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MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERS OF TOMATO (*Lycopersicon esculentum* Mill) CULTIVARS UNDER WATER STRESS

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Tomato (*Lycopersicon esculentum* Mill) is one of the most popular and versatile vegetable in the tropical and subtropical areas including Bangladesh. It occupies an area of about 10919 hectare with a total production of 81005 tons. The average yield of tomato, in this country is very low (7.42t/ha) in comparison with that of other countries (Anon., 1989).

In 1997, the average yield was 4.2 t/ha in Bangladesh, 54.7 t/ha in Japan, 65.l t/ha in the United States (FAO, 1997). The yield differences between these countries are not only due to different environments but also to the differences in cultural practices and varietal characters.

Tomato is sensitive to a number of environmental stresses, especially extreme temperature, drought, salinity and inadequate moisture stresses (Kalloo, 1993). In Bangladesh, lack of irrigation and drought resistant cultivars are the central problems for tomato cultivation. In the dry season with high temperature, flower abortion occurs and fruits drop frequently, which causes very poor yield of tomato. For this reason, farmers are not interested in cultivating tomato, especially in the summer season. But recently, Bangladesh Agricultural Research Institute (BARI) has released two varieties (BARI Tomato-4, BARI Tomato-5) which can grow both in summer and winter. Present investigation was undertaken to study some of the physiological and morphological parameters of tomato plants as affected by water stress.

The pot experiments were carried out in Bangladesh (November to March) to evaluate the effect of water stress on some morphological and physiological parameters of tomato plants, such as growth, yield, flowering and fruiting characters, water consumption, leaf relative water content and transpiration of plants. Two tomato cultivars, namely BARI Tomato-4 and BARI Tomato-5 were used in this study. Three treatments were imposed viz, 100%, 70%, and 40% of the field capacity (F.C.). Yield and yield attributes were found high at 70% F.C. compared with other treatments, water consumption, leaf relative water content, and transpiration decreased with increasing stress.

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The experiments were carried out in the net house of the Dept. of Soil, Water and Environment, Dhaka University. The seeds of two cultivars were collected from Bangladesh Agricultural Research Institute (BARI) and 30 days old seedlings were transplanted in 25cm height and 30 cm diameter clay pots. The pots were filled with silty clay loam soil. The field capacity of the soil was 33%. The soil was air- dried and sieved through a 2 mm sieve for chemical and other analyses. The general characteristics of the soil were sand - 5.8%; silt - 60.2%; clay - 34.0%; maximum water holding capacity - 46%; hygroscopic moisture - 1.40%; porosity - 49%; bulk density - 1.27g/cc; particle density - 2.57g/cc; pH - 7.2; EC - 143µS; 0M - 1.14%; CEC - 17.9meq/l00g soil, and N - 0.06%.

The experiment was arranged in a completely randomized block design with three treatments and four replications. The treatments were maintained by adding required amount of water lost through evaporation and transpiration everyday. The pots were covered with aluminium foil to prevent evaporation loss from the soil surface. Nutrient supply and other intercultural operations were done as and when necessary. Harvesting of tomato fruits was started 60 days after transplanting and there were 5 harvests altogether at 5-7 days interval, over one month period. At maturity yield, yield component data and other physiological parameters were recorded.

After the last fruit harvest, plants were harvested. All the plant samples were dried in an oven at 65°C and dry weight of the plants were also recorded. Finally the results were statistically analyzed employing the Duncan's New Multiple Range Test (DMRT).

The performance of two varieties under water stress with respect to the growth, yield, plant water relation and other horticultural characteristics was investigated. The statistically evaluated results of yield and yield attributes in two cultivars at different water stresses were presented in Table 1 and 2, respectively.

Table 1. Yield and yield attributes of two tomato cultivars overall treatments.

Cultivar	Dry matter (g/pot)	Yield (g/pot)	Cluster/ plant	Flowers/ cluster	Fruits/ cluster	Fruits/ plant	Average fruit wt (g)	Fruit stalk length (cm)	Fruit length (cm)	Fruit diameter (cm)
BARI Tomato-4	8.2a	180.9a	8.5a	6.0a	5.7a	15.9a	20.8a	2.7b	3.6b	3.5a
BARI Tomato-5	7.4a	174.2ab	8.2a	5.8a	4.9a	12.8ab	20.9a	2.9a	3.8a	3.5a

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Table 2. Effect of water stress on yield and yield attributes of tomatoes overall cultivars.

Treatment	Dry matter (g/pot)	Yield (g/pot)	Cluster/ plant	Flowers/ cluster	Fruits/c luster	Fruits/ plant	Average fruit wt (g)	Fruit stalk length (cm)	Fruit Length (cm)	Fruit diameter (cm)
100% F.C.	5.2c	136.8b	4.8c	4.6c	4.0c	10.0b	16.3c	2.4c	3.3b	3.2c
70% F.C.	11.1a	201.3a	12.6a	7.4a	6.8a	19.4a	26.4a	3.3a	3.9a	3.7b
40% F.C.	7.1b	194.5ab	7.6b	5.6b	5.1b	13.8b	19.9b	2.7b	3.8ab	3.5b

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

The results (Table 1) revealed that BARI Tomato-4 gave higher yield and fruits/plant but lower fruit length and fruit stalk length than that of BARI Tomato-5.There were no differences in dry matter, fruit yield flowers/cluster, fruits/cluster, and clusters/plant between the two varieties of tomato plants. The variations in the performance were due to individual characteristics of two varieties.

The effect of different soil moisture regimes on yield component in tomato fruits and dry matter production revealed that there was a significant interaction effect between the varieties and soil moisture regimes (Table 2).

The two varieties responded better with respect to increased number of fruits/plant and consequently yield at 70%F.C. and 40% than that of 100% F.C. (Table 2). The highest fruit yield was obtained at 70% F.C., which differed only slightly from that of 40% F.C. but significantly from that of 100% F.C. The slight stress followed by severe stress and control. The slight stress condition (70%F.C.) out- yielded the other irrigation treatments. Such findings may prove that optimum water supply for tomato plants is an important factor in maximizing its fruit production.

These results also confirm the findings of Lampine *et al.* (1995), who showed an optimum level of water stress required to give high fruit production in French prune.

In the present investigation, the number of fruits per plant and yield per plant indicated better partitioning ability of assimilates towards fruit development at

70% F.C. and the lowest yield per plant in the control treatment (100%F.C.) and further showed the susceptibility of these plants to low soil moisture regimes (40%F.C.).

These results agree with the findings of Singh *et al.* (1988) and Lal *et al.* (1988). In dry matter production, the two cultivars were statistically insignificant. The highest dry matter production was at 70%F.C. followed by 40% F.C. and control. The ability of the cultivars to produce dry matter under depleted soil moisture regimes might be due to the effect of osmotic adjustment (Richter and Wagner 1983; Flower *et al.,* 1990).

Other flower and fruit characteristics of tomato plants i.e. flowers/cluster, fruits/cluster, clusters/plant, fruit stalk length, fruit length, and diameter and average fruit weight as affected by soil moisture stress are presented in Table 3. Results showed that all the flower and fruit characters were significantly affected by water stresses. The highest values were obtained at 70%F.C (slight stress) followed by severe stress (40%F.C) and control (100%F.C.). All the parameters were affected by water stresses. Maximum yield and yield attributes were observed at 70% of the field capacity. It attributed the highest yield (201.31g). Its fruit number/plant (19.37) was also higher than that of the other treatments. Its average fruit weight was 26.38g, which is considered as a big fruit. Such results indicate that 40% and 100%F.C. affected greatly the fruit size, which was reflected on the final plant yield. It can be concluded that moisture stress of 70% F.C. was adequate moisture supply for the investigated tomato plants and could be recommended for higher fruit yield and better fruit size. This result also confirmed the findings of Sharma and Kumar (1989) and Nahar *et al.* (2002, 2011), who observed higher yield in stressed condition than that of non- stressed condition.

The plant water relation includes leaf relative water content, water consumption and transpiration in plants. Plant water relation parameters are presented in Table 3 and 4.

Table 3. Water consumption, leaf relative water content and transpiration in two tomato cultivars overall treatments.

Cultivars	Water consumption (ml/plant)	Leaf relative water content (%)	Transpiration (ml/day)
BARI Tomato-4	20954.2a	28.61a	275.00a
BARI Tomato-5	18087.5b	78.07a	220.83b

In column; means with the same letter are not significantly different at 5% level by DMRT.

Table 4. Effect of different water stress treatments on water consumption, leaf relative water content and transpiration in plants overall cultivars.

Treatment	Water consumption (ml/plant)	Leaf relative water content (%)	Transpiration (ml/day)
100% F.C.	24881.3a	80.41a	331.25a
70% F.C.	20193.5c	78.72ab	237.50b
40% F.C.	13487.5c	75.89b	175.00c

In a column; means followed by a common letter are not significantly different at 5% level by DMRT.

Water consumptive use by tomato plants under different stress treatments are presented in Table 3 and 4. It was found higher in BARI Tomato-4 than in BARI Tomato-5 (Table 3). The values of water use ranged from 13487.5 ml to 24881.3 m1 depending on the level of soil moisture.

Data in Table 4 indicated that water consumptive use increased as soil moisture was maintained high. The higher water use was attained under 100%F.C. followed by 70% of F.C. whereas the lowest value was found at severe stressed condition (40%F.C.). In other words, the rate of water consumption increased in an ascending order i.e.40%F.C<70%F.C. < 100%F.C. moisture levels.

The probable explanation of this result could be attributed to the availability of soil water to tomato plant in addition to the higher consumptive rate from the wet soil than a comparatively dry one. This result also confirms the findings of Qasem and Judah. (1985) and Ali *et al.* (1998) who observed highest water consumptive use obtained from the wet treatment followed by medium and dry. Results on relative water content in tomato plants under different water stresses are presented in Table 3 and 4.

In the current investigation, the relative water content for tomato plant varied from 80 to 76% at 100% to 40% F.C. treatments (Table 4). It was found that the relative water content did not differ significantly between cultivars (Table 3), but decreased significantly with increasing stress (Table 4). The highest value was obtained from 100%F.C. (80.41) followed by 70%F.C. (78.72) and 40% F.C. (75.89) of the soil.

These results were in consistent with Srinivasa et al. (1990), who observed leaf relative water content decreased with increasing stress.

The daily transpiration rate in tomato plants at different water stresses were presented in Table 3 and 4. It was found that transpiration rate was comparatively high in the cultivar BARI Tomato-4 than in BARI Tomato-5 (Table 3). The result also revealed (Table 4) that the transpiration rate (mI/day) of the plants decreased with the increase in water stress. The highest transpiration was obtained at 100%F.C. and the lowest at 40%F.C.

These results were also in well agreement with the findings of Rahman *et al.* (1998), who observed a decreased transpiration rate with increased stress. In conclusion variety BARI Tomato-4 and BARI Tomato-5 were drought tolerant by virtue of their partitioning ability of assimilates towards fruit development. Variety BARI Tomato-4 and BARI Tomato-5 showed drought tolerance in providing higher dry matter production and greater fruit yield at depleted soil moisture conditions (70% and 40% F.C.) probably due to osmotic adjustment.

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