

Original Research Article

Water requirements of Wheat crops in a small watershed by using CROPWAT

Abstract

A study was carried out to determine the crop water requirement of wheat crops for the area around Tons pump canal. Crop water requirement for the wheat crops was determined by using 2017-2018 climatic data in CROPWAT. Reference crop evapotranspiration (ET_o) was determined using the FAO Penman Monteith method. The four growth stages of wheat were analysed. They were: the initial stage, the development stage, the mid-season, and the late season. The crop coefficient for each stage was determined after the 2017 Rabi Season. The study also showed that the area under study had varying evapotranspiration rates from 1.48 to 3.98 mm/day. Crop evapotranspiration (ET_c) and crop water requirement for wheat crop varied from 0.44 to 3.75 mm/day and 1.9 to 39.8 mm/day. The peak water requirement was 0.13 l/s/ha or 1.1 mm/day with an application efficiency of 65%. Irrigation water requirement was estimated at about 27.93 mm/day while the actual water diverted was 81000.29 m³. Thus, the canal can conveniently supply the water required for irrigation in the area.

Keywords: Crop Evapotranspiration, Reference evapotranspiration, Crop water requirement, Peak water requirement, total crop water requirement, and climatic data.

Abbreviations: l/s/ha_Litres/Second/Hectare, mm/day_Millimetre/days, Eta_Crop Evapotranspiration, NIWR_Net irrigation water requirement, ET_o_Reference crop Evapotranspiration.

Introduction

Water is important for plant growth and food production. With competition among local governments, industrial users, and agriculture for limited amounts of available water, accurate estimation of water needs for irrigation is critical for planning and managing water projects (Michael, 1999). The main purpose of irrigation is to apply water to maintain crop evapotranspiration (ET_c) when rainfall is insufficient. The limited amount of water available is of critical importance to the economy, health, and well-being of a very large number of people in developing countries. Hess (2013) defines plant water demand as the period between planting and harvesting of a particular crop under particular climatic conditions, provided that sufficient soil moisture is maintained by rain or irrigation such that plant growth is not restricted (Gitelson, 2013). We defined it as the total amount of water required

for evaporation. and harvest.FAO (2005) defined crop water requirement(CWR) for a given crop as:

$$\text{CWR} = \text{Kc} \times \text{ETo}$$

Where,Kc is the Crop coefficient of the given crop and ETo is the Reference evapotranspiration. Eachcrop has its own water requirements. Net irrigation waterrequirements (NIWR) in anexact scheme for a given yearare thus the sum of individual crop water requirements(CWR) intended for each irrigated crop. Multiple cultures (several culture periods per year) are therefore automatically taken in the direction of account by explicitly calculating the culture water requirements for each individual culture period. Dividing by the area of the system gives the required irrigation water value. It can be expressed in mm or m³/ha. FAO (1992), Smith et al. (1991) and Smith (1992) stated that CROPWAT allows agrometeorologists, agronomists, and irrigation engineers to perform evapotranspiration and plant water use studies, particularly standard calculations for irrigation system design and management. reported that it is intended as a practical tool to assist in It enables making recommendations for improving irrigation practices, planning irrigation schedules under different water supply conditions, and evaluating production under rain conditions or under-irrigation. Broner and Schneckloth (2003) reported that plant water requirements depend primarily on environmental conditions. Plants use water for cooling purposes, and the driving force behind this process is prevailing weather conditions. Different cultures have different water usage requirements under the same weather conditions. When the soil moisture reaches the capacity of the field, the plants evaporate the moisture at maximum rate. Battay(2013) reported that knowing the seasonal water demands of plants is important for planning planting combinations, especially during drought years. Anderson(2011) Adequate data on water requirements for irrigation of most crops are not available in the world's developing countries. This is one reason why large-scale irrigation projects fail in most of the world's developing countries. The purpose of this study was to determine the moisture requirements of Harrai village wheat crop.

Materials and methods

Study area

It is located on the banks of the Tons canal within 7 km of Rampur on the Mirzapur highway in Prayagraj. Harrai village come under the Karchhana block. In this village farmers are depending on canals and artificial resources for water supply in agriculture and most of the farmer do the maximum cultivation of wheat and paddy under the cereal-based farming system. Some general class farmers also do animal husbandry along with farming. In which

most of the farmers reared cows and buffaloes. In Harrai village some lower- and middle-class farmer is also rearing pig and goat. Harrai village lies between the longitude and latitudes are 81.9624 to 81.9813 and 25.2806 to 25.2876.

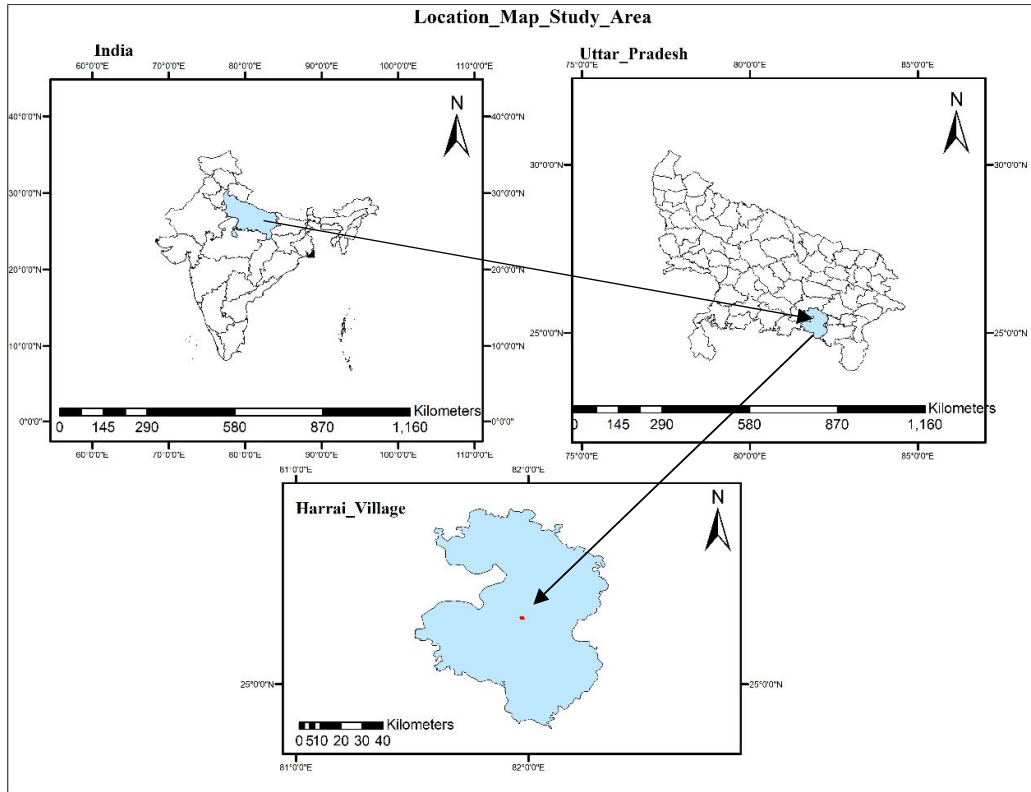


Fig 1: Study areas at Harrai village, Prayagraj

Stages of growth

Four distinct stages of plant growth were used in determining water requirement of the crop. The decades include I, II, and III while the crop growth stages include initial stage, development stage, mid-season and late season stage.

Estimation of water requirement

Crop water requirement was determined from the interrelationships of the ET, soil type, bulk density of the soil, field capacity and permanent wilting point of the soil and the effective rootzone of okra plant at the project site. The crop ET (ET_c) was estimated by FAO Penman-Monteith equation (FAO, 1998) Hatfield and Fuchs (1992) and Smith et al., 1991)

$$ET_o = ET_c = K_c (ET_o)$$

where the reference crop ET (mm/day) is as defined in equation below as:

$$ET_o = 0.408 \Delta (R_n - G) + \gamma \left[\frac{900}{T + 273} \right] u_2 (e_a - e_d) / \Delta + \gamma (1 + 0.34 u_2)$$

Where, ETo = reference evapotranspiration [$mm\ day^{-1}$], Rn =net radiation at the crop surface [$MJ\ m^{-2}\ day^{-1}$], G = soil heatflux density [$MJ\ m^{-2}\ day^{-1}$], T = mean daily air temperature at 2 m height [$^{\circ}C$], u_2 = wind speed at 2 m height [ms^{-1}], e_s =saturation vapour pressure [kPa], e_a = actual vapour pressure[kPa], $e_s - e_a$ = saturation vapour pressure deficit [kPa], D =slope vapour pressure curve [$kPa\ ^{\circ}C^{-1}$], g =psychrometricconstant [$kPa^{\circ}C^{-1}$]. Irrigation frequency was calculated usingthe relationship discussed by Michael (1999) Irrigationfrequency (days) = Field capacity of Soil – Moisture contentbefore irrigation / Daily consumptive use,

$$f_i = dg/ Cu$$

where, f_i = irrigation frequency (days), dg = gross depth of application (mm), and CU = daily consumptive use (mm/day). The CROPWAT programme(version 8.0) developed for the FAO Penman-Monteithmethod (FAO, 56) was utilized for estimating the cropwater requirement of wheat crops studied. Toensure the integrity of computations, the weathermeasurements were made at 2 m (or converted to that height)above an extensive surface of green grass, shading theground. The climatic data used for the calculations wereobtained from a meteorological station located at Lokoja.

Results

Reference crop evapotranspiration

The results obtained when a 2017-2018 period was used with theFAO-Penman Monteith method to determine the referencecrop evapotranspiration (ETo) for the area under study showthat ETo varied from a minimum value of 1.48 mm/day inDecember to the highest value of 3.98 mm/day in Aprilgiven below in Table1. The results show that ETo was lowest during the peak ofthe winter season to highest during the peak of the summer season.

Table 1. Reference Crop Evapotranspiration

Country: India Meteorological Station: SHUATS Crop: Wheat Duration: 145 days			Planting date: 27-11-2017	Harvesting date: 20- 04-2018		Altitude: 98m	
Day	Min Temp ($^{\circ}C$)	Max Temp ($^{\circ}C$)	Humidity (%)	Wind (km/day)	Sun (hours)	Rad (MJ/m ² /day)	ETo (mm/day)
Nov	9	28	38.75	1	8.55	15.425	1.59
Dec	9.7	27.6	42	1	7.5	13.9	1.48
Jan	8.5	25.8	48	1	6.1	13	1.55
Feb	11.7	30.2	43	1	7.2	16.1	2.24
Mar	18.8	36.3	37	1	8.7	20.5	3.31
Apr	24.56	39.31	38.55	2.45	8.04	21.15	3.98

where ETo = Reference Crop Evapotranspiration computed using the FAO Penman-Monteith Method.

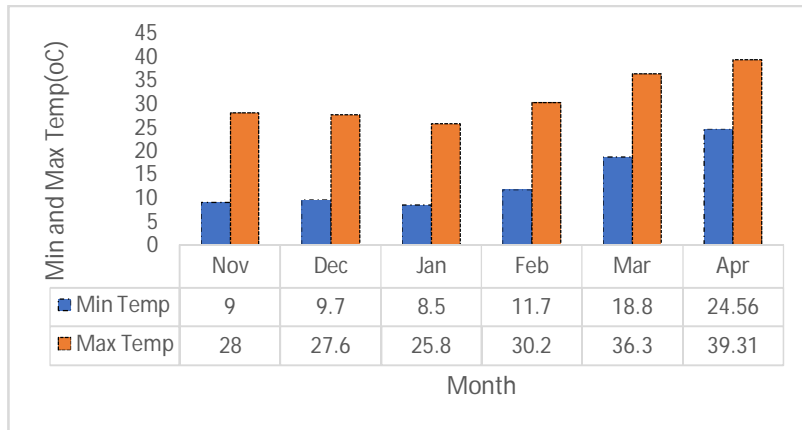


Fig 2: Minimum and Maximum Temperature 2017-2018

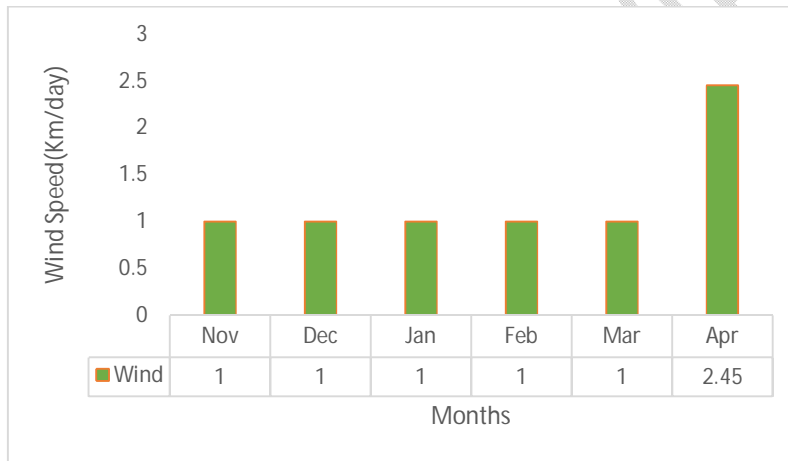


Fig 3: Wind Speed 2017-2018

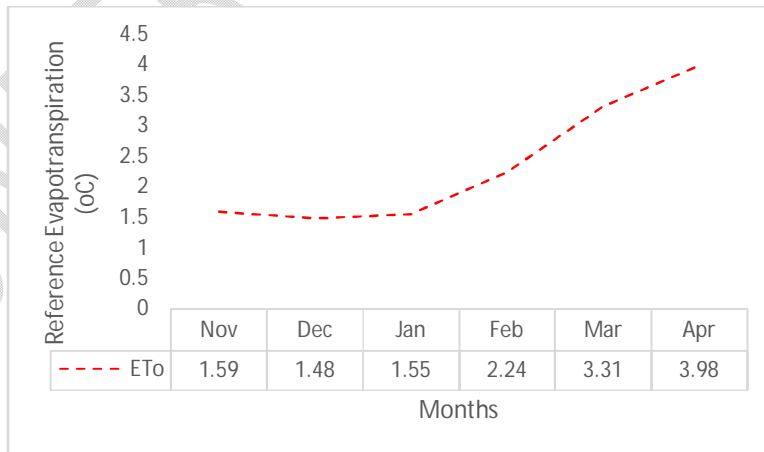


Fig 4: Reference Evapotranspiration 2017-2018

Crop water requirement

Results show that for wheat, crop evapotranspiration(ETc) and crop water requirement for varied from 0.44 to3.75 mm/day and 0.19 to 3.98 respectively (Table 2).

Table 2. Evapotranspiration and Irrigation Requirement for Wheat 2017-2018.

Month	Decade	Stage	Crop Coeff (Kc)	ETc (mm/day)	ETc (mm/dec)	Eff rain (mm/dec)	IR. Req. (mm/dec)	IR. Req. (mm/day)
Nov	3	Init	0.3	0.48	1.9	0	1.9	0.19
Dec	1	Init	0.3	0.44	4.4	0	4.4	0.44
Dec	2	Init	0.3	0.46	4.6	0	4.6	0.46
Dec	3	Deve	0.33	0.47	5.2	0	5.2	0.52
Jan	1	Deve	0.52	0.65	6.5	0	6.5	0.65
Jan	2	Deve	0.73	1.13	11.3	0	11.3	1.13
Jan	3	Deve	0.95	1.75	19.2	0	19.2	1.92
Feb	1	Mid	1.13	2.23	22.3	0	22.3	2.23
Feb	2	Mid	1.14	2.46	24.6	0	24.6	2.46
Feb	3	Mid	1.14	3.01	24.1	0	24.1	2.41
Mar	1	Mid	1.14	3.35	33.5	0	33.5	3.35
Mar	2	Mid	1.14	3.75	37.5	0	37.5	3.75
Mar	3	Late	0.99	3.62	39.9	0.1	39.8	3.98
Apr	1	Late	0.68	2.5	25	0.2	24.9	2.49
Apr	2	Late	0.38	1.63	16.3	0.3	16.1	1.61

IR = Irrigation Requirement (mm/day), IR = Irrigation Requirement (mm/dec), Kc = Crop Coefficient and ETc = Crop Evapotranspiration (mm/day) and ETc = Crop Evapotranspiration (mm/dec).

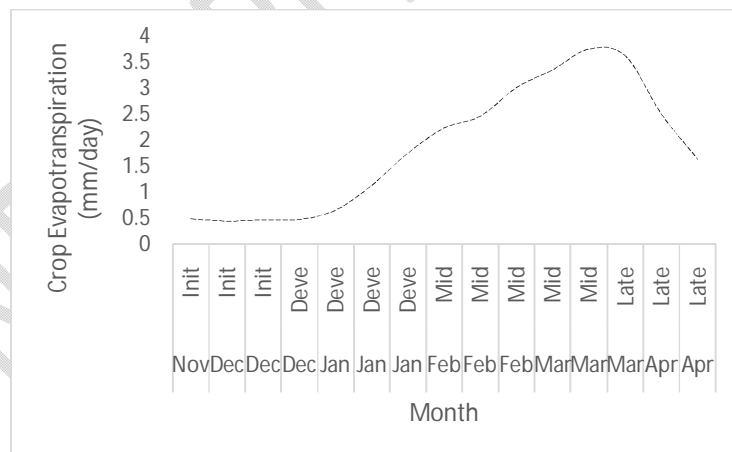


Fig 5: Crop Evapotranspiration 2017-2018

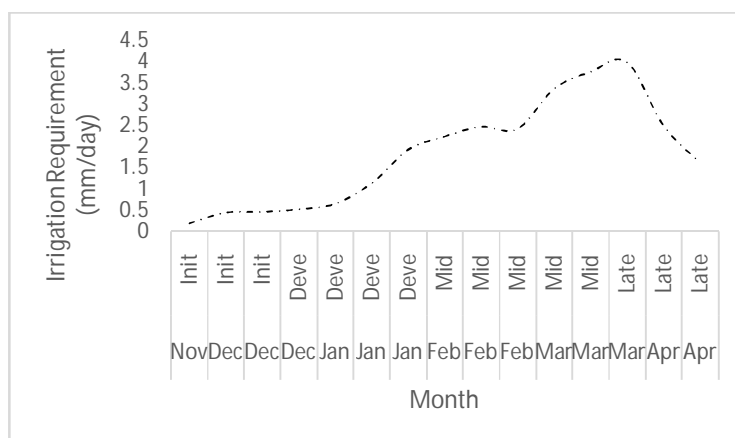


Fig 6: Irrigation Requirements 2017-2018

Scheme irrigation requirement

The estimation of actual irrigation requirement at Harrai village was carried out (Table 3). The net irrigation water requirement is 259.3 mm/season (Table 3). This is summation of the water requirement values from Planting date (27th Nov, 2017 to 20th April, 2018). Using an irrigation application frequency of 65%, the gross water requirement of 398.92 mm/season was obtained. Therefore, the entire land area of 94.43 ha will require 0.292 mm/day/ha water. The results show that the canal can conveniently supply the water required for irrigation in the area.

Table 3. Scheme Irrigation Requirements

ETo Station: SHUATS	Rain Station: SHUATS			Cropping Pattern: Wheat		
	Nov	Dec	Jan	Feb	March	April
Wheat	1.9	14.2	37.1	71.0	110.8	4.09
Net Scheme Irr. Req.						
mm/day	0.1	0.4	1.1	2.4	3.4	1.3
mm/month	1.8	13.3	34.9	66.7	104.1	38.5
l/sec/h	0.01	0.05	0.13	0.28	0.39	0.15
Irrigated area						
Total area (Ha)	102.14	102.14	102.14	102.14	102.14	102.14
Irr. Req. for actual area						
l/sec/h	0.01	0.05	0.14	0.29	0.41	0.16

Discussion

The results showed that reference and crop evapotranspiration (E_{To} and E_{Tc}) were higher in plants with a longer growing season than in plants with a shorter growing season. Also, E_{To} and E_{Tc} were higher in dry season than in winter. FAO (2005) reported that summer-grown crops require more water than winter-grown crops. Water demand was very low during peak season (due to heavy rainfall) and very high during peak season (due to lack of rain), so the range of water demands for small-field wheat was particularly high.

Conclusion

The study shows that dams can provide sufficient water for irrigation across the areas and lands currently in use. The results obtained from the study can be used by farmers to guide the selection of irrigation water quantity and frequency for the crops under study.

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