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Evapotranspiration and water-use efficiency of chilli crop (*Capsicum annum* L.) in arid environment

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ABSTRACT

Lysimetric studies on chilli crop *Capsicum annum* L. cv. Haripur and Raipur) were conducted at Jodhpur during three *kharif* seasons viz., 2006, 2007 and 2008 to determine evapotranspiration requirements during different growth stages under three treatments of irrigation (viz., 100% potential evapotranspiration (PET), 50% of PET and control (10 irrigations each of 30 mm depth). The crop coefficients (ratio of evapotranspiration to reference evapotranspiration) were 0.38-0.47 at early growth stage, 0.39-0.69 at vegetative stage, 0.85-1.00 at flowering/fruit formation stages and 0.34-0.91 at fruit development/maturity stage with an average value of 0.62 for the entire season. The seasonal evapotranspiration for unstressed chilli crop (Irrigated @100%ET) was 620 mm in 2006, 548 mm in 2007 and 552 mm in 2008 with a mean of 573 mm. The highest dry fruit yield was obtained in 2008 due to the favourable weather conditions and least termite attack, resulting in highest water-use-efficiency of 1.84 kg of dry-fruit ha^{-1} mm^{-1} The water-use efficiency of chilli was highest (0.295-2.392 kg of dry-fruit ha^{-1} mm^{-}) for the crop grown at 50%ET rate of irrigation.

Key words: Chilli crop, arid zone, evapotranspiration rates, crop coefficients, water use efficiency

Chillies are extensively grown in the tropics. India is one of the leading chilli producing countries in the world with an area of 0.45 million ha and production 0.9 million tonnes. The average yield of chilli is 12 t ha^{-1} (Hegde and Srinivas, 1991).

High day temperatures 36±2^{O}C and night temperatures 27±2^{O}C significantly reduced the fruit growth of chilli, inhibit fresh and dry fruit weight and reduced the carbohydrate content (Pagamas and Nawata, 2007). The fruit yield of hybrid chilli cultivars increase with N fertilizer up to 150 kg N ha^{-1} irrespective of cultivars (Khurana *et al.,* 2006). The water requirement of summer chilli (Capsicum sp.) at Akola increased with stage of the crop (Ingle, 2007). Additional irrigation significantly increased the fruit yield (Palled *et al*., 1985 and Lourduraj, 2003). The present study is to quantify the crop evapotranspiration and water use efficiency of chilli in arid environment.

MATERIALS AND METHODS

The lysimetric study on chilli (*Capsicum annum* L. cv. Haripur and Raipur) was conducted at Central Arid Zone Research Institute, Jodhpur (26^{0}18$^{'}$N, 73^{0}01$^{'}$ E and 223 m above MSL) in Northwest India during three *kharif* seasons 2006, 2007 and 2008. The weather data were recorded at agrometeorological observatory located close to the crop field. The evapotranspiration (ET) was measured using three gravimetric lysimeters. The reference evapotranspiration was determined from class A pan evaporation after multiplying with a pan coefficient (Allen *et al*., 1998 and FAO, 1977). The pan coefficients for *kharif* season at Jodhpur region were between 0.75 and 0.85, the values were taken based on FAO (1977) guidelines as well as pan coefficients determined comparing with potential evapotranspiration using Penman-Monteith formula. The chilli plants raised in a nursery during pre-monsoon season (May-June) were taken after 30 days and planted in lysimeters as well as in surrounding field (5 X 5 m) after receiving a good shower of southwest monsoon rainfall. After transplanting, the crop was maintained under three irrigation treatments, namely (a) irrigated daily with an amount equal to 100% of potential evapotranspiration (PET) of the previous day (b) irrigated every fourth day with an amount equal to 50% of PET of the previous 4 days, and (c) control plots with 10 irrigations (weekly) each of 30 mm depth. Each of these three lysimeters were surrounded by field plots of size 5 x 5 m which were maintained with irrigation at the same level as in the lysimeters. From the daily data, weekly totals/means of weather parameters from the date of transplanting to maturity were computed. Water use efficiency (WUE) was computed as a ratio of dry fruit yield (kg ha^{-1}) to crop evapotranspiration (mm).

RESULTS AND DISCUSSION

Daily evapotranspiration rates

The weekly variation in evapotranspiration (ET)

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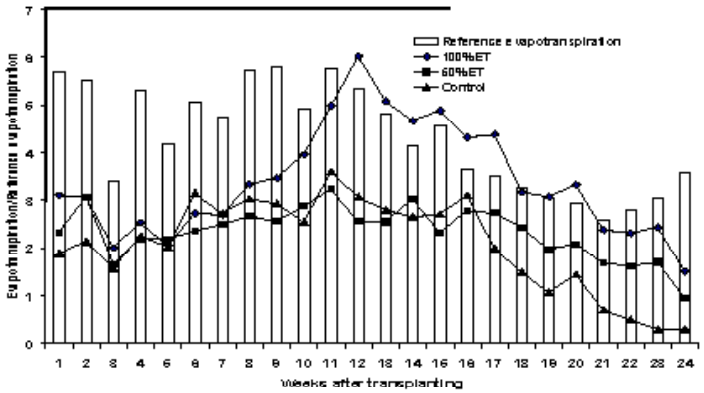

Fig. 1: Evapotranspiration rates of chilli crop and reference evapotranspiration at Jodhpur (2006-2008)

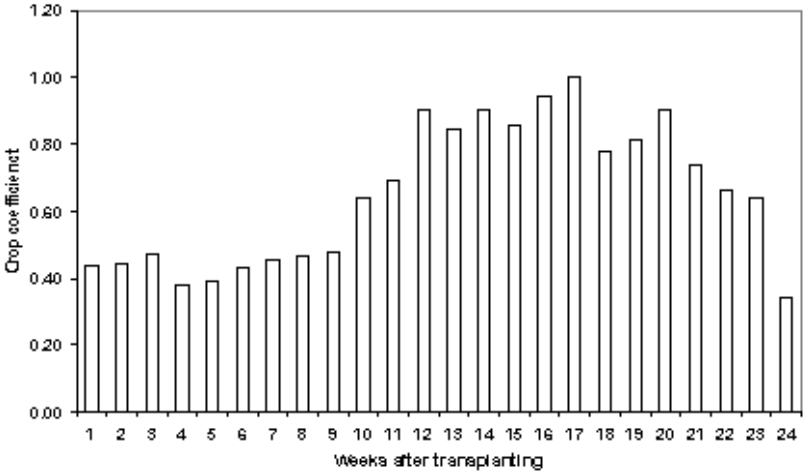

Fig. 2: Crop coefficients for chilli at Jodhpur (2006-2008)

rates of chilli crop (cv.*Haripur Raipur*) at 100%ET rate irrigated, 50%ET rate irrigated and control crops measured at Jodhpur using gravimetric lysimeters along with reference evapotranspiration during 2006 to 2008 *kharif* season are shown in Fig.1. The mean evapotranspiration rates of unstressed (100%ET rate irrigated) chilli crop were 2.0-3.1 mm day^{-1} during early growth, 2.1-6.0 mm day^{-1} at vegetative stage, 3.1-5.1 mm day^{-1} at flowering/fruit formation stage and 1.5-2.4 mm day^{-1} at fruit development/maturity stage (Fig.1)

Crop coefficients

The weekly mean crop coefficients (ratio of evapotranspiration to reference evapotranspiration) of chilli for the three year period were 0.38-0.47 at early growth stage, 0.39-0.69 at vegetative stage, 0.85-1.00 at flowering/fruit formation stages and 0.34-0.91 at fruit development/maturity stage (Fig.2). The mean crop coefficient for the entire season was 0.62. It is due to the shallow type of root system (2-30 cm deep) that chilli crop requires frequent irrigation rather than heavy irrigation.

Fruit yield, seasonal evapotranspiration and water-use efficiency

The fresh and dry fruit weight of chilli during 2006 to 2008 under three moisture conditions are given in Table 1. Highest yield of 1018 kg ha^{-1} of dry chilli was achieved during 2008 due to the good weather conditions and least termite attack. Termite attack was reduced when soil temperature was below 35^{o}C and soil moisture was adequate (> 50% AWC). The seasonal evapotranspiration (from transplanting to maturity + water used towards nursery) for unstressed chilli crop was 620 mm in 2006, 548 mm in 2007 and 552 mm in 2008 with a mean of 573 mm.. The water of 125 mm used by chilli plant during 30 days of nursery of a small plot was equivalent to 25 mm of transplanted area, an amount which was added to the seasonal evapotranspiration from transplanting to maturity. The average seasonal evapotranspiration of chilli grown at 50%ET rate irrigation was 397 mm, whereas for chilli grown under control conditions it was 349 mm (Table

Table 1: Fresh and dry fruit yield of chilli at Jodhpur

Year	Fresh fruit yield (kg ha^{-1})			Dry fruit yield (kg ha^{-1})		
	100%ET	50%ET	Control	100%ET	50%ET	Control
2006	1272	1189	296	163	155	54
2007	1127	872	620	141	113	81
2008	8491	6899	5828	1018	897	758
Mean	3630	2987	2248	440	388	298

Table 2: Seasonal evapotranspiration and water-use efficiency of chilli

Year	Seasonal evapotranspiration (mm)			Water-use efficiency (kg ha^{-1} mm^{-1})		
	100%ET	50%ET	Control	100%ET	50%ET	Control
2006	620	432	284	0.263	0.358	0.190
2007	548	383	380	0.257	0.295	0.213
2008	552	375	384	1.844	2.392	1.974
Mean	573	397	349	0.768	0.977	0.854

2). The mean water-use efficiency of chilli was 0.768 kg ha^{-1} mm^{-1} at 100%ET rate irrigated crop, 0.977 kg ha^{-1} mm^{-1} for 50%ET rate irrigated crop and 0.854 kg ha^{-1} mm^{-1} for control chilli (Table.2), thus indicating highest water-use efficiency at 50%ET rate irrigated crop.

CONCLUSIONS

The daily evapotranspiration rates of chilli for un-stressed (100%ET rate irrigated) were between 1.9 and 7.2 mm day^{-1}. The crop requires shallow and frequent irrigation with the seasonal values 548-620 mm for 100%PET crop, 383-432 mm for 50%PET crop and 284-384 mm for control crop (10 irrigations of 30 mm each). The crop coefficients for chilli were between 0.38 and 1.00 depending upon the stage of the crop. The water-use efficiency of dry fruit of chilli varied from 0.190 to 2.392 kg ha^{-1} mm^{-1}.

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