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Influence of protected environments and irrigation methods on plant growth and seed yield of coriander *(Coriandrum sativum)*

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ABSTRACT

A field experiment to study the effect of different protected environments and irrigation methods on growth and yield of coriander (*Coriandrum sativum* L.) was conducted at NRCSS, Tabiji, Ajmer, Rajasthan during *rabi* season of the year 2008-09 to 2010-11. The experiment comprising four treatments of protected environments, viz. plastic covered walk in tunnel, insect proof net covered walk in tunnel, shade net covered walk in tunnel, plastic low tunnel and control (open conditions) in main plots and three irrigation method treatments (pressurized drip irrigation, low pressure drip irrigation and surface irrigation) in subplots was conducted with three replications in split plot design. The soil of the experimental plot was sandy loam, with low organic carbon and nitrogen, medium in available phosphorus and sufficient in available potassium. Impact of protected environment and methods of irrigation was recorded with respect to plant growth, yield attributes and seed yield. The plastic covered walk in tunnel protection resulted highest plant height, maximum branches/plant at harvest, maximum number of umbels/plant, maximum number of seeds/umbel and highest seed yield. Among irrigation methods, low pressure drip irrigation exhibited significantly higher plant height at 60 days after sowing (DAS) as well as at harvest with maximum number of umbels per plant, maximum number of umbellates/umbel and maximum seed yield. On the basis of above study it is concluded that plastic covered walk in tunnel with low pressure drip method of irrigation is best for realizing better plant growth and seed yield of coriander as compared to all other treatments.

Key word: Coriander, Irrigation methods, Plant growth, Protected conditions, Seed yield

Green houses, insect proof net, green net, black net, poly houses etc. are various structures used in protected cultivation which protect the crop from extremely low or high temperatures, cold or hot winds, insect-pests and diseases (Lal *et al*. 2010). Protected cultivation practices can be defined as a cropping technique wherein the micro climate surrounding the plant body is modified partially/ fully as per the requirement of the plant species grown during their period of growth. With the advancement in agriculture various types of protected cultivation practices suitable for a specific type of agro-climatic zone have emerged (Salunke and Rai 2014). Crop production under structures not only increases the total annual yield per unit area, but also improves the quality. Vegetables have a better flavor and appearance when they are grown in a controlled environment, where growers can make precise adjustments of nutrients and other inputs. Environmental control under protected structures allows raising plants anywhere in the world at any time of the year, i.e. crops could be grown under the inclement climatic conditions when it would not be otherwise possible to grow crops under the open field conditions.

Water has played a central role in sustaining life on earth. Over the years, this precious natural resource has been rapidly diminishing as a result of rising population, economic development and its irresponsible use by mankind. In India about 80% available water is used for agriculture where water use efficiency is very low nearly 35-40% due to use of inefficient methods of irrigation. Moreover nearly 65-70% area is still rainfed where productivity is very low as compared to irrigated agriculture. In most parts of the Asia including India, water is increasingly becoming scarce and costly due to continuous lowering of water table on account of burgeoning population. Agriculture's share of fresh water supply is likely to decline by 8 to 10 % because of increasing competition from other sector (Seckler *et al*. 1998). With fast decline of irrigation potential and continued expansion of population and economic activity in most of the area located in arid and semi arid region, the problem of water scarcity is expected to increase further (Rosegrant *et al*. 2002). Drip irrigation method supply moisture directly in the root zone therefore, there are very less chances of water loss through conveyance, percolation and

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evaporation resulting in higher water use efficiency.

As coriander (*Coriandrum sativum* L.) is grown in *rabi* (winter) season, the occurrence of cold waves and frost many a times in December and January causes heavy loss to the crop by chilling injury. Besides this the cloudy weather during the growing season owing to western disturbances is the major factor for spreading of diseases like blight, powdery mildew and insect pests like aphids which also cause a severe loss to the crop. The crop can be saved from these types of biotic and abiotic stresses by giving some environmental protection. Protected structures provide protection to the crop especially during December–January from low temperature, frost, diseases and insect pests which consequently may increase the plant growth, development and yield with quality produce. Hence, the present study was undertaken to see the performance of different protected environments created by plastic sheets and shade nets on the environmental factors (like temperature, relative humidity and light) and with the combination of irrigation methods on plant growth, development and yield of coriander crop.

MATERIALS AND METHODS

A field experiment was carried out during three years (2008-09 to 2010-11) at Research Farm, ICAR- National Research Center on Seed Spices, Ajmer, Rajasthan, India. The center lies on 74° 35' 39" E to 74° 36' 01" longitude and 26° 22' 12" to 26° 22' 31" N latitude at an altitude of 460.17 m above mean sea level. The region falls under agro climatic zone III 'A' of the Rajasthan state. The climate of this zone is typically semi-arid and arid type with mild winter and moderate summers. The mean annual rainfall is 590 mm, mostly received from South-west monsoon during the last week of June to October. The soil of the experimental plot was sandy loam, poor in fertility having organic carbon 0.18 to 0.24 %, available N 75.41 kg/ha (low), P_2O_5 8.61 kg/ha (medium), K_2O 215.26 kg/ha (high) with pH 7.8 to 8.1, EC 0.23 dS/m. Water holding capacity of soil is low due to sandy nature of the soil thus it require frequent application of irrigation with less water use efficiency. Impact of climatic variations and method of irrigation was observed with respect to plant growth, fruiting and yield.

Treatments comprising of four protected conditions namely plastic covered walk-in-tunnel (500 micron thick sheet), insect proof net covered walk-in-tunnel (20% mesh), black shade net covered walk-in-tunnel (50% shade), plastic covered low tunnel (200 micron thick sheet) and open conditions (Control) were taken in main plots and three irrigation methods (pressurized drip irrigation, low pressure drip irrigation and surface irrigation) in subplots. The protected structures as per treatments were erected in the form of walk in tunnels (6 feet high) with the help galvanized iron pipes of 25 feet long 0.5" inside diameter and low tunnel (1. 5 feet high) with the help of GI wires (5 mm thickness) during December-January (peak winter season) and meteorological parameters (temperature and relative humidity) were recorded of each treatment. Drip lines having drippers at 30 cm spacing were placed in between two rows of the crop in both pressurized and low pressure drip irrigation systems. Pressurized drip irrigation system was operated with the help of an electric motor of 3.0 HP at 1.0 pound per square inch (psi) pressure with 2.5 l/hr water discharge capacity of a dripper. The low pressure drip irrigation system was operated with the help of an overhead tank of 1000 liters capacity placed at the height of 5.0 feet from ground. The system runs on gravity at 0.25 psi pressure with 1.0 l/ha water discharge capacity of a dripper. Ajmer Coriander-1 (ACr-1) variety of coriander was sown at 30 cm row to row and 10 cm plant to plant spacing using 16 kg seed /ha.

The observations with respect to vegetative growth parameters, viz. number of basal leaves, length of basal leaves, plant height and number of primary branches of five randomly selected and tagged plants in each treatment were recorded and averaged. Harvesting of the crop was done at physiological maturity and yield parameters (like umbel/plant, umbellates/umbel, seeds/umbellate, test weight) and seed yield/ha was recorded accordingly.

The experiment was laid out in split plot design with three replications. There were fifteen treatment combinations comprising five protected conditions and three irrigation methods. Analysis of variance was done as suggested by Panse and Sukhatme (1985) using PC Excels software.

RESULTS AND DISCUSSION

Environmental effects

Results revealed that plastic sheets and shade nets affect environmental variables. Temperature, RH and light impact plant growth and physiology including disease development, in various ways (Grantz 1990, Went 1953 and Arthurs *et al*. 2013). Maximum and minimum air temperature (Fig 1 A) and morning-evening RH (Fig 1 B) were highest inside plastic low tunnel (P_4 treatment), which caused loss to the coriander crop due to low height of the tunnel. In contrast to this, moderately higher temperature and RH was seen under plastic covered walk-in-tunnel (P_1 treatment) than that of black net, insect proof net and ambient conditions, where crop growth and development was much better than other treatments. It is further inferred from our study that all treatments reduced daily light integral (DLI) as compared to ambient but there were differences among environments. Calculated DLI values were reduced most under black shade net walk-in-tunnel and least under plastic sheets (Fig 1 C). These findings are consistent with previous work done by Stamps and Chandles (2008) on different types of colored nets. Various studies also indicate that light in the ultraviolet range plays an important role in plant defenses. For example, natural or attenuated ultraviolet (especially ultraviolet-B) radiation helps to protect plants from herbivores and microbial pathogens, possibly through production of phenolic compounds and/or antioxidants (Ballare *et al*. 2012 and Wei *et al*. 2013).

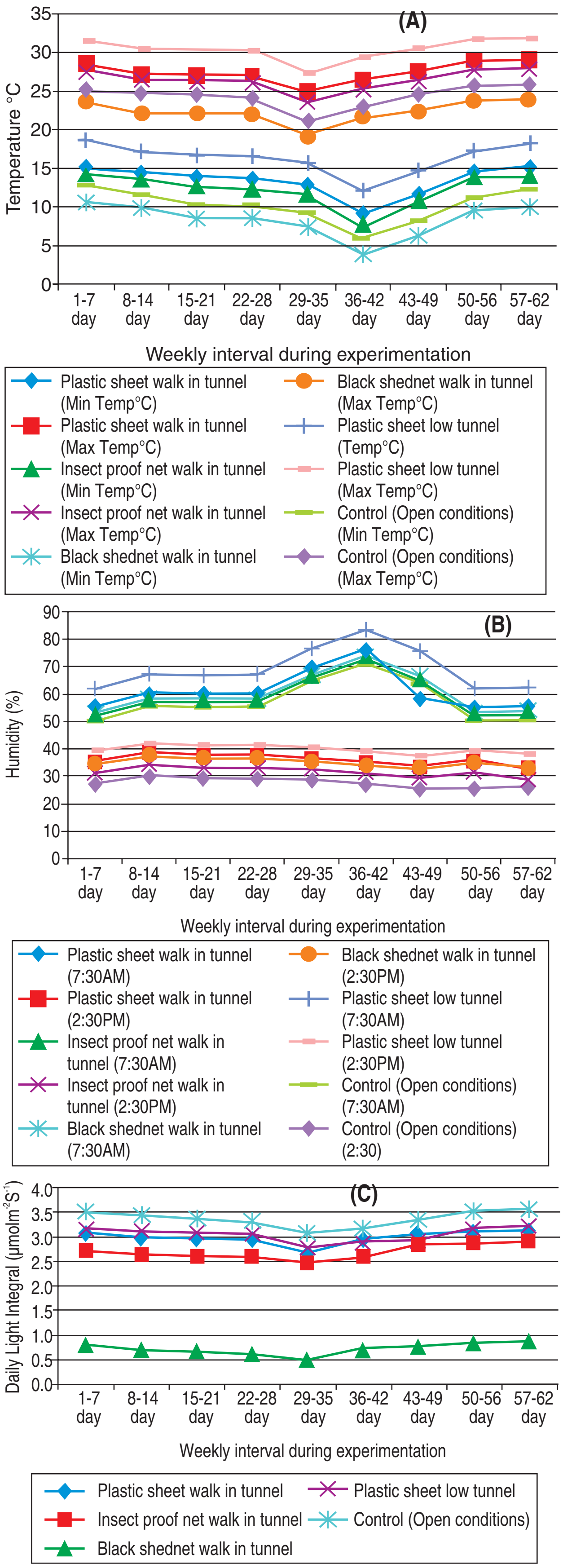

Fig 1 Effect of different protected environments on (A) temperature, (B) humidity and (C) Daily Light Integral (DLI) during experimentation.

Vegetative growth parameters

Growth attributes like number of basal leaves, length of basal leaves, plant height and number of primary branches of coriander plants were significantly influenced with different conditions of crop cultivation. The maximum number of basal leaves (7.83/plant) and primary branches (9.83/plant) with highest length of basal leaves (23.9 cm) and plant height at harvest (94.00 cm) were recorded in the crop grown under plastic walk in tunnels (Table 1) as compared to minimum number of basal leaves (5.68/plant) and number of primary branches (6.47/plant) with lowest length of basal leaves (17.20 cm) and plant height (54.25 cm) were recorded in the crop grown in plastic low tunnels. The crop grown under open environmental conditions (control) exhibited better results than the plastic low tunnels and shade net tunnels with respect to all the growth parameters described above.

The maximum number of basal leaves and primary branches with highest length of basal leaves and plant height in the crop grown under plastic covered walk-in-tunnels were obtained due to better environmental conditions provided to the coriander crop. Slightly higher temperature (minimum as well as maximum) with moderate relative humidity as compared to the other treatments and control were maintained in plastic covered walk-in-tunnels and less evapo-transpirational loss of water might have facilitated better growth and development of the crop. The result are in the agreement with the findings of Singh *et al.* (2005 a and b) in tomato and sweet pepper, respectively.

Data (Table 1) showed that among the irrigation systems low pressure drip irrigation system exhibited encouraging results and vegetative growth parameters of coriander crop were influenced significantly with the application of water through different irrigation systems. Maximum number of basal leaves (7.11/plant) and primary

Table 1 Effect of protected environments and irrigation methods on vegetative growth of coriander plants (Pooled analysis of three years data)

Treatment	Number of basal leaves/ plant	Length of basal leaves (cm)	Plant height at harvest (cm)	Number of primary branches/ plant
Protected environment (P)				
Plastic walk in tunnel	7.83	23.69	94.00	9.83
Insect proof net tunnel	7.02	21.19	80.78	9.20
Black shade net tunnel	6.19	18.66	69.67	8.10
Plastic low tunnel	5.68	17.20	54.25	6.47
Open conditions	7.06	19.15	82.27	8.70
CD (P=0.05)	0.33	0.86	1.22	0.86
Irrigation methods (I)				
Low pressure drip irrigation	7.11	20.57	80.96	8.95
Pressurized drip irrigation	6.77	19.95	75.91	8.33
Surface irrigation	6.39	19.42	71.71	8.10
CD (P=0.05)	0.20	0.54	2.74	0.23
Interaction P × I	NS	NS	NS	NS

branches (8.95/plant) with longest plant (80.96 cm) and length of basal leaves (20.57 cm) were recorded in the crop irrigated with low pressure drip irrigation system as compared to minimum number of basal leaves (6.39/plant) and number of primary branches (8.10/plant) with lowest length of basal leaves (19.42 cm) and plant height (71.71 cm) recorded in the crop irrigated by surface irrigation method. The higher plant height and branches/plant with low pressure drip irrigation might be due to supply of moisture directly in the root zone compared to flood irrigation method resulting in congenial moisture status in soil favoring better absorption of nutrient and water resulting in better growth of plant. Similar findings have also been reported by Malhotra *et al.* (2009) in seed spices.

Data further revealed that interactive effect of different protected conditions and irrigation methods did not influence the vegetative growth parameters significantly in coriander crop.

Table 2 Effect of protected environments and irrigation methods on yield attributes and seed yield of coriander (Pooled analysis of three years data)

Treatment	Number of umbels/ plant	Number of umbellates/ umbel	Number of seeds/ umbellate	Test weight of seed (g)	Seed yield (kg/ha)
Protected environment (P)					
Plastic walk in tunnel	120.1	9.8	7.7	8.90	1739.97
Insect proof net tunnel	111.9	7.8	7.1	7.69	1186.11
Black shade net tunnel	99.0	6.2	6.3	6.42	621.45
Plastic low tunnel	52.2	4.9	3.9	6.24	436.11
Open conditions	105.6	6.3	7.0	7.72	1040.46
CD (P=0.05)	4.3	0.3	0.3	0.34	53.41
Irrigation methods (I)					
Low pressure drip irrigation	108.0	7.9	7.0	7.78	1146.04
Pressurized drip irrigation	96.6	6.9	6.2	7.32	1016.20
Surface irrigation	88.7	6.2	5.9	7.08	852.22
CD (P=0.05)	2.6	0.2	0.2	0.21	32.42
Interaction P×I	S	S	S	NS	S

Yield attributes and seed yield

Various protected cultivation practices significantly influenced yield attributes and seed yield of coriander. The maximum number of umbels (120.10/plant), umbellates (9.80/ umbel), seeds (7.70/umbel), test weight (8.90 g) and seed yield (1 739.97 kg/ha) were obtained in the crop grown under plastic covered walk-in-tunnel followed by insect proof net tunnel as compared to minimum number of umbels (52.20/plant), umbellates (4.90/ umbel), seeds (3.90/umbel), test weight (6.24 g) and seed yield (436.00 kg/ha) in the crop produced under plastic low tunnel. However, open environmental conditions (control) exhibited healthier crop with higher seed yield than that of plastic low tunnel and shade net tunnel (Table 2). Further it is clear from the findings that application of water through different irrigation system influenced the yield attributes and seed yield significantly. Maximum number of umbels (108.00/plant), umbellates (7.9/umbel), number of seeds (7.0/umbellate), test weight (7.78 g) and seed yield (1 146.04 kg/ha) were recorded in the crop irrigated by low pressure drip system as compared to minimum number of umbels (88.70/ plant), umbellates (6.2/ umbel), seeds (5.9/umbel), test weight (7.08 g) and seed yield (852.22 kg/ha) in the crop irrigated by surface irrigation system.

It is inferred from the data (Table 3) that interactive effect of different environmental treatments and irrigation systems influenced significantly the seed yield and its

Table 3 Interactive effect of protected environments and irrigation methods on yield attributes and seed yield of coriander (Pooled analysis of three years data)

Protected cultivation	Number of umbels/plant			Number of umbellate/umbel			Number of seeds/umbellate			Seed Yield (kg/ha)		
	Low pressure drip irrigation	Pressurized drip irrigation	Surface irrigation (I_3)	Low pressure drip irrigation	Pressurized drip irrigation	Surface irrigation (I_3)	Low pressure drip irrigation	Pressurized drip irrigation	Surface irrigation (I_3)	Low pressure drip irrigation	Pressurized drip irrigation	Surface irrigation (I_3)
Plastic walk in tunnel (P_1)	124.56	119.67	116.11	9.00	8.00	8.00	8.03	7.67	7.30	2036.6	1677.3	1506.0
Insect proof net tunnel (P_2)	114.78	111.44	109.56	8.00	7.00	8.00	7.63	6.86	6.82	1306.5	1289.8	962.0
Black shade net tunnel (P_3)	111.44	100.67	84.89	7.00	6.00	7.00	6.83	6.54	5.62	675.0	613.0	576.4
Plastic low tunnel (P_4)	79.00	46.56	31.00	7.00	6.00	5.00	5.40	3.16	3.04	513.4	431.9	363.0
Open conditions (P_5)	110.22	104.67	101.89	8.00	7.00	1.00	7.23	6.90	6.87	1198.7	1069.0	853.7
CD (P=0.05)			5.85		1.03			0.42			72.50	

attributes except test weight of seed. Maximum number of umbels (124.56/plant), umbellates (9.00/umbel), number of seeds (8.03/ umbellate), and seed yield (2036.60 kg/ha) were recorded in the crop grown under plastic covered walk-in-tunnel and irrigated by low pressure drip irrigation system (P_1I_1 treatment combination) as compared to minimum number of umbels (31.00/plant), umbellates (5.00/umbel), seeds (3.04/umbel), and seed yield (363.00 kg/ha) in the crop grown under plastic low tunnels and irrigated by surface irrigation system (P_4I_3 treatment combination).

During December and January the low temperature in open condition reduce physiological process and metabolic activities of the plant but plastic sheet walk in tunnel helped in moderating temperature, which favoured higher physiological process leading to higher photosynthesis and better translocation of photosynthates from source to sink hence, higher yield attributes and yield were obtained in the crop sown in plastic sheet walk in tunnel. These findings corroborate the results of El-Aidy (1984) and El-Aidy and Moustafa (1978).

Further, it can be inferred from this study that yield attributes and yield of coriander were significantly influenced with irrigation methods. The higher yield attributes and yield under low pressure drip irrigation system followed by conventional drip irrigation system might be due to maintenance of congenial moisture status in the vicinity of root zone of the plant which facilitate better absorption of water and nutrients in the plants accelerating the photosynthetic process leading to better translocation of photosynthates from soil to plant system favouring more yield attributes and yield of coriander. The findings are in conformity with those reported by Malhotra *et al*. (2009) who obtained higher plant height and yield in seed spices with drip irrigation as compared to other methods of irrigation.

Based on the above research findings, it can be concluded that plastic covered walk-in-tunnel as the growing environment with low pressure drip system of irrigation is best for realizing higher plant growth, development and yield in coriander crop.

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