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Effect of moisture stress on Stomatal diffusive resistance, Chlorophyll stability index, transpiration rate and light interception of coriander (*Coriandrum sativum* L.) genotypes

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ABSTRACT: *The present study was carried with 22 genotypes and ruling variety CO (CR) 4 as check to study the effect of moisture stress at different stages of growth (Vegetative phase and Reproductive phase) at farm of Horticulture college and Research Institute, TNAU Coimbatore to study the physiological variations among the genotypes in coriander during stress. The light interception was highest under normal irrigated condition compared to moisture stress at vegetative stress condition and reproductive stress condition. Whereas, reduction was more when moisture stress was induced at reproductive stage. CSI was affected among the genotypes when moisture stress induced during reproductive growth period than moisture stress at vegetative growth period and non-stressed condition. More stomatal diffusive resistance and Reduced transpiration rate was recorded when moisture stress induced at reproductive growth period. Whereas, genotype CS 127 excelled over other genotypes in all these characters at any stage of stress.*

Keywords: *Moisture stress, coriander, CSI, Transpiration rate, Stomatal diffusive resistance, Light interception*

INTRODUCTION

Coriander commonly known as "Dhania" (*Coriandrum sativum L.*) belongs to family Apiaceae. Coriander fruits are an important spice of many countries of Europe, Northern Africa, West, Central and South Asia. In India, it is cultivated in 3.40 lakh hectares with an annual production of 2.23 lakh tonnes. It is cultivated in Rajasthan, Gujarat, Madhya Pradesh, Tamil Nadu, U.P., etc.

Light Interception

Light interception is a function of the leaf area, the distribution of leaves and their orientation relative to the sun. When water stress occurs, the relationship among these factors is modified, changing the crop's ability to capture light. Leaf folding commonly occurs under water stress and fractional radiation interception is reduced (Williams and Boote, 1995).

Chlorophyll stability index (CSI)

Chlorophyll stability is a function of temperature, and it is found to correlate with drought tolerance. The chlorophyll stability index (CSI) is a parameter used to measure frost or drought resistance of a plant. Sanandachari (1978) reported that CSI appeared to be more reliable to assess the drought tolerance capacity.

The drought hardy types of tomato showed higher values of chlorophyll stability index (Babu, 1980). Decreasing water potential reduced the chlorophyll content and its stability in cotton plants (Gadallah, 1995). Sairam *et al.*, (1997) reported that both drought stress and temperature stress decreased membrane stability, chlorophyll content and chlorophyll stability index in all wheat genotypes. Chlorophyll stability index decreased with increasing drought stress in most of the maize genotypes (Meenakumari *et al.*, 2004).

Pigeon pea experiencing water deficit recorded reduced chlorophyll stability index (Nagajothi, 2005).

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Patil *et al.* (2005) reported that CSI method is more reliable to confirm the drought tolerance in grape varieties and he reported CSI varying from 10.44 to 85.35 per cent among 54 grape varieties.

Stomatal diffusive resistance

Srivastava *et al.*, (1996) revealed that the varieties CoS 88225, CoS 767, CoS 88216, Co 1148, CoS 90265, CoS 90269 and CoS 88230 tended to conserve water during soil moisture stress phase showing greater stomatal diffusive resistance (rS) and lower transpiration rate, whereas at recovery phase (re-watering) Co 1148, CoS 767, CoS 88230 and CoS 90269 exhibited lower rS and higher transpiration compared to their respective normal soil moisture condition. Chauhan *et al*., (1996) revealed that improved cv. Vandana transpired less water and exhibited higher stomatal diffusive resistance than the traditional cv. Brown gora under stressed conditions.

Transpiration rate

Balasubramanium and Maheswari (1990) have reported that in groundnut plants the leaf water potential, transpiration rate and photosynthetic rate decreased progressively with increasing duration of water stress. Ravindra *et al*., (1990) observed that leaf transpiration rate under stress at vegetative, flowering and peg formation were significantly reduced in groundnut. Under severe stress conditions water loss was minimized by a steep decline in transpiration (Balasubramanium and Maheswari, 1990; Srivastava *et al*., 1996). Meera (2003) stated that in chilli plants transpiration rate decreased progressively with increasing duration of water stress.

MATERIALS

The following 22 accessions screened based upon laboratory studies were utilized for field trial along with ruling variety C0 (CR) 4 as check.

CS – 18	CS – 127	CS – 161	CS – 208
CO (CR) 4	CS – 131	CS – 168	CS – 210
CS – 33	CS – 134	CS – 178	CS – 213
CS – 73	CS – 150	CS – 196	CS – 220
CS – 90	CS – 153	CS – 201	CS – 267

Treatment details

1. Moisture stress I – Imposed during vegetative phase *i.e.,* 30 to 50 days after sowing for 20 days
2. Moisture stress II – Terminal stress *i.e.,* flowering to grain filling stage 70 to 90 days
3. Control – Irrigation as per the crop need

Design : Split plot design
Main plot : Treatments (3)
Subplot : Genotypes (23)
Number of replications : 2

The field trial was conducted during December 2007 to March 2008. A plot size of 1m x 1m formed as the basic experimental unit. The seeds were sown at a spacing of 15 x 10 cm uniformly.

Seeds of twenty three coriander accessions including CO (CR) 4 check were lightly pressed to separate inter mericarps. The standard package of practices recommended for coriander (Peter *et al.*, 2005) was adopted uniformly in all the plots.

METHODS

Light interception (LI)

The light interception (LI) was calculated by the formula.

$$LI(\%) = \frac{I_a - I_b}{I_a} \times 100$$

where,

I_a – Light intensity in open

I_b – Average light intensity in the middle canopy and earth surface

Chlorophyll stability index (CSI)

Two leaf samples of 250 mg each were put in two test tubes containing 10 mL of distilled water. One of the test tubes was placed in a water bath and heated at 65^{o} C for 30 minutes while the other was kept as a control. Then, total chlorophyll content was estimated using a spectrophotometer at 652 nm (Koleyoreas, 1958). CSI was calculated using the following formula:

$$CSI\,(\%) = \frac{Total\,chlorophyll\,content\,(heated)}{Total\,chlorophyll\,content\,(control)} \times 100$$

Stomatal diffusive resistance (rS)

The rS on the abaxial surface was recorded using the steady state porometer (Model LI–1600, LICOR Inc., Nebraska, USA) as described by O' Toole and Tomar (1982) and expressed in s cm^{-1}.

Transpiration rate (E)

The transpiration rate in abaxial leaf surface was recorded with the steady state promoter (Model LI-1600, LICOR Inc., Nebraska, USA) as described O' Toole and Tomar (1982) and expressed in m g H_2O m^{-2} s^{-1}.

RESULT AND DISCUSSION

Light interception (LI)

Light interception is a function of the leaf area, the distribution of leaves and their orientation relative to the sun. When water stress occurs, the relationship among these factors is modified, changing the crop's ability to capture light. Leaf folding commonly occurs under water stress and fractional radiation interception is reduced (Wiilliams and Boote, 1995). Similarly LI was affected under moisture stress conditions induced at reproductive stage than vegetative growth phase and non-stress condition. Among the genotypes, CS 127 recorded higher LI of 59.51, 56.95 and 58.78 under non-stress, moisture stress at reproductive growth phase and moisture stress under vegetative growth phase respectively than the other genotypes along with ruling variety CO (CR) 4 (52.49, 42.65 and 49.65 at non-stress, moisture stress at reproductive growth phase and moisture stress under vegetative growth phase respectively). Reduced leaf area might have affected LI under moisture stress at reproductive growth phase.

Chlorophyll stability index (CSI)

It is an indication of the stress tolerance capacity of plants. A high CSI value indicated that the stress did not have much impact on chlorophyll content of plants. CSI was the highest under vegetative stress condition than in the reproductive stress condition. It may due to loss of chlorophyll content during reproductive stress condition. Among the genotypes CSI was the highest in CS 127 (52.96, 51.83 and 52.15% at non-stress, moisture stress at reproductive growth phase and moisture stress at vegetative growth phase respectively) and the lowest CSI was observed in CS 178 (37.02% under moisture stress at reproductive growth phase) while in ruling variety CO (CR) 4, CSI was 39.87, 37.74 and 38.07 per cent under non-stress, moisture stress at reproductive growth phase and moisture stress under vegetative growth phase respectively. In drought resistant genotype, CSI was higher than in drought susceptible genotype. Reduced CSI in drought susceptible genotypes during drought stress was also observed in wheat (Sairam *et al*., 1997) and maize (Meenakumari *et al*., 2004). It may be attributed to the decrease in chlorophyll content upon exposure to oxidative stress. Higher CSI helped the

Table 1
Effect of moisture stress on Chlorophyll stability index (CSI) (%) and Light interception (LI)) of coriander genotypes

Genotypes	*Chlorophyll stability index (CSI) (%)*				*Light interception (LI)*			
	T_1	T_2	T_3	*Mean*	T_1	T_2	T_3	*Mean*
Co (CR) 4	38.07	37.74	39.87	38.56	49.65	42.67	52.49	48.27
CS 18	46.64	46.46	48.33	47.14	55.47	54.40	57.68	55.85
CS 33	38.33	38.09	40.05	38.82	50.34	49.20	54.97	51.50
CS 73	40.77	41.03	41.92	41.24	53.02	45.02	54.23	50.76
CS 90	38.26	37.74	40.23	38.74	47.61	43.43	50.37	47.14
CS 122	39.82	39.43	41.74	40.33	50.06	44.17	52.90	49.04
CS 127	52.15	51.83	52.96	52.31	58.78	56.95	59.51	58.41
CS 131	40.43	40.50	41.92	40.95	47.91	44.42	51.84	48.05
CS 134	37.97	38.09	39.34	38.47	42.10	41.29	42.43	41.94
CS 150	41.86	41.30	43.88	42.34	49.49	45.67	50.66	48.61
CS 153	40.82	39.69	43.43	41.32	41.17	39.95	41.82	40.98
CS 154	41.38	39.87	38.54	39.93	47.09	41.01	48.64	45.58
CS 161	48.58	48.33	50.29	49.06	56.47	54.68	57.76	56.30
CS 168	41.30	40.32	43.79	41.80	49.41	46.81	48.68	48.30
CS 178	37.43	37.02	39.34	37.93	50.26	40.28	42.83	44.46
CS 196	37.14	37.20	43.88	39.41	49.89	43.48	52.17	48.51
CS 201	40.65	39.69	43.08	41.14	47.05	41.94	48.92	45.97
CS 202	43.89	43.25	46.32	44.49	53.59	52.94	57.32	54.61
CS 208	42.84	42.76	45.47	43.69	53.38	51.23	56.10	53.57
CS 210	39.00	39.25	40.23	39.49	47.95	49.16	55.05	50.72
CS 213	38.08	37.74	39.87	38.56	42.75	42.96	43.73	43.15
CS 220	37.53	37.02	39.52	38.02	49.16	38.01	55.90	47.69
CS 267	40.60	40.50	42.19	41.09	47.82	35.90	52.69	45.47
Mean	41.16	40.78	43.01	41.65	49.58	45.59	51.65	48.94
	T	**G**	**T at G**	**G at T**	**T**	**G**	**T at G**	**G at T**
S Ed.	0.0847	0.7717	1.3099	1.3366	0.7745	1.1623	2.1158	2.0132
CD	0.3645**	1.5408**	2.6281 NS	2.6687NS	3.3325*	2.3207**	4.8782**	4.0196**

* - Significant at 5% level of significance, ** - Significant at 1% level of significance, NS-Non significant

Table 2
Effect of moisture stress on Stomatal diffusive resistance (rS) ($s\ cm^{-1}$) and Transpiration rate (E) ($m\ g\ H_2O\ m^{-2}\ s^{-1}$) of coriander genotypes

Genotypes	*Stomatal diffusive resistance (rS) ($s\ cm^{-1}$)*				*Transpiration rate (E) ($m\ g\ H_2O\ m^{-2}\ s^{-1}$)*			
	T_1	T_2	T_3	*Mean*	T_1	T_2	T_3	*Mean*
Co (CR) 4	0.077	0.079	0.064	0.072	58.71	57.79	60.79	59.10
CS 18	0.135	0.137	0.119	0.128	53.19	51.38	53.96	52.84
CS 33	0.071	0.072	0.048	0.060	63.39	55.64	64.75	61.26
CS 73	0.072	0.074	0.066	0.070	62.79	60.29	64.05	62.38
CS 90	0.075	0.077	0.077	0.077	59.59	57.72	58.61	58.64
CS 122	0.076	0.078	0.073	0.075	57.49	55.34	58.51	57.11
CS 127	0.148	0.151	0.145	0.148	50.19	48.71	51.98	50.29
CS 131	0.072	0.073	0.068	0.071	61.19	58.81	62.27	60.76
CS 134	0.090	0.092	0.065	0.078	61.29	59.30	62.07	60.89
CS 150	0.079	0.080	0.069	0.075	58.39	56.23	59.40	58.01
CS 153	0.078	0.079	0.062	0.071	58.29	56.53	58.91	57.91
CS 154	0.085	0.086	0.076	0.081	62.59	62.07	60.39	61.69
CS 161	0.146	0.149	0.135	0.142	50.99	49.50	52.37	50.96
CS 168	0.090	0.092	0.068	0.080	57.59	55.44	59.20	57.41
CS 178	0.067	0.069	0.056	0.062	61.89	59.50	63.16	61.52
CS 196	0.061	0.062	0.057	0.060	58.49	56.53	58.41	57.81
CS 201	0.089	0.091	0.074	0.083	60.19	58.31	60.89	59.80
CS 202	0.104	0.106	0.099	0.103	55.49	52.54	56.78	54.94
CS 208	0.101	0.103	0.097	0.100	55.94	53.71	57.99	55.88
CS 210	0.079	0.080	0.061	0.071	61.39	59.40	62.17	60.99
CS 213	0.081	0.082	0.075	0.078	57.79	55.54	58.91	57.41
CS 220	0.067	0.069	0.063	0.066	62.79	60.69	63.76	62.41
CS 267	0.087	0.089	0.086	0.088	57.69	55.44	58.81	57.31
Mean	0.088	0.090	0.079	0.084	58.58	56.30	59.42	58.10
	T	**G**	**T at G**	**G at T**	**T**	**G**	**T at G**	**G at T**
S Ed.	0.00219	0.00225	0.00440	0.00389	0.0578	1.0348	1.7538	1.7923
CD	0.00944^{NS}	0.00449**	0.01130**	0.00777**	0.2487**	2.0660**	3.5061^{NS}	3.5784^{NS}

* - Significant at 5% level of significance, ** - Significant at 1% level of significance, NS-Non significant

plants to withstand stress through better availability of chlorophyll. This resulted in increased photosynthetic rate, more dry matter production and higher productivity (Madhanmohan *et al.*, 2000). Patil *et al.* (2005) suggested that CSI method is more reliable to confirm the drought tolerance in grape varieties.

Stomatal diffusive resistance (rS)

Stomatal diffusive resistance was more under moisture stress conditions. Due to moisture stress, the turgidity of plant cell was reduced and stomatal closure mechanism was triggered off to reduce water loss. This resulted in increased rS in crop plants under restricted moisture supply. Higher rS is a drought adaptive mechanism. In the present study higher rS was observed in plants under moisture stress at reproductive phase than vegetative growth phase and non-stress condition. Among the genotypes, CS 127 was better adapted to drought at any stage of moisture stress as compared to other genotypes. The results hold good with the reports in tomato (Rao and Bhatt, 1991) and in soybean (Lee *et al.*, 1990). The increased rS in groundnut genotypes may be due to decreased water potential, increased leaf canopy temperature and increased proline content (Nogueira *et al.*, 1998). Davies *et al.*, (1994) reported that decreased stomatal conductance or increased stomatal resistance may be due to non-hydraulic signal transmitted from roots which are experiencing soil drying.

Transpiration rate (E)

Transpiration rate showed an exactly reverse trend of rS. Transpiration rate was lowered due to restricted moisture availability and enhanced stomatal closure. Reduction of transpiration due to moisture stress has been reported by Tan *et al.*, (1981) in tomato and Hesse and Lenz (1982) in french bean. Transpiration rate was affected by moisture stress induced in different stages of growth. Similarly reduced transpiration rate was recorded under moisture stress condition at reproductive growth phase than moisture stress condition at vegetative growth phase and non-stressed conditions. Reduction in transpiration rate varied with genotypes over the growth stages. In genotype CS 127, minimum transpiration rate was noticed, whereas transpiration rate was comparatively high in genotype CS 220 under water stress. The results are in concurrence with observations of Sivakumar and Sarma (1985) that fully irrigated groundnut plants recorded a daily mean transpiration of 10 µg H_2O m^{-2} s^{-1} and it was 1.8 µg H_2O m^{-2} s^{-1} in groundnut plants undergoing drought stress at flowering to start seed growth. In groundnut Ravindra *et al*., (1990) observed that leaf transpiration rate and RWC were significantly reduced under stress at vegetative, flowering and peg formation. Balasubramanium and Maheswari (1990) reported that as water stress developed, transpiration rate declined slowly while stomatal conductance declined very faster in groundnut.

CONCLUSION

The light interception was highest under normal irrigated condition compared to moisture stress at vegetative stress condition and reproductive stress condition. Whereas, reduction was more when moisture stress was induced at reproductive stage. CSI was affected among the genotypes when moisture stress induced during reproductive growth period than moisture stress at vegetative growth period and non-stressed condition. More stomatal diffusive resistance and Reduced transpiration rate was recorded when moisture stress induced at reproductive growth period. Whereas, genotype CS 127 excelled over other genotypes in all these characters at any stage of stress.

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