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Assessment of effects of water stress on growth and seed yield of coriander

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ABSTRACT

The experiment was conducted to evaluate the effects of various magnitudes of water stress viz 25, 50 and 75 per cent deficit on growth and seed yield of coriander. Water stress conditions imposed at flower forming phase for 15 days resulted in significant reduction in plant growth characters viz shoot height, number of branches, number of umbels, number of umbellets, fresh and dry weight of root and shoot, root-shoot ratio and days to maturity. Yield characteristics viz number of seeds and seed weight showed substantial reduction in stressed as compared to unstressed plants. The maximum reduction in growth and yield attributes was registered for plants subjected to 75 per cent water deficit whereas growth and yield were not substantially affected at 25 per cent. This study indicated that water stress imposed at flowering stage reduced seed yield substantially therefore the crop must not suffer from water stress of higher magnitude during and after flowering in order to sustain yield.

Keywords: Biological yield; harvest index; water deficit; root-shoot ratio

INTRODUCTION

Coriander (*Coriandrum sativum* L) commonly known as cilantro or Dhania belongs to family Apiaceae (Umbelliferae) and is an annual herbaceous plant and powerful herb with many health benefits. In India the major coriander growing areas lie under semi-arid climate where the crop is cultivated on conserved moisture during rabi season requiring 2-3 irrigations depending upon soil conditions and rainfall. Major portion of cultivable land in India is under rainfed condition which may decrease further on account of continuously depleting water resources. In Himachal Pradesh coriander is mainly grown under rainfed conditions. Moreover the rainfall is not well distributed throughout the year. Limited water supply is the major abiotic constraint for optimum productivity of coriander. Irrigation as an environmental factor has an important role in plant growth and is essential to increase yield and quality of plants (Singh and Goswamy 2000). Drought, one of the environmental stresses is the most significant factor restricting plant growth and crop productivity in the majority of agricultural fields of the world (Tas and Tas 2007). Identifying growth stages of a particular cultivar under local climatic conditions and soil fertility allows irrigation scheduling to maximize crop yield and most efficient use of scarce water resources (Mahal and Sidhu 2006).

One of the major repercussions of climate change is the threat of widespread drought which adversely affects crop growth and yield especially in vegetable crops. Water is one of the most important critical resources and water stress at flowering stage can be deleterious affecting yield. The present investigations were conducted to understand the intrinsic ability of coriander to sustain growth and yield under different levels of water deficit.

MATERIAL and METHODS

A pot experiment having four treatments replicated four times under completely randomized design was conducted in the field of Department of Seed Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during the rabi season of 2012-13.

The suitable methodology was adopted to understand the responses of coriander plants to different levels of imposed conditions of water stress under polyhouse. Plants were raised in pots with dimensions of 20 x 30 cm (diameter x height) and filled with soil and FYM (3:1). The seedlings were allowed to grow and all the necessary agro-techniques were applied to maintain normal growth of plants. Watering was done at regular intervals in order to avoid water stress. The plants were subjected to different levels of water stress namely T_1 (Control, no water stress), T_2 (25% water deficit), T_3 (50% water deficit) and T_4 (75% water deficit) for 15 days. Water stress conditions were imposed by withholding watering at flower forming phase. The calculated amount of water for each treatment on the eve of imposing water stress conditions was applied to the pots. Well-watered control was maintained at nearly field capacity for comparison. The plants were allowed to experience different levels of water deficits for 15 days. Thereafter normal watering was done in all unstressed and stressed plants till harvesting. Growth performance under stressed and unstressed conditions was observed.

Growth parameters namely shoot height, branch number and fresh and dry weight of shoot and root were measured after completion of 15 days of water stress period viz before releasing water stress in plants which were subjected to 25, 50 and 75 per cent water deficit along with the control (unstressed). Root-shoot ratio was calculated by taking the dry weight of root and shoot after 15 days of stress period.

Biological yield was expressed by taking total weight of above ground biomass. It included all the plant parts except roots. Number of umbels and umbellets per plant was counted after completion of 15 days of water stress period for each unstressed and stressed plant in each row to arrive at mean.

Soil moisture content was recorded by using soil moisture meter (HH 2).

RESULTS and DISCUSSION

The data in Table 1 indicate that soil moisture content in unstressed sets ie control was maximum (20.82%) followed by 17.52 per cent at 25 per cent, 15.92 per cent at 50 per cent and least (13.40%) at 75 per cent water deficit. Thakur et al (1998) reported that moisture content on 25^{th} day of stress declined and ranged between 7.26-8.01 per cent among various cultivars of olive and resulted in growth inhibition. Demir and Samit (2001) reported that decreased soil moisture content resulted in lower yield and poor seed quality of tomato.

The shoot height and number of branches per plant decreased with increasing level of water stress. The adverse effect of water stress on these growth parameters was maximum in plants subjected to 75 per cent water deficit conditions since these plants registered least shoot height (70.25 cm) and number of branches (10.64). Number of umbels per plant was minimum (33.41) under 75 per cent water deficit which was at par with 50 per cent water deficit (37.91) and number of umbellets per plant was higher in control (300.08) as compared to stressed plants all of them being at par (Table 2). The reason for decrease in growth parameters with increase in level of water stress might be that drought inhibits growth in association with changes in cell size and division (Karamanos 1978). This reduction in growth under drought stress (Maqsood and Azam Ali 2007) could probably be one of the water conservation and drought tolerance mechanisms.

The effect of water stress on shoot fresh and dry weight has been described in Table 3. It was observed that stressed plants registered significantly lower shoot fresh weight as compared to control. The shoot fresh weight in unstressed plants was recorded maximum (38.39 g). The maximum shoot dry weight (22.46 g) was observed in unstressed plants and minimum (14.03 g) under 75 per cent water stress level. Similarly root fresh weight was significantly decreased with increasing stress level. The maximum root fresh weight (11.06 g) was recorded in unstressed plants and minimum (5.46 g) under 75 per cent water stress level. Similarly the maximum root dry weight (9.49 g) was observed in unstressed plants followed by 7.56 g at 25 per cent and 6.68 g at 50 per cent water stress level. The minimum shoot dry weight (3.96 g) was observed at 75 per cent water stress level the latter two being at par.

The maximum root length (14.85 cm) was observed in unstressed plants followed by 14.45 cm at 25 per cent and 14.1 cm at 50 per cent water stress level. The minimum root length (13.2 cm) was observed in plants at 75 per cent water deficit. Similar findings were reported by Barnabas et al (2007). They observed that lettuce (*Lactuca sativa*) plants were shorter and had reduced dry weight due to water stress. Water deficit conditions affect water relations in plants. Root characteristics studied were root length, fresh

Table 1. Soil moisture content after 15 days of water stress in pots planted with *Coriandrum sativum* L

Soil moisture content (%)					$CD_{0.05}$
Control	25% water deficit	50% water deficit	75% water deficit	Mean	
20.82 (4.56)	17.52 (4.18)	15.92 (3.99)	13.40 (3.66)	16.91 -	- (0.17)

Figures in parentheses are square root values

Table 2. Effect of water stress on growth characteristics of *Coriandrum sativum* L

Treatment	Shoot height (cm)	Number of branches/plant	Number of umbels/plant	Number of umbellets/plant
T_1 (control)	87.42	15.34	50.08	300.08
T_2 (25% water deficit)	82.27	14.81	42.16	248.38
T_3 (50% water deficit)	78.83	13.87	37.91	207.65
T_4 (75% water deficit)	70.25	10.64	33.41	196.83
Mean	79.60	13.66	40.89	238.23
$CD_{0.05}$	8.44	1.30	8.63	58.71

Table 3. Effect of water stress on shoot and root characteristics of *Coriandrum sativum* L

Treatment	Shoot fresh weight (g)	Shoot dry weight (g)	Root fresh weight (g)	Root dry weight (g)	Root length (cm)	Root-shoot ratio
T_1 (control)	38.39	22.46	11.06	9.49	14.85	0.44
T_2 (25% water deficit)	31.11	18.61	9.51	7.56	14.45	0.41
T_3 (50% water deficit)	25.28	16.03	7.80	6.68	14.10	0.39
T_4 (75% water deficit)	19.89	14.03	5.46	3.96	13.20	0.28
Mean	28.66	17.70	8.45	6.92	14.15	0.31
$CD_{0.05}$	3.96	0.92	0.50	0.99	0.29	0.11

weight, dry weight and root-shoot ratio. Adverse effects of water stress on root characteristics were especially evident on root fresh and dry weight and root-shoot ratio. Root development in coriander plants is expected to undergo a drastic transformation due to non-availability of soil moisture. Water stress not only results in reduction of photosynthetic rate but also disturbs source-sink relationship resulting in decreased availability of photosynthates to below ground portion. Decreasing water potential on account of water stress reduces overall root development (Thakur et al 2000). Shah et al (2010) reported that moisture stress reduced all the root parameters compared to control in *Withania sominifera*. The results are in agreement with the findings of Abdalla and El-Khoshiban (2007) who reported decrease in total dry weight of roots. Pratap and Sharma (2010) also reported that fresh and dry weight of both root and shoot decreased with increasing water stress.

The data in Fig 1 depict the per cent inhibition in seed weight per plant, number of seeds per plant, biological yield and harvest index below the control. It is concluded that the per cent inhibition in seed weight per plant (44.4%), number of seeds per plant (45.79%), biological yield (47.89%) and harvest index (42.89%) was found maximum at 75 per cent water deficit treatment.

The results are also in accordance with the work of Contreras et al (2009) on lettuce where water stress resulted in reduction in size of fruits

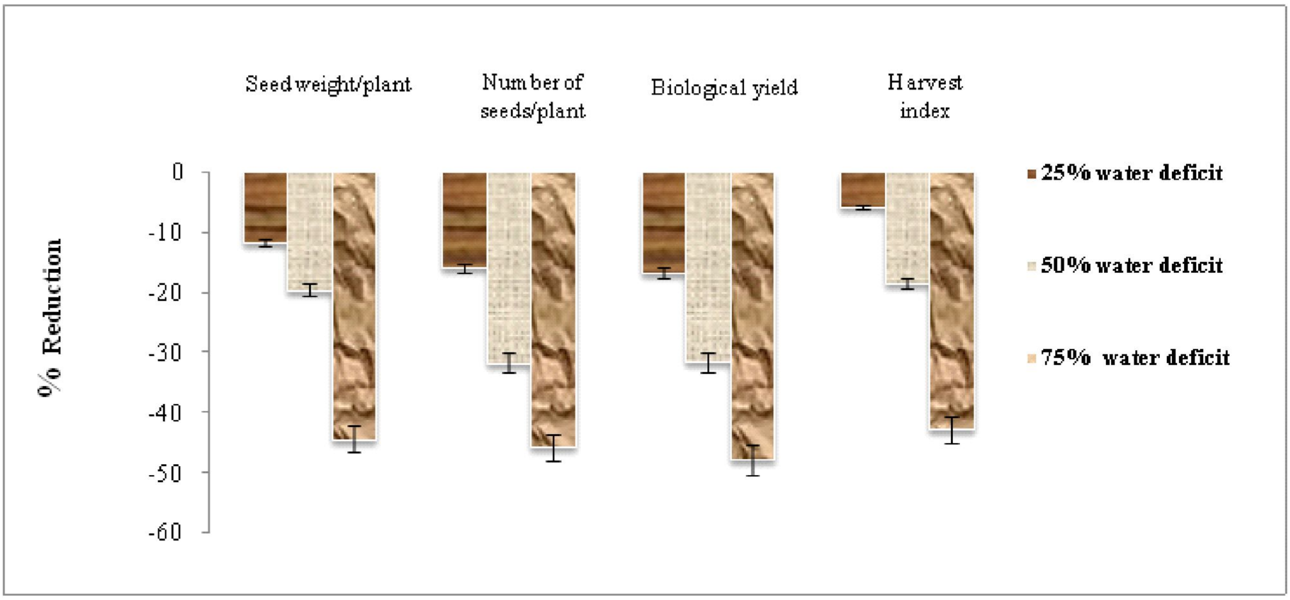

Fig 1. Per cent reduction in seed weight, seed number, biological yield and harvest index of water-stressed plants of coriander

and produced fewer seeds per plant. The stress shortened the seed filling period in peas (Pervez et al 2009) which resulted in reduction of final seed size and yield. During the investigations the number of seeds per plant, seed weight per plant, biological yield and harvest index were negatively affected by different stress magnitudes.

CONCLUSION

It can be concluded that under various levels of induced water stress there was significant affect on the shoot height, number of branches, number of umbels and umbellets, root and shoot fresh weight, root dry weight of coriander plants. The water deficit of 25, 50 and 75 per cent caused reduction in growth and seed yield per plant with maximum reduction (44.4%) registered in plants subjected to 75 per cent water deficit followed by reduction of 30 per cent at 50 per cent water deficit whereas no substantial reduction was observed at 25 per cent water deficit indicating the better ability of plants to cope up with lower water stress conditions compared to higher levels.

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