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Water and Irrigation Requirement for Sunflower Crop of North Central Plateau Zone of Odisha

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Abstract

The crop water requirement (CWR) and irrigation requirement (IR) of Sunflower crops were calculated using a web based software. Relevant crop coefficients (Kc), duration of crops and cropping pattern were used to calculate CWR from ETo. These coefficients present the relationship between references (ETo) and crop evapotranspiration (ET crop) or ET crop = Kc * ETo. The covered area of all crops (canopy cover) was collected. The Kc values were taken from the FAO.The CWR were calculated for the north central plateau zone of Odisha for which climatic data were available and were applied to the nearest Research station. The effective rainfall was calculated with web based software by using FAO conversion tables. The CWR and IR value was also calculated through this web based software Water requirement of Sunflower, is a 518.6 mm Irrigation requirement is 442.8 mm in this zone 2. By using the software a farmer of this zone can find out the water requirement and irrigation requirement by giving the crop name according to their season and duration of the crop.

Key words: Crop Water Requirement, Irrigation Requirement, Sunflower

Introduction

India with its large population is facing unique challenges of water scarcity due to diverse geographical, climatic and geo-environmental conditions apart from unequal spatio-temporal distribution of fresh water resources.Therefore, efficient and effective water management strategies are essential for meeting the increasing water needs of agricultural, domestic, industrial and environmental sectors. Considering the current water resources problems and rapid increase in its demand, the importance of effective utilization of water resources cannot be underestimated if India has to remain self-reliant in food production. Agriculture is the major user of water, improving agricultural water management is essential. Generally, the yield decreased by 50% due to water stress. Efficient agricultural water management requires reliable estimation of crop water requirement. Crop need available water sufficiently and at the right time during its growth stages. However, irrigation scheduling has been based on the predicted crop water requirements (CWR). Which is the amount of water needed to supply its evapotranspiration needs from planting to harvest for a given crop in a specific climate regime? When adequate soil water is maintained by rainfall and/or irrigation, it does not limit plant growth and crop yield. CWR is calculated for a given crop under the different climatic conditions defined that CWR is the depth (or amount) of water needed to meet the water loss through evapotranspiration. Abdelhadi et al. (2000) estimated the crop water requirements (CWRs) of Acala cotton in the Gezira area of Sudan by taking recommended Penman-Monteith reference crop evapotranspiration (ET0) with derived crop coefficients (Kc) from the phenomenological stages of Acala cotton. Beyazgu et al. (2000) studied an inter-comparison on evapotranspiration (ET), six methods for estimating the reference ET had been applied to a cotton field in the Gediz Basin, Turkey. Irmak et al. (2003) compared the performances of solarand net radiation based methods withother methods. The performance of the derived equations was evaluated for 6 years (1995-2000) including dry and wet years, for the same site and for other humid locations in the Southeast United States. Yin et al. (2008) calibrated the empirical equation to estimate radiation by taking observed solar radiation of 81 meteorological stations over China during (1971-2000). Nazeer (2009) studied CROPWAT simulation under irrigated and rain-fed conditions for the maize crop in order to provide information necessary in taking decisions on irrigation management. The model was used to calculate evapotranspiration and crop water requirements for improved irrigation practices, planning of irrigation schedules under varying water supply conditions and the yield reduction under various conditions.

The aim of present study is to estimate the crop water and the ir-

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rigation requirement of the Sunflower crop by using a web based software. This software first calculates ETo value and effective rainfall, which is necessary for estimation of CWR and IR. Espada for et al. (2011) estimated reference evapotranspiration (ET0) by taking a data set consisting of observed daily values of air temperature, relative humidity, sunshine duration and wind speed from eight weather stations in Andalusia and covering the period 1960–2005. Perez et al. (2015)finds that onion, seasonal water requirements are highly variable depending on agro climate, location and season, as are the crop coefficients (Kc) which range from 0.4 to 0.7 (initial stage), 0.85 to 1.05 (middle development) and 0.6 to 0.75 (final stage). Esquiva et al. (2017) design and developed a new web application with two different color segmentation techniques to estimate the percentage of green cover.

Objectives of the Study

To find out water requirement and irrigation requirements of Rice in North Central Plateau Zone of Odisha season wise and duration wise.

Matertials and Methods

Study Area

North central plateau zone is taken as the study area for this study. Which latitude is 22°01'07.84"N and longitude is 86°24'52.66"E with mean annual rainfall 1535 mm. This zone has 2 districts Keonjhar and Mayurbhanj. Research station of this zone is located at Keonjhar district (Figure.1).

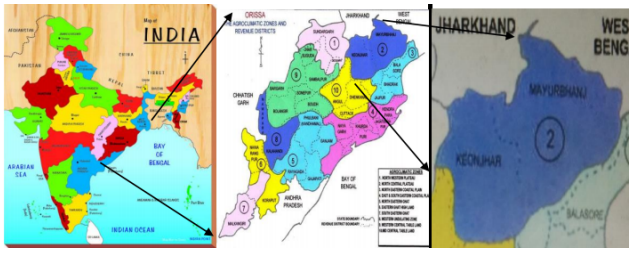

Figure 1. Map of different Agro-climatic zones of Odisha

Calculation of ETo

For calculation of ETo Climatic data, maximum and minimum temperature, relative humidity, sunshine duration and wind speed are required.

The water needs for other crops are directly linked to the climatic parameter. For calculation of ETo, the Penman-Monteith Method was recommended.

The Penman-Monteith form of the combination equation is

$Et_0 = \frac{0.45\Delta(R_n-G)+\gamma\frac{900}{T+273}U2(es-ea)}{\Delta+\gamma(1+0.32U2)}$ Where

Et_0=reference evapotranspiration (mm/day)

Rn = net radiation at the crop surface (MJ/m^2/day)

G = soil heat flux density (MJ/m^2/day)

T = mean daily air temperature at 2m height (°C)

U2=wind speed (m/s)

e_s=saturation vapour pressure (kPa)

e_a=actual vapour pressure (kPa)

$e_s - e_a$= saturation vapour pressure deficit (kPa)

Δ=slop vapour pressure curve [kPa $°C^{-1}$]

γ= psychometric constant. [KPa $°C^{-1}$]

Climate Data Collection

In order to calculate ETo, the respective climatic data (1979-2002) was collected from the website http://globalweather.tamu.edu/home/view/13292. The climate data include maximum and minimum temperature in (°C),Relative Humidity data [in percentage], Average Daily Wind speed data in (m/s), and sunshine duration in hours is taken

Temperature data

Mean Daily Maximum (Tmax,°C) and Minimum Temperature (Tmin,°C),

T = mean daily air temperature

$T = \frac{Tmax+Tmin}{2}$

Net Solar Radiation Calculation (Rn)

The net radiation (Rn) is the difference between the incoming net shortwave radiation (Rns) and the outgoing net long wave radiation (Rnl):

Rn=Rns-Rnl

Where Rn, Rns, Rnl in the above equation are expressed in MJ/m^2/day.

Calculation of incoming net shortwave radiation (Rns)

Rns=(1-$\propto$)Rs

Where Rns net solar or shortwave radiation [MJ/m^2/day],

Rs the incoming solar radiation [MJ/m^2/day].

$Rs=(0.25+0.50\frac{n}{N})Ra$

Rs=shortwave radiation, [MJ/m^2/day]

Ra=extraterrestrial radiation, values of Ra in(mm/day) calculated for different months and latitudes are given in Table a and b .

$\propto = \frac{n}{N}$ is the ratio between actual measured bright sunshine hours and maximum possible sunshine hours. The values of N calculated for different months and latitudes are given in Table c. Where n, actual measured bright sunshine hours values are collected from climate data. Both n and N expressed in mean daily values, in hours. The value of Rs is calculated in mm/day. We have to convert it to MJ/m^2 /day.

1 mm/day=2.45 MJ/m^2/day

Calculation of Outgoing Net Long Wave Radiation (Rnl)

$Rnl = f(T) \times f(ed) \times f(\frac{n}{N})$

Where, f(T)=Effect of temperature on long wave radiation (Rnl),Table d.

f(ed)=Effect of vapor pressure on long wave radiation (Rnl),Table e.

f(n/N)=Effect of the Ratio of actual and maximum bright sunshine hours on longwave radiation (Rnl),Table f

Soil heat flux (G)

The soil heat flux, G, is the energy that is utilized in heating the soil. G is positive when the soil is warming and negative when the soil is cooling. Although the soil heat flux is small compared to Rn and may often be ignored, the amount of energy gained or lost from the soil in this process should theoretically be subtracted or added to Rn when estimating evapotranspiration. As the magnitude of the day or ten-day soil heat flux beneath the grass reference surface is relatively small, it may be ignored Gday ≈ 0

Calculation of pshychromatic constant γ

$\gamma=0.665 \times 10^{-3}p$

$P = (\frac{293-0.0065Z}{293})5.26$

Where, P=atmospheric pressure (Kpa)

Z=elevation above sea level (m)

Calculation of Slope vapour pressure curve Δ

$\Delta = \frac{4098\left[0.6108\exp(\frac{17.27T}{T+237.3})\right]}{(T+237.3)^2}$

Δ= = slope vapour pressure curve [kPa $°C^{-1}$]

T =air temperature [°C],

Calculation of Saturation Vapour Pressure Deficit ($e_s - e_a$)

$e_s = \frac{e^0(Tmax-Tmin)+e^0(Tmin)}{2}$

$e_a = e_s\frac{RHmean}{100}$

e_s = saturation vapour pressure (kPa)
e_a = actual vapour pressure (kPa)
e^0(Tmax)= saturation vapour pressure at daily maximum temperature (kPa)
e^0(Tmin)= saturation vapour pressure at daily minimum temperature (kPa)
RH= Relative Humidity (%)
$e^0(Tmax) = 0.6108\exp\left(\frac{17.27Tmax}{Tmax+17.27}\right)$
$e^0(Tmin) = 0.6108\exp\left(\frac{17.27Tmin}{Tmin+17.27}\right)$

Calculation of Effective Rainfall

The rainfall contributes to a greater or lesser extent in satisfying CWR, depending on the location. So how much amount of rainfall effectively used by the crop after rainfall losses due to surface run off and deep percolation was determined. The precipitation data were required for software (daily, decade or monthly Rainfall). For effective rainfall calculation, rainfall data records from a range of years (1979-2002) were collected from the nearest climatic research station.
Monthly irrigation requirement of selected crops has been calculated by deducting ETc values from the effective precipitation. Effective precipitation is obtained from the rainfall values, following FAO conversion table shows in Table 3

Calculation of ET Crop

For crop water need of North Central Plateau Zone of Odisha, information on the various crop characteristics data were collected.

Crop data Collected from the Field

- Crop and crop variety
- Sowing and harvesting date
- Crop characteristics:
  - Length of individual growth stages
  - Crop factors, relating crop evapotranspiration to reference evapotranspiration.

The Crop duration is and crop stages are taken from Agril. Handbook and Kc values of the selected crops are taken from FAO 24, irrigation and drainage paper. Crop co-efficient Kc is the ratio between evapotranspiration of crop (Etc) and reference evapotranspiration and expressed as
$Etcrop = ET0 \times K_c$

Calculation of Crop Water Requirement (CWR)

The Crop Water requirement (CWR) includes losses during the application of irrigation water to field (percolation, seepage, and runoff) and water required for special operation such as land preparation, transplanting, leaching etc. Crop Water Requirement is
CWR=ETcrop+application lost+Water needed for special operations

Calculation of Irrigation Requirement

Irrigation requirement is the total quantity of water applied to the land surface in supplement to the water supplied through rainfall and soil profile to meet the water needs of crops for optimum growth.
IR = CWR − (ER + S)
IR = Irrigation requirement
CWR =Crop Water requirement
ER =effective rainfall
S= soil profile contribution including that from shallow water tables

Result and Discussion

Crop water requirement and Irrigation Requirement

Reference Evapotranspiration (ET_0) Estimation

For the estimation of water and irrigation requirement of North Central Plateau Zone of Odisha, first calculation of ET0 was necessary. Daily climatic data were collected from 1979 to 2002. FAO-56 Penman-Monteith method used for ETo calculation. For calculation of ETo climatic data like minimum and maximum air temperature, mean relative humidity, wind speed and sunshine hour of that zone are required. From table 4.1, it was observed that daily mean ETo was maximum during may (6.89 mm/day) and minimum during December (3.12 mm/day) in the North Central Plateau Zone of Odisha and mean daily ETo value over the year was 4.61 mm/day.

Effective Rainfall Estimation

For effective rainfall calculation, rainfall data records from a range of years (1979-2002) were collected from the nearest climatic research station. Effective rainfall determination is always a top task. In this study, rainfall is converted to effective rainfall by following the rainfall effective rainfall relationship given in the website file://E:/CHAPTER%203%20%20EFFECTIVE%20RAINFALL.html. The linear relation between rainfall and effective rainfall is shown figure. 2. Then values of effective rainfall are calculated from the graph.

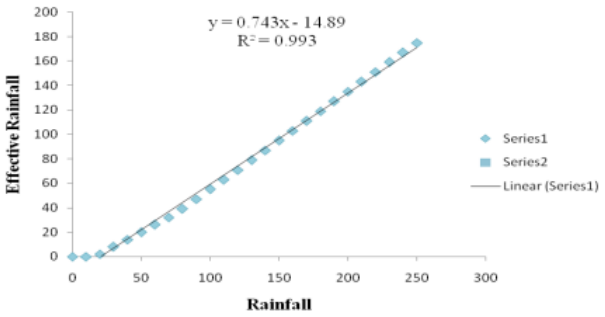

Figure 2. Relation between Rainfall and Effective Rainfall.

ET Crop Value Calculation

The Crop duration is and crop stages are taken from Agril. Handbook and Kc values of the selected crops are taken from FAO 24, irrigation and drainage paper.
Kc values of the Sunflower for different season are shown in Table 1
Crop co-efficient Kc is the ratio between evapo transpiration of the crop (Etc) and reference evapotranspiration and expressed as
$ETcrop = ET0 \times Kc$

CWR and IR Estimation

The Crop Water requirement (CWR) includes losses during the application of irrigation water to field (percolation, seepage, and runoff) and water required for special operation such as land preparation, transplanting, leaching etc. Crop Water Requirement is
CWR=ETcrop+application lost+Water needed for special operations
The Water needed for special operations are calculated as for Sunflower taking ET crop 84%, 12% land preparation, 4% seepage loss in field channel including evaporation
Irrigation requirement is the total quantity of water applied to the land surface in supplement to the water supplied through rainfall and soil profile to meet the water needs of crops for optimum growth.
IR = CWR − (ER + S)
IR = Irrigation requirement
CWR =Crop Water requirement
ER =effective rainfall
S= soil profile contribution including that from shallow water tables

Water and Irrigation Requirement of All the Crop Season Wise

In water and the irrigation requirement of Sunflower is given below Table 2, which were calculated by using web based software. Water requirement of Sunflower, is a 518.6 mm Irrigation requirement is

Table 1. Kc Values of Sunflower

Crops	Total Durations	Stages (In Duration)				Kc Value For Different Stages			
		Initial stage (I)	Crop Dev (II)	Mid Stage (III)	Late season (IV)	Initial stage (I)	Crop Dev (II)	Mid Stage (III)	Late season (IV)
Sunflower	130	25	35	45	25	0.35	0.70	1.15	0.35

442.8 mm in this zone 2.

Table 2. Effective rainfall, crop water and irrigation requirement of crops in summer

Crop Name	Crop variety	CWR, mm	ER, mm	IR, mm
Sunflower 90	KBSH-1	518.16	75.34	442.82

Conclusion

Crop water and irrigation requirement of crops were estimated by using this Software. And following conclusions were found out from the study

- Water requirement of Sunflower, is a 518.6 mm Irrigation requirement is 442.8 mm in this zone 2.
- Software was developed for easily getting CWR and IR of crop season wise can be found

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