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Studies on bio-chemical parameters of coriander (*Coriandrum sativum* L.) genotypes under drought condition

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Abstract
A field experiment was carried out to screen the coriander germplasm for drought tolerance at various Locations in Horticultural College and Research Institute, TNAU, Coimbatore. Preliminary screening was done with 240 accessions and 50 accessions were selected based on yield performance along with check CO (Cr) 4 and were raised in main field in a Randomized Block Design in three replications. The crop was grown purely under rain fed condition. Biochemical parameters were measured during crop growth. A considerable reduction was noticed in biochemical components such as soluble protein contents and NRase activity. In contrast, proline content was significantly increased under water deficit. The expression of characters under water deficit revealed the tolerant nature of coriander accessions. ACC 18, followed by ACC 87 is thus grouped as drought tolerant accessions and ACC 145, ACC 202, ACC 201, ACC 230 as drought susceptible accessions.

Keywords: Coriander, proline, drought

Introduction
Coriander (*Coriandrum sativum* L.) is an annual herb, which belongs to the family Apiaceae. It is native of Mediterranean region. The plant is named by the Greek word koris, meaning bug because of the special odour of coriander leaves and unriped fruits. Green coriander is also called as Cilantro, Chinese parsley, Mexican parsley and Japanese parsley. The major producers are Morocco, Canada, India, Pakistan, Romania and Russia. Other producers include Iran, Turkey, Egypt, Israel, China, Thailand, Myanmar, Poland, Bulgaria, Hungary, France, Netherlands, USA, Argentina and Mexico.

In India, coriander is mainly cultivated in Rajasthan and Gujarat with a sizeable acreage in Madhya Pradesh, Haryana, Punjab, Uttar Pradesh, Andhra Pradesh, Tamil Nadu and Bihar. It is cultivated in an area of 5, 91,090 hectares with a production of 3, 38, 260 tonnes [17]. Rajasthan alone shares 40-45 per cent of the area and production. Coriander is valued for its tender leaves and grains. The essential oil present in the coriander adds aroma and flavour to the food. The dried fruit is an important ingredient of curry powder and is also used in pickling spices, sauces, seasoning, confectionary and in medicine [11]. Despite its importance, the productivity of coriander in India continues to be low. The average productivity is only 519 kg ha^{-1}. Indian coriander is also poor in essential oil content (0.04 to 0.8 per cent) as compared to European countries (1.4 to 1.7 per cent) Thus, there is great scope for crop improvement in coriander for increasing yield potential [9].

Rain fed crop production is highly dependent on monsoons and occurrence of moisture stress at degrees and at different growth phases is a common problem. The nature and intensity of stress is determined by rainfall distribution, which is generally uncertain. This often results in poor production and productivity. Soil moisture profoundly influences the availability and uptake of mineral nutrients. Water deficit in leaves is associated with reduced rate of organ development. It has many indirect effects on physiological processes, plant growth and productivity. A study to understand the physiological responses of the plant to water deficit and to evaluate suitable management practices is therefore essential.

Among the various environmental stresses, drought is the most common phenomenon in tropical countries. Coriander is very sensitive to moisture stress particularly at the growth of reproductive organs. Water deficit, the consequence of imbalance between water supply and plant water needs affect coriander growth depending on the stage of crop growth and degree of intensity of the drought stress.

The aminoacid proline is synthesized at an accelerated rate during water stress, while its oxidation is inhibited, resulting in large accumulations of proline in stressed tissues [4], [26]. It has been advocated that proline accumulation is advantageous for the plant in coping with the drought situation and can be used as an indicator in selecting species for drought resistance [27]. In coriander there are many varieties and accessions available, inspite of it, no varieties have so far been screened in Tamil Nadu, especially for rain fed cultivation and the work done on this line is much scanty. With this background in view, the present study was undertaken.

Materials and methods

In the present study, for preliminary screening 240 accessions were raised in a plot size of 1 m x 1m in a Randomized Block Design. From the 240 accessions, 50 accessions along with check CO (Cr) 4 obtained from Tamil Nadu Agricultural University, Coimbatore-3, and were selected based on yield performance.

Table 1: Selected accessions to raise in Coimbatore location under rainfed conditions

S. No.	Accession	Source
1.	ACC 13	Regional Agrl. Station – Lam
2.	ACC 14	Regional Agrl. Station – Lam
3.	ACC 15	NBPGR
4.	ACC 16	Hissar
5.	ACC 16	Hissar
6.	ACC 32	Guntur A.P.
7.	ACC 33	Guntur A.P.
8.	ACC 50	Jobner
9.	ACC 51	Coimbatore
10.	ACC 76	Coimbatore
11.	ACC 86	Coimbatore
12.	ACC 87	Coimbatore
13.	ACC 103	Hissar
14.	ACC 110	Coimbatore
15.	ACC 114	Coimbatore
16.	ACC 115	Coimbatore
17.	ACC 116	Coimbatore
18.	ACC 118	Coimbatore
19.	ACC 119	Coimbatore
20.	ACC 129	Coimbatore
21.	ACC 130	Coimbatore
22.	ACC 131	Coimbatore
23.	ACC 134	Coimbatore
24.	ACC 144	Coimbatore
25.	ACC 145	Coimbatore
26.	ACC 158	Coimbatore
27.	ACC 185	Coimbatore
28.	ACC 186	Coimbatore
29.	ACC 192	Coimbatore
30.	ACC 194	Coimbatore
31.	ACC 196	Coimbatore
32.	ACC 201	Bulgarian
33.	ACC 202	Coimbatore
34.	ACC 203	Coimbatore
35.	ACC 204	Coimbatore
36.	ACC 213	TNAU
37.	ACC 219	LAM
38.	ACC 225	Jobner
39.	ACC 228	Hissar
40.	ACC 230	Namdhari
41.	ACC 231	NDUA&T Faizabad
42.	ACC 232	NDUA&T Faizabad
43.	ACC 233	NDUA&T Faizabad
44.	ACC 234	NDUA&T Faizabad
45.	ACC 235	NDUA&T Faizabad
46.	ACC 236	NDUA&T Faizabad
47.	ACC 237	NDUA&T Faizabad
48.	ACC 238	NDUA&T Faizabad
49.	ACC 239	NDUA&T Faizabad
50.	ACC 240	NDUA&T Faizabad

Selected 50 genotypes (Table-1) were raised in the main field for further screening. The plot size was 3 m x 3 m and 2 rows were maintained for each genotype and replicated thrice in two locations (Coimbatore I and Coimbatore II) purely under rain fed conditions. The row to row and plant to plant distance was kept 30 cm and 15 cm respectively. The field

observations were recorded from randomly selected and tagged five plants from each replication in two locations. The data were recorded and the biochemical parameters *Viz;* proline, Soluble protein content, Nitrate reductase activity and Peroxidase activity were estimated.

Results and discussion

The study revealed that the quality parameters was significantly influenced in two location. The data on proline content in the accessions under moisture stress condition are presented in Table 2. At Coimbatore I, the proline content showed significant differences among different accessions, which ranged from 206.67µg g^{-1} to 878.55 µg g^{-1}. The ACC 18 showed higher proline content (878.55 µg g^{-1}) followed by ACC 87 (745.21 µg g^{-1}) ND –CO-19 (739.79 µg g^{-1}) over the CO(Cr)4 (640.37 µg g^{-1}). Low level of proline content was recorded in ACC 201 (206.67 µg g^{-1}). At Coimbatore II, proline content was more in ACC 18 (925.17 µg g^{-1}) followed by ACC 87 (877.09 µg g^{-1}) ND –CO-19 (863.83) µg g^{-1} and ND –CO-50 (768.39 µg g^{-1}) over CO(Cr)4 (767.01 µg g^{-1}). Low level of proline content was recorded in ACC 201 (210.62 µg g^{-1}). In the pooled mean, ACC 18 recorded the highest proline content (901.86 µg g^{-1}) followed by ACC 87 (811.15 µg g^{-1}) and ND –CO-19 (801.81 µg g^{-1}) when compared to CO(Cr)4 (703.69 µg g^{-1}). Low level of proline content was recorded in ACC 201 (208.64 µg g^{-1}).

Table 2: Proline content (µg g^{-1}) of coriander accessions grown under rainfed conditions at different regions of Tamil Nadu

S. No	ACC. No	Orchard Coimbatore 1	Tank bed Coimbatore II	Pooled mean
1	ACC13	424.71	448.78	436.74
2	ACC14	413.88	482.09	447.98
3	ACC15	316.95	346.95	331.95
4	ACC16	425.35	456.55	440.95
5	ACC18	878.55	925.17	901.86
6	ACC32	435.86	462.41	449.14
7	ACC33	234.57	245.39	239.98
8	ACC50	508.85	525.17	517.01
9	ACC51	274.94	320.35	297.65
10	ACC76	325.97	350.63	338.30
11	ACC86	353.25	378.09	365.67
12	ACC87	745.21	877.09	811.15
13	ACC103	518.63	523.43	521.03
14	ACC110	250.91	239.60	245.25
15	ACC114	324.43	376.63	350.53
16	ACC115	324.43	765.73	545.08
17	ACC116	315.98	331.37	323.68
18	ACC118	342.18	362.42	352.30
19	ACC119	419.96	418.65	419.31
20	ACC129	421.29	451.03	436.16
21	ACC130	434.10	433.57	433.84
22	ACC131	475.29	518.56	496.93
23	ACC134	436.51	475.01	455.76
24	ACC144	216.49	215.31	215.90
25	ACC145	224.10	212.97	218.54
26	ACC158	330.58	373.90	352.24
27	ACC185	341.23	368.62	354.92
28	ACC186	417.94	427.78	422.86
29	ACC192	362.44	413.82	388.13
30	ACC194	325.11	374.63	349.87
31	ACC196	422.59	435.14	428.86
32	ACC201	206.67	210.62	208.64
33	ACC202	315.17	323.91	319.54
34	ACC203	456.30	484.15	470.23
35	ACC204	365.23	386.54	375.89
36	ACC213	457.17	484.21	470.69
37	ACC219	624.98	759.77	692.38
38	ACC225	485.94	515.65	500.79
39	ACC228	475.89	464.91	470.40
40	ACC230	468.59	483.05	475.82
41	K selection	484.45	486.18	485.32
42	ND – CO- 2	317.01	321.18	319.10
43	ND – CO-19	739.79	863.83	801.81
44	ND – CO- 20	353.11	355.98	354.54
45	ND – CO- 22	425.69	423.37	424.53
46	ND – CO- 26	433.97	453.15	443.56
47	ND – CO- 31	612.17	783.90	698.03
48	ND – CO- 34	623.77	764.33	694.05
49	ND – CO- 38	616.31	748.57	682.44
50	ND – CO- 50	615.46	768.39	691.93
51	CO(Cr)4	640.37	767.01	703.69

	Mean	430.59	478.15	454.37
	SEd	8.081	4.133	4.538
	CD (*P=0.05*)	16.00	8.18	8.89

Soluble protein in leaves was significantly different among the genotypes. There was increasing trend in soluble protein during moisture stress (Table 3). At Coimbatore I, the soluble protein ranged from 6.10 mg g^{-1} to 12.44 mg g^{-1}. In ACC 18 recorded highest soluble protein (12.44 mg g^{-1}), followed by ACC 115, ND –CO-34, ACC 87, ND –CO-38, ACC 219 ND –CO-50, ND –CO-19 which recorded (10.24, 0.92, 9.86, 9.54 and 9.26 mg g^{-1}) respectively as compared to (8.90 mg g^{-1}). Soluble protein was low in ACC 144 and ACC 145 (6.10 mg g^{-1}). At Coimbatore II, the soluble protein ranged from 6.10 mg g^{-1} to 13.64 mg g^{-1}. Soluble protein was high in ACC 18 (13.64 mg g^{-1}) followed by ND –CO-31 (11.86 mg g^{-1}), ND –CO-38 (10.82 mg g^{-1}), ND –CO-50 (10.56 mg g^{-1}), ND –CO-34 and ACC 87 (10.46 mg g^{-1}) ND –CO-19 (10.22 mg g^{-1}) and ACC 115 (10.10 mg g^{-1}) as compared to CO(Cr)4 (9.22 mg g^{-1}). Low level of soluble protein was noticed in ACC 202 (6.10 mg g^{-1}). In the pooled mean, ACC 18 (13.04 mg g^{-1}) was significantly high followed by ND –CO-38 (10.34 mg g^{-1}), ND –CO-34 (10.19 mg g^{-1}), ACC 115 (10.17 mg g^{-1}), ND –CO-31 (10.15 mg g^{-1}) ACC 87 (10.05 mg g^{-1}), ND –CO-50 (9.99 mg g^{-1}), ND –CO-19 (9.74 mg g^{-1}), ACC 219 (9.69 mg g^{-1}) when compared to CO(Cr)4 (0.06 mg g^{-1}). Lowest amount of soluble protein was observed in ACC 202 (5.99 mg g^{-1}).

Table 3: Soluble protein content (mg g^{-1}) of coriander accessions grown under rainfed conditions at different regions of Tamil Nadu

S. No	ACC. No	Orchard Coimbatore 1	Tank bed Coimbatore II	Pooled mean
1	ACC13	7.22	7.42	7.32
2	ACC14	7.88	8.42	8.15
3	ACC15	7.10	7.22	7.16
4	ACC16	7.42	8.68	8.05
5	ACC18	12.44	13.64	13.04
6	ACC32	6.28	7.68	6.98
7	ACC33	6.20	6.42	6.31
8	ACC50	8.82	9.10	8.96
9	ACC51	6.48	6.88	6.68
10	ACC76	6.92	7.20	7.06
11	ACC86	6.86	7.84	7.35
12	ACC87	9.86	10.24	10.05
13	ACC103	8.20	8.82	8.51
14	ACC110	6.20	6.40	6.30
15	ACC114	6.44	6.82	6.63
16	ACC115	10.24	10.10	10.17
17	ACC116	6.20	6.44	6.32
18	ACC118	6.52	6.84	6.68
19	ACC119	7.20	7.86	7.53
20	ACC129	8.10	8.42	8.26
21	ACC130	8.42	8.92	8.67
22	ACC131	8.22	8.86	8.54
23	ACC134	7.82	8.20	8.01
24	ACC144	6.10	6.24	6.17
25	ACC145	6.10	6.20	6.15
26	ACC158	7.24	7.82	7.53
27	ACC185	7.52	7.84	7.68
28	ACC186	8.24	8.82	8.53
29	ACC192	7.88	8.20	8.04
30	ACC194	7.24	7.89	7.57
31	ACC196	8.22	8.62	8.42
32	ACC201	6.22	6.82	6.52
33	ACC202	5.88	6.10	5.99
34	ACC203	7.64	8.24	7.94
35	ACC204	6.84	7.20	7.02
36	ACC213	7.80	8.12	7.96
37	ACC219	9.54	9.84	9.69
38	ACC225	7.76	8.42	8.09
39	ACC228	6.58	7.44	7.01
40	ACC230	7.24	7.82	7.53
41	K selection	7.52	8.20	7.86
42	ND – CO- 2	6.20	6.24	6.22
43	ND – CO-19	9.26	10.22	9.74
44	ND – CO- 20	6.20	6.22	6.21
45	ND – CO- 22	7.84	8.24	8.04
46	ND – CO- 26	8.20	8.88	8.54
47	ND – CO- 31	8.44	11.86	10.15
48	ND – CO- 34	9.92	10.46	10.19

49	ND – CO- 38	9.86	10.82	10.34
50	ND – CO- 50	9.42	10.56	9.99
51	CO(Cr)4	8.90	9.22	9.06
	Mean	7.70	8.25	7.98
	SEd	0.451	0.345	0.284
	CD (*P=0.05*)	0.893	0.683	0.556

The data on nitrate reductase activity (NRase) in different accession under moisture stress condition are presented in (Table 4). At Coimbatore I, the nitrate reductase activity ranged between 170.3 and 253.5 µg of NO_2 g^{-1} h^{-1}. Nitrate reductase activity was maximum in ACC 18 (253.5 µg of NO_2 g^{-1} h^{-1}) followed by ACC 87 (230.3 µg of NO_2 g^{-1} h^{-1}), ND –CO-31 (228.6 µg of NO_2 g^{-1} h^{-1}), ACC 115 (224.9 µg of NO_2 g^{-1} h^{-1}) ND –CO-34 (225.8 µg of NO_2 g^{-1} h^{-1}) ACC 219 (225.9 µg of NO_2 g^{-1} h^{-1}), ND –CO-50 (220.3 µg of NO_2 g^{-1} h^{-1}), ND –CO-50 (215.8 µg of NO_2 g^{-1} h^{-1}) and ACC 129 (210.8 µg of NO_2 g^{-1} h^{-1}) when compared to CO(Cr)4 (210.7 µg of NO_2 g^{-1} h^{-1}). Low NRase activity was observed in ACC 110 (170.3 µg of NO_2 g^{-1} h^{-1}). At Coimbatore II, the ACC 18 recorded the highest NRase activity (260.2 µg of NO_2 g^{-1} h^{-1}) followed by ACC 87 (240.3 µg of NO_2 g^{-1} h^{-1}), ND –CO-19 (238.6 µg of NO_2 g^{-1} h^{-1}), ND –CO-31 (233.8 µg of NO_2 g^{-1} h^{-1}), ACC 115 (232.9 µg of NO_2 g^{-1} h^{-1}) ND –CO-50 (231.8 µg of NO_2 g^{-1} h^{-1}), ND –CO-34 (230.4 µg of NO_2 g^{-1} h^{-1}) ACC 219 (230.9 µg of NO_2 g^{-1} h^{-1}) and ND –CO-38 (230. 5µg of NO_2 g^{-1} h^{-1}) over CO(Cr)4 (228.7 µg of NO_2 g^{-1} h^{-1}). In ACC 202 (172.4 µg of NO_2 g^{-1} h^{-1}) NRase activity was the lowest. In the pooled mean, ACC 18 (256.9 µg of NO_2 g^{-1} h^{-1}) recorded maximum NRase activity, followed by ACC 87 (235.3 µg of NO_2 g^{-1} h^{-1}), ND –CO-31 (231.2 µg of NO_2 g^{-1} h^{-1}), ACC 115 (228.9 µg of NO_2 g^{-1} h^{-1}), ACC 219 (228.4 µg of NO_2 g^{-1} h^{-1}) ND –CO-34, (228.1 µg of NO_2 g^{-1} h^{-1}), ND –CO-19 (229.5 µg of NO_2 g^{-1} h^{-1}), ND –CO-38 (225.6 µg of NO_2 g^{-1} h^{-1}), ND –CO-50 (203.8 µg of NO_2 g^{-1} h^{-1}) when compared CO(Cr)4 (219.7 µg of NO_2 g^{-1} h^{-1}). Minimum amount of NRase activity was recorded in ACC 202 (171.6 µg of NO_2 g^{-1} h^{-1}).

Table 4: Nitrate reductase activity (µg NO_2 $g^{-1}h^{-1}$) of coriander accessions grown under rainfed conditions at different regions of Tamil Nadu

S. No	ACC. No	Orchard Coimbatore 1	Tank bed Coimbatore II	Pooled mean
1	ACC13	194.4	190.8	192.6
2	ACC14	203.2	225.6	214.4
3	ACC15	190.6	212.2	201.4
4	ACC16	199.5	215.6	207.5
5	ACC18	253.5	260.2	256.9
6	ACC32	180.6	203.9	192.2
7	ACC33	183.4	200.6	192.0
8	ACC50	204.9	210.3	207.6
9	ACC51	170.2	189.4	179.8
10	ACC76	184.8	206.9	195.9
11	ACC86	180.8	210.6	195.7
12	ACC87	230.3	240.3	235.3
13	ACC103	206.6	211.6	209.1
14	ACC110	170.3	192.5	181.4
15	ACC114	186.2	201.2	193.7
16	ACC115	224.9	232.9	228.9
17	ACC116	180.2	203.5	191.8
18	ACC118	193.6	190.2	191.9
19	ACC119	208.6	200.8	204.7
20	ACC129	210.8	212.6	211.7
21	ACC130	209.6	224.2	216.9
22	ACC131	205.8	218.6	212.2
23	ACC134	200.2	202.7	201.4
24	ACC144	184.2	193.4	188.8
25	ACC145	180.3	186.4	183.4
26	ACC158	201.4	208.2	204.8
27	ACC185	203.7	206.2	205.0
28	ACC186	207.8	229.9	218.8
29	ACC192	202.8	224.6	213.7
30	ACC194	209.6	210.4	210.0
31	ACC196	205.7	225.2	215.5
32	ACC201	174.3	180.2	177.3
33	ACC202	170.9	172.4	171.6
34	ACC203	202.7	208.6	205.7
35	ACC204	195.4	188.4	191.9
36	ACC213	210.9	210.3	210.6
37	ACC219	225.9	230.9	228.4
38	ACC225	208.6	218.7	213.7
39	ACC228	199.8	205.8	202.8
40	ACC230	24.6	210.6	117.6
41	K selection	202.9	220.8	211.8
42	ND – CO- 2	192.6	192.6	192.6

43	ND – CO-19	220.3	238.6	229.5
44	ND – CO- 20	190.4	189.4	189.9
45	ND – CO- 22	208.5	209.6	209.0
46	ND – CO- 26	210.8	212.5	211.7
47	ND – CO- 31	228.6	233.8	231.2
48	ND – CO- 34	225.8	230.4	228.1
49	ND – CO- 38	220.7	230.5	225.6
50	ND – CO- 50	215.8	231.8	223.8
51	CO(Cr)4	210.7	228.7	219.7
	Mean	198.2	211.5	204.9
	SEd	11.57	10.49	7.81
	CD (*P=0.05*)	22.90	20.78	15.31

The data on Peroxidase activity in the accessions under moisture stress conditions are furnished in Table 5. At Coimbatore I, peroxidase activity showed significant deviations which ranged from 0.180 to 0.400 µmoles H_2O_2 g^{-1} min^{-1}. In ACC 18 and ACC87 peroxidase activity was high (0.400 µmoles H_2O_2 g^{-1} min^{-1}) followed by ACC115 (0.373 µmoles H_2O_2 H_2O_2 g^{-1} min^{-1}.) over CO(Cr)4 (0.362 µmoles H_2O_2 H_2O_2 g^{-1} min^{-1}.). Low level of peroxidase activity was recorded in ND-CO-20 (0.182 µmoles H_2O_2 H_2O_2 g^{-1} min^{-1}.). At Coimbatore II peroxidase activity ranged between 0.140 and 0.440 µmoles H_2O_2 H_2O_2 g^{-1} min^{-1}. Peroxidase activity was high in ACC 18 (0.440 µmoles H_2O_2 H_2O_2 g^{-1} min^{-1}.) followed by ACC 87, ACC 115 (0.420, 0.400 µmoles H_2O_2 H_2O_2 g^{-1} min^{-1}. respectively) over CO(Cr)4 (0.380 µmoles H_2O_2/g/min). Low peroxidase activity was recorded in ND-CO-20 (0.140 µmoles H_2O_2/g/min). In the pooled mean, ACC 18 (0.420 µmoles H_2O_2 H_2O_2 g^{-1} min^{-1}) recorded maximum followed by ACC 87 (0.410 µmoles H_2O_2/g/min) over CO(Cr)4 (0.371 µmoles H_2O_2 H_2O_2 g^{-1} min^{-1}). Low peroxidase activity was recorded in ACC ND-CO-20 (0.160 µmoles H_2O_2 H_2O_2 g^{-1} min^{-1}.).

Table 5: Peroxidase activity (µmoles H_2O_2 g^{-1} min^{-1}) of coriander accessions grown under rainfed conditions at different regions of Tamil Nadu

S. No	ACC. No	Orchard Coimbatore 1	Tank bed Coimbatore II	Pooled mean
1	ACC13	0.240	0.367	0.303
2	ACC14	0.260	0.300	0.280
3	ACC15	0.260	0.300	0.280
4	ACC16	0.220	0.240	0.230
5	ACC18	0.400	0.440	0.420
6	ACC32	0.260	0.260	0.260
7	ACC33	0.220	0.333	0.277
8	ACC50	0.260	0.320	0.290
9	ACC51	0.240	0.340	0.290
10	ACC76	0.280	0.240	0.260
11	ACC86	0.320	0.260	0.290
12	ACC87	0.400	0.420	0.410
13	ACC103	0.340	0.280	0.310
14	ACC110	0.220	0.280	0.250
15	ACC114	0.260	0.240	0.250
16	ACC115	0.373	0.400	0.387
17	ACC116	0.240	0.353	0.297
18	ACC118	0.200	0.260	0.230
19	ACC119	0.347	0.260	0.303
20	ACC129	0.360	0.260	0.310
21	ACC130	0.220	0.240	0.230
22	ACC131	0.240	0.260	0.250
23	ACC134	0.260	0.340	0.300
24	ACC144	0.320	0.360	0.340
25	ACC145	0.240	0.240	0.240
26	ACC158	0.300	0.300	0.300
27	ACC185	0.360	0.240	0.300
28	ACC186	0.300	0.227	0.263
29	ACC192	0.300	0.200	0.250
30	ACC194	0.260	0.320	0.290
31	ACC196	0.220	0.340	0.280
32	ACC201	0.200	0.220	0.210
33	ACC202	0.240	0.227	0.234
34	ACC203	0.260	0.280	0.270
35	ACC204	0.220	0.240	0.230
36	ACC213	0.260	0.360	0.310
37	ACC219	0.220	0.240	0.230
38	ACC225	0.340	0.220	0.280
39	ACC228	0.247	0.280	0.264
40	ACC230	0.220	0.160	0.190

41	K selection	0.200	0.320	0.260
42	ND – CO- 2	0.182	0.180	0.180
43	ND – CO-19	0.220	0.260	0.240
44	ND – CO- 20	0.180	0.140	0.160
45	ND – CO- 22	0.360	0.360	0.360
46	ND – CO- 26	0.300	0.380	0.340
47	ND – CO- 31	0.240	0.360	0.300
48	ND – CO- 34	0.340	0.340	0.340
49	ND – CO- 38	0.340	0.360	0.350
50	ND – CO- 50	0.360	0.380	0.370
51	CO(Cr)4	0.362	0.380	0.371
	Mean	0.275	0.292	0.284
	SEd	0.015	0.015	0.011
	CD (*P=0.05*)	0.031	0.031	0.021

Moisture stress in different crop growth stages resulted in increased proline accumulation in different genotypes, particularly stress during flowering stage increased the proline content. This was corroborated by accumulation of proline in cereals and legume crops during water stress and its relation to drought resistance [24]. Increase in free proline may be due to hydrolysis of proline rich proteins and decrease in protein content which can be ascribed to accelerated proteolysis, as well as reduced rate of proline synthesis [22]. Reduction in leaf water potential (or) relative water content increased the proline synthesis in crop plants [5]. The accumulation of proline takes place due to stimulation of its synthesis from glutamate by loss of feedback inhibition, decline in proline oxidation or decreased incorporation into proteins [18]. Proline is synthesized to depress the internal osmotic potential to maintain a positive gradient for water uptake under water stress conditions. From the data, it was observed that there was differential accumulation µ g g^{-1} of proline in drought resistant genotype ACC 18 (901.86 µ g g^{-1}) and in CO(Cr)4 (703.69 µ g g^{-1}). Proline accumulation was low in ACC 201 (208.64 µ g g^{-1}). This is in confirmation with Steward and Hanson (1980) [28] who found that accumulation of free proline under water stress condition is genetically controlled. Gniazdowsk and Bandurska (1994) [12] reported that free proline accumulation in barley leaves under water stress condition depends on the leaf water content and genetic predisposition of barley to accumulate this amino acid. Accumulation of proline is related to the reduction in the water stress of the tissue [3] and the highest accumulation at the pod initiation stage is attributable to the occurrence of low RWC at this stage. The variability in the accumulation of proline appears to be the characteristic effect of different genotypes. The increase in proline content under water stress was also reported in soybean [29] and cluster beans [19], [13]. Handa *et al*. (1986) [16] reported that proline was synthesized to depress the internal osmotic potential, to maintain a positive gradient for water uptake under water stress conditions. Enormous increase in proline content was encountered as the stress advanced. Soluble protein content being a measure of RuBP carboxylase activity was considered as an index for photosynthetic efficiency. About 50 per cent of total protein in the leaf extract is accounted by RuBP carboxylase [10]. Moisture stress had an adverse effect on soluble protein in different genotypes. The maximum soluble protein content was observed in ACC 18 (13.04 mg g^{-1}) while CO(Cr)4, recorded the soluble protein content of (9.0 mg g^{-1}). Minimum soluble protein was observed in ACC 202 (5.99 mg g^{-1}). The soluble protein generally tends to be less under water deficit conditions. The stress assumes importance, as it regulates the carboxylation and ultimately photosynthesis. Similar results were observed in cluster bean genotypes [13] and green gram [1]. Kramer (1983) [18] reported that synthesis of protein is impaired in plants under water stress and in extreme stress conditions besides protein degradation. The decrease in soluble protein under drought stress may be either due to the increased proteolysis or decreased synthesis or both [15, 14].

Leaf NRase activity is sensitive to change in water status of plants and is inhibited when the ψw of the plant declines [30]. Leaf nitrate reductase activity was correlated with the nitrate flux, which in turn regulated the rate of synthesis of the enzyme [30]. From the observations recorded in the present study, the NRase activity got decreased in susceptible genotypes. In ACC 18, NRase activity was higher (256.9 µg NO_2 g^{-1} h^{-1}) than in CO(Cr)4, (219.7 µg NO_2 g^{-1} h^{-1}). NRase was minimum in ACC 202 (177.6 µg NO_2 g^{-1} h^{-1}). This contrasting difference might be due to maintenance of considerably high ψw in drought tolerant than drought susceptible genotypes. Therefore, nitrate flux for the induction of nitrate reductase might be high in tolerant genotypes, thereby maintaining high NRase activity than susceptible genotypes under water stress condition. The loss in enzyme activity due to water deficit was also reported by Sivaramakrishnan *et al*. (1988) [31] and Leonar *et al*. (1994) [21]. The reduced nitrate reductase activity was due to decrease in nitrate content, which was caused by reduced nutrient uptake under stress conditions in chickpea [35]. Bardzik *et al*. (1971) [6] in maize and Nicholas *et al*., (1976) [25] in soybean suggested that the reduction in nitrate reductase activity might have been brought about by the reduction in enzyme level or inactivation of enzyme. Plants have endogenous protective mechanisms including glutathione, ascorbate, carotenoids and enzymes, such as peroxidase, which scavenge and remove toxic products. Modulation in the activities and these enzymes may be important in plant resistance in environmental stress. The enzyme peroxidase is very sensitive to environmental fluctuations and is considered as the measure of plant resistance to abiotic stress. Peroxidase is a key enzyme involved in morphogenesis and auxin oxidation [8].

Generally, a decrease in water potential and stomatal closure results in an increased production of active oxygen species [32]. Generation of active oxygen species might be responsible for most of the damage caused to cellular components under water stress [36]. Active oxygen species detoxifying enzymes like peroxidase got increased in drought resistant genotypes [2], [34]. High peroxidase content was observed in ACC 18 (0.420) and low in ND-CO-20 (0.160). The enhancement in peroxidase activity was observed with increasing day temperatures in bean plants [7]. Moran *et al*. (1994) [23] also reported an increased peroxidase activity under moisture

conditions in peas. Peroxidase activity is also involved in hydrogen peroxide scavenging and its activity has been correlated with relative tolerance/susceptibility of a particular crop variety [33, 20].

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References

1. Anderson Amalan Kumar A. Physiological studies on water stress and its amelioration in greengram (*Vigna radiata* (L.) Wilczek) genotypes. Ph.D. thesis submitted to Tamil Nadu Agricultural University, Coimbatore, 1998.
2. Allen RD. Dissection of oxidative stress tolerance using transgenic plants. Plant Physiol. 1995; 107:1049-1054.
3. Aspinall D, Paleg LG. Proline accumulation: Physiological aspects. In: Physiology and Biochemistry of drought resistance in plants (Eds L. G. Palag and D. Aspinall), 1981, 205-207.
4. Boggers ST, Steward CRD, Aspinall, Paleg LG. Effect of water stress on proline synthesis from radioactive precursors. Plant Physiol. 1976; 58:398-401.
5. Blum A, Ebercon A. Genotypic responses in sorghum to drought stress III free proline accumulation and drought resistance. Crop Sci. 1976; 16:428-431.
6. Bardzik JM, Marsh HVJ, Havis JR. Effects of water stress on the activities of three enzymes in maize seedlings. Plant Physiol. 1971; 47:828-831.
7. Badiani M, Schenone G, Paolacci AR, Fumagalli I. Daily fluctuations of antioxidants in bean (*Phaseolus vulgaris* L.) leaves. The influence of climatic factors. Agrochemica. 1994; 38:25-36.
8. Bowler C, VanMontagu MV, Inze D. Super oxide dismutase and stress tolerance. Ann. Rev. Plant Physiol., Plant Mol. Biol. 1992; 43:83-116.
9. Choubey PC, Sharma BR, Verma BK, Banafar RNS. Variability studies in coriander (*Coriandrum sativum* L.). Scientific Hort. 1991; 2:137-144.
10. Cook MG, Evans LT. Some physiological aspects of the domestication and improvement of rice (*Oryza* spp.). Field Crops Res. 1983; 6:219-238.
11. Dimri BR, Khan MNA, Narayana MR. Some promising selections of Bulgarian coriander (*Coriandrum sativum* L.) for seed and essential oil with a note on cultivation and distillation of oil. Indian Perfumer. 1976; 20:13-21.
12. Gnaizdowsk-Sherzek H, Bandurska H. Proline accumulation and ribonuclease activity in three barley genotypes during water stress. Acta physicol. Planta. 1994; 16:309-315.
13. Garg BK, Vyas SP, Kathju S, Lahiri AN. Influence of water deficit stress at various growth stages on some enzymes of nitrogen metabolism and yield in cluster bean genotypes. Indian J Plant Physiol. 1998; 3(3):214-218.
14. Garg BK, Kathju S, Lahiri AN, Vyas SP. Drought resistance in pearl millet. Biol. Plant. 1981; 23:182-185.
15. Hsiao TC. Plant response to water stress. Ann. Rev. Plant Physiol. 1973; 24:519-570.
16. Handa S, Handa A, Hagegave K, Paul M, Bressan R. Proline accumulation and adaptation of cultured plant cells to water stress. Plant Physiol. 1986; 80:938-945.
17. Kallupurackal JA, Ravindran PN. Hints for cultivation of coriander, cumin, fennel and fenugreek. Spice India. 2003; 16:2-21.
18. Kramer PJ. Water relations of plants. Academic press, New York, London, 1983, 489.
19. Kuhad MS, Sheoran LS. Physiological and biochemical changes in cluster bean (*Cyamopsis tetragonoloba* L.) genotypes under water stress. Indian J. Plant Physiol., 1986; 29:46-52.
20. Kraus TE, Mckersie BD, Fletcher RA. Paclobutrazole induced tolerance of wheat leaves to paraquat may involve antioxidant enzyme activity. J Plant Physiol. 1995; 145:570-576.
21. Leonar DC, Hunt S, Layzell DB. The role of oxygen in the regulation of NRase activity in drought stressed soybean nodules. Plant Physiol. 1994; 106:949-955.
22. Mukane MA, Chavan UD, Desai BB. Effects of water stress on metabolic alterations in pigeon pea (*Cajanus cajon (L) Millspaugh*) genotypes Legume Research. 1993; 16(2):45-50.
23. Moran JF, Becana M, Iturbe-Ormaetxe I, Frenchilla S, Aparicio RV, Tejo P. Drought induced oxidative stress in pea plants. Planta. 1994; 194:346-352.
24. Nandwal AS, Bharati S, Kuhad MS, Singh J. Response of pigeon pea cultivars to water stress, Biol. Planta. 1993; 35(4):641-644.
25. Nicholas JC, Harper JS, Hageman RH. Nitrate reductase activity in soybean. I. Effect of light and temperature. Plant Physiol. 1976; 58:731-735.
26. Stewart CR, Boggers SF, Aspinall D, Paleg LG. Inhibition of proline oxidation by water stress. Plant Physiol. 1977; 59:930-932.
27. Singh TN, Paleg LG, Aspinall D. Stress metabolism III. Variations in response to water deficit in the barley palnt. Aus. J Boil. Sci. 1973; 26:65-76.
28. Steward CR, Hanson AD. Proline accumulation and metabolic response to water stress. In: N.C.P.J. Kramer (cds). Adaptation of plants to water and high temperature stress, Wiley, New York, 1980, 173-189.
29. Sarkar RK. Effect of water stress on proline accumulation and its association with certain biochemical characters in soybean. Indian J Plant Physiol. 1993; 36(3):184-186.
30. Shaner DL, Boyer JS. Nitrate reductase activity in maize (*Zea mays*) leaves. II regulation of nitrate flex at low leaf water potential. Plant Physiol. 1976b; 58:505-509.
31. Sivaramakrishnan S, Patel VZ, Flower DJ, Peacock JM. Proline accumulation and nitrate reductase activity in contrasting sorghum lines during mid-season drought stress. Physiol. Plant. 1988; 74:418-426.
32. Sgherri CLM, Pinzino C, Izzo L. Chemical changes and superoxide production in thylakoid membrane under water stress. Physiol. Plant. 1993; 87:211-216.
33. Upadhaya AT, Davis TD, Larsen MH, Sankhala N. Uniconazole-induced thermotolerance in soybean seedling root tissue. Physiol. Plant., 1990; 79:78-84.
34. Willekens H, Chamnongpol S, Montagu MV, Inze D, Camp MV. Role of H_2O_2 and H_2O_2 scavenging enzymes in environmental stress. Ag Biotech News Inform. 1995; 7:189-N-195N.
35. Yadav N, Gupta V, Yadav VK. Role of benzoic acid and gibberellic acid in alleviating water stress effect in gram (*Cicer arietinum*). Indian J Agric. Sci. 1997; 67(9):381-387.
36. Zhu HS, Huang PS. Soil water stress and active oxygen metabolism in rice. J Nanjing Agric. Univ. 1994; 17:7-11.