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REGULAR ARTICLE

Exogenous application of triazoles modifies growth and biochemical characteristics of *Lycopersicon esculentum* Mill. under water limited conditions

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Abstract

The present investigation was carried out to find the morphological and biochemical variation in Tomato (PKM-1) seedlings under drought with triazole treatments. The pots were arranged in Completely Randomized Block Design (CRBD). The seedlings were allowed to grow up to 30 days with regular water irrigation. The water was irrigated by 4 Days Interval Drought (DID) and the control plants were regularly irrigated. The Triazole (Hexaconazole at 15 mg L^{-1} and Tebuconazole at 10 mg L^{-1}) treatments imposed on 30, 40 and 50 Days After Sowing (DAS). The plant samples were collected on 40, 50 and 60 DAS. The plants were separated into root, stem and leaves for analysing the morphological variations and biochemical contents. Under drought condition the plant growth was increased in root length and decreased in shoot length, fresh weight and dry weight. In drought with treatments the root length, shoot length, total leaf area, fresh and dry weight were increased when compared to drought plants but it was lower than the control. Under drought condition the protein content was decreased but the proline, amino acid, total sugar and glycine betaine content were increased when compared to control plant. In drought with triazole treatments the protein content was increased and proline, amino acid, total sugar and glycine betaine were reduced when compared to drought treated plant, however it was lower than that of control. This study was concluded that under drought stress the plant reduced shoot length and protein content, and shows increased root length, proline, amino acid, total sugar and glycine betaine content, but drought with triazole treatments to increase root length, fresh and dry weight and protein content, reduced proline, amino acid, total sugar and glycine betaine content when compared to drought tomato plant

Key words: Drought, *Lycopersicon esculentum*, Triazole, Hexaconazole, Tebuconazole

Introduction

Tomato (*Lycopersicon esculentum* Mill) is one among the most used and cultivated vegetable all over the world. It is a very versatile vegetable for culinary purposes. It belongs to the family Solanaceae (Shah et al., 2014). Tomatoes contatin vitamin C and it depending on variety and growing conditions (Guil-Guerrero and Rebolloso-Fuentes, 2009), and the nutrient contents vary according to packaging methods and post-harvest storage practices (Zewdie, 2017). Tomato fruits are eaten raw or cooked and are being utilized for a variety of purposes like soups, juice, ketchup, pickles, sauces, etc., (Ahmed and Shak-Sabjee 1995).

Drought is a major abiotic stress mainly in the agricultural fields all over the world. It affects

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almost all agricultural crops and greatly diminish the productivity (Yanni et al., 2016). The studies of drought stressed plants in biochemical and molecular aspects are necessary to deal with the tolerance and resistance capabilities and production of tolerant species of plants (Reddy et al., 2004; Zhou and Shao, 2008). Tomato plants responses under drought stress was a major field of study to many researchers, and many aspects are revealed in the past (Hsieh et al., 2002; Mayak et al., 2004; Subramanian et al., 2006).

The drought stress mitigation with the help of plant growth regulators attained considerable attention. The application of triazole fungicides mitigated stress in many plants, and changed the antioxidant status in plants like *Solanum trilobatum* (Nivedithadevi et al., 2017). But the studies on the effects of triazole compounds in drought stress amelioration in tomato plants is scanty. Recently we reported the effects of triazoles on the antioxidant metabolism of tomato plants (Arivalagan and Somasundaram, 2017). The main objective of the present investigation was to find the morphological and biochemical variation in Tomato (PKM-1) seedlings under drought with triazole (Hexaconazole and Tebuconazole) treatments.

Materials and methods

Plant cultivation

The *Lycopersicon esculentum* Mill, var. PKM -1 was selected as plant material for the present investigation. The seeds of this variety were obtained from Horticulture College and Research Institute, Periyakulam at Theni district, Tamilnadu, India. The triazole compound Debuconazole, Hexaconazole was obtained from syngenta India ltd., Mumbai.

The experimental part of this work was carried out in Botanical Garden and Water Stress Physiology Lab, Department of Botany, Annamalai University, Tamil Nadu, India. The plants were raised in mud pots. The mud pots were filled with homogenous mixture of garden soil containing red soil, sand along with farmyard manure in the ratio of 1:1:1. The pots were arranged in Completely Randomized Block Design (CRBD).

Imposition of water stress triazole application

The experimental seeds were surface sterilized with 0.2% Mercuric chloride solution for five minutes with frequent shaking and thoroughly washed with tap water. The plants were allowed to grow up to 30 days with regular water irrigation. After 30days, well established plants were selected for treatments. The drought stress given on 4 DID (Days Interval Drought) and drought stress with TBZ at 15 mg L^{-1}, HEX at 10 mg L^{-1} treatments are given on 30, 40, and 50 DAS plant. Then one-day interval irrigation on ground water was kept as control. The plant samples were collected on 40, 50 and 60 DAS.

Plant growth analysis

The plant height was measured from the soil level to the tip of the shoot and expressed in cm. The plant root length was measured from the point of first cotyledon node to the tip of the root and expressed in cm. The total leaf area was measured using LICOR Photo Electric Area Meter (Model LI-3100, Lincoln, USA) and expressed in cm^2 per plant. After washing the plants in the tap water, the fresh weight was determined by using an Electronic balance (Model-XK3190-A7M) and the values were expressed in grams. After taking fresh weight, the plants were dried at 60°C in hot air oven for 48 hours. After drying, the plants weight was measured for dry weight and the values were expressed in grams.

Biochemical analysis

Extraction and estimation of the protein content was followed by the method of Lowry et al. (1951). The Proline content was estimated by the method of Bates et al. (1973). The amount of Amino acid content was estimated according to the method of Moore and Stein (1948). Total soluble sugar content was assayed as described by Nelson (1944). Glycine betaine contents were estimated by the method of Grieve and Grattan (1983).

Statistical analysis

Statistical analysis was performed using one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT). The values are mean ± S.D. for seven samples in each group. *P*-values$\leq$0.05 was considered as significant.

Results and discussion

Effect of triazole on growth parameters of tomato under drought stress

The drought stress increases the root length at all sampling days and it was 112.02 percent over control on 60 DAS. Drought with TBZ and HEX treatment plants root length was increased when compared to control. The extents of increase were 143.82 and 148.15 percent over control on 60 DAS. Drought stress inhibited the shoot length in tomato plant to a larger extent and it was 81.05 percent over control on 60 DAS. Drought with triazole treatments caused an enhancement in shoot length when compared to drought stressed plants in all sampling days and it was 89.70 in TBZ and 94.59 percent over control in HEX treatments was noted in 60 DAS plants.

The fresh and dry weight of the tomato plant decreased at all growth stages under drought stress (Table 1). The lowest fresh and dry weight and there were 81.86, 79.92 percent over control recorded in 60 DAS drought stress plant. The extent of increase was more in drought with TBZ treated plants and it was 89.70 fresh weight, 85.64 percent over control dry weight and drought with HEX treated plant and it was 94.59 fresh weight 87.30 percent over control dry weight were noted in 60 DAS. Total leaf area was reduced under drought stress when compared to control and it was 86.87 percent over control on 80 DAS. Drought with triazole treatments increased total leaf area when compared to drought stressed plants but lower than that of control and they were 93.03 in TBZ and 94.94 percent over control in HEX treatment in 60 DAS plants.

Drought stress increased the total root length in tomato plant. An increased root growth due to water stress was reported in *Catharanthus roseus* (Jaleel et al., 2008). The plant roots play an important role in plant survival in drought conditions. Under the drought with triazole treatments the root length of the tomato plant will be increased. Similar observations were made in Sorghum (Arivalagan and Somasundaram, 2015). Drought stress decreased the stem length when compared to all other treatments in tomato plants. The declined stem length was recorded in *Abelmoscus esculentus* (Sankar et al., 2007) under drought stress. The present study results showed that root and shoot lengths of tomato plants were increased in drought with triazole treatments. The similar results were observed the stem length under drought with triazole treatment increased in *Lycopersicon esculentum* (Mohamadi and Rajaei, 2013).

Drought stress was reduced in total fresh and dry weight of the tomato plant. Similar results were observed in *Pearl millet* (Kusaka et al., 2005) and maize (Odiyi, 2013). The drought with triazole treated plants increased in the biomass of the tomato plant. The same results were reported in *Basella alba* (Shanmugam et al., 2012).

Table 1. Drought with triazole treatments induced changes in Root length (cm plant^{-1}), Shoot length (cm plant^{-1}), Fresh weight (gm plant^{-1}), Dry weight (gm plant^{-1}), and Total leaf area (cm^{2} plant^{-1}) of *Lycopersicon esculentum*. Mill. Values are given a common superscript (a, b, c, d) differ significantly at ≤0.05 (DMRT).

	Control	Drought	Drought+Debu	Drought+Hexa
Root length (cm plant^{-1})				
40 DAS	11.73±1.234^{c}	14.27±0.929^{b}	16.77 ± 0.800^{a}	17.00 ± 0.436^{a}
50 DAS	15.27±0.451^{c}	18.23±0.416^{b}	22.77 ± 0.907^{a}	22.17 ± 1.665^{a}
60 DAS	17.80±0.819^{c}	20.83±0.757^{b}	25.60 ± 0.794^{a}	26.37 ± 0.416^{a}
Shoot length (cm plant^{-1})				
40 DAS	33.37±0.874^{a}	25.60±1.179^{c}	29.30 ± 0.794^{b}	30.60 ± 1.044^{b}
50 DAS	37.43±1.106^{a}	28.63±1.250^{c}	33.17 ± 0.945^{b}	33.63 ± 1.106^{b}
60DAS	40.10±0.800^{a}	32.50±0.656^{c}	35.97 ± 0.404^{b}	37.93 ± 0.611^{b}
Fresh weight (gm plant^{-1})				
40 DAS	199.28±1.75^{a}	155.78±2.71^{c}	168.39 ±5.06^{b}	172.16 ± 3.14^{b}
50 DAS	207.91±2.39^{a}	160.21±3.54^{c}	176.76 ± 3.38^{b}	179.12 ± 1.67^{b}
60DAS	219.87±2.99^{a}	179.98±3.00^{c}	188.30 ± 3.01^{b}	191.94 ± 2.81^{b}
Dry weight (gm plant^{-1})				
40 DAS	87.49±1.94^{a}	62.91 ± 2.12^{c}	73.67 ± 1.33^{b}	76.38 ± 2.06^{b}
50 DAS	95.42±1.38^{a}	67.97 ± 1.85^{d}	77.82 ± 1.16^{c}	80.64 ± 1.73^{b}
60DAS	103.69±2.54^{a}	79.76 ± 1.25^{c}	84.19 ± 1.74^{c}	88.51 ± 0.66^{b}
Total leaf area (cm^{2} plant^{-1})				
40 DAS	112.59±3.01^{a}	89.48 ± 2.54^{c}	101.89 ± 1.79^{b}	105.25 ± 0.92^{b}
50 DAS	129.19±1.33^{a}	111.23±2.31^{c}	120.71 ± 1.20^{b}	122.45 ± 0.72^{b}
60DAS	140.48±2.06^{a}	122.03±1.99^{c}	130.69 ± 1.43^{b}	133.02 ± 1.82^{b}

Values are mean ± S.D. of three replicates are given a common superscript (a, b, c, d) according to Duncan's multiple range test (DMRT) at $p < 0.05$ level of probability.

Water deficit stress reduced the leaf area when compared to control. The leaf growth was more sensitive to water stress in maize (Nayyar and Gupta, 2006). Similar results were observed under drought stress in (Blouin et al., 2007) rice. Triazole treatment to the drought stressed plants resulted in increased leaf area in tomato plants when compared to drought stressed plants but decreased when compared to control. Triazole treatment increased the leaf area *Syzygium* (Mohd Roreli et al., 2012).

Effect of triazole on biochemical contents of tomato under drought stress

The highest reduction of protein content was observed in drought stressed plants and it was 85.20, 83.79 and 82.80 percent over control on root, stem and leaves at 60 DAS plants respectively. Drought with triazole treatment increased the protein content when compared to drought stressed plants and it was 89.03, 91.76 and 87.84 in TBZ and 90.31, 92.86 and 89.45 percent over control in HEX treated root, stem and leaves respectively at 60 DAS tomato plants. Drought stress increased the proline content. The highest proline content was recorded and it was 150.32, 175.43 and 173.90 percent over control on 60 DAS plants root, stem and leaves respectively. TBZ and HEX to the drought stressed plants decreased the proline content when compared to drought stressed plant and it was 125.81, 132.46 and 114.06 in TBZ and 131.61, 137.71 and 116.47 percent over control in HEX treated 60 DAS plants of root, stem and leaves respectively.

The higher accumulation of free amino acid content was found in all parts of plants and it was149.39, 140.63 and 117.41 percent over control at 60 DAS drought stressed plants. Drought with triazole treatments lowered the amino acid content when compared to drought stressed plants and it was 117.32, 120.26 and 106.72 in TBZ and 130.85, 123.88 and 109.92 percent over control on HEX treatment plant root, stem and leaves respectively at 60 DAS. Drought stress caused an increase in the total sugar content and it was 142.22, 126.90 and 120.32 percent over control on root, stem and leaves on 60 DAS plants respectively. Triazole to the drought stressed plants decreased the total sugar content when compared to drought stress, but it was higher than that of control and they were 122.42, 105.41 and 113.07 in TBZ and 129.13, 114.77, 113.37 percent over control respectively on root, stem and leaves of 60 DAS plants. In all the sampling days glycine betaine content accumulation was high in tomato plants under drought stress when compared to control and it was 132.82, 135.41 and 130.35 percent over control at root, stem and leaves respectively at 60 DAS. Drought with triazole treatments showed a decreased glycine betaine content when compared to drought stressed plants but higher than that of control and it was 114.65, 112.11 and 110.10 on TBZ and 115.50, 116.40 and 114.03 percent over control at root, stem and leaves respectively on 60 DAS.

These results are in accordance with the results of some other author who reported in wheat, the sugar and proline content was increased under drought stress conditions (Amirjani and Mahdiyeh, 2013). The triazole treatment caused an enhancement in proline content when compared to control but it was lower than that of drought stressed tomato plants. The similar report was point out in *Helianthus annuus* (Amalan Rabert et al., 2013). Drought stress to increase the amino acid accumulation in all parts of the tomato plant. The amino acid content has been shown to increase under drought condition in wheat (Fahim Nawaz et al., 2015). The amino acid content was reduced in drought with triazole treatment but higher than that of control. The similar finding was suggested in *Helianthus annuus* (Manivannan et al., 2008).

The total sugar content of the tomato plant was increased under drought stress then compared to control plant. This finding agrees with the suggested role of soluble sugars as signalling molecules under stress (Chaves and Oliveira, 2004; Mutava et al., 2015) in soybean. The triazole treatments to reduce the total sugar content. The similar reports were observed in olive plants seedlings of *Abelmoscus esculentus* (Sujatha et al., 1999). Our study shows that drought resulted in an increase in total sugars accumulation in the tomato plant.

Drought stress caused an increase in the glycine betaine content in all parts of the tomato plant when compared to control. Accumulation of glycine betaine under drought stress was observed in many crop plants, including in *Panicum sumatrense* (Paul Ajithkumar and Panneerselvam, 2013). It is concluded that the results showed the drought stress to reduce the plant height, biomass of the plant and the accumulation of compatible solute will be increased. The triazole compound to increase the biomass and height then reduced the biochemical content of the plant. The plants are highly regulated by triazole compounds, in terms of enhanced components of osmoprotectants under drought stress. The triazole compound may be useful to trigger drought avoidance mechanisms and the adverse effects of drought stress by modifying morphological and biochemical content, there by paved the way for overcoming drought stress in tomato plants.

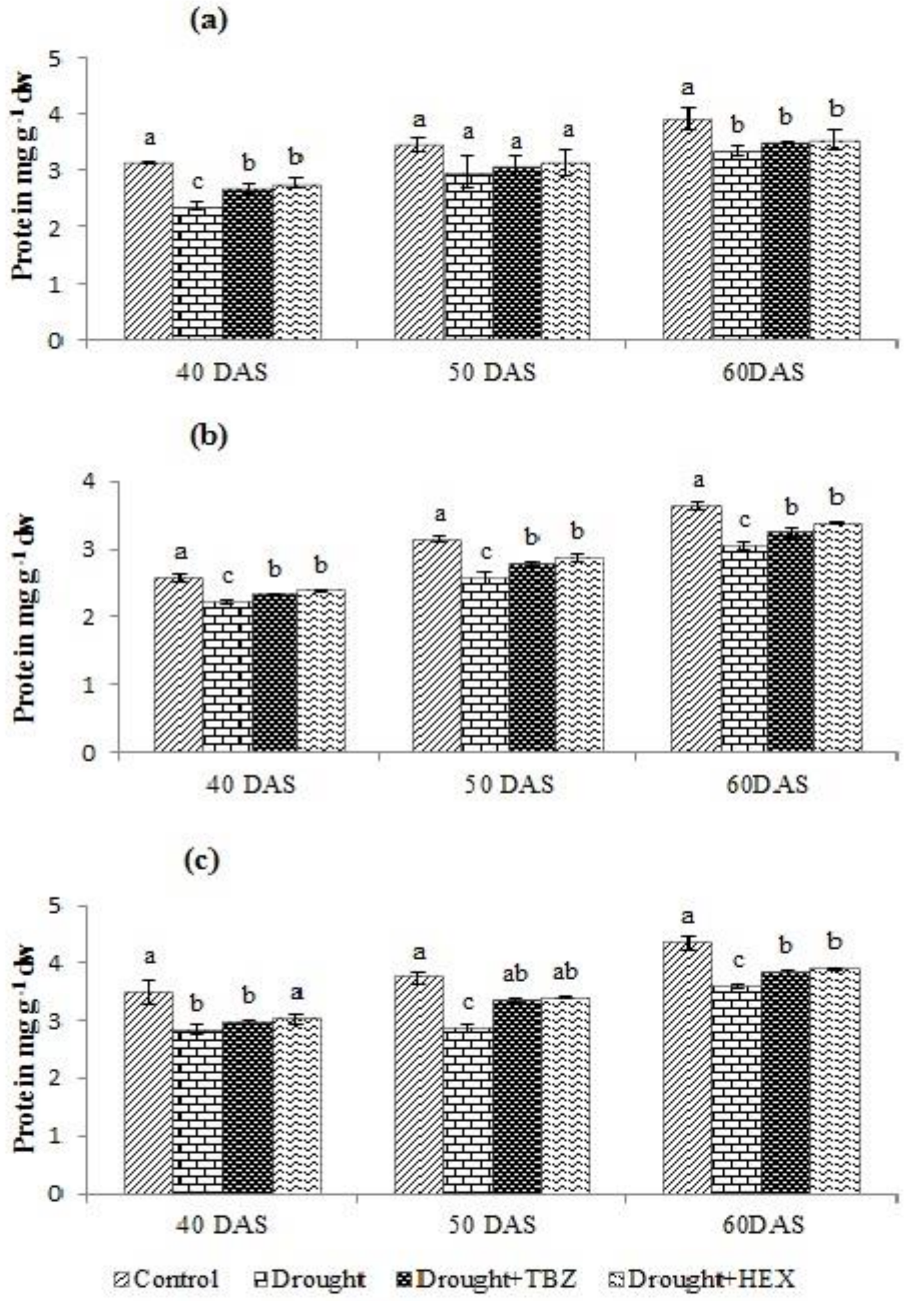

Fig. 1. Effect of drought with triazole treatments on protein (a) Root (b) Stem and (c) Leaves of tomato plants. Values are given as mean ± SD. of three samples in each group. Bar values are significantly at ≤ 0.05 (DMRT).

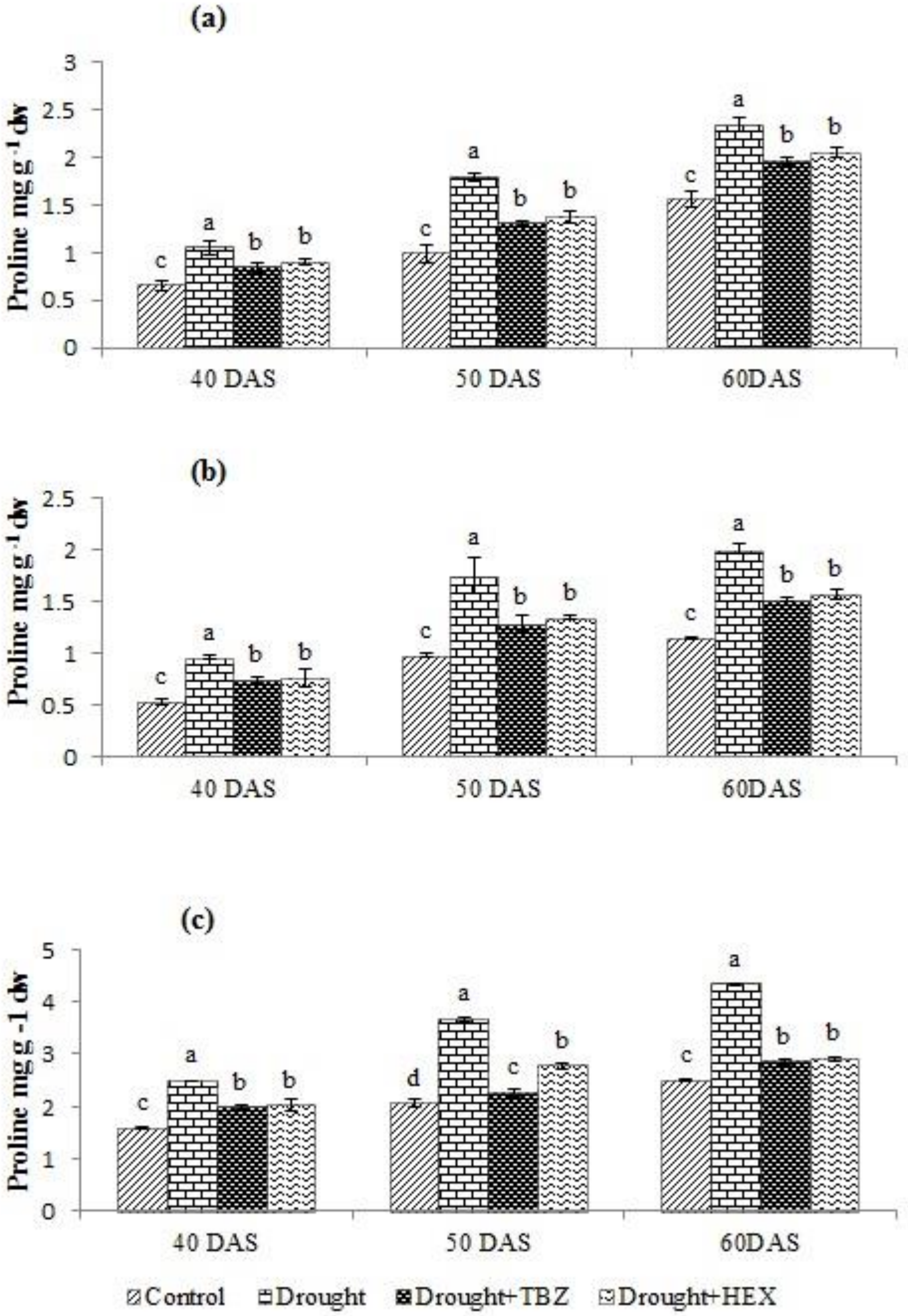

Fig. 2. Effect of drought with triazole treatments on proline (a) Root (b) Stem and (c) Leaves of tomato plants. Values are given as mean ± SD. of three samples in each group. Bar values are significantly at ≤ 0.05 (DMRT).

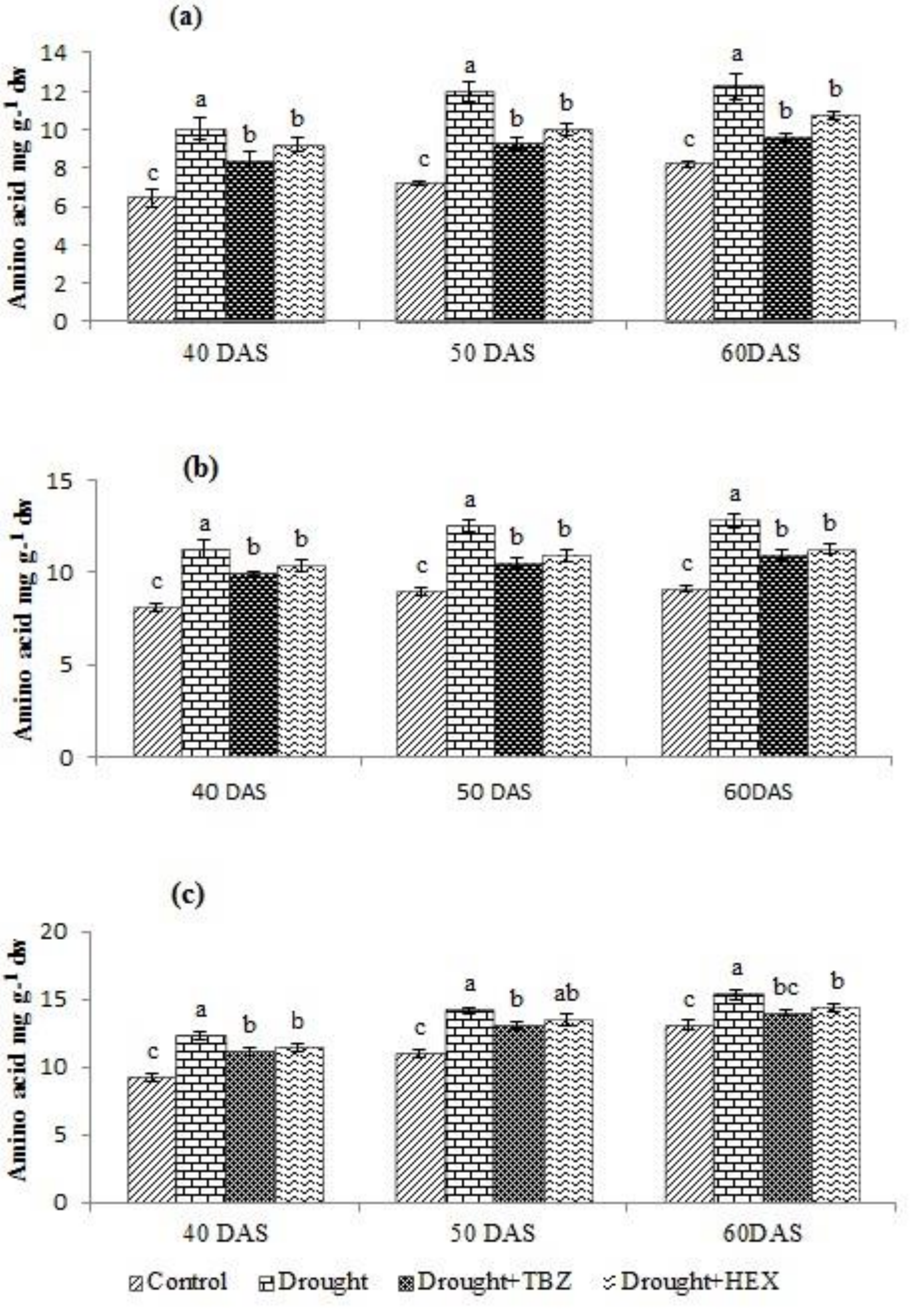

Fig. 3. Effect of drought with triazole treatments on Amino acid (a) Root (b) Stem and (c) Leaves of tomato plants. Values are given as mean ± SD. of three samples in each group. Bar values are significantly at ≤ 0.05 (DMRT).

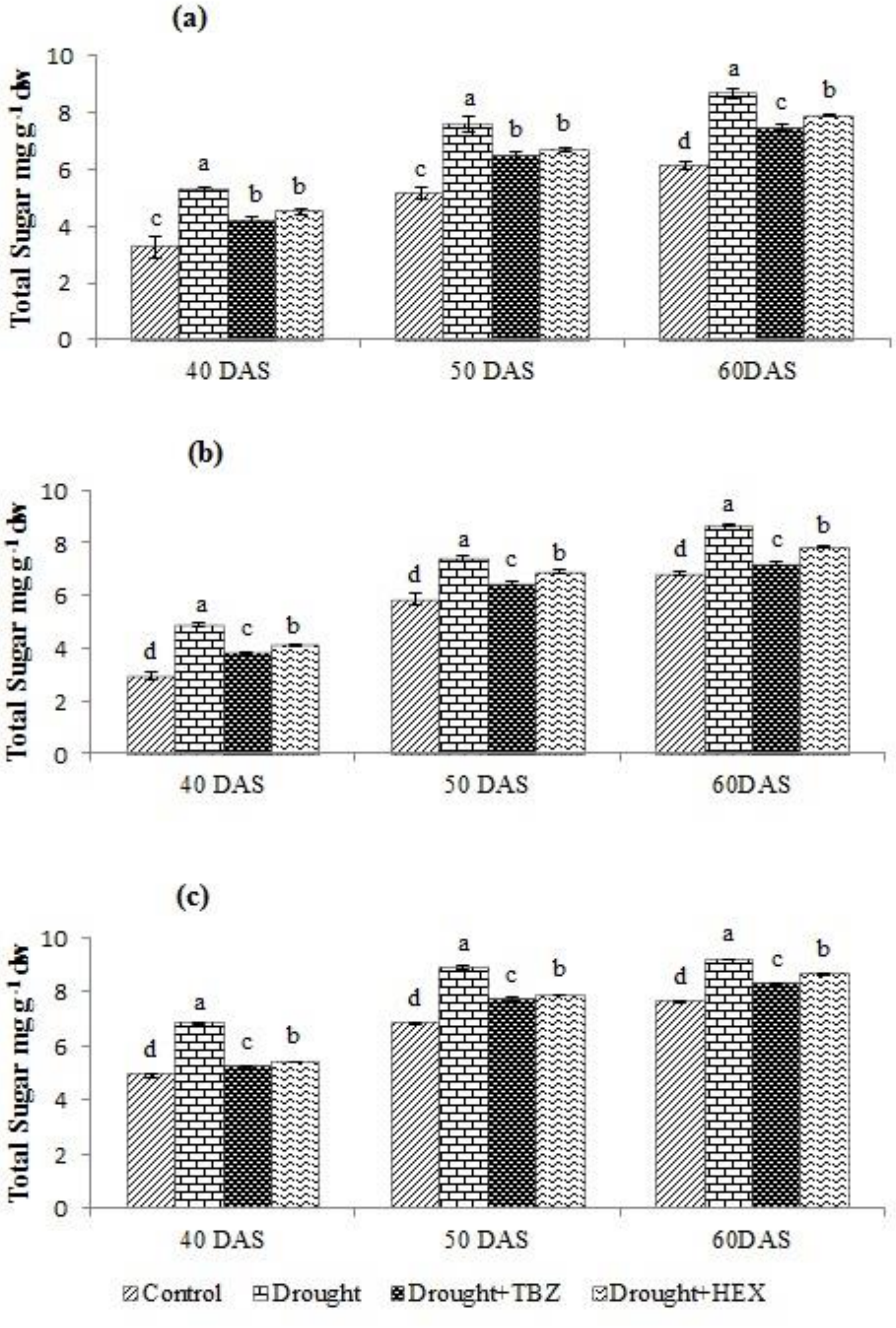

Fig. 4. Effect of drought with triazole treatments on Total sugar (a) Root (b) Stem and (c) Leaves of tomato plants. Values are given as mean ± SD. of three samples in each group.
Bar values are significantly at ≤ 0.05 (DMRT).

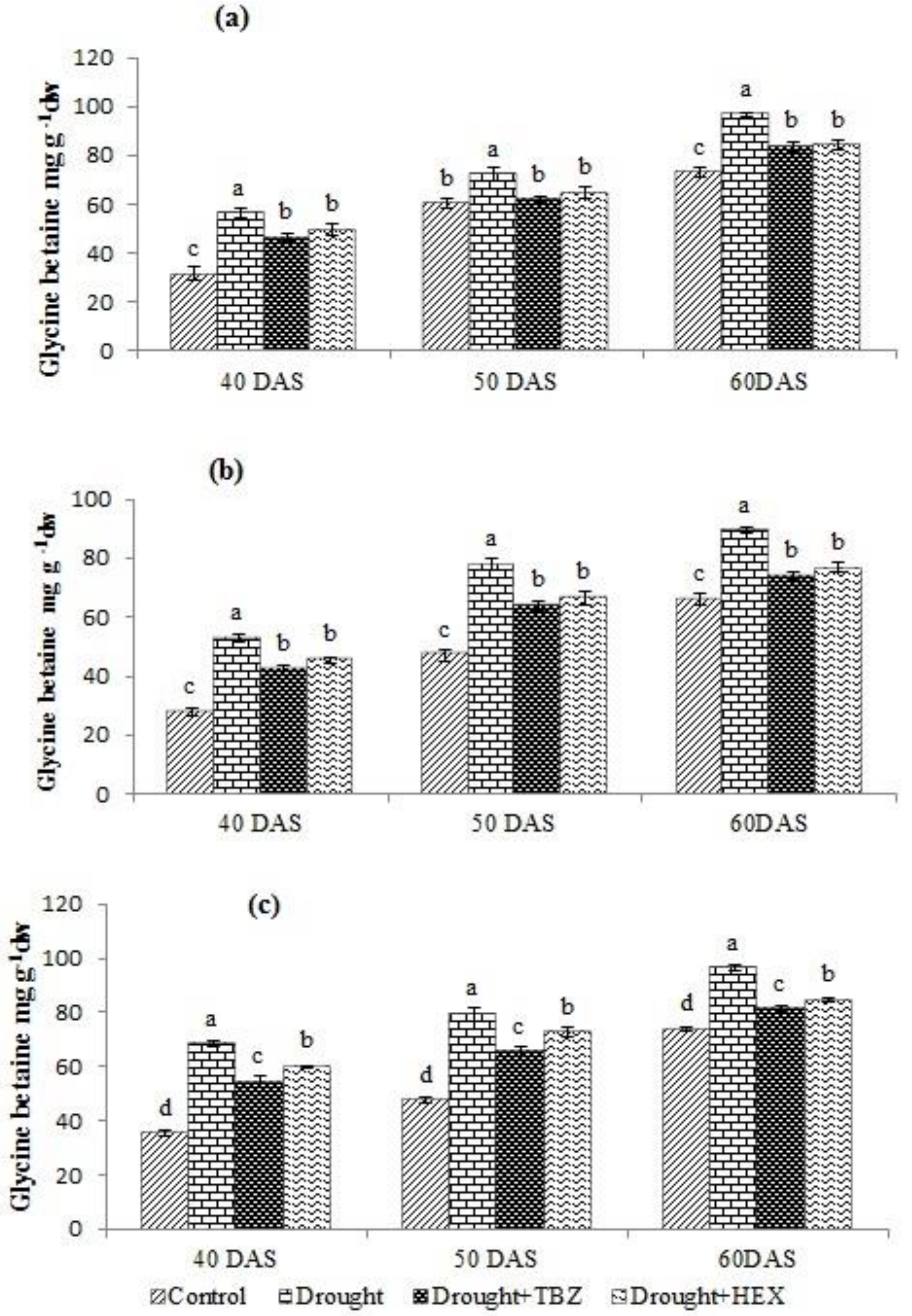

Fig. 5. Effect of drought with triazole treatments on Glycine betaine (a) Root (b) Stem and (c) Leaves of tomato plants. Values are given as mean ± SD. of three samples in each group.
Bar values are significantly at ≤ 0.05 (DMRT).

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Author contributions

M.A worked under the supervision of R.S. Both the authors participated in the writing of the manuscript. Both the authors agreed the final version of manuscript for publishing in Journal of Scientific Agriculture.

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