Academic Journal of Plant Sciences 4 (2): 57-63, 2011
ISSN 1995-8986

Response of Shoot and Root Development of Seven Tomato Cultivars in Hydrophonic System under Water Stress

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Abstract: The Experiment with nutrient solution was conducted in the glasshouse of the University of Applied and life Science, Vienna, Austria to evaluate the effect of water stress on root and shoot development of seven tomato cultivars. The stress levels were 20, 25 and 30 minutes (withholding water) as low, medium and severe stress. The experiment revealed that the cultivars BR-4 and BR-5 showed comparatively tolerance to drought as their root length, root dry weight and root/shoot ratio were higher under water stress condition (30 minutes stress).

Key words: Water Stress · Nutrient Solution · Morphology · Dry Matter · Root Length

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is one of the most popular and versatile vegetable all over the world. It plays a vital role in providing a substantial quantity of vitamin C and A in human diet. The fruits are eaten raw or cooked. It is most popular as salad in the raw state and is made into soups, juice, ketchup, pickles, sauces, conserves, puree, paste, powder and other products [1-3].

Water plays an important role in plant life and in determining the yield of tomato [4]. Under conditions of drought the free energy of water available to the plant is reduced well below that of pure free water. The accumulation of solutes within the cell occurs due to osmotic adjustment and help in maintaining turgor at decreasing water potential. The solutes are Glucose, Fructose, Sucrose, Proline, Ascorbic Acid etc. [5].

Plant water status controls the physiological process and conditions, which determine the quality and quantity of its growth [6]. Since water is essential for plant growth, it is axiomatic that water stress, depending on its severity and duration, will affect plant growth, yield and quality of yield. Although, yield can possibly be reduced due to stress, they are not necessarily significant. Similarly, water stresses may show insignificant effect on height and dry matter production of plants [7].

To breed drought tolerant cultivars, it is necessary to identify morphological characters of the plants that can attain a high and stable growth under deficient moisture conditions. Present investigation was undertaken to study some of the morphological parameters, like root and shoot development of tomato plants as affected by water stress.

MATERIAL AND METHODS

The nutrient solution culture experiment was conducted in the Glasshouse of the Institute of Plant Production and Plant Breeding, University of Applied and life Science, Vienna, Austria, to evaluate the effect of water stress on root and shoot development of plants.

To evaluate the root length, application of nutrient solution is a measure of water stress.

Seven varieties of tomato seeds were sown in sand in a plastic tray. Each seed was 1 cm apart from the other and the seeds were sown in two rows per variety. Water was added time to time to keep the sand wet.

The seedlings about 7 cm height were transplanted in perforated plastic pot and placed on a tray containing nutrient solution. 14 ml of Blaukorn Fluessig (2ml /10L) and 7g of Fe fertilizer (Fertrilon, 1g / 10L) were mixed with 70 L of water and the pH was adjusted between 5.5-6.0.

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The plants were grown in a glasshouse with average day night temperature of 27/22° ± 1°C. The pots were arranged in a randomized block design with four treatments and three replications and were rotated once in a week so that the plants got uniform light and temperature.

The water stresses in nutrient solution culture experiment were applied 25 days after transplantation to evaluate the development of roots. Treatment consisted of a well watered control and three water stress treatment.

Control plant (C treatment) was irrigated 24 hours with nutrient solution and water stressed plants (S treatment) received no water for 20, 25 and 30 minutes (withholding water) during which roots were kept completely in the air (were hanging from an open trolley) out of the contact of nutrient solution.

These, three treatments, low, medium and severe (20, 25 and 30 minutes) were imposed thrice in a week and continued up to 21 days. After every stress, root and shoot length of the plants were measured. Twenty one days after the imposition of stresses, plants were harvested by cutting at the base and the final root and shoot length per plant were recorded.

The root and shoots are then dried in oven at 105°C for 24 hours and weights were recorded.

RESULTS AND DISCUSSION

The results of this experiment revealed that the variations in length and dry matter production of roots and shoots were dependent on variety.

The nutrient solutions withholding period was the indicator of drought stress tolerance. Cultivar differences were observed in the nutrient solution withholding period, at which plants could tolerate water deficiency. After re-suspension in the nutrient solution, a rapid recovery from wilting appeared within a few minutes but it took longer time for some varieties.

In this experiment, it was found that all root and shoot growth parameters in different cultivars responded differently with increasing stress periods. All the root growth parameters i.e. root length, root fresh and dry weight were affected differently in different stress level.

Fig. 1: Setting of Pots in Glass House

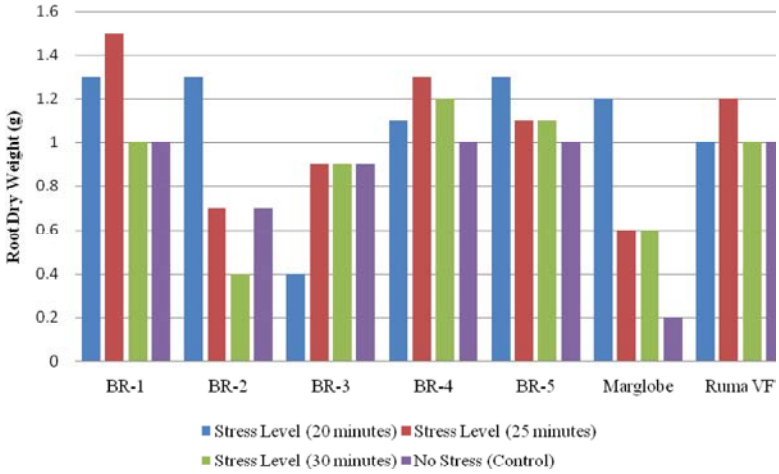

Fig. 2: Effects of different levels of moisture stress on root dry weight in seven tomato cultivars.

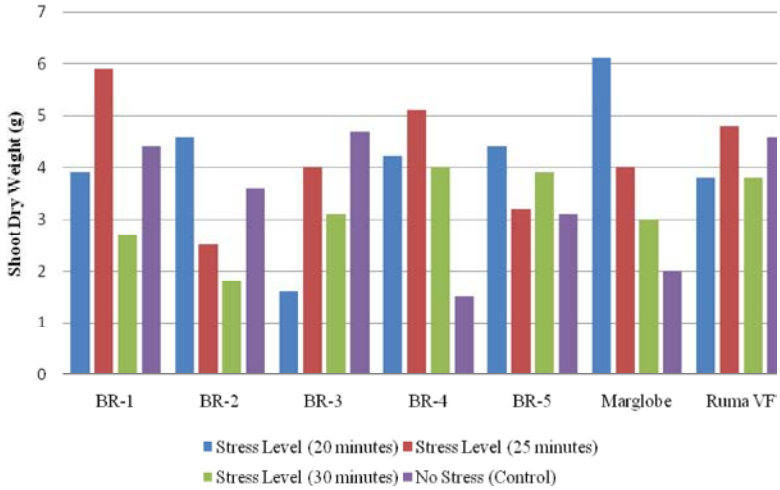

Fig. 3: Effects of different levels of moisture stress on shoot dry weight in seven tomato cultivars.

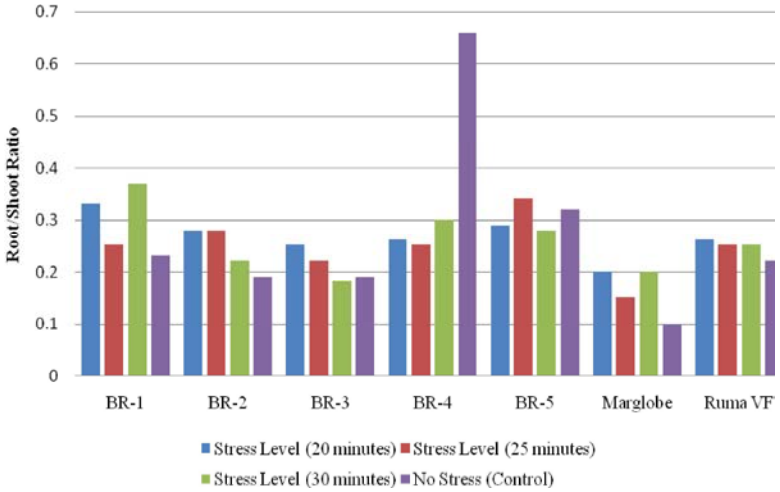

Fig. 4: Effect of water stress on root/shoot ratio seven tomato cultivars

Root length of the intercultivars differed little compared with the control but differed significantly among the varieties as the stress level increased. Reduction in root length due to increasing stress was found more pronounced in BR-1 and BR-2.

Results showed increased root length in low followed by medium and sever stress in BR-3, low followed by severe stress in Marbloge and Ruma VF and medium followed by severe stress in BR-4 and BR-5, whereas the root lengths of these two cultivars were longer than the other three.

The results revealed that among the seven cultivars the root length of BR-4 and BR-5 was higher in all stress level compared to control (Fig 9-12) and pictured in Fig 13 and 14. Although in most of the cultivars, water stress increased both root and shoot length of the cultivars, the root length development was more than that of the shoot length. Result on the root and shoot dry matter production and root/shoot ratio of seven tomato cultivars are presented in (Fig 2-4). It reveals that among seven cultivars BR-4, BR-5, BR-1 and Ruma VF seemed to be more resistant to stress as it was evident from the increase in shoot and root dry matter yield at all stress level compared to control. Although root/shoot ratio was higher in BR-4 and BR-5 in all treatments.

In case of other varieties, it was found that in BR-2 and Margbloe, root and shoot weight were decreased with increasing stress, whereas in BR-1 and Ruma-VF root and shoot dry weight increased in medium stress followed by low and severe stress but in BR-3 the root dry weight was same in medium and severe stress, whereas the shoot dry weight was more in severe followed by medium stress. Water stress, reduced the length of shoot than root but there were considerable variation in the extent of reduction among the cultivars.

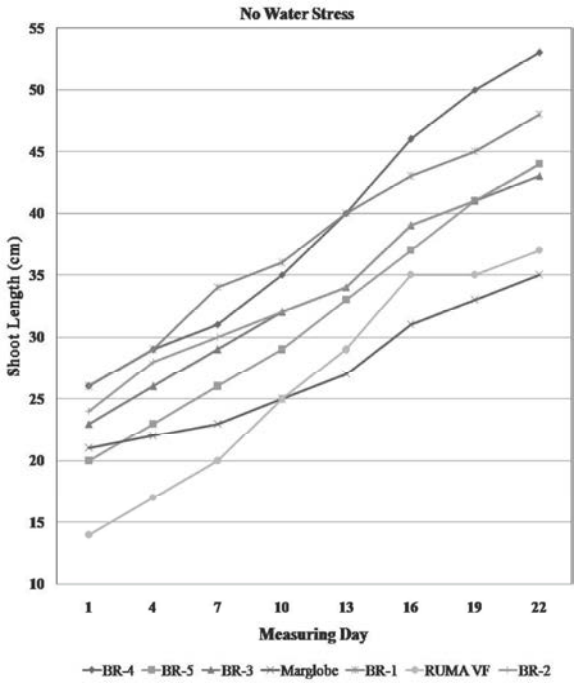

Fig. 5: Effect of no stress (Control) on Shoot Length of seven tomato cultivars

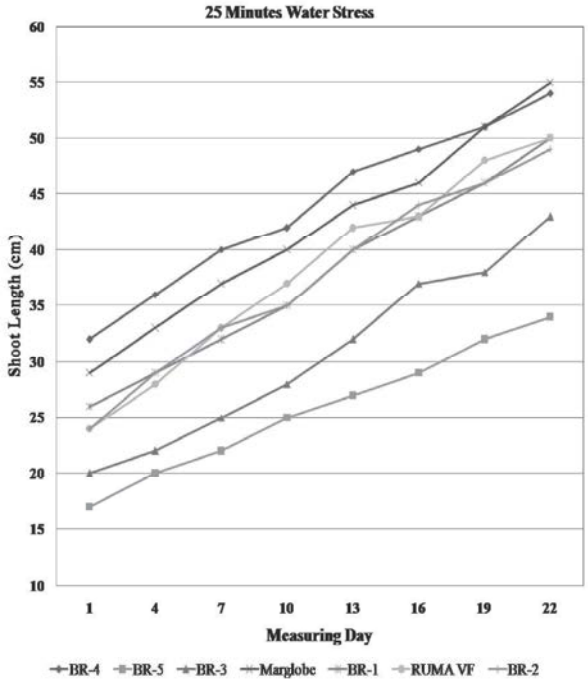

Fig. 7: Effect of 25 minutes water stress on Shoot Length of seven tomato cultivars

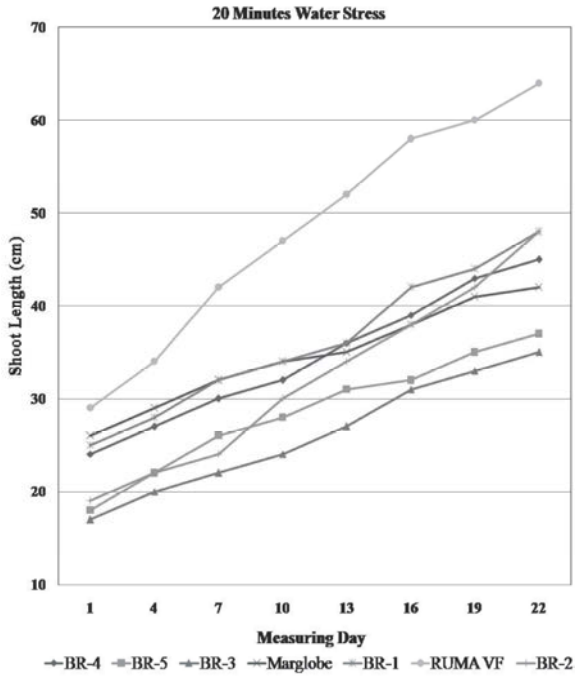

Fig. 6: Effect of 20 minutes water stress on Shoot Length of seven tomato cultivars

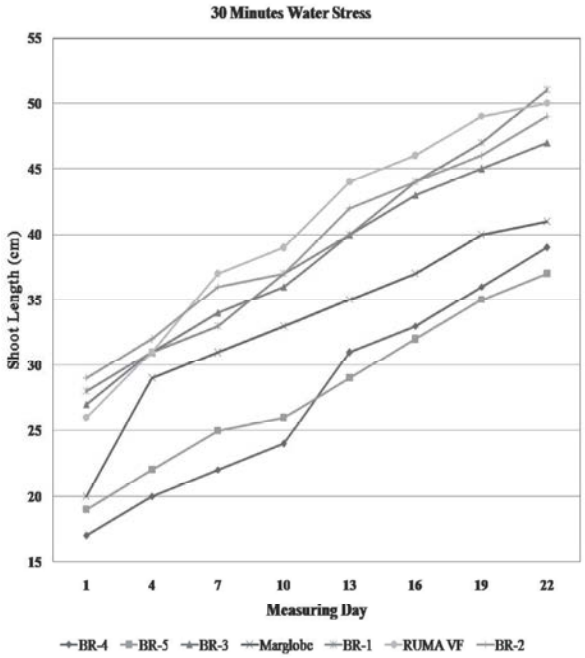

Fig. 8: Effect of 30 minutes water stress on Shoot Length of seven tomato cultivars

In case of root/ shoot ratio, it was found that the ratio of root dry weights to shoot dry weight in BR-4 and BR-5 cultivars were considerably higher in the control and stressed plants than the others. The ratio was also higher in BR-1 in stressed treatments.

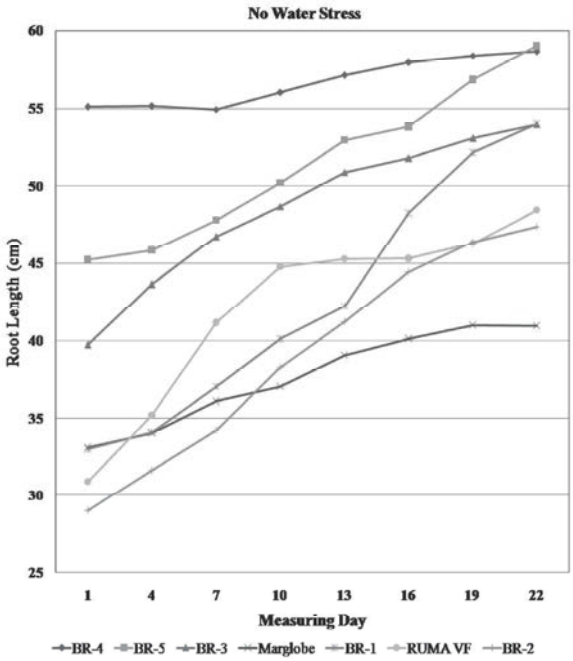

Fig. 9: Effect of no stress (Control) on Root Length of seven tomato cultivars

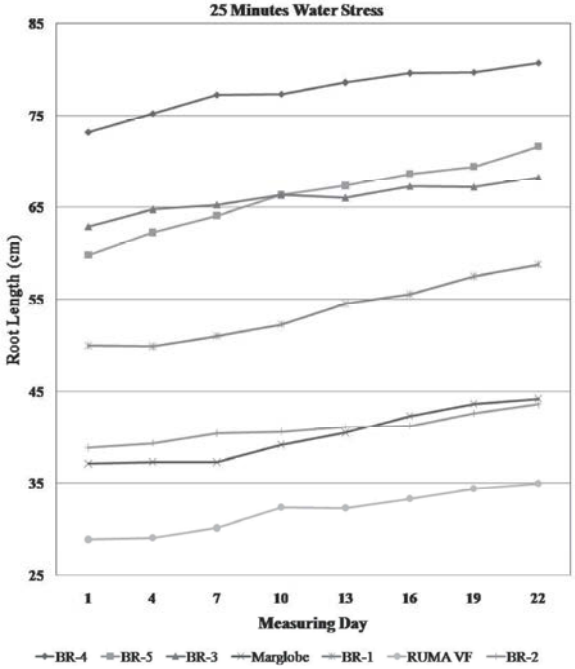

Fig. 11: Effect of 25 minutes water stress on Root Length of seven tomato cultivars

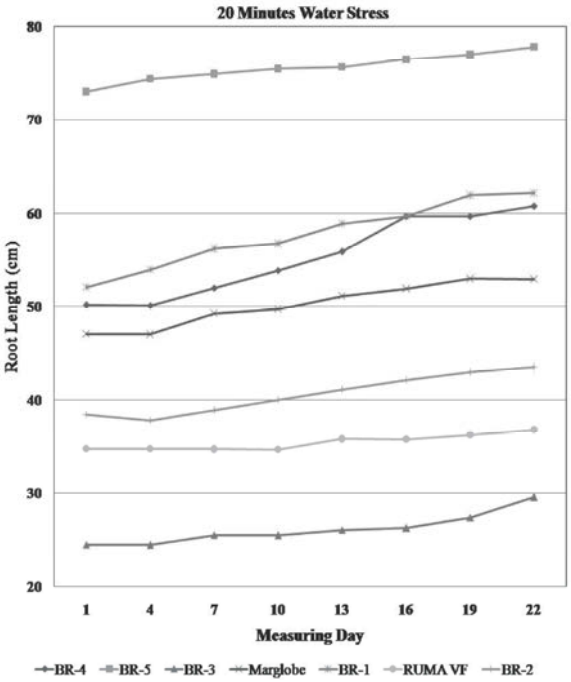

Fig. 10: Effect of 20 minutes water stress on Root Length of seven tomato cultivars

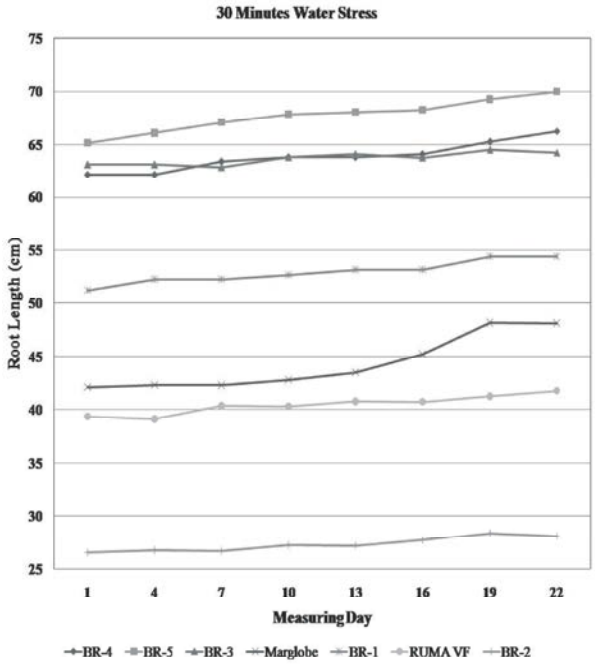

Fig. 12: Effect of 30 minutes water stress on Root Length of seven tomato cultivars

The length of shoot increased in cultivars BR-3, BR5 and Ruma VF with increasing stress compared with control. In Marglobe, it decreased with increasing stress, whereas in BR-2 it decreased in medium and same in low and severe stress. In BR-1, this trend increases in medium stress but decreased in low followed by severe stress whereas in BR-4 it increased from low to medium stress but decreased in severe stress (Fig 5-8).

Fig. 13: Length of Roots in Control and low Stress Level (no Stress and Stress-1)

Fig. 14: Length of Roots in medium and severe Stress Level (Stress-2 and Stress-3)

It was found that the length of root increased in BR-4 and BR-5 cultivars in all stressed plants than the others compared to control followed by BR-1 and BR-3 (Fig 9-12).

DISCUSSION

The results of this experiments showed that the two varieties BR-4 and BR-5 were different in their response to water stress than the others and a rapid recovery from wilting was observed. These observations are in agreement with those of Shimshi *et al.* [8] who postulated that drought tolerant plants possess morphological or metabolic properties that enable them to maintain a high degree of tissue hydration even under limited water supply.

The results on the root and shoot dry matter production of two cultivars BR-2 and Marglobe indicated that root and shoot dry weight decreased gradually with increasing water stress. The results are in consistent with that of Thakur [9] who reported a similar trend of root and shoot dry matter production of tomato in India.

These two cultivars (BR -2 and Marglobe) seemed to be more susceptible to water stress as it was evident from the reduction of shot and root dry matter yield. No significant difference was observed in other cultivars by the water stress treatments.

The results on root dry weight, root lengths and root/shoot ratio of BR-4 and BR-5 revealed that the root development in these varieties were significantly higher than those of others in all treatments showing that water stress did not have any influence on them. These results confirm the findings of Boyer [10] who observed no evidence of water stress in deeper rooted plants.

CONCLUSION

It is concluded from the result that BR-4 and BR-5 were superior stress tolerance cultivars that merit further consideration as potential breeding material. The result suggests that it is possible to use water stress tolerance as a selection criterion in tomato breeding programs for drought resistance.

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