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YIELD AND WATER USE OF ALMOND UNDER DRIP IRRIGATION

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ABSTRACT

An experiment was conducted at Central Institute of Temperate Horticulture, Srinagar, Kashmir on almond (*Prunus dulcis* Mill.) cv. 'Shalimar' plantation to standardize the water requirement for yield optimization in almond. The study revealed that vegetatively propagated almond plants positively responded to irrigation. The irrigation, applied according to different ETc levels, improved yield and yield contributing attributes of almond significantly. Highest nut yield (2.42 kg tree^{-1}) was recorded at 100% ETc during 1st year of experimentation which increased to 2.91 kg tree^{-1} in the subsequent year. Similarly, highest shelling percentage (53%) was recorded in nuts receiving full irrigation during the 2nd year of experimentation. The highest yield and yield contributing attributes of almond, recorded at 100% ETc level of irrigation, were statistically at par with measured parameters recorded at 75% ETc level of irrigation.

Keywords: Almond, evapotranspiration, micro-irrigation, *Prunus dulcis,* water requirement, yield

INTRODUCTION

Water status of a plant is the single most important factor that must be controlled through irrigation to obtain higher yields and good quality fruits. For maximum growth, optimum yield, quality and orchard longevity, almond trees should receive fairly good quantity of water. Water stress affects almond trees not only during the years of stress but also in the subsequent seasons (Goldhamer and Fereres, 2004). It also reduces vegetative growth and subsequently reduces nut load and yield (Prichard, 2003).

Almond (*Prunus dulcis* Mill.) is one of the most important nut crop, grown mainly for its kernels which are concentrated source of energy and rich in fat, protein, minerals and vitamins. The kernels and their oil (Rogne-Badam) have medicinal value and are important meteria-medica in Ayurvedic and Yunani system of medicine. Almond is considered a drought tolerant plant and is often grown as a rainfed crop (Girona *et al.*, 1993). For commercial production, almond needs to be irrigated during growing season (Goldhamer and Smith, 1995). Almond trees utilize water at a fast rate; much faster than any other fruit and nut tree. If almond trees are under-irrigated during stress-sensitive periods then several important tree processes get adversely affected (Goldhamer, 1995). A major amount of almonds are imported from California (USA) primarily because of bold kernel size and attractive colour which is lacking in Indian almonds. The almonds in India are produced under rain-fed conditions so nuts are often shrivelled and less attractive in colour.

A very high percentage of almond orchards in India and particularly in Kashmir valley lack irrigation facilities and the rainfall is the only source of moisture, which is unevenly distributed. On the other hand, traditional irrigation system i.e. flooding is still practiced by a majority of orchardists resulting in wastage of a scarce commodity besides its ill effects on fruit quality. There is a great potential for bringing more area of land under fruit cultivation in hilly rainfed areas of Kashmir, provided appropriate irrigation methods are devised for adoption by farmers in these areas. Since no work has been done on the water requirement of almond in Kashmir valley so far, therefore, the present investigation was aimed to standardize the requirement of drip irrigation almond and to determine its response to different irrigation levels.

MATERIALS AND METHODS

The present investigation was conducted at Central Institute of Temperate Horticulture (CITH), Srinagar, KAshmir on almond (*Prunus dulcis* Mill) plantation during 2008 and 2009. The study was undertaken on 8 year old almond cv. 'Shalimar' trees, spaced at 4 x 4 m on a sandy loam soil. The experiment was carried out in a randomized block design with each treatment replicated four times. The treatments consisted of 3 irrigation levels *viz*., 100% ETc (I_1), 75% ETc (I_2) and 50% ETc (I_3), applied at different phenological stages and no irrigation [0% ETc (I_0)]. The irrigation was applied through drip scheduled daily. Pressure compensated drippers @ 4 L h^{-1} discharge was used. Four drippers were placed equidistant in east, west, north and south directions at 50% distance of canopy radius. Crop evapotranspiration (ETc) was estimated by using evaporation data recorded with class-A evaporation pan and crop-coefficients (K_c) for mature almond trees, adjusted for canopy size based on orchard floor shaded area (Snyder and Pruitt, 1989). The Kc was taken as 0.38 for the month of March, 0.52 for April-May, 0.60 for June, July and August, and 0.54 for September. The quantum of irrigation was estimated as per FAO method (Allen *et al.*, 1999).

$$ETc = \frac{E_{pan} \text{ x } K_p \text{ x } K_c \text{ x AA x AC}}{IE}$$

Where, ETc = Crop evapo-transpiration; E_{pan} = Daily pan evaporation data; K_c = Crop efficient; K_p = Pan coefficient (taken as 0.8); AA = Area allotted per plant; AC = Area shaded by canopy at noon; IE = Irrigation efficiency of system (85%) taken as decimal.

$$\therefore \text{ Irrigation amount (L tree}^{-1} \text{ day}^{-1}) = [\text{ETc} - \text{Effective rainfall}]$$

The effective rainfall in experimental soil was 50% of total rainfall (calculated as water holding capacity). Nut yield of almond was recorded after nut harvest from each experimental tree and nuts weighed after air-drying to 3.8-5.2% moisture level. From average weights of nuts and kernel, shelling percentage (proportion of initial almond weight that is the kernel) was worked out as under:

$$\text{Shelling percentage} = \frac{\text{Average kernel weight}}{\text{Average nut weight}} \text{ x } 100$$

The data was statistically analyzed as per Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The monthly weather data recorded at Meteorological Observatory, Srinagar (Kashmir) and Pan evaporimeter (installed in the field) during experimentation period is given in Table 1. The monthly average crop water requirement (ETc) of almond calculated during the study period is presented in Table 2.

Nut and yield characteristics

The irrigation is necessary for enhancing the yield of almond. For maximum growth, yield, crop quality and orchard longevity the almond trees need regular irrigation (Goldhamer, 1995). Any amount of water stress reduces vegetative growth therby resulting in subsequent reduction in nut load and yield

Table 1: Meteorological data (monthly average values) for the years 2008 and 2009

Months	2008					2009				
	Temperature (°C)		Relative humidity (%)	Rainfall (mm)	Evapo-ration (mm)	Temperature (°C)		Relative humidity (%)	Rainfall (mm)	Evapo-ration (mm)
	Maximum	Minimum				Maximum	Minimum			
January	4.84	-2.61	88.35	84.5	6.1	8.20	0.09	92.01	86.5	10.9
February	8.15	-1.86	90.10	102.4	9.0	10.42	1.02	87.21	103.8	13.2
March	18.97	3.76	70.25	2.3	70.0	15.65	3.79	81.93	48.0	56.1
April	19.41	6.28	77.56	114.0	78.2	19.91	6.93	79.30	108.3	88.2
May	24.97	9.73	76.70	39.0	138.2	24.95	8.84	74.26	52.2	124.5
June	29.47	16.45	78.73	29.0	154.7	27.48	11.12	80.35	70.6	136.7
July	29.50	17.24	77.74	84.0	150.0	29.70	14.98	81.64	46.6	165.5
August	29.51	17.78	76.74	45.0	142.9	31.57	16.45	76.41	22.2	170.5
September	26.55	11.25	76.13	30.0	88.6	28.98	10.71	83.76	29.0	119.6
October	22.93	6.91	79.51	32.0	69.4	22.89	3.74	86.16	4.0	74.1
November	14.69	0.37	89.71	57.0	32.1	14.08	0.17	85.03	48.2	34.1
December	9.69	0.20	91.00	51.0	16.7	10.09	-1.08	89.64	15.5	17.7

Table 2: Month-wise crop water requirement for almond during the growing season at 100% ETc by pan evaporation method during 2008 and 2009

Month	2008			2009		
	Epan (mm day^{-1})	Crop co-efficient (Kc)	ETc* (L tree^{-1} day^{-1})	Epan (mm day^{-1})	Crop co-efficient (Kc)	ETc (L tree^{-1} day^{-1})
March	-**	-	-	1.81	0.38	10.35
April	2.60	0.52	20.35	2.94	0.52	23.02
May	4.45	0.52	34.84	4.01	0.52	31.40
June	5.15	0.60	46.53	4.55	0.60	41.11
July	4.85	0.60	43.82	5.35	0.60	48.35
August	4.70	0.60	42.46	5.50	0.60	49.70
September	2.95	0.52	23.10	3.98	0.52	31.17

*Based on 85% irrigation efficiency of drip irrigation method;
**The experiment was started in April, 2008. The pan co-efficient (Kp) for experimental farm was taken as 0.8; Epan = Pan evaporation data; Etc = Crop evapo-transpiration

(Prichard, 2003). In present investigation irrigation improved nut yield of almond significantly (Fig. 1). Highest nut yield (2.42 kg tree^{-1}) was recorded at 100% ETc in the 1st year of experimentation which increased to 2.91 kg tree^{-1} at the same irrigation level in the subsequent year. However, the nut yield of almond recorded at 100% Etc was at par with that of 75% Etc level of irrigation during respective same years. The better performance of crop at higher evaporation replenishment is probably a result of better maintenance of internal water balance by the plants and an improved utilization of water and nutrients, thereby increasing the amount of carbohydrates available for fruit growth. The low yield at lower irrigation levels could be due to the significant reduction in photosynthesis that resulted in lower canopy volume and carbohydrate accumulation therby reducing the necessary reserves for shoot growth in the subsequent year (Romero *et al.*, 2004). Since the almond trees, besides spurs, bear fruit buds on one year old shoots, the vigorous shoot growth occurs during early fruit growth stages. Water deficit reduces canopy development and thus decreases the yield (Torrecillas *et al.*, 1989). The carry-over effect of a few consecutive years of deficit irrigation reduces the plant capacity to accumulate dry matter in their kernels,

Table 3: Effect of different irrigation levels on nut yield, shelling percentage and percent shrivelled kernel of almond cv. 'Shalimar'

Irrigation levels*	2008			2009		
	Nut yield (kg tree^{-1})	Shelling (%)	Shrivelled (%)	Nut yield (kg tree^{-1})	Shelling (%)	Shrivelled (%)
I_0	1.69	47.84	9.18	1.70	46.07	10.56
I_1	2.42	52.16	0.00	2.91	53.00	0.00
I_2	2.33	51.50	0.00	2.84	52.38	0.25
I_4	2.03	50.90	2.06	2.21	50.42	0.93
$CD_{0.05}$	0.26	0.78	0.6	0.28	0.76	0.5

*I_0 = 0% ETc; I_1 = 100% ETc; I_2 = 75% ETc; I_3 = 50% ETc

therebyinfluencethecropping efficiency (Girona *et al.*, 2005). The present findings are in conformity with those of Mousavi and Alimohamadi (2006). The findings of Hutmacher *et al*. (1994) also revealed that the yield of almond decreased significantly by reducing water to 50% ET_C level and low yield was due to decrease of canopy size and weight of fruit as well as number of flowers. Significantly higher yield with irrigation in peach has been reported by Bryla *et al.* (2003) and in plum by Naor *et al.* (2004).

The shelling percentage of almond significantly increased with irrigation (Table 3). Maximum shelling percentage (53%) was observed at 100% ET_C followed by 75% ET_C levels of irrigation and minimum in no irrigation (47.84%). The increase in shelling percentage was owing to irrigation as the irrigated trees produced least number of shrivelled kernels (Table 3), besides a significant improvement in kernel weight and size. Significantly higher kernel percentage with irrigation have been noted by Velverde *et al.* (2006). The present findings are in agreement with Mousavi and Alimohamadi (2006) who reported that deficit irrigation and drought increased the percentage of shrivelled kernels and decreased the shelling percentage of almond. Similar results have been found by Goldhamer and Smith (1995).

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