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Short Communication

Estimation of water requirement and irrigation schedule for groundnut and sunflower crops in southern Odisha using FAO CROPWAT8.0 model

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Due to increase in demand of water for irrigation and other sectors, the availability of water for agriculture sector may be limiting. Agriculture consumes the most of water in India (81 percent), which require most efficient use of water in agriculture (Surendran *et al*., 2015). In India, a greater understanding is a critical component for production of crops, proper planning and distribution of irrigation water is required. Accurate data on evapotranspiration, crop water requirements, and net irrigation requirements are required for effective irrigation planning. Crop water requirements vary from one crop to the other, season to season and region to region as well as over the course of a single crop's whole growth period. Scientific data on agricultural water requirements is required for efficient irrigation scheduling in order to determine crop production potential (Smith, 1992; Kuo *et al*., 2001). Bahadur *et al*., (2021) also reported that modeling of water requirement, water planning may be more effective in accordance with the climatic conditions and requirements for resilient agriculture.

The groundnut and sunflower crops occupy an area of 123 and 16.8 thousand ha during *rabi* season in Odisha (Odisha Agriculture Statistics, 2018-19). The groundnut crop is irrigated in an area of 5.93 thousand ha during *rabi* season. However, the irrigated area under *rabi* sunflower is low. The productivity of these crops was low due to insufficient irrigation water and poor irrigation management. The South Odisha consists of Gajapati, Kalahandi, Koraput, Malkangiri, Nabrangpur and Rayagada districts have low irrigated area during *rabi* season. These districts have 16.54 thousand ha under irrigated groundnut which accounts for 14.5 % of the rabi ground nut irrigated area in Odisha (114 thousand ha). On the otherhand, the sunflower crop in South Odisha is being grown on conserved moisture after kharif rice and only one or two irrigations are given where ever water is available. Therefore, in order to enhance the productivity of groundnut and sunflower in south Odisha through proper irrigation scheduling, the present study was carried out using long-term meteorological data of Koraput and the Penman-Monteith method (FAO, 2009).

CROPWAT 8.0 is an FAO-developed decision-support computer application that uses soil, crop, and climatic data to determine reference evapotranspiration (ET_0), crop water need, irrigation schedule, and irrigation water requirement. The programme provides general data for various crop characteristics, local climate conditions, and soil attributes and it aims to improve the irrigation schedules and the estimation of water supply for various crop patterns for both irrigated and rain-fed cropping systems. CROPWAT 8.0 can also be used to assess farmers' irrigation practices and to estimation the reference evapotranspiration, crop evapotranspiration, and irrigation water requirement.

The CROPWAT programme which requires meteorological data, soil data, and crop data for the computation of irrigation requirements for different crops. The present study was conducted by collecting the climatic data for 10 years from 2011-2020 from the Indian Institute of Soil and Water Conservation, Koraput meteorological station. Which include: monthly maximum and minimum temperatures (°C), sunshine hours (hrs), wind speed (km day^{-1}), rainfall data (mm), mean relative humidity (%), and effective rainfall data (mm). The crop coefficients for groundnut and sunflower are taken from FAO Manual 56 and soil and plant data were collaborated with CROPWAT software.

USDA method for soil conservation is used to calculate the effective rainfall using following methods.

Case 1 :Peff = Pmon * (125 - 0.2 * Pmon) / 125 (If Pmon<= 250 mm)

Case 2: Peff = 125 + 0.1 * Pmon (If Pmon> 250 mm)

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Table 1: Crop water requirement of groundnut and sunflower in the study area

Crop	Parameters	Stage				Total
		Initial	Development	Mid	Late	
Ground nut	Kc	0.4	0.80	1	0.77	
	ETc (mm)	17.0	46.4	99.6	63.7	226.7
	Effective rainfall (mm)	1.3	6.0	6.0	6.7	20.0
	Irrigation requirement (mm)	15.9	40.3	93.4	57.0	206.6
Sun flower	Kc	0.35	0.51	0.92	1.9	
	ETc (mm)	14.9	24.4	93.4	51.1	183.8
	Effective rainfall (mm)	1.3	4.4	5.6	6.5	17.8
	Irrigation requirement (mm)	13.8	20.1	87.7	44.2	165.8

Table 2: Irrigation schedules for groundnut and sunflower crop during the study period as per the CROPWAT model

Crop	Date	Day	Stage	Rain mm	Ka fraction	Eta %	Depletion %	Net irrigation (mm)	Deficit (mm)	Loss (mm)	Gross irrigation (mm)	Flow Ls^{-1} ha^{-1}
Ground nut	15Nov	1	Init	0.0	0.91	91	53	16.5	0.0	0.0	23.6	2.73
	22Nov	8	Init	0.0	1.00	100	29	11.2	0.0	0.0	15.9	0.26
	1Dec	17	Init	0.0	1.00	100	29	13.7	0.0	0.0	19.5	0.25
	13Dec	29	Dev	0.9	1.00	100	28	16.6	0.0	0.0	23.7	0.23
	24Dec	40	Dev	0.0	1.00	100	31	21.6	0.0	0.0	30.8	0.32
	4Jan	51	Mid	0.0	1.00	100	32	25.5	0.0	0.0	36.4	0.38
	16Jan	63	Mid	0.0	1.00	100	33	26.1	0.0	0.0	37.2	0.36
	27Jan	74	Mid	0.8	1.00	100	31	25.0	0.0	0.0	35.7	0.38
	6Feb	84	Mid	0.0	1.00	100	31	24.8	0.0	0.0	35.5	0.41
	16Feb	94	End	0.0	1.00	100	32	25.5	0.0	0.0	36.4	0.42
	27 Feb	105	End	1.2	1.00	100	31	24.9	0.0	0.0	35.6	0.37
	9 Mar	End	End	0.0	1.00	0	20					
Sunflower	15Nov	1	Init	0.0	0.91	91	53	17.0	0.0	0.0	24.3	2.81
	21Nov	7	Init	0.0	1.00	100	28	12.5	0.0	0.0	17.9	0.35
	30Nov	16	Init	0.0	1.00	100	27	17.8	0.0	0.0	25.5	0.33
	14Dec	30	Dev	0.0	1.00	100	29	28.1	0.0	0.0	40.1	0.33
	28 dec	44	Dev	0.0	1.00	100	30	38.3	0.0	0.0	54.8	0.45
	16Jan	63	Mid	0.0	1.00	100	31	39.7	0.0	0.0	56.7	0.35
	3Feb	81	End	1.0	1.00	100	31	40.0	0.0	0.0	57.1	0.37
	27 Feb	End	End	1.2	1.00	100	28					

Table 3: Estimated amount of irrigation (mm) required by groundnut and sunflower

Particulars	Groundnut	Sunflower
Gross irrigation	330.4	276.4
Net irrigation	221.3	193.5
Actual water use	224.6	182.5
Total rainfall	19.8	17.7
Effective rainfall	17.0	17.1
Actual irrigation requirement	207.7	165.4

Peff=Effective Precipitation; Pmon= Monthly Precipitation

In southern Odisha, during *rabi* season, the cultivation of crops usually begins after the harvest of *kharif* rice. Based on the local growing season, the groundnut and sunflower sowing dates were taken as November 15 and harvesting dates as March 14 and 4, respectively. The critical depletion ground nut and sunflower respectively considered were as 50 and 80 cm and rooting depth as 0. 80 and 1.30 m, The crop growth periods considered initial, development, mid and late season for ground nut were 20, 30, 40 and 25 days and for sunflower were 20, 25, 35 and 20 days, respectively. Crop and soil moisture conditions that are responsible for limiting crop yield than to its potential yield with respect to deficit evapotranspiration also estimated in the model.

The soils in Koraput are mainly of two types (1) Alfisols and (2) Ultisols (DLIC, 2016). In the present study, sandy loam soils were considered based on their predominance in the region. The total available soil moisture, maximum rooting depth, maximum infiltration rate, initial soil moisture depletion of this soil type were in the tune of 100 mm/meter, 30 mm/day, 900 cm, 50 per cent, respectively and the initial soil moisture was 50 mm/meter which was 50% of available soil moisture. The soil characteristics were taken from FAO, IDP-56.

The crop water requirement for the given crop duration was computed using the input *viz.* climate, crop and soil data of the region. The crop evapotranspiration (ETc) was calculated by the equation ETc = Kc × ETo.

Where, Kc: crop coefficient; ETc: crop evapotranspiration; ETo: reference evapotranspiration.

Difference between crop evapotranspiration and the effective rainfall determines the total irrigation requirement of the crop. Irrigation scheduling determines when the irrigation to be given and how much amount of water should be given to the crop at each irrigation. In this study, irrigation was scheduled at 50 per cent critical soil moisture depletion (50% Soil moisture depletion) and irrigation was applied till the soil is refilled to field capacity at 70 per cent efficiency. Estimation of the crop water requirement was carried out by using the historical weather data of the observatory of Koraput district.

Crop water and irrigation requirement

The analyzed data through CROPWAT 8.0 for sunflower and groundnut crops has been presented in Table 1. The initial to mid and later growth stages for water requirement of groundnut and sunflower was similar with the findings of Roja *et al*., (2020a, 2020b). From the observations for the groundnut crop, the Crop evapotranspiration (ET) and the crop water requirement varied from 1.04 - 2.68 mm/day and 6.4 - 25.7 mm/dec, respectively. In case of sunflower crop, it varied from 0.96 - 2.41 mm/day and 5.60 to 25.0 mm/dec, respectively. Pandey *et al.,* (2008) also reported water requirement of maize between (337 to 398 mm) in Narmada canal command area of Gujarat. From the results, the net irrigation requirement was maximum for groundnut (319.90 mm) than that of sunflower (276.40 mm). The decade (10 days) wise net irrigation requirement for groundnut varied from 11.2 - 26.10 mm/dec whereas in sunflower it varied from 6.70 - 41.10 mm/dec. The higher value for the net irrigation requirement may be due to the less effective rainfall (George *et al*., 2000; Singh *et al*., 2014; Gowda *et al*., 2013).

Irrigation scheduling

In southern Odisha, under sandy loam soils the irrigation scheduled at 50 per cent of critical depletion with a quantity of water sufficient to refill the soil upto 100% field capacity, the groundnut and sunflower require 11 and 7 irrigations, respectively during their growing periods. The total net irrigation requirement of groundnut and sunflower was 221.3 and 193.5 mm, respectively and gross irrigation requirement was 330.4 and 276.4 mm, respectively. Similar observations were also reported by Roja *et al*. (2020b) in sunflower and Roja *et al.* (2020a) in groundnut. The detailed irrigation scheduling has been reported in Table 2 and Table 3.

By using the FAO CROPWAT 8.0 model-based irrigation water estimation, the irrigation requirement of groundnut and sunflower in Southern Odisha during rabi was 206.6 and 165.8mm respectively. The model suggests that for groundnut and sunflower there is a need for 11 and 7 irrigations, respectively. Further, the use of CROPWAT model can assess the crop water requirement with a high level of accuracy and water needed for a particular crop pattern when adopted and will help in getting higher water productivity and gives greater scope in reducing the wastage of irrigation water.

Conflict of Interest Statement: The author (s) declares (s) that there is no conflict of interest.

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