** | **NoD** | **Duration** | **M** | **Supply from the canal (M cum)** | **C** |
| **1** | **2** | **4** | **5** | **6** | **7** | **8=7+6** | **9** | **10=8-9** | **Col 11 = Col 10 X (Col 5 + Col 6) X 10/(1000000)** | **12** | **13=11+12** | **14 = 13 X 1.2** | **15** | **16** | **17** | **18** | **19** |
| N | 2-Jul | 2954.7 | 1330.9 | 71.75 | | 71.8 | 37.70 | 34.05 | 1.46 | 0.44 | **1.90** | **2.28** | 7 | July 2 - 8 | P | 2.50 | Con |
| N | 9-Jul | 5745.8 | 2588.2 | 71.75 | | 71.8 | 37.70 | 34.05 | 2.84 | 0.44 | **3.28** | **3.93** | 6 | July 9 - 14 | T | 4.05 | Con |
| N | 16-Jul | 8189.2 | 3688.8 | 71.75 | | 71.8 | 37.70 | 34.05 | 4.04 | 0.44 | **4.48** | **5.38** | 6 | July 16 - 21 | F | 5.40 | Con |
| N /LP/V | 23-Jul | 8880.0 | 4000.0 | | 9.39 | 9.4 | 6.74 | 2.65 | 0.34 | 0.44 | **0.78** | **0.93** | 3 | July 22 - 24 | P | 1.08 | Int |
| N /LP/V | 30-Jul | 8880.0 | 4000.0 | | 22.7 | 22.7 | 17.28 | 5.42 | 0.70 | 0.44 | **1.14** | **1.36** | 4 | July 29 - Aug 1 | P | 1.44 | Int |
| N /LP/V | 6-Aug | 8880.0 | 4000.0 | | 34.99 | 35.0 | 28.17 | 6.82 | 0.88 | 0.44 | **1.32** | **1.58** | 5 | Aug 5 - 9 | P | 1.80 | Int |
| N /LP/V | 13-Aug | 8880.0 | 4000.0 | | 36.83 | 36.8 | 31.14 | 5.69 | 0.73 | 0.44 | **1.17** | **1.40** | 4 | Aug 12 - 15 | P | 1.44 | Int |
| N /LP/V | 20-Aug | 8880.0 | 4000.0 | | 35.43 | 35.4 | 31.19 | 4.24 | 0.55 | 0.44 | **0.98** | **1.18** | 4 | Aug 19 - 22 | P | 1.44 | Int |
| N /LP/V | 27-Aug | 8880.0 | 4000.0 | | 34.12 | 34.1 | 30.95 | 3.17 | 0.41 | 0.44 | **0.85** | **1.02** | 3 | Aug 26 - 28 | P | 1.08 | Int |
| N /LP/V | 3-Sep | 8880.0 | 4000.0 | | 32.86 | 32.9 | 30.41 | 8.00 | 1.03 | 0.44 | **1.47** | **1.76** | 5 | Sep 2 - 6 | P | 1.80 | Int |
| V/ F | 10-Sep | 8880.0 | 4000.0 | | 31.63 | 31.6 | 29.56 | 2.07 | 0.27 | 0.44 | **0.70** | **0.85** | 3 | Sep 9 - 11 | P | 1.08 | Int |
| V/ F | 17-Sep | 8880.0 | 4000.0 | | 30.45 | 30.5 | 28.43 | 2.02 | 0.26 | 0.44 | **0.70** | **0.84** | 3 | Sep 16 - 18 | P | 1.08 | Int |
| V/ F | 24-Sep | 8880.0 | 4000.0 | | 29.33 | 29.3 | 27.02 | 2.31 | 0.30 | 0.44 | **0.74** | **0.88** | 3 | Sep 23 - 25 | P | 1.08 | Int |
| V/ F | 1-Oct | 8880.0 | 4000.0 | | 28.23 | 28.2 | 25.38 | 2.85 | 0.37 | 0.44 | **0.80** | **0.97** | 3 | Sep 29 - Oct 1 | P | 1.08 | Int |
| V/ F | 8-Oct | 8880.0 | 4000.0 | | 27.18 | 27.2 | 23.53 | 3.65 | 0.47 | 0.44 | **0.91** | **1.09** | 3 | Oct 6 - 8 | P | 1.08 | Int |
| V/ F | 15-Oct | 8880.0 | 4000.0 | | 26.19 | 26.2 | 21.52 | 4.67 | 0.60 | 0.44 | **1.04** | **1.25** | 4 | Oct 12 - 15 | P | 1.44 | Int |
| F /YF | 22-Oct | 8880.0 | 4000.0 | | 25.34 | 25.3 | 19.40 | 5.94 | 0.77 | 0.44 | **1.20** | **1.44** | 4 | Oct 18 - 21 | P | 1.44 | Int |
| F /YF | 29-Oct | 8880.0 | 4000.0 | | 24.56 | 24.6 | 17.21 | 7.35 | 0.95 | 0.44 | **1.38** | **1.66** | 5 | Oct 25 - 29 | P | 1.80 | Int |
| F /YF | 5-Nov | 8880.0 | 4000.0 | | 23.53 | 23.5 | 15.02 | 8.51 | 1.10 | 0.44 | **1.53** | **1.84** | 5 | Nov 2 - 6 | P | 1.80 | Int |
| F /YF | 12-Nov | 8880.0 | 4000.0 | | 22.17 | 22.2 | 12.88 | 9.29 | 1.20 | 0.44 | **1.63** | **1.96** | 6 | Nov 9 - 14 | P | 2.15 | Int |
| R | 19-Nov | 8880.0 | 4000.0 | | 20.31 | 20.3 | 10.67 | 9.64 | 1.24 | 0.44 | **1.68** | **2.02** | 6 | Nov 16 - 21 | P | 2.15 | Int |
| R | 26-Nov | 6972.6 | 3140.8 | | 14.32 | 14.3 | 6.52 | 7.80 | 0.79 | 0.44 | **1.23** | **1.47** | 5 | Nov 22 - 26 | P | 1.80 | Int |
| R / H | 3-Dec | 4805.1 | 2164.5 | | 7.06 | 7.1 | 2.68 | 4.38 | 0.31 | 0.44 | **0.74** | **0.89** | 3 | Nov 29 - Dec 1 | P | 1.08 | Int |
| R / H /S M | 10-Dec | 1306.2 | 738.4 | | 1.62 | 1.6 | 0.80 | 0.82 | 0.02 | 0.44 | **0.45** | **0.55** | 2 | Dec 6 - 7 | P | 0.72 | Int |
| R / H /S M | 17-Dec | 2930.4 | 300.0 | | 2.06 | 2.1 | 1.29 | 0.77 | 0.02 | 0.44 | **0.46** | **0.56** | 2 | Dec 12 - 13 | P | 0.72 | Int |
| V/F | 24-Dec | 4351.2 | 400.0 | | 3.11 | 3.1 | 1.28 | 1.83 | 0.09 | 0.44 | **0.52** | **0.63** | 2 | Dec 18 - 19 | P | 0.72 | Int |
| V/F | 31-Dec | 4351.2 | 400.0 | | 0.45 | 0.5 | 0.13 | 0.32 | 0.02 | 0.44 | **0.45** | **0.54** | 2 | Dec 25 - 26 | P | 0.72 | Int |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| V/F | 1-Jan | 4351.2 | 400.0 | | 3.28 | 3.3 | 0.44 | 2.84 | 0.13 | 0.44 | **0.57** | **0.69** | 2 | Jan 1 - 2 | P | 0.72 | Int |
| V/F | 8-Jan | 4351.2 | 400.0 | | 4.2 | 4.2 | 0 | 4.20 | 0.20 | 0.44 | **0.64** | **0.76** | 2 | Jan 8 - 9 | P | 0.72 | Int |
| V/F | 15-Jan | 4351.2 | 400.0 | | 6.51 | 6.5 | 0 | 6.51 | 0.31 | 0.44 | **0.75** | **0.90** | 3 | Jan 14 - 16 | P | 1.08 | Int |
| V/F | 22-Jan | 4351.2 | 400.0 | | 9.83 | 9.8 | 0.2 | 9.63 | 0.46 | 0.44 | **0.90** | **1.07** | 3 | Jan 21 - 23 | P | 1.08 | Int |
| V/F | 29-Jan | 4351.2 | 400.0 | | 13.56 | 13.6 | 1.13 | 12.43 | 0.59 | 0.44 | **1.03** | **1.23** | 3 | Jan 28 - 30 | P | 1.08 | Int |
| YF | 5-Feb | 4351.2 | 400.0 | | 17.2 | 17.2 | 1.69 | 15.51 | 0.74 | 0.44 | **1.17** | **1.41** | 4 | Feb 4 - 7 | P | 1.44 | Int |
| YF | 12-Feb | 4351.2 | 400.0 | | 19.54 | 19.5 | 1.9 | 17.64 | 0.84 | 0.44 | **1.28** | **1.53** | 4 | Feb 11 - 14 | P | 1.44 | Int |
| YF | 19-Feb | 4351.2 | 400.0 | | 20.71 | 20.7 | 1.91 | 18.80 | 0.89 | 0.44 | **1.33** | **1.60** | 4 | Feb 18 - 21 | H | 1.80 | Int |
| YF | 26-Feb | 4351.2 | 400.0 | | 21.7 | 21.7 | 1.87 | 19.83 | 0.94 | 0.44 | **1.38** | **1.66** | 4 | Feb 25 - 28 | H | 1.80 | Int |
| YF | 5-Mar | 4351.2 | 400.0 | | 22.62 | 22.6 | 1.86 | 20.76 | 0.99 | 0.44 | **1.42** | **1.71** | 4 | Mar 4 - 7 | H | 1.80 | Int |
| YF | 12-Mar | 4351.2 | 400.0 | | 22.99 | 23.0 | 1.93 | 21.06 | 1.00 | 0.44 | **1.44** | **1.73** | 4 | Mar 11 - 14 | H | 1.80 | Int |
| R | 19-Mar | 4351.2 | 400.0 | | 21.74 | 21.7 | 1.96 | 19.78 | 0.94 | 0.44 | **1.38** | **1.65** | 4 | Mar 18 -21 | H | 1.80 | Int |
| R | 26-Mar | 4351.2 | 400.0 | | 19.08 | 19.1 | 1.85 | 17.23 | 0.82 | 0.44 | **1.26** | **1.51** | 4 | Mar 25 - 28 | P | 1.44 | Int |
| R | 2-Apr | 4351.2 | 400.0 | | 16.06 | 16.1 | 0.92 | 15.14 | 0.72 | 0.44 | **1.16** | **1.39** | 4 | April 1 - 4 | P | 1.44 | Int |
| H | 9-Apr | 4351.2 | 400.0 | | 11.06 | 11.1 | 0 | 11.06 | 0.53 | 0.44 | **0.96** | **1.16** | 3 | April 8 - 10 | P | 1.08 | Int |
| H | 16-Apr | 4351.2 | 400.0 | | 3.93 | 3.9 | 0 | 3.93 | 0.19 | 0.44 | **0.62** | **0.75** | 2 | April 15 - 16 | H | 0.90 | Int |
| | | | | | | | | | | | | 60.99 | | | | 65.37 | |

CA: Crop Activity, UCA: Unregistered cropped area, N and LP: Nursery and Land preparation, C W D at FL: Crop Water Demand at Field level, E F: Effective Rainfall, SL: Seepage Losses, W A at D: Water allowance at Distributory Level, G W A at D: Gross water allowance at Distributory, ISM and FC : Irrigation supply mode and flow condition, NoD: No of days, M: Mode, C: Condition, Con: Continuous, Int: Intermittent, N: Nursery, N /LP/V: Nursery /Land Preparation/Vegetative, V/ F: Vegetative/ Flowering, F /YF: Flowering /Yield Formation, R: Ripening , R / H /S M : Ripening / Harvesting /Sowing maize



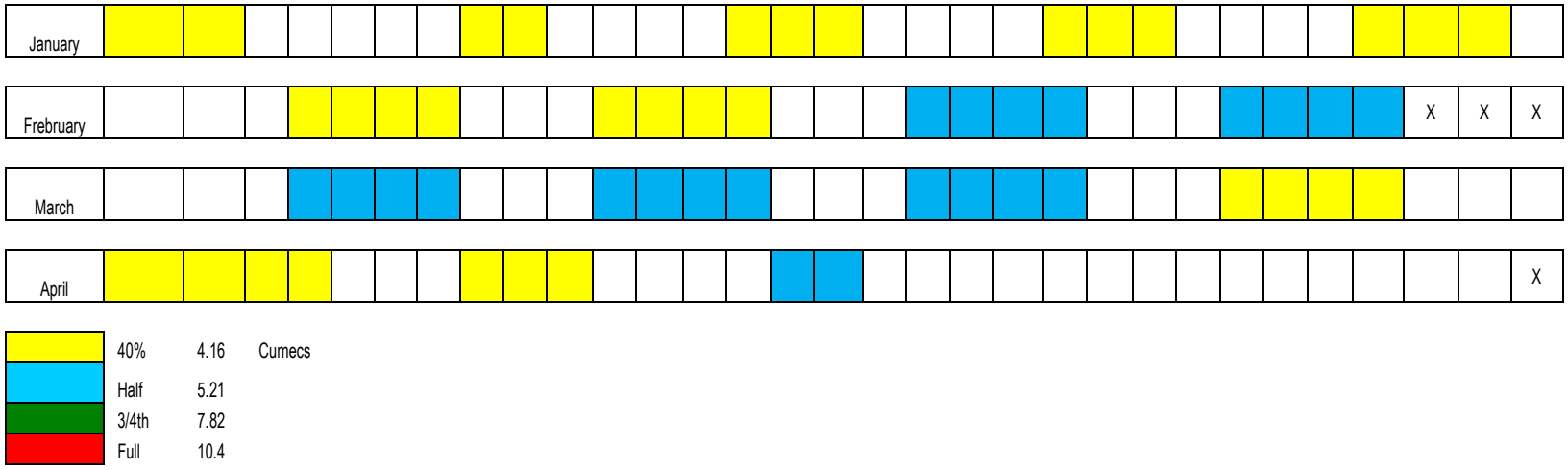



**Fig-1 Pictorial representation of canal operation plan**