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GROWTH AND PHYSIOLOGY OF *PANICUM* SPECIES FOR THERMOTOLERANCE UNDER HYDROPONIC CONDITIONS

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ABSTRACT

Experiment for study of growth and physiology of the three *Panicum* species (*Panicum coloratum*, *Panicum antidotale* and *Panicum maximum*) was conducted under self made hydroponic system at The Cholistan Institute of Desert Studies, The Islamia University of Bahawalpur, Pakistan. Three different panicum species and four treatments (Thermopore sheet thickness) to control the escape of heat from the pots were used in the study. One week older seedling of panicum were uprooted and transplanted in the hydroponics solution culture with thermopore sheet and each plant was supported with the help of foam and their roots immersed in plastic pot containing modified nutrient Solution. The experiment was laid out in completely randomized design and replicated three times. Main tiller length, number of leaf per plant, number of tiller, leaf area, fresh weight and dry weight per plant measured in all the three different *Panicum* species at different temperature levels were recorded. The result indicated that *Panicum* species gained maximum main tiller length, number of leaf and tiller per plant, leaf area, fresh and dry weight per plant at T_3 treatment, where hydroponic root temperature was reduced by using one and half inches thermopore sheets. But at control treatment whose root temperature shoots up to 50˚C, minimum growth was observed. Among different *Panicum* species *Panicum coloratum* was the better adapted to tolerate high water temperature in hydroponic culture than other *Panicum* species by gaining maximum tiller length, fresh and dry weight, thus proved to be tolerant of high temperature.

Key words: *Panicum* species, main tiller length, fresh weight, chlorophyll contents

INTRODUCTION

The family Poaceae comprised of nearly 10,000 species, which include annual and perennial grass species which are cultivated as source of grain and silage for livestock. On the bases of temperature range grasses are categorized into warm and cool-season grasses. C_3 photosynthetic pathway is present in cool-season grasses but the warm season grasses have C_4 pathway. Optimum growth temperature for C_3 grass species is ranging from 18˚C-24˚C, while C_4 grass species grow well at temperature ranging between 30˚C–35˚C (Fry and Huang, 2004).

Panicum species are one of C_4 plant species found in the tropical climate. C_4 plants have a distinctive leaf anatomy and photosynthetic metabolism for utilizing carbon dioxide as compared to C_3 plants (Taiz and Zeiger, 2006). Increase in 5˚C-10˚C temperature above the threshold may cause irreversible injury to plant growth and development, disturb its metabolism and decline in growth and yield (Porter, 2005). In arid environment, perennial grasses are nutritive in purpose and used as a main source of fodder for livestock as reported by Mansoor *et al*. (2002). The problem of aridity becomes severe in Cholistan desert due to maximum temperature of 52˚C during summer and average rainfall of 120 to 200 mm (Naeem *et al*., 2000).

Panicum species are the naturally occurring perennial grasses which found occur in the Cholistan desert, in Pakistan. As Cholistan desert (longitude = 71° - 41′0" E, latitude = 29° - 24′0" N and altitude = 116 m) has hot environment, these perennial grasses have a number of adaptations. *Panicum* species are exceptional sand binders and play an important role in stabilizing the sand dunes. *Panicum* species are drought resistant with highest forage production and high protein content increase their nutritive value (Saini *et al*., 2007), thus these became a major source of fodder in the hot areas of Cholistan desert. In desert vegetation is facing a severe problem of drought, salinity and overgrazing due to livestock. Due to over grazing of *Panicum* species, there is a shortage of fodder, thus disturbing livestock production in the Cholistan desert (Akhtar and Arshad, 2006). Due to global warming, there is an increase in adversaries. It is necessary to find out the effect of high temperature on plant growth, which can be helpful for the growth of *Panicum* species under hydroponic conditions, in the warmer area of country to prevail over the shortage of fodder.

As many reports existing, studies on the effect of high temperature on *Panicum* species under hydroponic conditions are lacking. These studies were conducted under hydroponics conditions, with the followings objectives: (1) to acclimatize the grasses from soil into the aerated water in nutrient solution and (2) to

study the growth and physiology of *Panicum* species under hydroponic conditions at various temperature levels.

MATERIALS AND METHODS

The present experiment was conducted to investigate the growth and physiology of *Panicum* species for thermotolerance under hydroponics conditions at the Cholistan Institute of Desert Studies (CIDS) Baghdad-ul-Jadeed campus, The Islamia University of Bahawalpur Pakistan, during the year 2009. Thermopore sheets of different diameter were used to control the escape of heat in the pots. The self made hydroponics system was used to conduct the experiment. The different *Panicum* species of experiment are: a) *Panicum coloratum* b) *Panicum antidotale* c) *Panicum maximum*

Treatments to control high temperature

T_0 = Control (pots without thermopore sheet cover)
T_1 = 0.75 inch thick thermopore sheet cover.
T_2 = 1.00 inch thick thermopore sheet cover
T_3 = 1.50 inch thick thermopore sheet cover

Plantlets/propagules of *Panicum antidotale*, *Panicum maximum* and *Panicum coloratum* were uprooted from the soil and transplanted in the hydroponics culture solution with thermopore sheet and each plant was supported with the help of foam and their roots immersed in plastic pot containing modified Long-Ashton Nutrient Solution (Hewitt, 1966). One week older, uniform seedling was transplanted in the thermopore sheets containing modified Long-Ashton Nutrient Solution in plastic pots. During the whole experiment, the pots were continuously aerated. Solution culture in the pots was replaced twice in a week. Four plants from each species and treatment were randomly tagged as A, B, C and D respectively, for recoding various parameters during the course of study.

Main tiller length (cm): Main tiller length was measured with the help of measuring scale from the base of the main tiller including inflorescence. The measurement was taken after the interval of two days and continued up to maturity. **Number of leaves on main tiller:** Total number of leaves present on the main tiller was taken of four tagged plants in each pot and average of four plants was calculated for statistical analysis. **Leaf area (cm^2) of fully expanded leaf**: From main tillers the area of leaf was calculated with the help of formula given by Carleton and Foote (1965).

Leaf area = Maximum leaf length x Maximum leaf width x 0.75

Number of tiller per plant: At maturity the plant from pot was harvested, their total numbers of tillers were counted. **Plant fresh weight (g):** The fresh weight of plant was determined immediately after harvesting on digital balance. **Plant dry weight (g):** The fresh harvested plants were shifted to paper bag and put in an oven running at 72˚C for a week and then determined the dry weight.

Chlorophyll contents (SPAD- 502 values): A chlorophyll meter (SPAD-502, Minolta, Japan) was used to measure chlorophyll contents in leaves of different *Panicum* species at 1st, 2nd and last harvest. Two uppermost fully expanded leaves were selected from each plant to measure and record the SPAD values. Three SPAD readings were taken around the midpoint of each leaf and then SPAD readings were averaged to get the mean SPAD values.

Statistical analysis: The experiment was carried out in Completely Randomized Design (CRD) with factorial arrangement. There were four replications of each treatment. The data collected during the whole experiment for various morphological characteristics were statistically analyzed using MSTAT–C (MSTAT Development Team, 1989) software. Significant means were separated by using least significant difference test (LSD) at 5% probability level (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Increase in temperature is one of the major disturbing stresses upon plant growth, which change the growth rate in plants depending upon the plant species (Wahid *et al*., 2007). Injuries at morphological and physiological level in plants occurred by exposure of plant to high temperature above the range of optimal temperature. In the present investigation it is observed that, there is a decreased in growth in all *Panicum* species with increase in temperature. Little increase in plant height was noted at control treatment with high temperature (T_0). Ashraf and Hafeez, (2004) has also been reported that there in decrease in plant growth with increase in temperature, in several plant species. **Main tiller length** (MTL) of three different *Panicum* species differed significantly from each other at different temperature levels (Figure 1). Value for main tiller length was observed in *Panicum coloratum* (159 cm) followed by *Panicum antidotale* having MTL of (151 cm). The lowest value for MTL (144 cm) was observed in species of *Panicum maximum*.

High temperature induced a decrease in fresh and dry weight, relative growth rate, and plant height and **number of leaves per plant**. In the present study, number of leaves per plant significantly differs among three *Panicum* species at different temperature levels. *Panicum coloratum* give the highest growth which is followed by *Panicum antidotale* and *Panicum maximum*. Similarly number of leaves per plant also varied significantly among different *Panicum* species at

different temperature levels (Figure 2). However, the highest number of leaves (17) was observed in *Panicum antidotale* followed by *Panicum coloratum* and *Panicum maximum* having values 8 and 6, respectively. The statistical mean value of number of leaves of different *Panicum* species also differs significantly from each other at different temperature levels.

More numbers of tillers were noted in *Panicum antidotale* by applying high temperature to different *Panicum* species. *Panicum* species produce less number of tillers as temperature of hydroponic solution increase (Figure 4). With respect to **number of tiller per plant**, statistically significant variation was recorded among three species of *Panicum* (Figure 4). *Panicum antidotale* was the highest scorer having 32 tillers per plant at T_3 treatment. Minimum tillers (15) were recorded in *Panicum maximum* at T_0 treatment.

In the study of growth of *Panicum* species for thermotolerance under hydroponic conditions, it was noted that there is maximum reduction in **fresh and dry weight per plant** in all the *Panicum* species by giving high temperature. Among the three *Panicum* species, *Panicum coloratum* has maximum tolerance for high temperature and produces maximum fresh and dry weight per plant. Increase in temperature reduced crop production and disturb the plant growth rate from germination up to maturity (Zinn and Jeffrey, 2010). The negative response of fresh and dry weight to increasing temperature may be due to reduced leaf area expansion, smaller amount of radiation received, thus less photosynthesis (Wahid *et al*., 2007). *Panicum coloratum* showed the highest value of fresh weight (Figure 5) producing (739.0 g) biomass at T_3 level and minimum (533 g) was observed in *Panicum antidotale*. Statistical mean values of fresh weight of different *Panicum* species at different treatment level indicated that at T_3 level maximum fresh weight was observed and minimum at T_0 level. *Panicum coloratum* showed the height value of dry weight (Figure 6) producing 268 g biomass at T_3 treatment, on the other hand lowest value (153 g) of this character was recorded in *Panicum antidotale*. The maximum mean value of dry weight was observed at T_3 level and minimum at T_0 treatment.

Fresh and dry matter production in plants is directly correlated with the **leaf area**, greater the leaf area in plant, maximum plant growth and photosynthetic ability which provide greater dry and fresh weight to plant (Khan and Khalil, 2010). In the present study, different leaf areas at different temperature levels were observed in *Panicum* species. *Panicum coloratum* showed maximum leaf area as compared to other species of it proved that it have more tolerance for heat (Figure 3). Maximum leaf area in *Panicum coloratum* showed that it give up highest fresh and dry matter as compared to other *Panicum* species because increasing leaf area result in forceful photosynthetic ability and plant growth (Figure 5). There is a significant reduction in shoot fresh and dry weight, plant height and leaf area in Indian mustered by increase in temperature (Chauhan, 2010). Highly significant differences were recorded among the *Panicum* species for leaf area of fully expended leaf. It is clear from data (Figure 3) that maximum (100 cm^2) leaf area was recorded in *Panicum maximum* at T_3 treatment and minimum (10 cm^2) in *Panicum antidotale* at T_0 treatment.

In the present experiment, all the *Panicum* species responded in a different way to imposition of different temperature levels. The high temperature conditions disturb the foliar chemistry of plants. The plant **chlorophyll contents** are reduced by increase in temperature levels (Hamid *et al*., 2009). In the present study it was noted that chlorophyll contents decreased with increase of temperature. Among different *Panicum* species, *Panicum maximum* have high chlorophyll contents at T_3 temperature level as compare to T_0 temperature levels. The Figure 7 indicates that the SPAD values for chlorophyll contents of different *Panicum* species at different temperature levels. Among *Panicum* species it was noted that *Panicum maximum* contain maximum chlorophyll contents at T_3 treatment and minimum chlorophyll contents was recorded at treatment T_0.

The Correlation coefficients between different growth parameter and leaf area of *Panicum* species at different temperature levels: The correlation of co-efficient (***r***) between different growth parameters (Table 1) clearly show a significantly positive relationship of *Panicum* species at different temperature levels (Table 1). The correlation between leaf area of fully expended leaf and different growth attributes were non- significant. Positive correlation exists between the fresh and dry weight of *Panicum* species at different temperature levels.

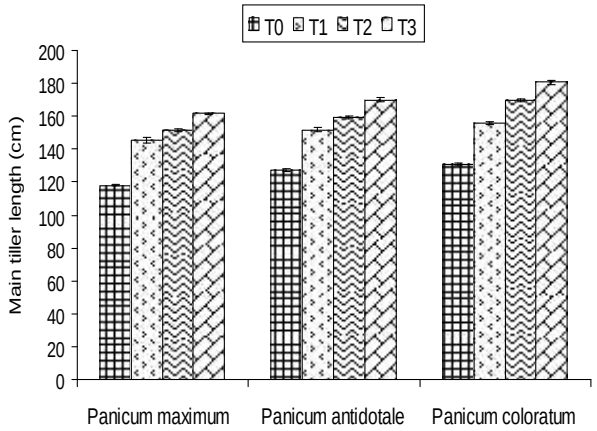

Figure 1. Effect of different temperature levels on main tiller length in different *Panicum* species

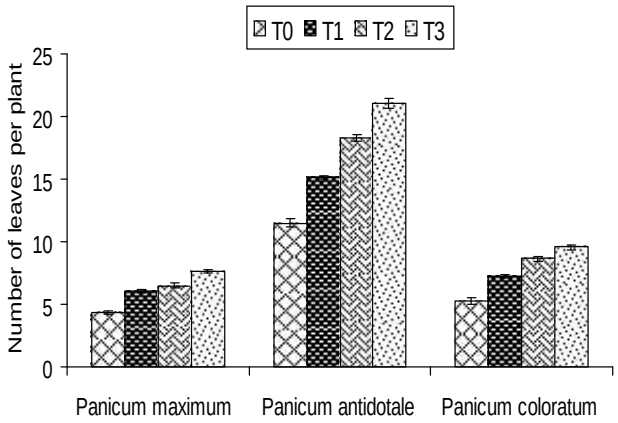

Figure 2. Effect of different temperature levels on number of leaves per plant in different *Panicum* species

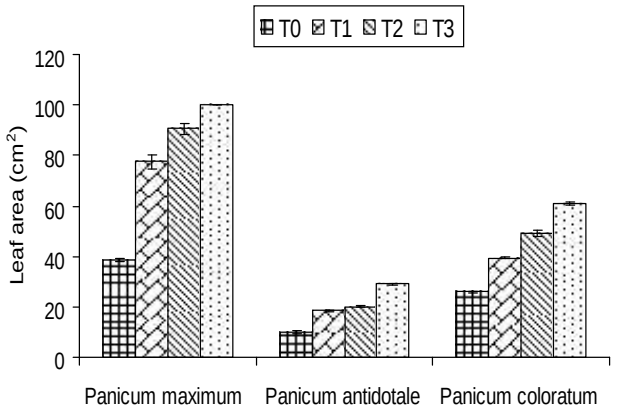

Figure 3. Effect of different temperature levels on leaf area of fully expended leaf in different *Panicum* species

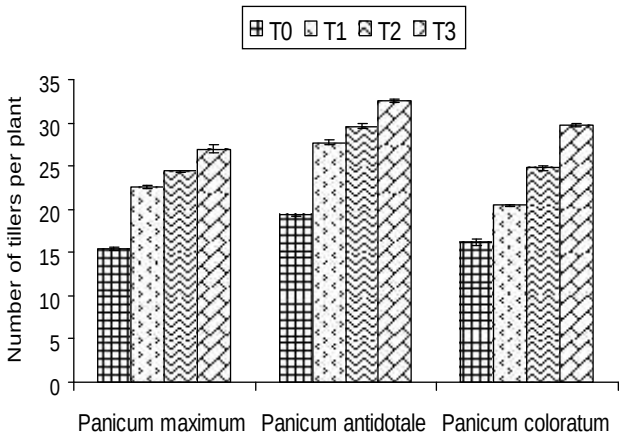

Figure 4. Effect of different temperature levels on number of tillers per plant in different *Panicum* species

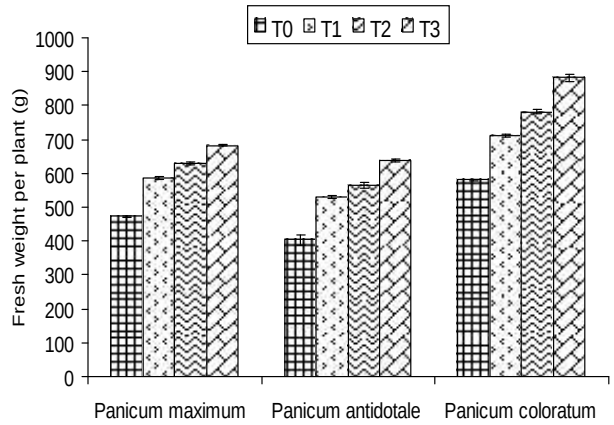

Figure 5. Effect of different temperature levels on fresh weight per plant in different *Panicum* species

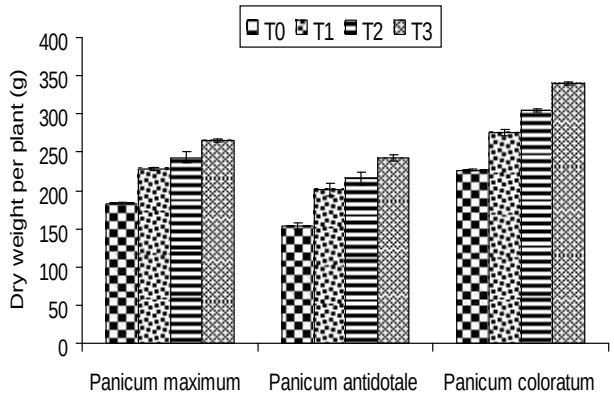

Figure 6. Effect of different temperature levels on dry weight per plant in different *Panicum* species

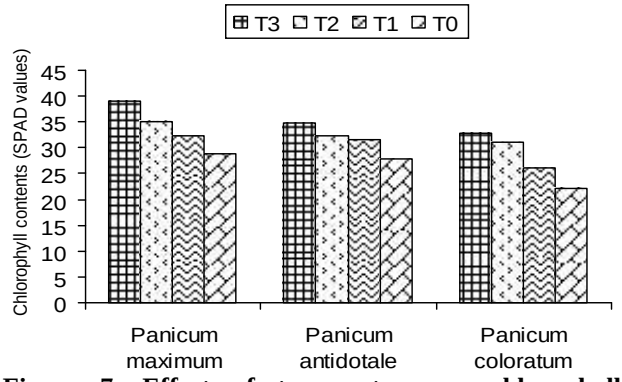

Figure 7. Effect of temperature on chlorophyll contents of different *Panicum* species at last harvesting under hydroponic conditions

T_0	=	Control	=	48˚C
T_1	=	0.75˝ TPS	=	39˚C
T_2	=	1.00˝ TPS	=	38˚C
T_3	=	1.5˝ TPS	=	36 ˚C

TPS = Thermopore Sheet

Table 1. Correlations coefficients (*r*) of physiological indices characterizing *Panicum* species grown under various temperature levels

Parameters	M.T.L	N.T.P	F.L.A	L.S.L	F.W	D.W
PH	0.99**	0.86*	0.30 NS	0.85*	0.83*	0.81*
MTL	_	0.85*	0.30 NS	0.86*	0.82*	0.82*
NTP	_	_	0.13NS	0.56NS	0.45NS	0.43NS
FLA	_	_	_	0.66*	0.47NS	0.48NS
LSL	_	_	_	_	0.93**	0.93**
FW	_	_	_	_	_	0.99**

Note: * and ** significant at 0.05 and 0.01 levels, respectively; NS—non-significant. MTL = Main tiller length (cm), NTP = Number of tillers per plant, NLP = Number of leaves per plant, LA = Leaf area of uppermost fully expended leaf (cm^2), LSL = Length of sheath of leaf (cm), FW = Fresh weight (g), DW = Dry weight (g)

Conclusions: It is concluded from the present study that among different *Panicum* species, *Panicum coloratum* is the better to tolerate more heat stress than other species by gaining maximum main tiller length, maximum fresh and dry weight and large leaf area and proved to be tolerant of high temperature. So it is useful, cheaper and rapid to grow *Panicum* species under hydroponic conditions than in soil.

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