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Water deficit condition and its impact on mulberry plant (*Morus* spp.) in relation to its growth and physiological parameters

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Water availability is one of the most limiting environmental factors affecting crop productivity. It is a well known fact that crop growth is frequently subjected to water stress during the course of its life time. Stress imposed during these periods drastically affects crop growth, ultimately leading to a massive loss in yield and quality (Govindarajan *et al*., 1996; Hudak and Patterson, 1996; Moreshet *et al*., 1996). Water deficit is very common in the production of most crops and numerous studies have indicated that it has substantial negative impacts on plant growth and development (Carrow, 1996; Crasta and Cox, 1996; LeCoeur and Sinclair, 1996). The numerous physiological responses of plant to water deficit generally vary with the severity as well as the duration of the stress. A number of researchers reported that reduction in crop photosynthesis and development of water stressed plant is due to reduction in leaf area and dry matter accumulation (Kriedemann 1986; Hamid *et al*., 1990b).

Leaf moisture content of mulberry has a tremendous impact on silk worm rearing since the mulberry leaf is the sole food of silkworm, *Bombyx mori*. The full potential of mulberry leaf production is seldom reached because of limitations on physiological and morphological processes imposed by environmental stress. Considering the present constraints, an experiment was conducted in mulberry variety S-1635 ((*Morus alba* L.) to study the growth and leaf water status under different water stress.

The experiment was carried out in the glasshouse of Central Sericultural Research and Training Institutes, Berhampore, Murshidabad, West Bengal during the period from February to May in the year 2011. One year old mulberry plants of S-1635 (*Morus alba L.*) variety grown in earthen pots (30cm) containing a mixture of soil and farm yard manure (2:1). The soil of earthen pots was sandy loam in texture with pH 7.2, medium in available nitrogen and phosphorus and high in potassium. The environmental temperature and relative humidity ranged from 17.34 to 32.50 ^{0}C as well as 40.33 to 86.25 % in the glass house during the period from February to May. The plants were pruned at 15 cm above from soil in last week of February, 2011. After 20 days of pruning twenty earthen pots were shifted to glass house and allowed to acclimatize for 10 days. During that period normal watering (watering in alternate day) was given for normal growth of plants. After 10 days of acclimatization of mulberry plants in the glass house, twenty plants were divided in four groups and considered as four treatments under different water stress condition created by withholding of water. The treatments were as i) watering at one day interval to remain the soil moisture at field capacity and the treatment was considered as control (T1), ii) watering once in a week (T2), iii) watering once in forghtnight (T3) and iv) watering once in a month (T4) respectively. In each treatment five pots were kept as five replications and the pots were arranged in complete randomised block design (CRD). Treatment wise soil samples were taken before watering in earthen pots at regular intervals and soil moisture was determined on oven dry weight basis. The soil moisture is as follows: i) watering in alternate day (T1); 34.76% ii). Once watering in 7 days (T2): 25.63% iii). Once watering in 15 days (T3): 20.40% and iv) Once watering in 30 days (T4): 11.42 %.

Plant height, number of branches, leaf number and 100 leaf dry weight were recorded before watering of each treatment. Leaf area was calculated according to Satpathy (1992). Total aerial biomass per plant was taken at the end of the experiment. Relative water content (RWC) and water saturation deficit (WSD) were determined according the method described by Barrs and Weatherly (1962).The chlorophyll content of mulberry leaves of each treatment was estimated using UV-VIS Spectrophotometer (117, Systronics) as per the method of Arnon (1949). Observations on leaf transpiration and diffusive stomatal resistance were measured of the 3rd to 7th leaves of each treatment using steady state porometer (Licor-1600) prior to watering in the pots. Data were computed and statistical analyses were done (Gomez and Gomez, 1984).

Data presented in table 1 showed a consistency in the rate of elongation of stem upto 7 days but declining in elongation rate was recorded in T3 and T4 where water was given once in 15 and 30 days respectively.

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Table 1: Growth performance of mulberry variety under different water regimes

Treatment	Plant height (cm)		Branch number		Leaf number		Average leaf area (cm^2)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
T1	49.8	64.1	9.3	11.6	36.3	75.7	64.5	71.6
T2	55.5	69.7	8.0	10.3	41.2	78.2	69.5	76.5
T3	58.7	69.5	10.0	11.4	36.0	67.0	55.2	61.7
T4	53.7	61.0	8.5	9.5	33.1	58.1	48.5	53.2

Table 2: Changes in water status, dry matter accumulation and biomass production of mulberry variety under different water regimes.

Treatment	RWC (%)	WSD (%)	Leaf moisture (%)	100 leaves dry wt.(g)	Total wt. (kg) plant $^{-1}$
T1	84.6	15.4	79.8	17.2	0.176
T2	81.6	15.8	79.5	18.0	0.165
T3	73.8	26.2	72.1	15.8	0.142
T4	68.9	31.1	68.6	11.0	0.119
LSD(0.05)	**6.5**	**3.7**	**4.2**	**3.6**	**0.014**

Table 3: Changes in chlorophyll content (mg g^{-1} fwt) and transpiration rate of mulberry variety under different water regimes.

Treatment	Chl-a	Chl-b	Total Chlorophyll	Chl a/b	Transpiration ($\mu g\ cm^{-2} s^{-1}$)	Diffusive resistance ($s\ cm^{-1}$)
T1	1.091	0.658	1.748	1.657	13.2	0.310
T2	1.141	0.714	1.855	1.598	12.4	0.330
T3	0.998	0.718	1.716	1.390	10.6	0.412
T4	0.635	0.533	0.968	1.190	9.1	0.439
LSD (0.05)	**0.020**	**0.10**	**0.320**	**-**	**3.2**	**0.007**

At 30 days, .the rate of plant height was maximum in T1 and gradually declined to T4 ranging from 14.3 cm >14.2cm>10.8>7.3cm.Number of branches per plant increased maximum in T1 and T2 treatments showing the effect of water regime almost similar. But water holding upto 15 days and 30 days i.e. T3 and T4 imposed slow leaf primordial growth causing less number of branch number. Similarly, the expansion of leaf area of mulberry at 30 days was observed higher in T1 (7.1 cm^2) followed by T2 (7.0 cm^2) over T3 (6.5 cm^2) and T4 (4.7 cm^2). Reduction of leaf area by water stress caused poor crop yield due to less capability of light interception (Hsiao *et al*., 1976). Ashraf *et al*., (2002) viewed leaf enlargement, stomatal conductance and photosynthetic activity are directly affected by leaf turgor potential. Under water stress conditions, plants lose their turgor and thus cell expansion and growth are reduced (Siddique *et al*., 2000).

Influence of water stress had a significant effect on relative water content where T1 exhibited the highest (84.6%). There was a sharp decrease in watering once in 15 days (T3) and 30 days (T4) as the turgid potentiality of mulberry leaves gradually reduced (Table 2). Likewise, leaf moisture under different water regimes was observed maximum (79.8 %) in T1 which was 16.3 % more over T4 (68.6%). Ashraf *et al*. (1994) reported that osmotic adjustment results from the accumulation of solutes which lowers the osmotic potential and helps in maintaining turgor of plants experiencing water stress.

Dry weight of 100 leaves were recorded maximum in T2 (18.0 g) followed by T1 (17.2 g) and minimum in T4 (11.0 g) showing the effect of water stress on different physiological processes like water uptake, plant water potential and photosynthetic activity. Water deficit reduces photosynthesis be reducing leaf area, closure of stomata and decrease in the efficiency of the carbon fixation process resulting decrease of dry matter accumulation (Kramer, 1983). Biomass production was reduced to the tune of 19.3 % in T3 and 67.6% in T4 treatments which were significantly lower than T1. However, the difference between T1 and T2 was found at par (Table 2).

Chlorophyll a, b, and total were increased up to 7 days watering interval. Chlorophyll a and b ratio was highest in T1 followed by T2 and lowest at T4 treatment indicating chlorophyll b was more sensitive to stress than chlorophyll a (Table 3). The chlorophyll formation was adversely affected under high water stress conditions which might lead to low photosynthetic activity and less dry matter production.

Alberte *et al* (1977) viewed that most of the chlorophyll loss occurs from the mesophyll cells and little from the bundle sheath chloroplasts.

Rate of transpiration was significantly low in T4 than that of other treatments where no significant difference was observed among T1, T2 and T3 treatments. Diffusive resistance was found to be maximum in T4 and minimum in T1 (Table 3). The reductions in uptake and transpiration are usually associate with are reduction in the water of the shoots and stomatal aperture suggesting that water stress developed in the leaves (Gerakis *et al*., 1975). The degree of water stress developed in plants is strongly dependent on the rate of transpiration, which in turn is strongly dependent on irradiance (Kramer, 1983).

Therefore, it is concluded that the physiological activity of S-1635 mulberry variety deteriorated when water retained below field capacity due to withholding of water upto 15 days and more. Normal watering or 7 days interval retains soil moisture above 25% which is ideal for normal growth of mulberry.

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