

2 **Impact of Drought on Chlorophyll, Soluble protein, Absciscic acid, Yield and Quality**

3 **Characters of Contrasting Genotypes of Tomato (*Solanum lycopersicum*)**

4
5 **Abstracts**

6 Impact of drought stress on chlorophyll, chlorophyll fluorescence (Fv/Fm), chlorophyll
7 stability index (CSI), soluble protein, absciscic acid (ABA), yield and quality of tomato (*Solanum*
8 *lycopersicum*) genotypes was investigated for the assessment of drought tolerance under field
9 conditions in rainout shelter. The drought condition was created first day from transplanting
10 based on Irrigation water (IW):Cumulative Pan Evaporation (CPE) of soil. Experiment was laid
11 out with 10 genotypes by adopting FRBD with three replications and two treatments of
12 1 IW:CPE and 0.5 IW:CPE. The result revealed that the reductions in chlorophyll content,
13 Fv/Fm, chlorophyll stability index (CSI), soluble protein and yield were noticed at drought
14 condition (0.5 IW/CPE). The genotypes LE 114, LE 57, and LE 118 which showed significantly
15 less reduction in the above parameters during drought were considered as drought tolerant. ABA
16 content and quality characters such as total soluble solids (TSS), lycopene content were
17 increased under drought condition. Genotypes LE 1 and LE 125 which recorded the lowest
18 chlorophyll content, Fv/Fm, CSI, soluble protein and higher ABA content ultimately poor yield
19 were considered as drought susceptible.

20 Key-words:

21 Drought; Tomato; Chlorophyll; Chlorophyll Fluorescence; Soluble protein; CSI; ABA; TSS

22 **1. Introduction**

23 Drought is the major inevitable and recurring feature of semi-arid tropics and despite our
24 improved ability to predict their onset, duration and impact, crop scientists are still concerned
25 about it as it remains the single most important factor affecting the yield potentials of crop
26 species. It is one of the serious environmental factor affecting plant growth, yield, and quality. It
27 induces various physiological and biochemical adaptations in plants. Drought is one of the most
28 important factors for yield reduction in the majority of the cultivated areas, affected 40 to 60% of
29 the world's agriculture lands [1].

30 Water deficit leads to the perturbation of most of the physiological and biochemical
31 processes and consequently reduces plant growth and yield [2]. Gladden *et al.* [3] showed that
32 water deficit earlier in the growth of tomato caused a significant reduction in leaf chlorophyll
33 content. Abdellah *et al.* [4] recorded the highest reduction in the chlorophyll content in
34 susceptible wheat cultivar under water stress of 30% FC. Water stress reduced the total
35 chlorophyll content significantly in different genotypes of moth bean and reduction was more
36 pronounced in late flowering genotypes [5]. Sanadhya *et al.* [6] reported that the water stress
37 reduced the chlorophyll content and hill activity with increased levels of stress in mung bean.

38 There was a reduction of only 1.3% and 2.2% in Fv/Fm under moderate and severe stress
39 compared to control in *Withania somnifera* [7]. Chlorophyll fluorescence emission well on the
40 level of water stress and, thus, can be used to identify elevated drought tolerance in tomato for
41 selection of resistant genotypes [8]. Decreased chlorophyll content and chlorophyll stability
42 index under both moisture stress and temperature stress were found by Sairam *et al.* [9] in wheat.

43

44 Daniel and Triboi [10] showed that heat stress decreased the duration of soluble protein
45 accumulation in terms of days after anthesis but not in terms of thermal time. Few studies have
46 investigated the combined influence of drought and heat stress on nitrogen metabolism. Abdellah
47 *et al.* [4] reported that the increased ABA content was observed in wheat cultivar by water stress
48 (30% FC) over control. Under intense water stress, the concentrations of ABA in plants
49 increases, which trigger a number of processes starting from decrease in turgor pressure, decline
50 in cellular expansion and stomatal closure to reduce water loss in leaves [11].

51 Meenakumari *et al.* [12] studied the physiological parameter governing drought tolerance
52 in maize and recorded more than 80 per cent reduction in yield in highly susceptible lines while
53 in relatively tolerant genotypes reduction was up to 50 per cent. Manojkumar *et al.* [13] reported
54 that water stressed tomato plants showed significant difference in the TSS level at different
55 irrigation levels. As the irrigation frequency increased TSS level decreased. Maximum per-cent
56 TSS was observed under IW/CPE ratio of 0.60 (6.10%) and **the** minimum was recorded at the
57 IW/CPE ratio of 1.20 (4.80%). The fruit quality improvement was observed under water deficit
58 condition in tomato as a result of the synthesis of ascorbic acid, citric acid and malic acid [14].

59 Tomato (*Solanum lycopersicum*) is one of the most popular and widely grown
60 vegetables in the world. Considering the potentiality of this crop, there is plenty of scope for
61 its improvement, especially under the drought situation. Some of the **adaptive** mechanisms of
62 plants to drought stress, which do not **decrease** plant yield to a greater extent, assume greater
63 importance. There are several physiological and biochemical traits contributing to the
64 drought tolerance of horticultural crops. However, **a** large number of tomato genotypes have not
65 been screened for drought tolerance or exploited for their cultivation under drought situation and

66 field condition.

67 To breed drought tolerant genotypes, it is necessary to identify physiological traits of plants,
68 which contributes to drought tolerance. Therefore, the present investigation was carried out to
69 study the chlorophyll characters, soluble protein and ABA to facilitate the screening and
70 selection of tomato genotypes for drought tolerance.

71 **2. Materials and Methods**

72 The study was undertaken to find out effect of drought on chlorophyll characters,
73 soluble protein, ABA, yield and quality in tomato in the field experiment at Rainout Shelter
74 of Crop Physiology Department, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.
75 The experiment was conducted with ten tomato genotypes *viz.*, LE 1, LE 27, LE 57, LE 114,
76 LE 118, LE 125, CO 3, PKM 1, TH CO 2 and TNAU TH CO 3 and two treatments *viz.*, 1.0
77 IW/CPE and 0.5 IW/CPE with three replications. Seeds of selected genotypes were sown in
78 trays filled with vermicompost for nursery. Twenty five days old seedlings were
79 transplanted and drought was imposed at first day after transplanting onwards based on
80 IW/CPE, 0.5 IW/CPE for drought stress and 1.0 IW/CPE for control were maintained by
81 irrigation the field at regular interval based cumulative pan evaporation. Crop was supplied
82 with fertilizers and other cultivation operations including plant protection measures as per
83 recommended package of practices of Tamil Nadu Agricultural University, Coimbatore. All the
84 observations were recorded on third leaf from top at 60 DAT. The experiment was laid out in
85 factorial randomized block design with three replications.

86

87

88 2.1. Chlorophyll characters

89 Total chlorophyll content was estimated following the method suggested by Arnon [15]
90 and expressed as mg g^{-1} . 250 mg of fresh leaf sample was weighed and transferred to a pestle and
91 mortar. The sample was macerated with 10 ml of 80% Acetone. The content was centrifuged at
92 3000 rpm for 10 minutes. After centrifuge, the supernatant was collected and made up the
93 volume to 25 ml by using 80% acetone. The optical density was measured at 652 nm in a
94 spectrophotometer.

95 Chlorophyll fluorescence measurements were recorded using Plant Efficiency Analyzer
96 (Hansatech, UK) following the method advocated by Lu and Zhang [16]. Measurements were
97 made on intact leaves, which were dark adapted for 30 min prior to measurement. The minimal
98 fluorescence level (F_0) with all PS II reaction centers open was assessed by measuring the
99 modulated light, which was sufficiently low ($< 0.1 \mu\text{mol m}^{-2} \text{s}^{-1}$) not to induce any significant
100 variable fluorescence. The maximal fluorescence level (F_m) with all PS II reaction centers closed
101 were determined by a 0.8 s saturating pulse at $8000 \mu\text{mol m}^{-2} \text{s}^{-1}$ in dark adapted leaves [17]. Using
102 light and dark fluorescence parameters, the maximal efficiency of PS II photochemistry in the dark
103 adapted state, $F_v/F_m = (F_m - F_0) / F_m$ [18] was calculated.

104 Estimation of CSI was carried out based on the protocol of Koleyoras [19]. Two clean test
105 tubes (Control and treatment) were taken. Two 250 mg of leaf samples were weighed and cut
106 into 8 to 10 leaf bits and transferred to test tubes. 20 ml of distilled water to control tube and 20
107 ml of hot water (55°C) to treatment test tube were added. The treatment tube was kept in a hot
108 water bath for exactly 30 minutes control tube in the lab condition. After the completion of the
109 reaction time, the leaf bits were taken out from the test tube and macerated with 10 ml of 80%
110 acetone. The contents were centrifuged at 3000 rpm for 10 minutes. The supernatant was
111 collected and made up the volume to 25 ml by using 80% acetone. OD was measured at 652 nm

112 in a spectrophotometer and total chlorophyll content of control and treated samples were
113 calculated. CSI expressed in terms of per cent by using following formula. Chlorophyll stability
114 index (CSI) = Total chlorophyll content (Treated)/Total chlorophyll content (Control) X 100.

115 2.2. Estimation of protein and ABA content

116 Soluble protein content of leaf was estimated as per the method of Lowry *et al.* [20]. 250 mg
117 of leaf sample was weighed and macerated with 10 ml of phosphate buffer solution. The content
118 was centrifuged at 3000 rpm for 10 minutes and the supernatant was collected and made up to 25
119 ml. 1 ml of the supernatant was pipette out to a test tube and 5 ml of alkaline copper tartarate
120 reagent and 0.5 ml of folin reagent were added. The colour intensity was measured at 660 nm in
121 spectrophotometer and the amount of soluble protein present in the sample was calculated by
122 using bovine serum albumin as standard and expressed as mg g⁻¹ fresh weight.

123 Quantification of abscisic acid was done by using the instrument HPLC cyber lab with
124 the column of RP 18 (4.6 mm ID x 250 mm) and mobile phase of acetonitrile (60) and water (40)
125 by adopting the protocol of Krochko *et al.* [21]. Leaf samples were powdered and
126 representative sample (10 g) in triplicate was extracted by homogenizing with extracted using
127 40 ml of 80 per cent chilled methanol for 30 min at 4°C. The mixture was filtered in a separate
128 conical flask using Whatman filter paper No. 1. The filtrate was vacuum evaporated in a
129 lyophilizer and the vacuum dried residue was re-dissolved in 10 mL of 0.5 M phosphate buffer
130 (pH 8) by stirring for 30 min. The suspension was washed with 20 mL of petroleum spirit. The
131 pH of sample was adjusted to 2.8 using dilute HCl and extracted four times with ethyl acetate
132 (4 x10 mL). Finally purified methanolic extracts were filtered through 0.52 µm Millipore
133 filters and injected into 20 µL injector loop fitted over the Cyber lab RP protected by guard
134 column.

135 A volume of 20 μL of sample was injected into HPLC. The elution was carried out by
136 a binary gradient of 60 per cent HPLC grade acetonitrile for 20 minute at the flow rate of
137 1 mL min^{-1} . The column elutes were passed through an UV detector set at 254 nm and the
138 ABA were estimated measuring the peak area and comparing with standard curve of
139 hormones. The peak areas were measured and ABA concentration quantified using the
140 standard curve obtained from ABA.

141 **2.3. Yield and Quality characters**

142 The total weight of fruits harvested from each plant of all picking was added and average
143 yield per plant was worked out and expressed in gram per plant. Later the yield per hectare was
144 calculated and expressed as tonnes per hectare.

145 Drop of juice extracted from cut fruit was used to determine TSS with the help of Hand
146 Refractometer (0 to 32°Brix) at room temperature and the value was noted in °Brix.
147 Lycopene content of fruit was extracted by using petroleum ether and OD of the extract was
148 measured at 503 nm in UV-VIS-spectrophotometer using petroleum ether as a blank [22].

149 Lycopene content of the sample was calculated by using the following formula and
150 expressed in $\text{mg } 100 \text{ g}^{-1}$. $\text{Lycopene} = (3.1206 \times \text{OD of sample} \times \text{volume made up} \times \text{dilution} /$
151 $\text{Weight of sample} \times 1000) \times 100$

152 The data on various parameters were analyzed statistically as per the procedure suggested
153 by Gomez and Gomez [23]. Wherever the treatment differences are found significant, critical
154 differences were worked out at five per cent probability level and the values were furnished and
155 discussed.

156

157 3. Results and Discussion

158 3.1. Impact of drought on chlorophyll characters

159 The intensity of the greenness in terms of chlorophyll content of the plant had influenced
160 the photosynthetic rate and thereby the efficiency of the plant for increased biomass production.
161 Chlorophyll content in terms of SPAD values can be used for evaluation for the response of plant
162 species to the drought and heat stresses in the field [26]. Ma *et al.* [24] reported a highly significant
163 correlation of chlorophyll in terms of SPAD value with photosynthetic rate in soybean and Kapotis
164 *et al.* [25] in weed species (*Amaranthus viltus* L.). In the present study, the adverse effect of drought
165 on greenness of the leaf could be observed through about 23.48% reduction in mean total
166 chlorophyll content. The reduction of chlorophyll content under drought might be due to the fact
167 that drought stress blemishes the chlorophyll content through causing internal modification in the
168 thylakoid membrane.

169 Among the genotypes, highest reduction of total chlorophyll content was recorded in the
170 genotype LE 1 (34.76%) followed by LE 125 (33.10%) and CO TH 2 (31.65%) under drought
171 (Table 1). The present study also indicated the ability of the genotypes LE 57 (18.79%), LE114
172 (19.65%) and LE 118 (21.37%) in maintaining total chlorophyll content under drought (0.5 IW/CPE)
173 by showing less reduction. Therefore, these genotypes were able to endure drought injury better than
174 the sensitive lines. Similar to this finding, Ghaffari *et al.* [27] stated that the tolerant sunflower
175 line had higher chlorophyll than the susceptible line under drought. These findings are in
176 agreement with the earlier findings of Petcu *et al.* [28] in sunflower.

177 A considerable reduction in chlorophyll fluorescence (Fv/Fm) was observed due to the
178 drought treatment. A possible reason for this effect is that the drought stressed plants have lower

179 capacity for the use of transported electrons and their electron transport chain is more reduced at
 180 any light condition [29].

181 For the treatments, smaller mean fluorescence value (0.63) was registered by 0.5 IW/CPE
 182 with the reduction of 25.88 per cent than 1.0 IW/CPE (0.85). Relating to the genotypes, LE 57
 183 was significantly superior chlorophyll fluorescence value (0.74) followed by LE 118 and LE 27
 184 while the lowest was recorded by LE 125 (0.47). The genotype, LE 57 proved its supremacy
 185 with less reduction (20.69%) of Fv/Fm followed by LE 118 (20.69%) (**Table 1**). The high Fv/Fm
 186 ratio indicates that genotype has more efficient in protecting their photosynthetic apparatus under
 187 drought. This result is in agreement with Mishraa *et al.* [8] in tomato. Lower values of Fv/Fm
 188 ratio under drought, indicated an injury to electron transfer system in photo system II, causing an
 189 imbalance between generation and utilization of electrons, resulting changes of quantum yield
 190 efficiency [30].

191 **Table 1. Effect of 1.0 and 0.5 IW/CPE treatments on total chlorophyll content and Fv/Fm**
 192 **of tomato genotypes at 60 days after transplanting.**

Genotypes	Total chlorophyll content (mg g ⁻¹)		Chlorophyll fluorescence (Fv / Fm)	
	1.0 IW/CPE	0.5 IW/CPE	1.0 IW/CPE	0.5 IW/CPE
LE 1	2.555	1.667	0.83	0.57
LE 27	2.932	2.284	0.87	0.67
LE 57	2.895	2.351	0.93	0.74
LE 114	2.932	2.356	0.81	0.56
LE 118	2.944	2.315	0.87	0.69
LE 125	2.007	1.878	0.75	0.47
CO 3	3.291	2.371	0.84	0.62
PKM 1	3.011	2.402	0.82	0.61
THCO 3	3.005	2.227	0.89	0.69
CO TH 2	3.425	2.341	0.90	0.67
Mean	2.900	2.219	0.85	0.63
	Genotype	Treatment	Genotype	Treatment

SD	0.0241	0.0108	0.007	0.003
CD (0.05)	0.0487	0.0218	0.015	0.007

194 *SD and CD are ...

195 Chlorophyll Stability Index (CSI) is an indicator of the stress tolerance capacity of the
196 plants and is a measure of integrity of membrane [31]. A higher CSI helps the plants to withstand
197 stress through better availability of chlorophyll, leading to increased photosynthetic rate, more
198 dry matter production and higher productivity. Kilen and Andrew [32] observed a high
199 correlation between CSI and drought tolerance in corn.

200 Drought condition aggravates chlorophyll degradation in later part of growth due to loss
201 of membrane compartmentation. Membrane stability index decreased significantly under water
202 stress condition over control in wheat varieties [33].

203 In the present study also corroborates the earlier findings with 18.49% reduction of CSI
204 in drought (0.5 IW/CPE) compared to 1.0 IW/CPE. The primary effect of drought at the cellular
205 level is to affect the integrity of membrane which in turn leads to disruption of cellular
206 compartment ultimately destruction chlorophyll contents. The earlier findings of Fariduddin *et*
207 *al.* [34] confirm the present study.

208 The lowest reduction of CSI was observed in the genotypes LE 114 (14.68%) followed
209 by LE 118 (15.46%) while the highest reduction was showed by LE 125 (24.73%) and CO TH 2
210 (24.29%) under drought condition (Table 2). The ability of the genotype maintained the higher
211 CSI under drought is a desirable character for tolerance. Maintenance of CSI at drought
212 condition by the genotype might be due to high membrane stability. Beena *et al.* [35] reported
213 that high membrane stability index and chlorophyll stability index were recorded in tolerant
214 inbred lines of rice than in susceptible lines under water stress condition.

215

216 3.2. Impact of drought on soluble protein

217 The soluble protein content of the leaf, being a measure of Rubisco activity was
218 considered as an index for photosynthetic efficiency due to the important enzyme involved in
219 photosynthesis. Rubisco enzyme forms nearly 80 per cent of the soluble proteins in leaves of
220 many plants [36]. Diethelm and Shibles [37] opined that the Rubisco content per unit leaf area
221 was positively correlated with that of soluble protein content of the leaf. The amount of Rubisco
222 in leaves is controlled by the rate of synthesis and degradation. Even under drought stress the
223 Rubisco holo enzyme is relatively stable with a half-life of several days [38].

224 However, drought stress in tomato [39], arabidopsis [40] and rice [41] leads to a rapid
225 decrease in the abundance of Rubisco small subunit (*rbcS*) transcripts, which may indicate
226 decreased synthesis. In the present study also confirms the earlier findings with 32.28%
227 reduction of soluble protein content under drought. The reduction of soluble protein content
228 might be due to the degradation of available soluble protein in plant and reduction of synthesis of
229 new protein.

230 Among the genotypes, CO TH 2 (15.63) and TH CO 3 (15.18) registered highest soluble
231 protein content at under 1.0 IW/CPE ratio level. During drought (0.5 IW/CPE), LE 57 recorded
232 significantly superior soluble protein content (11.99), however the genotype LE 118 proved its
233 endurance to water deficit with less reduction (19.48%) and LE 125 showed highest reduction of
234 52.66%.

235 Biochemical limitations of photosynthetic carbon fixation by the inhibition of Rubisco
236 activity play an important role mostly under conditions of prolonged or more severe drought [42,

237 43]. Maintenance of soluble protein content by the genotypes could be attributed to higher
 238 rubisco activity leads to more carbon fixation and ultimately to higher photosynthetic efficiency
 239 under drought is one of the important traits for drought tolerance.

240 **Table 2. Effect of 1.0 and 0.5 IW/CPE treatments on CSI and soluble protein content of**
 241 **tomato genotypes at 60 days after transplanting.**

242

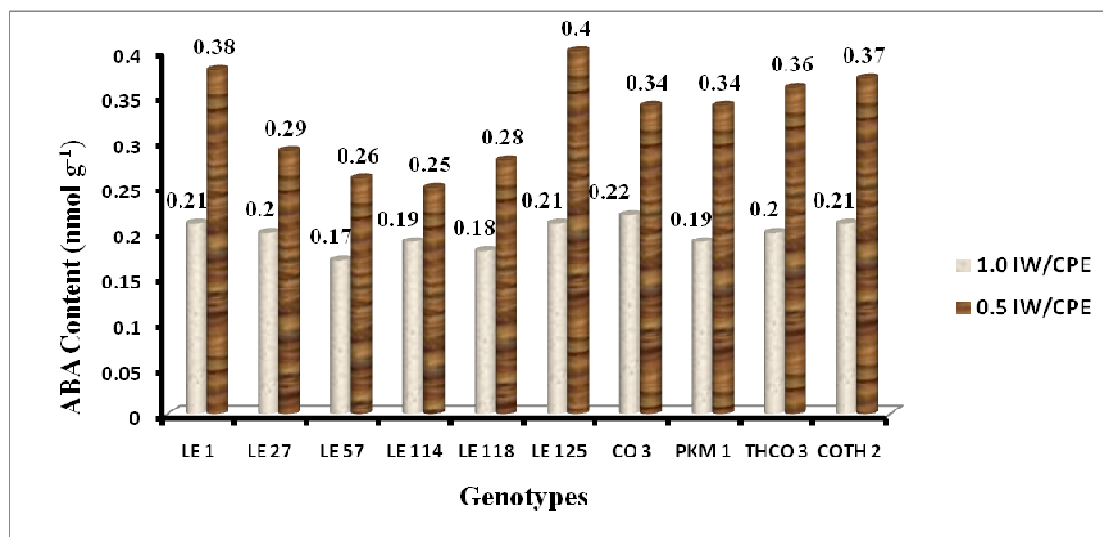
Genotypes	Chlorophyll stability index (%)		Soluble protein content (mg g ⁻¹)	
	1.0 IW/CPE	0.5 IW/CPE	1.0 IW/CPE	0.5 IW/CPE
LE 1	79.0	65.5	10.85	6.51
LE 27	83.3	70.2	13.98	10.72
LE 57	84.6	69.5	15.03	11.99
LE 114	83.8	71.5	13.43	10.19
LE 118	85.4	72.2	14.58	11.74
LE 125	79.9	63.9	11.07	5.24
CO 3	83.0	66.4	11.55	8.69
PKM 1	82.4	66.9	11.33	7.69
THCO 3	79.5	63.0	15.18	8.46
COTH 2	80.7	61.1	15.63	8.58
Mean	82.2	67.0	13.26	8.98
	Genotype	Treatment	Genotype	Treatment
SD	0.52	0.23	0.137	0.061
CD (0.05)	1.06	0.47	0.278	0.124

243 **3.3. Impact of drought on ABA content**

244 It was found a significant per cent increment of **ABA content** in leaf under drought
 245 condition (39.45%) over control. The increment of ABA content under drought condition was
 246 reported by several workers [4, 11, 44]. Accumulation of ABA under drought condition is a
 247 favourable mechanism for drought tolerance through reducing transpiration rate by closing of

248 stomata. However, complete closure of stomata leads to increment of leaf temperature which
249 produces reactive oxygen species ultimately death of the plant.

250 Among the genotypes, the elevation in ABA was less in LE 114 (24%) under drought,
251 whereas nearly double fold increment of ABA content was observed in LE 125 and LE 1 (Fig.
252 1). ABA synthesized in response to drought stress, is known to induce stomatal closure which
253 leads to reduced transpirational water loss [45]. In the present study, LE 1 and LE 125 showed
254 higher ABA content which ultimately recorded less transpiration rate by closing of stomata.
255 However, the genotype LE 114 showed a moderate increment of leaf ABA content leads to
256 partial closure of stomata with maintains the photosynthetic rate and leaf temperature. Hence,
257 both the physiological characters are important for drought tolerance. The present study is in
258 agreement with earlier findings of Wang and Huang [46], who reported that highly significant
259 negative correlation between ABA content and leaf water potential, stomatal conductance,
260 transpiration rate and net photosynthetic rate.



261
262 **Fig 1. Effect of water deficit on ABA content (nmol g⁻¹) of tomato genotypes at 60 days after**
263 **transplanting.**

- 264 **1- Remove the numbers from bars**
265 **2- Add SD, or Var for comparisons, significant differences of TRT/ Genotypes must be**
266 **seen on the chart**

267 **3.4. Impact of drought on yield characters**

268 Comparing two treatments, plants received 1.0 IW/CPE ratio recorded higher average fruit
269 yield of 62.32 than drought imposed plants (29.92) (Table 3). At 0.5 IW/CPE ratio level, LE 57
270 showed its supremacy of higher fruit yield of 54.94 which was on par with LE 118 (50.06), LE
271 114 (42.17) and LE 27 (40.17) while the lowest was recorded by LE 125 (10.95) and LE 1
272 (12.71). Drought stress resulted in the overall yield loss of tomato fruits up to 52 per cent under
273 field condition. The highest yield loss of 83.18 and 81.51 per cent were shown by LE 125 and
274 LE 1 respectively.

275 A significantly lesser reduction of 32.49% was exhibited by LE 118 followed by LE 57
276 (33.13%) and LE 114 (38.55%) showing their tolerance nature to drought stress. Therefore, it
277 could be clearly revealed that water deficit as the result of drying soil caused a major adverse
278 effect on yield and yield components even in tolerant genotypes. The reduction in fruit yield and
279 related parameters under drought probably due to reduction of water content in plant which
280 disrupting leaf gas exchange properties which limited the source size and activity
281 (photosynthesis) and partitioning of photo assimilates to fruits. The present study confirms the
282 early findings of Farooq *et al.* [47] and Manjunatha *et al.* [48]. Izzeldin *et al.* [49] also explained
283 that the impact of drought before the time of flowering affects the reproductive system with the
284 increasing sterility of flowers, so that flowering and fruiting will fail if the water shortage is
285 prolonged.

286 **3.5. Impact of drought on quality characters**

287 Plants imposed with 0.5 IW/CPE ratio recorded higher Total Soluble Solids (TSS: °Brix)
288 brix value (3.01) than 1.0 IW/CPE ratio (2.89). Among the genotypes, TH CO 3 recorded higher
289 average brix value of 4.00 than the rest of the genotypes. At 0.5 IW/CPE ratio condition, the
290 highest TSS value was recorded by TH CO 3 (4.1) followed by CO TH 2 (3.9), PKM 1 (3.6) and
291 CO 3 (3.4) while the lowest was registered by LE 125 (2.2). Regarding treatments, plants
292 imposed with 0.5 IW/CPE ratio recorded higher lycopene content (3.23) than 1.0 IW/CPE ratio
293 (3.02). With respect to the genotypes, CO 3 recorded significantly higher average lycopene
294 content (4.69). Hence, the present study indicated that the quality parameters like TSS and
295 lycopene increased slightly under drought compared to control.

296 Present study corroborates with early findings of Ali *et al.* [50] in tomato. Nahar *et al.*
297 [51] also explained that the fruit quality improvement under water deficit condition in tomato
298 might be due to the synthesis of ascorbic acid, citric acid and malic acid. In the present study, LE
299 118, LE 57 and LE 27 showed their primacy with highest increment of TSS and lycopene
300 content. This finding was strongly supported by Tambussi *et al.* [52] and it was also explained
301 that the increase in lycopene and TSS might be an effective strategy to protect membranes from
302 oxidative damage in water stressed condition.

303 **4. Conclusion**

304 Water stress causes detrimental effects on plant activities, which are likely to alter the
305 yielding potential of the crops. Hence, to identify the physiological parameters, which get altered
306 under drought conditions is pre-requisite to evaluate drought tolerant varieties. It is concluded
307 that the tomato genotypes LE 118, LE 57 and LE 114 were identified as the most tolerant lines to
308 drought stress imposed provided with Rainout shelter. As the genotypes LE 125 and LE 1

309 recorded significantly lesser yield under the same condition, these two genotypes were
 310 considered as susceptible to water deficit.

311 **Table 3. Effect of water deficit on yield and quality of tomato genotypes under two**
 312 **treatments of 1.0 and 0.5 IW/CPE.**

313

Genotypes	Estimated fruit yield (tonnes ha ⁻¹)		TSS (° Brix)		Lycopene (mg 100 g ⁻¹)	
	1.0 IW/CPE	0.5 IW/CPE	1.0 IW/CPE	0.5 IW/CPE	1.0 IW/CPE	0.5 IW/CPE
LE 1	68.74	12.71	2.5	2.7	2.21	2.39
LE 27	71.20	40.17	2.5	2.6	2.52	2.73
LE 57	82.16	54.94	2.4	2.6	2.46	2.68
LE 114	68.62	42.17	2.4	2.5	2.82	2.88
LE 118	74.15	50.06	2.4	2.5	2.85	2.95
LE 125	65.10	10.95	2.2	2.2	2.13	2.67
CO 3	41.04	22.74	3.3	3.4	4.54	4.84
PKM 1	38.98	20.94	3.5	3.6	3.78	4.05
THCO 3	54.33	22.38	3.9	4.1	3.35	3.53
CO TH 2	58.85	22.13	3.8	3.9	3.54	3.55
Mean	62.32	29.92	2.89	3.01	3.02	3.23
	Genotype	Treatment	Genotype	Treatment	Genotype	Treatment
SD	0.960	0.429	0.03	0.01	0.048	0.022
CD (0.05)	1.943	0.869	0.05	0.02	0.097	0.044

314

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