EFFECT OF DROUGHT STRESS ON PHYSIOLOGICAL GROWTH PARAMETERS OF TOMATO INBRED LINES AT GERMINATION STAGE

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Abstract

This study was carried out to investigate the effect of water stress condition in growth parameters of 35 tomato inbred lines. Those inbred lines are collected from different countries and they were screened with osmotic concentration of 12.5 % polyethylene glycol 6000 while their respective control treatments were treated using distilled water for twelve days at germination stage. The relative percentages of shoot length, root length, shoot weight; root weight and relative germination rate were computed to determine the effect of water stress on the growth parameters of the inbred lines. According the experiment's result, drought tolerant inbred lines have longer root length and higher root weight than the susceptible inbred lines. Shoot length and shoot weight was not much affected by the drought situation at the germination stage. The most drought tolerant inbred lines have the highest relative germination rate and the drought susceptible inbred lines have a lower relative germination rate. The highest germination percentage was recorded at control treatments than in the PEG treatments.

Keywords: Growth parameters, polyethylene glycol 6000, water stress, tomato inbred lines, germination rate, drought tolerance, susceptibility

Introduction

Water plays a vital role in the production of vegetables. In every part of the world, it is the limiting factor for agricultural crops in general and for vegetables in particular. (Lisar et al., 2012), stated that water is the core medium for carrying metabolites and nutrients and is a vital molecule in all physiological processes of plants. In the growth of plant, the response to shortage of water caused by drought has been a major force (Zhu, 2002).

Water stress is the most prevalent abiotic constraint that causes for widespread yield reduction in agricultural production (Robin et al., 2003). Drought is a condition that creates difficulties in completing normal physiological functions by lowering plant water potential and turgor (Lisar et al., 2012). Plants can overcome drought by dehydration avoidance or by dehydration tolerance (Blum, 2005). The reactions of plants to water stress vary significantly at different levels depending upon the intensity and duration of stress as well as kind of plant and its growth stage (Jaleel et al., 2008). Plants try to adapt to stress situations with biochemical and physiological interventions (Lisar et al., 2012).Water stress is principally caused by drought or high soil salinity which leads to water deficit and then it reduces plant growth by affecting various physiological and biochemical processes (Farooq et al., 2008).

It is very important to carry out research to understand the physiological responses of tomato inbred lines to water stress at their early growth stage. Therefore, in this study, the effect of water stress condition in growth parameters of 35 tomato inbred lines was investigated using PEG 6000 in their germination stage.

Materials and Methods

This research was conducted in Northwest A and F University, college of Horticulture, China.

It was designed to observe the effect of water stress on seedling growth parameters of tomato inbred lines at germination stage. First, thirty five tomato inbred lines were selected from different countries of origin as presented in Table 1.

Table 1. Name, source of countries/ provinces of the sample inbred lines

No.	Name	Source country	No.	Name	Source country
1	TTI1114A-1-2-2	Taiwan*	19	F0820	France
2	TTI1103B-2	Taiwan*	20	TTI1211B	Taiwan*
3	TTI1217A	Shaanxi*	21	TTI1101B-1	Taiwan*
4	TTI1216A	Shaanxi*	22	ZB1	Israel
5	HV-083	Taiwan*	23	ZB2	Israel
6	A0910	Yinchang*	24	B5	Shaanxi*
7	A6	Shaanxi*	25	B2	Shaanxi*
8	Roma	USA	26	M82	USA
9	TTI1210B	Shaanxi*	27	TTD203B	USA
10	A0911	Yinchang*	28	ZB5	USA
11	A0909	Yinchang*	29	L12	Taiwan*
12	A5	Shaanxi*	30	TTI1117A-1	Taiwan*
13	TTI1214-A	Nanjing*	31	A0907	USA

14	TTI1212B	Taiwan*	32	TTD210B	Egypt
15	F0818	Germany	33	L142	USA
16	TTI1229A	Shaanxi*	34	TTD211B	Egypt
17	TTI1108B-1-1-1-1	Taiwan*	35	TTI1105B-1	Taiwan*
18	A0916	USA			

Note: asterisk (*) indicates the source country is China.

300 uniform size, full and without damage seeds of each of the materials were soaked in an initial temperature of 55°C warm water for twelve hours, and after taken out of the water, they were divided into 6 replications of 50 seeds each, and placed on moistened plastic petri dishes of 9 cm diameter. Three replications were treated with osmotic concentration of 12.5 % PEG 6000 (Cui et al., 2011) and the other 3 replications treated with distilled water as a control. All the treatments were kept in an incubator with a temperature of 25°C and relative humidity of 90%. Distilled water and PEG were added regularly when required. First counting of germinated seeds was after 36 hours from the placement of the seeds in their respective individual petri dish, and then continued every day at the same time for 12 days. After the 12 days treatment, shoot and root length of 30 seedlings from each replication of the water treatments and the PEG treatments were measured. Moreover, fresh weight of 100 normal shoot and root seedlings of each individual inbred line under water and PEG treatments was measured in grams. Germination rate (GR) was calculated by the following formula (Li, 2008):

GR= Germination rate（GR） = a/b*100

Where,

a= total number of germinated seeds in PEG concentration or distilled water in 12 days.

b= total number of seeds evaluated in one replication

And the relative percentages of the other parameters were calculated as follows:

Relative percentage of shoot length = Shoot length in PEG/shoot length in water*100

Relative percentage of root length= root length in PEG/root length in water*100

Relative percentage of shoot weight= Shoot weight in PEG/shoot weight in water*100

Relative percentage of root weight= root weight in PEG/root weight in water*100

Relative germination rate= Germination rate in PEG/germination rate in water *100

The experiment was repeated and the average of the results found from the study was used to compute the above parameters.

Result

Relative percentage of shoot length

As it is revealed in figure 1-A, the highest relative percentage of shoot length was recorded in the inbred lines TTI1216A, A0916, TTI1217A, TTI1210B and Roma with their value of 76.93, 74.6,73.22, 69.99 and 69.99 respectively. The rank of those inbred lines to water stress out of 35 inbred lines is 11, 12, 20, 18 and 3 (table 2). The inbred lines L12, ZB2, B5, A0911 and B2 recorded the lowest relative percentage of shoot length with their value of 27.8, 32.22, 33.93, 38.06 and 38.93 and their respective rank to drought is 4, 32, 35, 2 and 19. As it is shown in figure 1-A, there is no any correlation between the relative percentage of shoot length at germination stage and their corresponding rank to water stress. Some of the inbred lines with good performance in water stress have a high relative percentage of shoot length and others have the reverse. There is no uniformity among the value of the relative percentage of shoot length and their respective rank to water stress among the inbred lines.

Relative percentage of root length

A0911, L12, TTI1214-A, Roma and TTI1103B-2 inbred lines have recorded relative percentage of root length 98.27, 96.67, 96.17, 96.05 and 95.93 respectively and their consequent rank to drought stress was 2, 4, 6, 3, and 1. And the lowest relative percentage of root length was observed in the inbred linesTTI1114A-1-2-2, M82, B5, ZB2 and A5 with their value of 44.79, 47.86, 55.02, 55.97 and 61.76 respectively. As shown in table 2, the rank of those inbred lines to water stress is 34, 29, 35, 32 and 33. In general, the inbred lines that have good rank to drought stress registered longer relative percentage root length and those with poor rank to drought stress have lower relative percentage root length.

Relative percentage of shoot weight

The highest relative percentage of shoot weight was recorded in the inbred lines ZB1, A0910, TTD210B, L12 and TTI1103B-2 with their corresponding values of 81.91, 79.17, 79.13, 77.78 and 77.45. The rank of these inbred lines to drought stress is 31, 28, 5, 4 and 1 (table 2). The lowest relative percentage of shoot weight was noticed in the inbred linesTTI1105B-1, B5, TTI1214A, TTI1117A-1 and B2 with their values of 34.43, 45.48, 47.41, 48.39 and 49.09 respectively. As it is given in table 2, their corresponding rank out of 35 inbred lines to water stress was 16, 35, 6, 21 and 19. As it can be observed in figure 1-C, there was no correlation between the rank to water stress and the relative percentage shoot weight of tomato inbred lines at their germination stage.

Relative percentage of root weight

Highest relative percentage of root weight was recorded in the inbred lines L12, TTI1101B-1, TTI1214-A, TTI1211B and TTD210B with their respective values of 94.62, 92.71, 92.68, 88.99 and 88.73; and their consequent rank to water stress is 4, 6, 6, 10 and 5. The lowest relative percentage of root weight was occurred in the inbred lines ZB1, A0907, ZB2, A0910 and B5 with their values of 11.7, 14.29, 14.81, 15.97 and 16.46 respectively. Generally, as it can be observed from figure 1-D, those inbred lines which have good performance to water stress have a higher relative percentage of root weight and vice versa.

Relative germination rate (RGR)

TTI1103B-2, A0911, TTD210B, L12 and Roma have the highest RGR with 96.4, 91.5, 90.2, 85.2, 84.4 percent respectively and their corresponding rank to drought stress is 1, 2, 5, 4 and 3 out of the 35 studied inbred lines. While the lowest values were found in the inbred-lines B5, A5, A0907, ZB1, M82, A0910 with their RGR 11.48, 16.44, 22.6, 22.73, 23.24,23.24 percent respectively and their corresponding rank to water stress is 35, 33, 30, 31, 29 and 28. As it is shown in figure 1-E, the inbred lines which have good rank to water stress have highest RGR and vice versa.

Figure 1 A-E. Relative percentages of shoot length, root length, shoot weight, root weight and relative germination rate of 35 tomato inbred lines versus their rank to water stress.

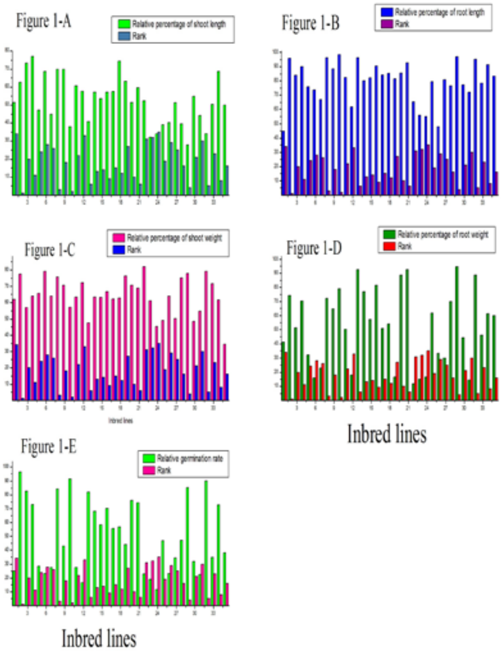

Table 2. Inbred lines and their rank to water stress

No.	Name	Rank to water stress out of 35 inbred lines	No.	Name	Rank to water stress out of 35 inbred lines
1	TTI1114A-1-2-2	34	19	F0820	27
2	TTI1103B-2	1	20	TTI1211B	10
3	TTI1217A	20	21	TTI1101B-1	6
4	TTI1216A	11	22	ZB1	31
5	HV-083	24	23	ZB2	32
6	A0910	28	24	B5	35
7	A6	26	25	B2	19
8	Roma	3	26	M82	29
9	TTI1210B	18	27	TTD203B	25
10	A0911	2	28	ZB5	16
11	A0909	22	29	L12	4
12	A5	33	30	TTI1117A-1	21
13	TTI1214-A	6	31	A0907	30
14	TTI1212B	13	32	TTD210B	5
15	F0818	14	33	L142	23
16	TTI1229A	9	34	TTD211B	8
17	TTI1108B-1-1-1-1	15	35	TTI1105B-1	16
18	A0916	12			

The rank in table 2 was computed based on their total score of relative germination energy, relative germination rate, relative germination index and relative vitality index. The rank of the inbred lines is arranged in chronological order from most tolerant to the most susceptible inbred lines to water stress.

Discussion

Relative percentage of shoot length

As it is revealed in figure 1-A, some of the inbred lines which are tolerant to drought stress has a high and others have low relative percentage of shoot length. Similarly, some susceptible inbred lines have a high relative percentage of shoot length and some of them have a low relative percentage of shoot length. Since there is no uniform trend between the relative percentage of shoot length and the rank of the inbred lines to water stress, thus shoot length may not be much affected by the drought situation at germination stage. The same result was described by (Kulkarni and Deshpande, 2007) in their study on tomato genotypes.

Relative percentage of root length

As it can be observed from figure 1-B, the inbred lines which have good performance to water stress were noted with a higher relative percentage of root length. Drought tolerant inbred lines have a longer root length than the susceptible inbred lines. These long roots may help the drought tolerant to extract water from the deep soil. Comparable results were reported on wheat cultivars (Almaghrabi, 2012) and pearl millet (Leila, 2007). (Macar et al., 2009) in their study also explained that drought stress induced by PEG prevented radical extension in Chickpea. This was the main reason that caused the susceptible inbred lines to have shorter root length under PEG treatment than the tolerant inbred lines. Therefore, it may be difficult for the susceptible inbred lines to absorb water from deep soil during drought condition. (Kulkarni and Deshpande, 2007) explained early and rapid elongation of roots is main indication of drought tolerance. Similarly, the tolerant inbred lines we studied showed a faster root elongation.

Relative percentage of shoot weight

As it is shown in Figure 1-C, when the rank to water stress and the relative percentage of shoot weight are compared there is no significant correlation. Some of the inbred lines tolerant to water stress have high and others low relative percentage of shoot weight. The inbred lines susceptible to water stress also have some high and others low relative percentage of shoot weight. This non significant trend may be correlated with the uneven relative percentage of shoot length. Similarly to the shoot length, the shoot weight also may not have much correlation with the drought condition at germination stage.

Relative percentage of root weight

Generally, as it can be observed from figure 1-D, those inbred lines which have good rank to water stress have a higher relative percentage of root weight compared to the inbred lines which recorded poor performance to water stress. The drought tolerant inbred lines have recorded higher root weight than that of the susceptible inbred lines. This may be because of their long root length. In addition, since the drought tolerant inbred lines have a better ability to absorb water under drought situation, the amount of water content available in the fresh root may be higher than the susceptible inbred lines and this can boost additional weight. Similarly,(Kulkarni and Deshpande, 2007) in their investigation on tomato cultivars found highest root weight by the drought resistant and lowest root weight by the susceptible cultivars.

Relative germination rate

As it is shown in figure 1-E, the inbred lines which have good rank to water stress have high RGR and those which have poor rank to water stress have low RGR. The most drought tolerant inbred lines have the highest relative germination percentage and the drought susceptible inbred lines have a lower relative germination rate. The highest germination percentage was recorded at control treatments and was lower at PEG treatments. The PEG concentration inhibited the germination of the susceptible inbred lines and caused them to record low germination percentage. The higher germination rates of the tolerant inbred lines were due to their ability to absorb water under PEG media. Previous studies investigated PEG treatments can lead to a reduction in germination percentage by decreasing the water potential gradient between seeds and their surrounding media (Dodd and Donavan, 1999). (Hegarity, 1977) and (Turk et al., 2004) in their investigation reported that water stress at germination stage can affect in delayed and reduced germination or may hinder germination completely. This is in agreement with our investigation.

Conclusion

Drought tolerant inbred lines have longer root length and higher root weight than the susceptible inbred lines.

Shoot length and shoot weight may not be much affected by drought situation at germination stage.

The most drought tolerant inbred lines have the highest relative germination percentage and the drought susceptible inbred lines have a lower relative germination rate. The highest germination percentage was recorded at control treatment and was lower at PEG treatments.

Acknowledgements

We are grateful to the sponsor of this research. This research was funded by the research project of the Shaanxi Provincial Coordinator (2011KTCL02-03) and the national "twenty-fifth" science and technology plan project (2011BAD12B03-03-5).

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