INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2007/09–2–271–273
http://www.fspublishers.org

Effect of Water Stress on Crop Yield and Yield Components of Cantaloupe

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ABSTRACT

The effects of water stress on yield and yield components of cantaloupe (*Cucumis melo* SP.) were studied. The site was located at 873 m altitude, 35°N latitude and 52°E longitude, in arid climate and a clay loam soil in the center of Iran. Four irrigation treatments based on 10, 30, 50 and 70% available water deficit (AWD) were applied in both the growing seasons. Irrigation treatments were designed to induce a range of water stress between emergence and harvest. Number of fruits per plant, fruit weight and fruit thickness were measured and consequently crop yield and water use efficiency (WUE) were determined. Results indicated that water stress significantly ($P \leq 0.01$) affected the number of fruits per plant and fruit weight, but there was no significant variation in fruit thickness among the irrigation treatments. Number of fruits per plant and fruit weight was highest at 30% and lowest for the treatment irrigated based at 70% AWD. Furthermore, water stress significantly affected yield of cantaloupe in the order of 10% > 30% > 50% > 70% AWD. The highest crop yield (29.10 t ha^{-1}) was obtained for the treatment applied based on 10% AWD. The yield from other treatments varied between 26.62 and 18.78 t ha^{-1} and found to be lowest (17.26 t ha^{-1}) for the treatment irrigated based on 70% AWD. The WUE of the treatments irrigated based on 10 and 30% AWD were markedly higher than the other treatments. The highest WUE (0.88 t ha^{-1} cm^{-1}) was obtained at 30% and lowest (0.52 t ha^{-1} cm^{-1}) at 70% AWD. Among the treatments, 30% AWD was more effective in improving WUE.

Key Words: Water stress; Cantaloupe; Yield; Water use efficiency

INTRODUCTION

Cantaloupe (*Cucumis melo*) is one of the most important vegetable crops of Iran and it ranks fifth in cultivated area and production after tomato, cucumber, watermelon and melon. The average production of cantaloupe has been 750 thousands tones during the last five years. The soil and climatic are ideal for cantaloupe production in Iran but aridity is a dominant factor for limiting the economical yield.

Water is a major constituent of living organism. It comprises about 80 - 90% of fresh weight of herbaceous plants and over 50% of woody plants. Water furnishes a suitable medium for many biochemical reactions. Also, sufficient water must be present in active crop root zone for germination, evapotranspiration, nutrient absorption by roots, root growth and soil microbiological and chemical processes that aid in the decomposition of organic mater and mineralization of nutrients. These factors are necessary for sustaining crop growth on a particular field (Fitter, 1981).

Under limited water supply conditions the farmer tends to increase the irrigation interval, which creates water stress (Jain *et al.*, 2000). Water stress is one of the most important factors affecting every aspect of plant growth (Rahman *et al.*, 2004). Physiological changes in plants, which occur in response to water stress conditions decrease photosynthesis and respiration (Hall *et al.*, 1990) and as a result overall production of the crop is decreased. As deficit irrigation results in crop water stress and reduced crop yields water must be applied frequently to avoid crop water stress and adequately to recharge the active plant root zone (Sammis *et al.*, 2000).

Although the effects of water stress on growth and yield of different crops have been studied during the last years (Tahir & Mehdi, 2001; Aslam & Tahir, 2003; Ahmad *et al.*, 2003; Kumaga *et al.*, 2003; Hussain *et al.*, 2004; Khan *et al.*, 2004; Rahman *et al.*, 2004) very little work has been done to study the effects of water stress on cantaloupe in arid lands of Iran. The present work was, therefore carried out to study the effects of water stress on crop yield and yield components of cantaloupe.

MATERIALS AND METHODS

The field experiments pertaining to the effects of different water stress level on the crop yield and yield components of cantaloupe were conducted during 2004 and 2005 growing seasons in the Garmsar, Iran. The site is located at 873 m altitude, 35°N latitude and 52°E longitude, in arid climate in the center of Iran, where the summers are dry and hot while winters are cool. The soil of the experiment site is a fine, mixed, thermic, Typic Haplacambids clay-loam soil with bulk density of 1.46 g cm^{-3}, field capacity of 23% and wilting point of 9.5% (dry basis weight).

The experiment was consisted of four irrigation treatments based on 10, 30, 50 and 70% available water deficit (AWD). Irrigation treatments were designed to induce a range of water stress between emergence and harvest. The experiment was laid out in a randomized complete block design (RCBD) having three replications. The net plot size was 10.0 m × 6.0 m. A buffer zone of 3.0

m was maintained between plots. There were two furrows in each plot. The furrows had 10.0 m long, 75 cm wide and 50 cm depth and crop was sown on the both sides of each furrow by keeping plant to plant distance 50 cm.

In both growing seasons, moldboard plow and disk harrow were used for tillage operations and furrower for making furrows in the plots. Cantaloupe variety Varamin Samsoori was sown manually at the rate of 2.5 kg ha^{-1} on 5th May. The seed moisture and germination percentage were 5 and 95%, respectively. Recommended levels of N (450 kg ha^{-1}), P (100 kg ha^{-1}) and K (100 kg ha^{-1}) were used as Urea, TSP and SOP, respectively. All other necessary operations such as pest and weed controls were performed according to general local practices and recommendations. For all treatments, irrigation scheduling was based on the basis of 10, 30, 50 and 70% depletion of the available soil water. The calculation assumed the soil to be at field capacity after establishment irrigation being applied to all treatments.

The main components observed in this study were number of fruits per plant, fruit weight and fruit thickness. Total three pickings of cantaloupe were taken. The weight and thickness of fruits from each plot were recorded at each peaking. Then, the total crop yield and WUE were determined for all treatments. The effectiveness of any crop to use water during its complete growth period is generally described in terms of WUE and is expressed as ratio of total crop yield to total depth of water applied to crop including effective rainfall during its complete growth period (Jain *et al.*, 2000; Steyn *et al.*, 2000):

$$WUE=CY/WA$$

Where:

WUE = water use efficiency, t ha^{-1} cm^{-1}

CY = total crop yield, t ha^{-1}

WA = total depth of water applied, cm.

Data on crop yield and yield components were recorded by using standard procedures. All the data were subjected to analysis of variance as proposed by Steel and Torrie (1984) and treatment means were compared by Duncan's Multiple Range test at 1% probability. The SPSS software was used for statistical analysis.

RESULTS

Number of fruits per plant. A significant effect of different water stress treatments on number of fruits per plant was noted during both the years of study (Table I). The highest number of fruits (3.77 plant^{-1}) was obtained at 30% and lowest (2.03) at 70% AWD (Table II).

Fruits weight. A significant effect of different water stress treatments on fruit weight was also found during the years of study (Table I). The highest fruit weight of 1520 g was obtained for the treatment irrigated based on 30% AWD and lowest (1030 g) for the treatment irrigated based on 70% AWD (Table II).

Fruits thickness. A non-significant effect of different water stress treatments on fruit thickness was found during both the years of study (Table I). However, the highest fruit thickness (3.60 cm) was obtained at 30% and lowest (3.20 cm) at 70% AWD (Table II).

Crop yield of cantaloupe. A significant effect of different water stress treatments on crop yield of cantaloupe was also found during the years of study (Table I). The mean crop yield of cantaloupe in different water stress treatments (mean of 2004 & 2005) revealed that the highest crop yield (29.10 t ha^{-1}) was obtained at 10% and lowest (17.26 t ha^{-1}) at 70% AWD (Table II).

Water applied and water use efficiency (WUE). Total amounts of irrigation water applied to each water stress treatment during both the years of study (mean of 2004 & 2005) showed that the highest amount of irrigation water (39.0 cm) was applied at 10% and lowest (30.0 cm) at 30% AWD. The WUE of treatments irrigated based on 10% and 30% AWD were markedly higher than the other treatments. The highest WUE (0.88 t ha^{-1} cm^{-1}) was obtained at 30% and lowest (0.52 t ha^{-1} cm^{-1}) at 70% AWD. The WUE for other treatments varied from 0.56 to 0.75 t ha^{-1} cm^{-1}.

DISCUSSION

In this study, there was significant difference in number of fruits per plant and fruit weight but no difference was recorded in fruit thickness among the different water stress treatments. However, water stress affected yield components in the order of 30% AWD > 10% AWD > 50% AWD > 70% AWD. The highest value of number of fruits per plant (3.77), fruit weight (1520 g), and fruit thickness (3.60 cm) was observed at 30%, while lowest value of number of fruit per plant (2.03), fruit weight (1030 g) and fruit thickness (3.20 cm) were noted at 70% AWD treatments. Also, water stress significantly affected crop yield of cantaloupe in the order of 10% > 30% > 50% > 70% AWD. The highest value of crop yield (29.10 t ha^{-1}) was obtained at 10% AWD treatment, while lowest value of crop yield (17.26 t ha^{-1}) was obtained at 70% AWD treatment. The higher value of crop yield obtained at 10% AWD might be due to the more frequent application of water resulting in more adequate moisture in active crop root zone, sufficient moisture conservation, and better utilization of nutrients. At 70% AWD, low crop yield obtained may be due to infrequent application of water resulting in a lack of moisture in active crop root zone, inadequate moisture conservation, and poor nutrient utilization (Tahir & Mehdi, 2001; Aslam & Tahir, 2003; Ahmad *et al.,* 2003; Kumaga *et al.,* 2003; Hussain *et al.,* 2004; Khan *et al.,* 2004; Rahman *et al.,* 2004).

Table I. Mean squares from the analysis of variance of crop yield and yield components of cantaloupe under different water stress treatments (mean of 2004 & 2005)

Source of variation	Degree of freedom	Crop yield	Number of fruits per plant	Fruit weight	Fruit thickness
Replications	2	104578.10^{NS}	0.06^{NS}	443.36^{NS}	0.13^{NS}
Treatments	3	100985089.40^{**}	1.83^{**}	131919.45^{**}	0.13^{NS}
Error	6	893993.42	0.12	6007.78	0.30
CV (%)	---	4.12	11.12	6.25	15.93

** = Significant at 0.01 probability level
^{NS} = Non-significant

Table II. Comparison of the means for crop yield and yield components of cantaloupe between different water stress treatments (mean of 2004 & 2005)

Treatments	Crop yield t ha^{-1}	Number of fruits per plant	Fruit weight g	Fruit Thickness cm
10% AWD	29.10 a	3.60 a	1270 a	3.57 a
30% AWD	26.62 a	3.77 a	1520 b	3.60 a
50% AWD	18.78 b	3.07 ab	1150 a	3.27 a
70% AWD	17.26 b	2.03 b	1030 a	3.20 a

Means in the same column with different letters differ significantly at 0.01 probability level according to Duncan's Multiple Range test

Table III. Water applied and water use efficiency (WUE) of different water stress treatments (mean of 2004 & 2005)

Treatments	Water applied cm	Water use efficiency t ha^{-1} cm^{-1}
10% AWD	39.0	0.75
30% AWD	30.0	0.88
50% AWD	32.5	0.56
70% AWD	33.0	0.52

In the present study, effects of water stress on water applied and WUE was also investigated. The results of the study indicated that water stress markedly affected water applied in the order of 30% AWD < 50% AWD < 70% AWD < 10% AWD and increased WUE in the order of 30% AWD > 10% AWD > 50% AWD > 70% AWD. The WUE of the treatments irrigated based on 10 and 30% AWD were markedly higher than that of the other treatments. The treatment irrigated based on 30% AWD attained the highest WUE of 0.88 t ha^{-1} cm^{-1} because this treatment consumed less water than the other treatments and produced comparative higher yield than them. The lowest WUE (0.52 t ha^{-1} cm^{-1}) realized for the treatment irrigated based on 70% AWD can be ascribed to the fact that more water was applied to this treatment than the other treatments, while yield of this treatment was less than them.

CONCLUSSION

Water stress significantly affected crop yield, number of fruits per plant and fruit weight but there was no significance variation in fruit thickness among the different water stress treatments. The highest crop yield was obtained for the treatment irrigated based on 10% AWD, while the highest number of fruits per plant, fruit weight and fruit thickness was obtained for the treatment irrigated based on 30% AWD. Also, irrigation based on 30% AWD was found to be more effective irrigation method in improving WUE.

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(Received 25 August 2006; Accepted 28 December 2006)