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Estimation of the effect of drought on morpho-physiological attributes in different coriander genotypes (*Coriandrum sativum* L.)

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Abstract
Eight Coriander varieties viz. Rcr-20, Rcr-41, Rcr-435, Rcr-436, Rcr-446, Rcr-475, Rcr-684 and Rcr-728 were conducted at the research farm of S.K.N. College of Agriculture, Jobner (Rajasthan) during *Rabi*, 2016 in randomized block design with three replications on loamy sand soil under control condition plot were irrigated at regular interval while in drought condition plots were maintained under rainfed condition. Yield and yield contributing parameters were recorded at maturity stages and after harvesting.
The Coriander varieties Rcr-20 and Rcr-446 behaved as drought tolerance varieties maintained higher seed yield along with number of umbels per plant, seeds per umbel, test weight, seed yield, biological yield, harvest index under drought conditions. The coriander varieties Rcr-435 and Rcr-728 maintained under higher seed yield along with number of umbels per plant, seeds per umbel, test weight, seed yield, biological yield, harvest index under control conditions.

Keywords: Drought, Yield traits, Coriander, Morpho-physiological attributes and *Coriandum sativum* L

Introduction
Coriander (*Coriandrum sativum* L.) is an important seed spice crop a member of family *Apiaceae*, a tall herbaceous annual diploid (2n=22). It is highly cross pollinated crop believed to be native of Mediterranean region. The dry seed contains 6.3 per cent moisture, 1.3 per cent protein, 0.3-0.4 per cent volatile oil, 19.6 per cent nonvolatile oil, 24.6 per cent carbohydrates and 5.3 percent mineral matter. In Rajasthan it is mainly grown in the district of baran, kota, bundi, chittorgarh and Jhalawar with an area of 212725 ha and annual production of 227203 tones (Anonymous, 2015-2016) [2]. Drought is a meteorological term and is commonly defined as a period without significant rainfall. It is one of the most universal and significant environmental stress affecting plant growth and productivity worldwide. Therefore, understanding crop response to this stress is very important. Drought is a meteorological term and is commonly defined as a period without significant rainfall. It is one of the most universal and significant environmental stress affecting plant growth and productivity worldwide.

Materials and methods
The study was conducted using eight genotypes (Two droughts tolerant and Six drought susceptible) in randomized block design with three replications. The eight varieties of *Coriandrum sativum* namely Rcr-20, Rcr-446 (Drought tolerant) and Rcr-41, Rcr-435, Rcr-436, Rcr-475, Rcr-684 and Rcr-728 (Drought susceptible) were grown in field. In field the varieties were grown in randomized block design with control and drought conditions. Under control condition the plants were irrigated at flowering and seed formation stage while in drought the plants were maintained under rainfed condition. Observation was taken from all the plots between 10 A.M. to 12 noon. Observations on relative water content (RWC), chlorophyll content, Carotenoids, proline content and Membrane stability index (MSI) were taken twice, first at flowering and second at seed forming stage. Observation on 50 Per Cent flowering was taken when half of the plants in a plot flowered. Plant height, number of umbel per plant and seeds per umbel, umbellets per umbel were measured at time of harvesting, whereas, test weight, seed yield, harvest index, biological yield, and drought susceptibility index were measured after harvesting and threshing of the crop.

Result and discussion
A reduction due to drought stress was noted in morpho- physiological parameters like relative water content (RWC), chlorophyll content Carotenoids, Membrane stability index (MSI) drought susceptibility index.

While biochemical parameter like proline content is increase. Yield and yield contributing parameters like plant height, number of seeds per plant and seeds per umbel, umbellets per umbel, test weight, seed yield, harvest index, biological yield whereas days to 50 Per cent flowering was noted earlier under drought condition than control condition. However, the degree of reduction or increase varied significantly among the varieties. Physiologically, drought is a complex physiological process, in which many molecules such as (DNA, RNA), proteins, carbohydrates, lipids, hormones, ions, free radicals, mineral elements and others are involved (Wang *et al*., 2003) [17]. The reactions of plants to water stress differ significantly at various organizational levels depending upon intensity and duration of stress as well as plant species and its stages of developments (Chaves *et al*., 2003) [6]. Water stress causes a wide array of biochemical and physiological changes, starting with a decrease in osmotic potential at the cellular level (Bajji *et al*., 2001) [5].

The relative water content decreased significantly in all the varieties at both flowering and seed formation stage during drought condition (Table-4.1 and fig 4.1 to 4.2). The mean reduction in relative water content was about 8.38 per cent at both stages. Leaf relative water content (LRWC) is an important physiological attributes which determines the tolerance of plants to drought stress (Sanchez-Blanco *et al.,* 2002) [16]. In present investigation a significant and positive correlation of relative water content with seed yield was observed at flowering and seed formation stages. Thus, varieties like Rcr-446 and Rcr-728 maintained higher relative water content to other varieties is important or registering less reduction under drought compared to control. Other researcher have also reported that the tolerant varieties maintain higher relative water content under stress condition (Desmukh and Kushwaha, 2002) [8]. Water stress decreased relative water content (RWC) and in soybean. Four days after re-watering stressed plants, the effect of RWC were almost eliminated and photosynthesis was only 10 per cent lower than that of water stressed plants. Kuhad and Sheoran (1986) [11] reported that the water stress was created by the decreased RWC in all the genotypes of guar.

Total chlorophyll content decreased significantly in all the varieties at both the stages due to water stress condition. Low level decrease in total chlorophyll in genotypes indicates that their photosynthetic apparatus is able to resist adverse condition due to water stress. On other hand accumulation of higher chlorophyll content at flowering compared to seed formation stages may be due to sugar is synthesized in photosynthesis and breaks down during respiration by plants. The resulted are supported by Abdouli *et al*., 2012 [1] and Aggrawal *et al*., 2013 [3]. Therefore, for better yields under stress, higher chlorophyll content might contributes to higher plants productivity (Rao *et al.,* 2012) [15]. Carotenoids have showed similar trends as by chlorophyll contents. The total carotenoids reduced significantly in all the varieties at flowering as well as seed formation stages under drought condition. The mean reduction at flowering and seed formation stages were 19.84 and 21.49 per cent, respectively. Drought condition reduced the carotenoids in crops (Anjum *et al.,* 2003b; Farooq *et al.,* 2009) [4, 9]. The varieties like Rcr-20 maintain higher chlorophyll and carotenoids under the drought condition produced higher grain yield. Rcr-446 recorded less reduction under drought compared to control.

Drought susceptibility index (DSI) varied significantly among the varieties. Higher mean seed yield along with lower drought susceptibility index values was considered to identify and select the genotypes under drought condition. In present study, the varieties Rcr-446 and Rcr-20 exhibited lower drought susceptibility index i.e 0.16 and 0.38 respectively, with along higher grain yield, thus showing the existence of drought tolerance mechanism. The highest MSI found in Rcr-20 and Rcr-446 thus indicating these to be highly tolerant at both the stages under drought condition. Lowest MSI values were observed in genotype Rcr-475 and Rcr-41 at both stages, indicating their high susceptibility to drought. The results are supported by Pant *et al*., 2014 [14], Mittal *et al*., 2006 [12], Mittal, 2010 [13], Karmakar *et al*., 2014 [10]. The results showing high accumulation of proline at seed formation compared to flowering in the stressed tissues of all genotypes indicates seed formation stage to be a more responsive stage in terms of cellular osmotic adjustment. Comparing performance of genotypes at the two stages, Rcr-20 and Rcr-728 were found to be tolerant to drought amongst all eight genotypes.

Table 1: Variations in relative water content (%) at flowering and seed formation stages among coriander varieties under drought conditions

Varieties	Flowering			Seed formation		
	Control	Drought	Mean	Control	Drought	Mean
Rcr-20	75.58	75.54	75.56	71.52	63.03	67.28
Rcr-41	80.12	70.32	75.22	75.58	57.22	66.40
Rcr-435	77.56	70.72	74.14	67.20	64.50	65.85
Rcr-436	76.55	78.90	77.73	73.32	66.90	70.11
Rcr-446	74.32	72.86	73.59	69.71	70.50	70.11
Rcr-475	74.56	69.55	72.06	70.06	65.90	67.98
Rcr-684	73.96	68.71	71.34	71.34	62.30	66.82
Rcr-728	78.50	63.51	71.01	73.71	64.50	69.11
Mean	76.39	71.26		71.56	64.36	
	SEm±	CD (p=0.05)		SEm±	CD (p=0.05)	
Variety (V)	1.02	2.93		1.30	3.74	
Stress (S)	0.51	1.47		0.65	1.87	
V x S	1.44	4.15		1.83	5.29	

Table 2: Variations in total chlorophyll content (mg/g f. w.) at flowering and seed formation stages among coriander varieties under drought conditions

Varieties	Flowering			Seed formation		
	Control	Drought	Mean	Control	Drought	Mean
Rcr-20	1.81	1.73	1.77	1.25	1.18	1.22
Rcr-41	1.68	1.38	1.53	1.24	1.18	1.21
Rcr-435	1.66	1.51	1.59	1.25	1.08	1.17
Rcr-436	1.87	1.56	1.72	1.37	1.16	1.27
Rcr-446	1.83	1.62	1.73	1.36	1.18	1.27
Rcr-475	1.92	1.40	1.66	1.63	1.10	1.37
Rcr-684	2.45	1.29	1.87	1.65	1.03	1.34
Rcr-728	2.45	1.50	1.98	1.65	1.01	1.33
Mean	1.96	1.50		1.43	1.12	
	SEm±	CD (p=0.05)		SEm±	CD(p=0.05)	
Variety (V)	0.04	0.12		0.03	0.09	
Stress (S)	0.02	0.06		0.02	0.04	
V x S	0.06	0.17		0.04	0.12	

Table 3: Variations in carotenoids (mg/g f. w.) at flowering and seed formation stages among coriander under drought conditions

Varieties	Flowering			Seed formation		
	Control	Drought	Mean	Control	Drought	Mean
Rcr-20	2.50	1.90	2.20	0.92	1.27	1.10
Rcr-41	2.40	2.00	2.20	0.95	0.80	0.88
Rcr-435	2.45	2.09	2.27	0.98	0.90	0.94
Rcr-436	2.65	2.10	2.38	0.97	0.89	0.93
Rcr-446	3.10	2.06	2.58	1.20	0.88	1.04
Rcr-475	2.60	2.40	2.50	0.95	0.70	0.83
Rcr-684	2.85	2.10	2.48	1.15	0.60	0.88
Rcr-728	2.40	2.15	2.28	1.40	0.70	1.05
Mean	2.62	2.10		1.07	0.84	
	SEm±	CD (p=0.05)		SEm±	CD (p=0.05)	
Variety (V)	0.075	0.216		0.026	0.076	
Stress (S)	0.037	0.108		0.013	0.038	
V x S	0.106	0.305		0.037	0.107	

Table 4: Variations in MSI (%FW) at flowering and seed formation stages among coriander varieties under drought conditions

Varieties	Flowering			Seed formation		
	Control	Drought	Mean	Control	Drought	Mean
Rcr-20	60.95	57.80	59.38	59.25	55.60	57.43
Rcr-41	54.30	48.30	51.30	43.87	37.85	40.86
Rcr-435	59.60	51.25	55.43	47.75	38.80	43.28
Rcr-436	52.50	48.45	50.48	58.20	52.70	55.45
Rcr-446	55.75	47.20	51.48	60.25	48.50	54.38
Rcr-475	52.55	45.20	48.88	55.10	45.15	50.13
Rcr-684	55.20	47.30	51.25	48.30	44.20	46.25
Rcr-728	58.10	50.15	54.13	52.10	47.50	49.80
Mean	56.12	49.46		53.10	46.29	
	SEm±	CD (p=0.05)		SEm±	CD (p=0.05)	
Variety (V)	1.04	3.01		1.58	4.57	
Stress (S)	0.52	1.51		0.79	2.28	
V x S	1.47	4.26		2.24	6.46	

Table 5: Variations in proline (mg $100g^{-1}$ FW) at flowering and seed formation stages among coriander varieties under drought conditions

Varieties	Flowering			Seed formation		
	Control	Drought	Mean	Control	Drought	Mean
Rcr-20	56.90	64.60	60.75	100.00	195.20	147.60
Rcr-41	43.65	53.09	48.37	95.85	124.95	110.40
Rcr-435	42.80	48.81	45.81	94.25	117.95	106.10
Rcr-436	35.85	60.60	48.23	81.48	142.67	112.08
Rcr-446	48.50	49.80	49.15	108.70	116.58	112.64
Rcr-475	57.10	78.70	67.90	90.50	105.68	98.09
Rcr-684	52.84	56.98	54.91	99.10	120.60	109.85
Rcr-728	53.30	95.50	74.40	100.15	150.10	125.13
Mean	48.87	63.51		96.25	134.22	
	SEm±	CD (p=0.05)		SEm±	CD (p=0.05)	
Variety (V)	1.49	4.31		4.04	11.66	
Stress (S)	0.75	2.16		2.02	5.83	
V x S	2.11	6.10		5.71	16.49	

Table 6: Variations in Drought susceptibility index (DSI) among coriander varieties influenced by drought condition

Varieties	DSI
Rcr-20	0.38
Rcr-41	1.01
Rcr-435	1.55
Rcr-436	1.61
Rcr-446	0.16
Rcr-475	0.71
Rcr-684	0.88
Rcr-728	1.51
SEm±	0.010
CD (P=0.05)	0.031

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