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Effects of High Temperature Stress on Physiological and Yield Parameters of Mulberry Varieties

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Abstract

High temperature causes alteration in physiological and yield parameters of mulberry plant. The present study was conducted to examine the tolerance/susceptibility of five popularly cultivated mulberry varieties *viz.*, V_1, G_2, G_4, MR_2 and S_{36} exposed to high temperature stress. The varieties were maintained in Open Top Chambers (OTCs) at 40 °C for two weeks. It is found that the variety V_1 was tolerant to high temperature stress followed by MR_2 and S_{36}. After 14 days of high temperature stress, significant differences were observed among the varieties for leaf yield per plant under control and stress conditions compared to control and 7th day after stress. The variety G_2 and G_4 recorded highest reduction in Total Dry Matter Accumulation (TDMA) (55.60% and 55.96%) at 14th day after stress. Whereas, the lowest reduction percent of TDMA was recorded in V_1 (23.06%) followed by MR_2 (30.80%) and S_{36} (36.76%) compared over its control values at 14th day after stress.

Keywords: High temperature, Leaf yield, Mulberry varieties, Total dry matter accumulation

Introduction

Mulberry (genus, *Morus*), is an important crop used for yielding foliage and is the primary food for silkworm, *Bombyx mori* L. The mulberry foliage yield and its quality depend on soil type, variety available, plant nutrients in soil, agronomical factors and agro-climatic conditions. Mulberry thrives under a varied climate ranging from temperate to tropical. The ideal range of temperature for normal growth of mulberry is 24-28 °C.

Tamil Nadu is one of the major states of India with great potential for development of mulberry crops. The state has ten agro-climatic regions suitable for growing variety of mulberry around the year. Average global combined temperature of land and ocean surface has increased by 0.85 °C (IPCC, 2014). An average increase of at least 0.2 °C decade^{-1} is projected from now onwards. The increase in the levels of the greenhouse gasses is becoming a major cause of the global warming. Mulberry is cultivated under semi-irrigated conditions, and hence gets exposed to high temperature stress during summer in Tamil Nadu. Heat stress due to high ambient temperature is a serious threat to crop production.

Leaf area is the important economic part of mulberry crop and hence, it is a direct component of leaf yield (Susheelamma and Dandin, 2006). Leaves are the main assimilatory organs predominantly concerned with photosynthesis and the leaf area is a reliable index of determining the overall metabolic efficiency of a plant in terms of dry matter accumulation, yield and quality of the crop (Song *et al.*, 2013). Plant height is an important trait for growth, since increase in plant height would allow greater biomass production and yield potential in plants (Zhang *et al.*, 2004). It has been stated that heat stress is a limiting factor at the initial phase of plant growth and development. Heat stops the elongation and expansion growth of crop plants (Shao *et al.*, 2008).

Article History

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Leaf yield in mulberry is a polygenic character influenced by several quantitative characters and is the cumulative consequence of various physiological and biochemical process. Dry matter partitioning varied widely under different temperatures. The effect of temperature on growth and dry matter accumulation showed a decrease in dry weight of mulberry saplings (Fukui, 2000). Hence, the present experiment was undertaken to identify the stress tolerance/ susceptibility of mulberry varieties through observing the alterations in leaf area, plant height, leaf yield and total dry matter accumulation in mulberry varieties exposed to high temperature stress at open top chambers.

Materials and Methods

Mulberry varieties *viz.,* V_1, G_2, G_4, MR_2 and S_{36} were examined for high temperature stress tolerance (Table 1). Plants were normally grown until 120 days. After 120 days, the plants were kept in Open Top Chambers (OTCs). Here, three sets of pots were used in which one set of pots were maintained as control, one set of pots were exposed to high temperature stress for 7 days and another set of pots were exposed for 14 days in OTCs. In high temperature chamber, temperature of 40 ºC was maintained from 9.00 hrs to 13.00 hrs. Inside the OTCs, required levels of relative humidity and temperature were maintained by giving commands through control panel. Crop management practices were taken as per recommendation. The observations were taken during the experiments *viz.,* before imposing stress (120th day), 7th day after stress (127th day) and 14th day after stress (134th day). Each variety was replicated four times. Observations on yield parameters were recorded as per Naveenkumar (2017) are described below.

Table 1: List of five mulberry varieties used in the present study

Sl. No.	Mulberry varieties	Parentage/ Origin
1	V_1	S 30 × C 776
2	G_2	*Morus multicaulis* × S 34
3	G_4	*Morus multicaulis* × S 13
4	MR_2	Open pollination of unknown origin
5	S_{36}	Chemical mutagenesis - Ethyl Methane Sulphonate treatment of Berhampore local variety.

Leaf area plant^{-1} was measured using a Leaf Area Meter (LICOR, Model LI 3000) and expressed as m^2 plant^{-1}. Plant height was measured from the ground level to the tip of the growing point and expressed as cm. Leaves were harvested from different replicated plants and their weight was recorded. The average leaf yield plant^{-1} was estimated. The total leaf yield plant^{-1} was expressed in grams. For Total Dry Matter Accumulation (TDMA), the plants were first shade dried and then oven dried at 72 °C for 48 hours. The dry weight of the whole plant at maturity were recorded and expressed as g plant^{-1}.

Completely Randomized Design was used for data analysis of mulberry varieties before imposing stress (120th Day after planting) and Factorial Completely Randomized Design (FCRD) was used for data analysis of mulberry varieties maintained at high temperature stress (127th and 134th day after planting) maintained under OTCs. The experiment is carried out on various parameters as per the procedure suggested by Gomez and Gomez (1984). Wherever the treatment differences are found significant, critical differences were worked out at 5% probability level and the values with respective standard errors of means are furnished.

Results and Discussion

From the results obtained, it is clearly seen that the physiological and yield parameters were greatly reduced in mulberry varieties on exposure to high temperature stress. Before imposing stress, leaf area and plant height of the plants were measured. There was no significant variation among the varieties. The leaf area ranged from 17.28-19.15 m^2 respectively (Table 2). Generally, compared to the control, stress brought about the reduction in leaf area in mulberry varieties exposed to high temperature stress. At 7th day after stress, the leaf area of varieties was found to have small variation compared to control. The 14th day after stress showed a greater variation in leaf area, where the variety V_1 recorded the highest value 19.79 m^2 followed by MR_2 with the value 18.01 m^2 and least values were recorded in S_{36}, G_2 and G_4 (17.92, 17.75 and 16.57) respectively (Table 3). Similarly, Guha *et al.* (2010) also reported a decrease in leaf area under drought stress in mulberry varieties. Reduction in leaf area might be an adoptive mechanism under heat and drought stresses for survival, but larger leaf area reduction affects the capturing of light and ultimately photosynthesis. Drought also decreased leaf area owing to loss of turgor and reduced leaf numbers (Farooq *et al.,* 2009).

Table 2: Genetic variation in physiological traits of mulberry varieties at 120th day after planting (before imposing stress)

Varieties	Leaf area (m^2 plant^{-1})	Plant height (cm)
1	19.15 ± 0.02	95 ± 0.81
2	18.28 ± 0.01	*70 ± 0.66*
3	18.41 ± 0.04	*68 ± 0.54*
4	18.20 ± 0.03	86 ± 0.76
5	17.28 ± 0.01	75 ± 0.65
S. Ed	0.030	0.894
CD (p<0.05)	0.064	1.90

Plant height is an important parameter for growth, as increased height of plant will allow greater biomass production and yield in crop (Zhang *et al.,* 2004). In the present study, the growth of the plant was suppressed under high temperature stress. High temperature stress limited the increase of growth in mulberry varieties. Compared to 7th day after stress, the 14th day after stress brought about greater reduction in plant height. The variety V_1 was found to have

Table 3: Leaf area in mulberry varieties exposed to high temperature stress for two weeks interval

Mulberry varieties	Leaf area (m^2 $plant^{-1}$)			
	7th DAS		14th DAS	
	Control	Stress	Control	Stress
V_1	19.79 ± 0.05	19.16 ± 0.11	22.53 ± 0.14	19.79 ± 0.02
G_2	18.52 ± 0.12	17.74 ± 0.08	21.69 ± 0.07	17.75 ± 0.24
G_4	17.53 ± 0.14	16.25 ± 0.03	19.55 ± 0.21	16.57 ± 0.15
MR_2	18.97 ± 0.02	17.66 ± 0.15	21.53 ± 0.24	18.01 ± 0.27
S_{36}	18.67 ± 0.20	17.50 ± 0.13	21.27 ± 0.16	17.92 ± 0.21
CD (p<0.05), V	NS		NS	
T	NS		1.17^{**}	
V × T	NS		NS	

NS: Non significant; **Highly significant

taller plants under control and stress treatments. Variety V_1 showed lesser reduction (110.0-105.8 cm) followed by MR_2 (101.0-92.70 cm) and S_{36} (93.3-85.60 cm) (Table 4). Similarly, Pace *et al.* (1999) reported that plant height reduced under water deficit stress in cotton plant. Among the varieties, G_2 and G_4 were short. G_2 and G_4 did not grow further at OTCs maintained at 40 °C. Guha *et al.* (2010) reported that drought stress significantly slows down the plant height in all the mulberry genotypes taken for the study.

Table 4: Plant height in mulberry varieties exposed to high temperature stress for two weeks interval

Mulberry varieties	Plant height (cm)			
	7th DAS		14th DAS	
	Control	Stress	Control	Stress
V_1	104.00 ± 0.33	100.50 ± 0.30	110.0 ± 0.39	105.8 ± 0.43
G_2	82.01 ± 0.73	75.10 ± 0.60	86.5 ± 0.74	78.50 ± 0.61
G_4	78.00 ± 0.61	73.20 ± 0.65	83.5 ± 0.73	74.50 ± 0.60
MR_2	97.00 ± 0.91	89.50 ± 0.71	101.0 ± 0.31	92.70 ± 0.64
S_{36}	88.01 ± 0.78	83.00 ± 0.73	93.3 ± 0.64	85.60 ± 0.73
CD (p<0.05), V	0.60^{**}		0.39^{**}	
T	0.38^{**}		0.24^{**}	
V × T	0.85^{**}		0.55^{**}	

** Highly significant

Regarding leaf yield $plant^{-1}$, significant differences were observed among the varieties under control and stress conditions. The leaf yield recorded in mulberry varieties were described as follows: V_1 (69.50, 62.0 and 54.0), G_2 (58.0, 43.50 and 30.1), G_4 (55.0, 40.10 and 27.30), MR_2 (64.80, 52.60 and 40.20) and S_{36} (66.30, 55.20 and 45.50) at control, 7th day after stress and 14th day after stress. At 14th day after stress, the variety V_1 recorded lesser percent reduction in leaf yield (22.3%) followed by S_{36} (31.0%) and MR_2 (37%) compared to control. And, the lowest yield was recorded in G_2 and G_4 (Table 5). In line with the above findings, Guha *et al.* (2010) noticed higher leaf yield in mulberry varieties with better gas exchange parameters when plants were exposed to drought stress. Similar to the above findings, Lavanya *et al.* (2017) also confirmed the reduction in leaf yield when mulberry genotypes were subjected to elevated CO_2 and temperature.

Total Dry Matter Accumulation (TDMA) is the reflection of the biological yield in mulberry varieties. The dry weight recorded were V_1 (50.50, 44.74 and 38.55), G_2 (46.85, 35.70 and 20.80), G_4 (46.10, 34.60 and 20.30), MR_2 (48.70, 40.60 and 33.70) and S_{36} (47.60, 38.30 and 30.10) at control, 7th day after stress and 14th day after stress. The variety G_2 and G_4 recorded highest reduction in TDMA (55.60% and 55.96%) at 14th day after stress. Whereas, the lowest reduction percent of TDMA was recorded in V_1 (23.06%) followed by MR_2 (30.80%) and S_{36} (36.76%) compared over its control values at 14th day after stress (Table 6). Similar to the above findings, Paul and Quaiyyum (2015) noticed a reduction in dry weight of five mulberry varieties subjected to drought stress conditions.

Table 5: Changes in leaf yield in mulberry varieties exposed to high temperature stress for two weeks interval

Mulberry varieties	Leaf yield (g $plant^{-1}$)		
	Control	Stress	
		7th DAS	14th DAS
V_1	69.5 ± 1.20	62.0 ± 1.24	54.0 ± 1.07
G_2	58.0 ± 1.04	43.5 ± 1.38	30.1 ± 1.54
G_4	55.0 ± 1.37	40.1 ± 1.52	27.3 ± 1.49
MR_2	64.8 ± 1.41	52.6 ± 1.35	40.2 ± 1.25
S_{36}	66.3 ± 1.26	55.2 ± 1.43	45.5 ± 1.37
S.Ed	0.198	1.35	2.21
CD (p<0.05)	0.399**	2.94**	4.35**

** Highly significant

Table 6: Changes in TDMA in mulberry varieties exposed to high temperature stress for two weeks interval

Mulberry varieties	TDMA (g $plant^{-1}$)		
	Control	Stress	
		7th DAS	14th DAS
V_1	50.50 ± 1.32	44.74 ± 1.43	38.85 ± 1.32
G_2	46.85 ± 1.34	35.70 ± 1.32	20.80 ± 1.33
G_4	46.10 ± 1.32	34.60 ± 1.34	20.30 ± 1.54
MR_2	48.70 ± 1.34	40.60 ± 1.32	33.70 ± 1.43
S_{36}	47.60 ± 1.43	38.30 ± 1.43	30.10 ± 1.34
S.Ed	0.175	1.27	2.00
CD (p<0.05)	0.374**	2.71**	4.26**

** Highly significant

Conclusion

In the select five mulberry varieties *viz.,* V_1, G_2, G_4, MR_2 and S_{36}, the leaf area was greatly reduced under high temperature stress compared to control. The variety V_1 showed greater tolerance capacity by recording higher leaf area even under high temperature stress. Similarly, the plant height also followed the same trend as of leaf area, where the variety V_1 was found to be tallest and the varieties G_2 and G_4 stopped its growth under high temperature stress which shows their susceptibility to heat stress. Yield and yield components showed that the variety V_1 recorded higher biomass and leaf yield even under high temperature conditions. The variety G_2 and G_4 showed greater reduction in yield components under high temperature stress. Mulberry leaf quality is determined both genetically and environmentally, where heat stress causes reduction in yield and quality of mulberry foliage. From this study, it is clearly observed that the variety V_1 has highly heat stress tolerant capacity followed by varieties MR_2 and S_{36}.

References

Farooq, M., Wahid, A., Kobayashi, N., Fujita, D., Basra, S.M.A., 2009. Plant drought stress: effects, mechanisms and management. *Agron. Sustain. Dev*. 2, 185-212.

Fukui, K., 2000. Effects of temperature on growth and dry matter accumulation in mulberry saplings. *Plant Production Science* 3(4), 404-409. DOI:10.1626/pps.3.404.

Gomez, K.A., Gomez, A.A., 1984. Statistical Procedures for Agricultural Research. New York, USA. pp. 7-20.

Guha, A., Rasineni, G.K., Reddy, A.R., 2010. Drought tolerance in mulberry (*Morus* spp.): A physiological approach with insights into growth dynamics and leaf yield production. *Experimental Agriculture* 46(4), 471-488. DOI:10.1017/s0014479710000360

IPCC, 2014. Intergovernmental Panel on Climate Change. Fourth Assessment Report of the intergovernmental Panel on Climate Change: The Impacts, Adaptation and Vulnerability. United Kingdom and New York: Cambridge University Press. p. 189.

Lavanya, C., Ashoka, J., Sreenivasa, A.G., Nadagoud, S., Beladhadi, B.V., 2017. Effect of Elevated Carbon Dioxide and Temperature on Growth, Yield and Quality Parameters of Mulberry. *Int. J. Curr. Microbiol. App. Sci*. 6(11), 3351-3356. DOI:10.20546/ijcmas.2017.611.393.

Naveenkumar, R., 2017. Studies on the variability in photosynthesis and related physiological parameters in mulberry genotypes/varieties. (M.Sc., (Agri.) in Sericulture), Forest College and Research Institute, TNAU, Mettupalayam, Coimbatore, Tamil Nadu. pp. 22-33.

Pace, P.F., Cralle, H.T., El-halawany, S.H.M., Cothren, J.T., Senseman, S.A., 1999. Drought-induced changes in shoot and root growth of young cotton plants. *J. Cotton Sci*. 3, 183-187.

Paul, N.K., Quaiyyum, M.A., 2015. Study of root characters, leaf yield and yield components of mulberry under high and low soil moisture. *Rajshahi University Journal of Life & Earth and Agricultural Sciences* 40, 9-13.

Shao, H.B., Chu, L.Y., Shao, M.A., Abdul Jaleel, C, Hong-Mei, M., 2008. Higher plant antioxidants and redox signaling under environmental stresses. *Comp. Rend. Biol*. 331, 433-441. DOI:10.1016/j.crvi.2008.03.011.

Song, Q., Zhang, G., X-G, Z., 2013. Optimal crop canopy architecture to maximize canopy photosynthetic CO_2 uptake under elevated CO_2: a theoretical study using a mechanistic model of canopy photosynthesis. *Funct Plant Bio*. 40, 108-124.

Susheelamma, B.N., Dandin, S.B., 2006. Improvement for qualitative traits and leaf productivity in mulberry (*Morus* spp.) and its effect on bivoltine cocoon production. *Adv. Plant Sci*. 19(1), 23-28.

Zhang, M., Duan, L., Zhai, L., Li, J., Tian, X., Wang, B., He, Z.P., Li, Z.H., 2004. Effects of plant growth regulators on water deficit induced yield loss in soybean In: *Proceedings of the 4th Int. Crop Sci. Congress*. Brisbane, Australia. p. 575.