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Effect Of Reduced Irrigation On Flowering, Fruit Set And Yield Of Indeterminate Tomato

Daniela Ganeva, Stanislava Grozeva, Galina Pevicharova

Abstract*—Drought stress has become an important limiting factor for tomato growth and yield. To evaluate the effect of water stress on the productivity nine tomato genotypes were grown in a field at the Maritsa Vegetable Crops Research Institute under two watering regimes - optimum and 50% reduced. Flower number, fruit number, fruit weight and flower abortion rate were measured. The studied tomato genotypes showed different behavior in response to drought stress. A decrease of flower number, fruit number and fruit weight from 2nd to 5th trusses was observed in scarcity. Water stress reduced the flower number by 25% and fruit number by 58% compared to the control plants. The highest reduction of the fruit weight of 76.1% and 78.3% respectively was registered in the 4th and 5th trusses.

Keywords*—Water deficit, flower abortion, Solanum lycopersicum L.

I. INTRODUCTION

Climatic change due to the global warming has a serious impact on water resources influencing underground and surface water. Drought stress is one of the determining factors for plant growth and is one of the major environmental constraints affecting photosynthetic efficiency and limiting the yield of crop plants. In recent years, many studies have focused mostly on the demand for gene sources of drought tolerance [1], [2]. Secondly, it is also important to achieve a minimizing/sustainable use of water supply with maintaining a relatively constant yield and quality [3], [4].

Tomato (*Solanum lycopersicum* L.) is a vegetable crop grown all over the word in different climatic regions, continental, tropical and sub-tropical where they are often exposed to environmental stress especially high temperature and drought [5]. Tomato is a high-water-consumption vegetable crop and is one of the most demanding in terms of its use [6]. Furthermore, studies have shown that flowering and fruit set stages are the most sensitive to water stress [7], [8]. The water deficit applied in the flowering stage increases flower abortion and the yield decreases as a result of reduce of the amount of fruits. The drought stress during the growing season usually reduces the yield because of the reduction in both fruit weight and number [9]. Depending on the intensity and duration of exposure, growth stage of the plant and genotype, the decrease of yield varies in wide range from 30% to over 80% [10]–[13]. In indeterminate tomato flowering and fruit set are continuous processes therefore stress during flowering and fruit set could not be avoided [14]. The highest percentage of flower abortion (22%) in the most stressed plants (40% of PC) was observed in 3rd and 4th trusses [15]. The authors indicated that the number of flower buds that failed to form fruit increased with a decrease in water levels and leads to 69% yield reduction in the most stressed plants.

In Bulgaria the growth and development of tomatoes take place during the warmest period of the year (June to August). A combination between water scarcity and high summer temperatures has a negative impact on flowering and fruit formation. Regardless of the conducted studies, there is still a large difference in the yield of modern tomato varieties grown under optimal and reduced irrigation [16], [17]. The aim of this experimental work was to evaluate the influence of reduced irrigation on flowering and productivity characteristics of local tomato accessions.

II. MATERIALS AND METHODS

The field experiment was carried out at the Maritsa Vegetable Crops Research Institute in Plovdiv during the 2016 and 2017. The plant material consisted of three tomato varieties BG Ideal, BG Rozovo sartse, BG Aleno sartse and six local forms BG 720, BG 735, BG 785, BG 822, BG 2066 and BG 21β. All genotypes were of indeterminate growth habit and intended for fresh consumption. The seeds were sown at the beginning of April in an unheated greenhouse. Five weeks old tomato seedlings were transplanted into the field. The plants

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were grown according to the standard technology for mid-season production of indeterminate tomatoes in two watering regimes - optimum and 50% reduced. The reduced irrigation was applied 20 days after transplanting when the plants were well adapted to the field. The experiment was conducted in a randomized complete block design with two replications by 10 plants (area 2.4 m^2). A micro-flow drip irrigation method was used with dripping wings and distributors giving 2 L h^{-1}, spaced 20 cm apart and placed along the row.

In order to quantify the water stress the flower number, fruit number and fruit weight (g) were measured. The flower abortion was based on the formation of flower number and fruit number in percentage (%). All these characters were recorded from 2 to 5 trusses on five individual plants of each genotype and replication.

Weather data were collected from June to August in 2016 and 2017. Air minimum and maximum temperature (°C), air humidity (%), rainfalls (l/m^2) and soil moisture at 15 and 30 cm depth (kPa) were recorded by weather station Caipos Wave (Caipos GmbH, Austria).

The results were given as means of twenty independent (biological) replications. The chart and trend functions of the excel program were used to build the chart and trend lines describing the dynamics of the flower abortion from the 2nd to the 5th truss with optimum and 50% reduced irrigation [18].

III. Results And Discussion

The effect of the irrigation regime on the growth and the yield of tomato genotypes was connected with the weather conditions during the vegetation period. During the growing season June-August of 2016 the daily mean temperature ranged between 19.78 and 28.80 ºC. The highest maximum air temperature over 37 ºC was recorded in the last decade of June and July. The data measured for 2017 showed that the daily mean temperature varied from 17.10 to 32.02 ºC with peaks of maximum temperature over 40 ºC in the last decade of June and the second decade of July. The total rainfalls were 134 l/m^2 and 76.5 l/m^2 respectively. The highest value of rainfalls was recorded in August 2016 (64.5 l/m^2) and July 2017 (52.5 l/m^2) (Fig. 1).

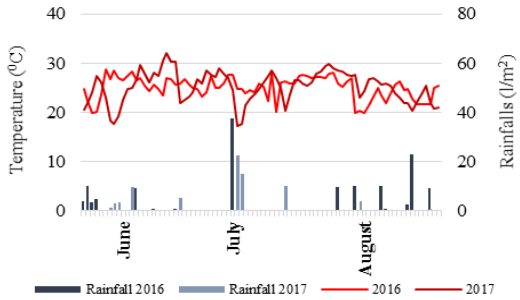

Fig. 1. Daily mean temperature and rainfalls during the 2016 and 2017

Under condition of optimum irrigation the number of flowers from 2 to 5 inflorescences kept constant with 3 to 5 flowers depending on the genotypes (Fig. 2). The only plants from local accessions BG 720 and BG 785 formed average flowers of 1.8 in 5 truss. The studied genotypes showed a slight decrease of flower number from 2 to 5 inflorescence under the conditions of 50% reduced irrigation. A decrease in flower number over 50% was observed in 5th trusses only. The highest decrease of number of flowers was registered in lines BG 622 and BG 720 (34.4% and 39.5% respectively) and the lowest ones in variety BG Ideal and line BG 21β (14.5 and 12.2% respectively).

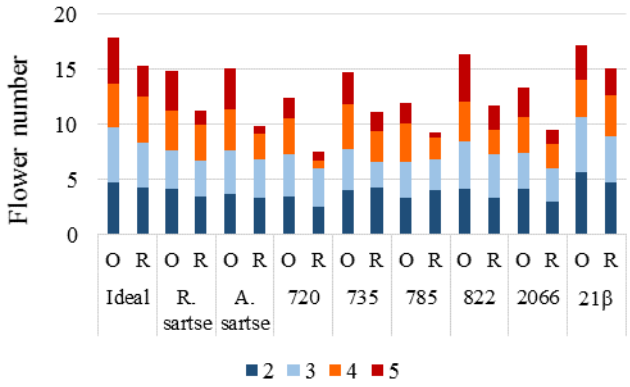

Fig. 2. Number of flowers from 2nd to 5th trusses in nine tomato genotypes growing in optimum (O) and 50% reduced (R) irrigation

Water deficit significantly affected the number of formed fruits per trusses (Fig. 3). The highest percentage of decrease in a fruit number was registered in the 4th and 5th trusses (76.1% and 78.3% respectively). This was probably due to the fact that these two trusses had been formed between the end of June and the beginning of July when the highest summer temperatures were recorded during two studied years. Among the genotypes the decrease of the number of fruits in 2nd truss was from 34.8% (BG 720) to 57.1% (BG 2066) and 20.0% (BG 720) to 78.3% (BG 785) in the 3th truss respectively. Fruit formation was not found on 4th truss in accession BG 822, and on 5th trusses in accessions BG 785, BG 2066 and variety BG Aleno sartse. Similar results concerning the increase of the flower abortion and limiting fruit set under drought and the elevated temperatures were obtained by [19].

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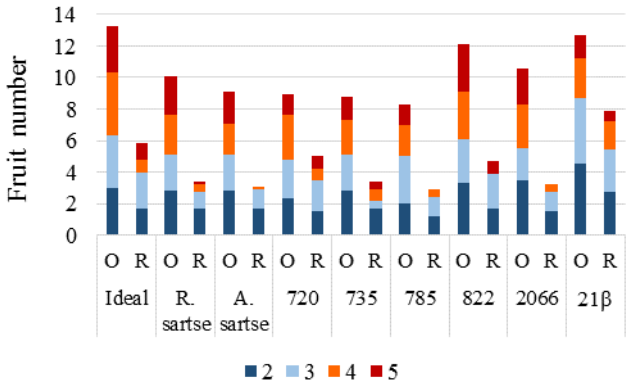

Fig. 3. Impact of 50% irrigation (R) on number of fruits in 2nd to 5th tursses comperd to optimum irrigation (O)

The data showed significant differences in flower abortion between plants grown under optimum and reduced irrigation. In well watered plants over 60% of the flowers from 2nd to 5th trusses formed fruits while the number of flowers that failed to form fruits increased especially in the 4th and 5th trusses in drought stress (Fig. 4a, b). Significant coefficients of correlation (r = 0.71) and determination (R^2 = 0.50) were established in optimum irrigation. The described model was statistically proved. A high correlation (r = 0.84) and determination (R^2 = 0.71) were reported for reduced irrigation. The exponential trend function describing the model was significant and showed that 71% of flower abortion was due to the water stress.

In regard to fruit setting under reduced irrigation the highest percentage of flower abortion in 2nd truss was recorded in line BG 785 (70%) and the lowest one in line BG 720 (40%). At 3rd truss the flower shedding varied from 37.7% (BG 21β) to 78.3% (BG 720). Flower abortion over 80% was observed in 55.6% and 44.4% of the studied genotypes in 4th and 5th trusses respectively (Table 1). The same results with the flower abortion over 70% in the 4th truss compared to the control were also reported by other authors [15]. The development of the 4th truss in the studied indeterminate tomato genotypes was during the warmest and driest period of the two years and maybe this was the reason for the highest abortion rate compared to the other trusses under the conditions of 50% reduced irrigation. The explanation of the negative effect by sub-optimal water supply and abnormal temperatures due to physical damages, physiological disruptions, and biochemical changes was made by [20].

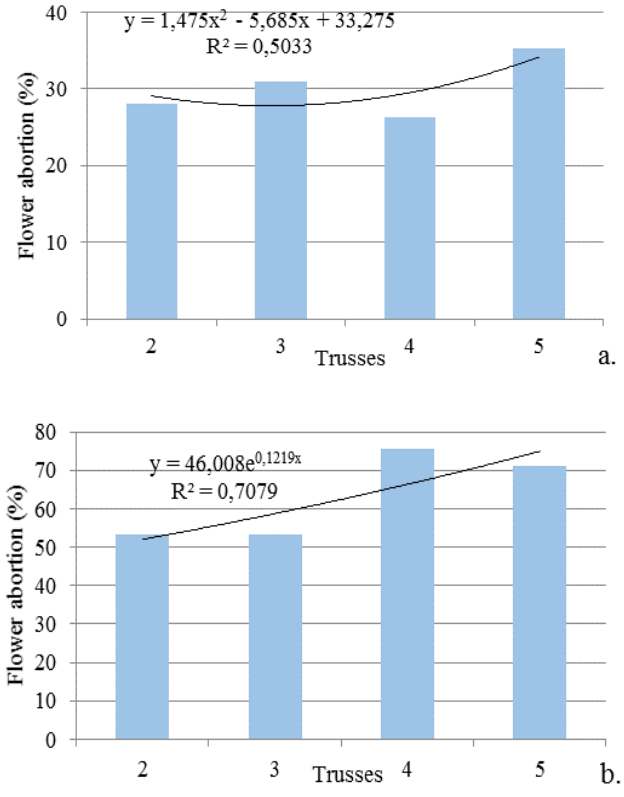

Fig. 4. Flower abortion rate from 2nd to 5th trusses; (a) optimum irrigation, (b) reduced irrigation

TABLE I
FLOWER ABORTION (%) OF NINE TOMATO GENOTYPES BY TRUSSES DISTANCE GROWN UNDER OPTIMUM AND 50% REDUCED IRRIGATION

Genotype	Irrigation regime	Number of trusses			
		2	3	4	5
BG Ideal	Optimum	36.2	34.0	0.0	28.6
	Reduced	60.5	42.5	81.0	64.3
BG R. sartse	Optimum	33.3	34.3	28.6	32.4
	Reduced	51.4	68.7	84.8	83.3
BG A. sartse	Optimum	24.3	42.5	45.9	45.9
	Reduced	48.5	65.7	91.3	100
BG 720	Optimum	34.3	34.2	15.2	27.8
	Reduced	40.0	42.9	0.0	0.0
BG 735	Optimum	30.0	39.5	45.0	50.0
	Reduced	60.5	78.3	75.0	71.0
BG 785	Optimum	39.4	9.1	42.9	27.8
	Reduced	70.0	57.1	75.0	100
BG 822	Optimum	21.4	33.3	18.9	30.2
	Reduced	48.5	45.0	100	64.0

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Genotype	Irrigation regime	Number of trusses			
		2	3	4	5
BG 2066	Optimum	16.7	37.5	15.2	14.8
	Reduced	50.0	60.0	77.3	100
BG 21β	Optimum	21.1	16.0	24.2	53.1
	Reduced	42.6	35.7	51.4	72.0

The water deficit had the strongest negative effect on the fruit weight (Fig. 5). It was reduced by 54.9% and 89.3% from 2nd to 5th trusses respectively. In all tested genotypes, the loss of the fruits weight was over 70% with the exception of line BG 21β and variety Ideal (57.5% and 68.7% respectively). The results were very close to those reported by Sivakumar and Srividhya [8] who observed a reduced yield from 30 to 80% among the studied genotypes.

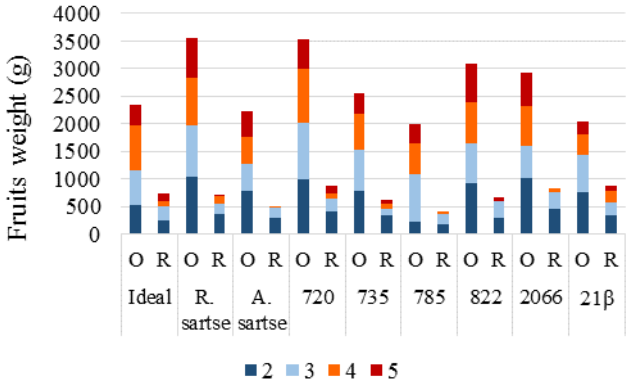

Fig. 5. Effect of water deficit on fruit yield from 2nd to 5th trusses

CONCLUSION

More sensitive to applied stress were 4th and 5th trusses. Among the genotypes only accession BG 21β showed higher tolerance to 50% reduced irrigation with below 37% decrease of fruit number and 57% of fruit weight. The water deficit during the growing season reduced number and weight of fruits strongly than flower number in the studied nine tomato genotypes.

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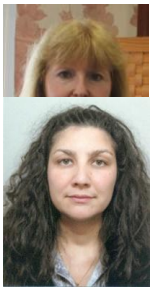

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