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Crop water estimation and requirement of short duration rice using CROPWAT software CROPWAT 8.0

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Abstract
Crop water requirements of short duration rice crop in of Khurda district of Bhubaneswar computed with CROPWAT 8.0 using the meteorological parameters. This paper estimated the crop reference and actual evapotranspiration (ETO and Etc) respectively and the irrigation water requirement of rice (*Oryza sativa* L.). The six crop growth stages (nursery, land preparation, initial, development, mid-season, late season) and three decades (I, II, III) were considered for this crop. Crops was planted during 2016 kharif season. The study shows that crop water requirement for entire crop growth period for Kandagiri variety at Deras farm is 419.2 mm. The crop water requirement was partially met from effective rainfall (304.3 mm) and the remaining amount of water was given to crop through ground water source. The gross irrigation demand was 787.9 mm and total net irrigation was 551.6mm during crop growth period. During initial stage of crop, irrigation requirement comes around 278.8 mm for nursery and land preparation. The effective rainfall from nursery operation (July 1 decade) to initial stage (August 3 decade) was only 124.7 mm. The difference between irrigation water requirement amount and effective rainfall was about 154.7 mm which was supplied through ground water.

Keywords: crop water requirement, reference crop evapotranspiration, crop evapotranspiration, CROPWAT, irrigation water requirement and effective rainfall

Introduction
The continuing growth of world population places new demands on water resources every day. Improved management and planning of water resources are needed to ensure properuse and distribution of water among competing users. Fortunately there are opportunities for conservation and significantly more effective use of water use by the world's largest user, agriculture (Aghdasi, 2010). Accurate planning and delivery of the necessary amount of water in time and space can conserve water. The primary objective of irrigation is to apply water to maintain crop Evapotranspiration (ETc) when precipitation is insufficient. Hess (2005) [7] defined crop water requirements as the total water needed for evapotranspiration, from planting to harvest for a given crop in a specific climate regime, when adequate soil water is maintained by rainfall and/or irrigation so that it does not limit plant growth and crop yield. Each and every crop has individual water requirements. Net irrigation water requirement (NIWR) is the quantity of water necessary for crop growth. It is expressed in millimeters per year or in m3/ha per year (1 mm = 10 m3/ha). It depends on the cropping pattern and the climate. Information on irrigation efficiency is necessary to be able to transform NIWR into gross irrigation water requirement (GIWR), which is the quantity of water to be applied in reality, taking into account water losses. Multiplying GIWR by the area that is suitable for irrigation gives the total water requirement for that area. CROPWAT is a decision support system developed by the Land and Water Development Division of FAO for planning and management of irrigation. CROPWAT is meant as a practical tool to carry out standard calculations for reference evapotranspiration, crop water requirements and crop irrigation requirements, and more specifically the design and management of irrigation schemes. It allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules under varying water supply conditions, and the assessment of production under rain fed conditions or deficit irrigation (FAO, 1992) [4]. Water use requirement for same crop varies under different weather conditions. The objective of this study was to determine crop water requirements of short duration rice.

Materials and Methods
Study area: The study site is located at the research farm of ICAR-Indian Institute of Water

Management, Deras, Mendhasal situated in khurdha district, Odisha. It lies between Latitude 20°17' N and, Longitude 85°41' E; 23 m above sea level. The farm is situated 30 km away from the main institute complex.

Stages of growth: Three decades and six stages of plant growth were used in crop water requirement determination. The decades include I, II and III while the crop growth stages include nursery, nursery/land preparation, land preparation, initial stage, development stage, mid-season stage and late season stage.

Crop water requirement estimation

The term crop water requirement is defined as the "amount of water required to compensate the evapotranspiration loss from the cropped field". "Although the values for crop evapotranspiration and crop water requirement are identical, crop water requirement refers to the amount of water that needs to be supplied, while crop evapotranspiration refers to the amount of water that is lost through evapotranspiration (Allen *et al*. 1998). FAO (2005) [6] defined crop water requirement (CWR) for a given crop as:

$$CWR_i = \sum_{t=0}^{T} [K_{ci}.ET_0 - P_{eff}]$$

Unit= mm

Where

kci	=	is the crop coefficient of the given crop
i	=	during the growth stage t
T	=	is the final growth stage.

$$ETc = Kc \times ETo$$

Where

Kc = crop coefficient and

ETO = reference crop Evapotranspiration (mm/day) is as defined in equation below as:

Reference crop Evapotranspiration

The reference evapotranspiration ET_0 of individual agro-ecological units are calculated by FAO Penman- Monteith method, using decision support software –CROPWAT 8.0 software, developed by FAO (FAO Irrigation and Drainage Paper 56) (FAO 1998). The FAO CROPWAT program (FAO, 2009) incorporates procedures for reference crop evapotranspiration and crop water requirements and allow the simulation of crop water use under various climate, crop and soil conditions (www.fao.org). Reference crop Evapotranspiration (mm/day) is as defined in equation below as

$$ET_0 = \frac{0.408\Delta(Rn - G) + Y\frac{000}{T+273}\mu_2[e_s - e_a]}{\Delta + \gamma[1 + 0.34\mu_2]}$$

Where

ET_o = reference evapotranspiration [mm day^{-1}]
R_n = net radiation at the crop surface [MJ m^{-2} day^{-1}]
G = soil heat flux density [MJ m^{-2} day^{-1}]
T = mean daily air temperature at 2 m height [°C],
μ_2 = wind speed at 2 m height [m s^{-1}]
e_s = saturation vapour pressure [kP$_a$]
e_a = actual vapour pressure [kP$_a$]
$[e_s - e_a]$ = saturation vapour pressure deficit [kP$_a$]
Δ = slope vapour pressure curve [kP$_a$ °C^{-1}]
γ = psychrometric constant [kP$_a$ °C^{-1}]

Results

It is understood that the crop water requirement for entire crop growth period for Kandagiri variety at Deras farm is 419.2 mm. The crop water requirement was partially met from effective rainfall (304.3 mm) and the remaining amount of water was given to crop through ground water source. During initial stage of crop, irrigation requirement comes around 278.8 mm for nursery and land preparation. The effective rainfall from nursery operation (July 1 decade) to initial stage (August 3 decade) was only 124.7 mm. The difference between irrigation water requirement amount and effective rainfall was about 154.7 mm which was supplied through ground water.

The crop water demand from development stage of the crop (September 1 decade) to final stage (November 1 decade) was 140.3 and effective rainfall from development stage of the crop (September 1 decade) to final stage (November 1 decade) was 252.6 mm which was higher than irrigation requirement. It indicates that at initial and final stage crop, additional water resource like canal / ground water / stored rainwater in on-farm reservoirs is very much needed in addition of rainfall to meet crop water demand as well for land preparation in this area. It is also understood that, if there is no additional water sources like ground water, it is better to go for direct seeding of rice where farmer can avoid water demand for nursery and land preparation.

Table 1: Evapotranspiration and Irrigation Requirement for short duration Rice

Station: Deras **Transplanting Date**: 19 August 2016 **Crop**: Rice							
Month	**Decade**	**Stage**	**Kc Coeff**	**Etc mm/day**	**ETc mm/dec**	**Eff. Rain mm/dec**	**Irr.Req mm/dec**
Jul	3	Nurs/LPr	1.11	4.23	12.7	12.2	79.4
Aug	1	Nurs/LPr	1.06	5.96	59.6	39.6	20
Aug	2	Init	1.07	5.89	58.9	35.3	153.6
Aug	3	Init	1.1	5.77	63.5	37.6	25.8
Sep	1	Deve	1.1	5.52	55.2	43.6	11.6
Sep	2	Deve	1.13	5.36	53.6	46.7	6.9
Sep	3	Mid	1.15	5.3	53	36.7	16.3
Oct	1	Mid	1.15	5.16	51.6	24.1	27.5
Oct	2	Late	1.14	4.95	49.5	15	34.6
Oct	3	Late	1.06	4.3	47.3	11.2	36.1
Nov	1	Late	1	3.77	11.3	2.4	7.3
Total					516.2	304.3	419.2

Where N = Nursery Stage, N/LP = Nursery/Land Preparation Stage, I = Initial Stage,D = Development Stage, M = Mid- Season Stage, L = Late Season Stage, Kc = Crop coefficient, ETc = Crop Evapotranspiration, IR = Irrigation Requirement

Discussion

The range of water requirement for lowland rice was particularly high because the water requirement during the peak rainy season (due to large amount of rain water) was very low while that of the peak dry season (no rainfall) was very high.

Conclusion

The study shows that the dam can conveniently supply the water required for irrigation in the area used at present and also in the entire land area. The results obtained from the study can be used as a guide by farmers for selecting the amount and frequency of irrigation water for the main crops. Irrigation requirement will vary based on the availability of rainfall. Therefore it is further suggested that water saving practices or techniques for water conservation should be adopted for irrigation on rice crops

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