Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(2): 1180-1182
Received: 08-01-2018
Accepted: 09-02-2018

Suren Limbu
Department of Horticulture, School of Life Science, Sikkim University, 6th Mile Tadong, Gangtok, Sikkim, India

Laxuman Sharma
Department of Horticulture, School of Life Science, Sikkim University, 6th Mile Tadong, Gangtok, Sikkim, India

AP Rao
Department of Horticulture, School of Life Science, Sikkim University, 6th Mile Tadong, Gangtok, Sikkim, India

Correspondence
Laxuman Sharma
Department of Horticulture, School of Life Science, Sikkim University, 6th Mile Tadong, Gangtok, Sikkim, India

Growth and photosynthetic gas exchange characteristics in *Solanum aethiopicum* under water stress in organic production system

Suren Limbu, Laxuman Sharma and AP Rao

Abstract
Water stress is one of the challenging problems faced by agriculture. More often, crop growth and yield fails when exposed to water stress. However, water requirement is crop specific, they tend to develop own defense mechanism to combat the stress. It is highly imperative to study the response of plant to water stress. The present was carried out to evaluate the effects of different levels of water on growth and gas exchange parameters of *Solanum aethiopicum* and *Solanum macrocarpon*. Plants were grown at different level of water viz. 100% PC (pot capacity), 75% PC, 50% PC and 25% PC. Parameters like leaf number, leaf area, plant height, plant spread, shoot dry weight, chlorophyll content, photosynthetic rate, transpiration rate, stomatal conductance were reduced with reduced in water levels, however, *Solanum aethiopicum* performed normal even at 50% PC which was at par with plants at 75% PC, though there was significant difference from 100% PC. All the levels of water showed significant differences on root dry weight, root shoot ratio and water use efficiency and similar trend in all studied parameters was found in *S. macrocarpon.* Major finding of the study was non-significant differences in fruit yield at three levels of water i,e 100, 75 and 50% PC in *S. aethiopicum*, which infers the possibility of growing *S. aethiopicum* at reduced level of water. However, *S. macrocapon*, on the other hand, could not sustain its growth due to water stress. Detail studies on crop physiology and the mechanism of drought tolerance in *S. aethiopicum*can be explored to establish more facts.

Keywords: Gas exchange, Organic, *S. aethiopicum*

Introduction
Solanum aethiopicum belonging to Solanaceae family is native to Africa. Its leaves and fruits are cooked as vegetables and many have reported their medicinal properties (Diop *et al.*, 2003) [3]. The crops are more popular in Sikkim (a small Himalayan state in North-East India), where entire cultivable land is organically certified.

The indigenous and underutilized crops showing tolerance to biotic and abiotic stresses are now intensified for successful cultivation in organic farming system. Amongst such crops, "*Bihi*" (*S. aethiopicum*) is the major vegetable crop in low and mid hills of the state of Sikkim. Though native to African countries, growing in the tropical climate, this crop has attained considerable place in the diet of population of North East India. However, there is no written evidence of introduction of the crop in Sikkim Himalayas.

The crop is found growing in the homestead garden in the entire state of Sikkim. Oflate, it is highly ranked vegetable by the consumers and available in the local market fetching the better price than the commercial *S. melongena*. The crop is projected to be suitable for organic farming system. Being minor crop, no studies have undertaken in line of production aspects or its response to various biotic and abiotic conditions, which are of immense importance for expanding their cultivation in organic farming. It is believed to have its medicinal properties too.

One of the most important limiting factors for the growth and photosynthetic activities is the soil water, owing to its vital role photosynthesis, nutrient uptake and transpiration. Water scarcity imposes huge reductions in crop yield and is one of the greatest limitations to crop expansion. There is always a chance of increased aridity in future due to global climate change (Houghton *et al.*,2001) [7].The effects of water stress, however, vary with plant species. Water being the critical factor for physiological function of the plant, present study was envisaged for assessing the performance of crop in terms of growth and photosynthetic activities at different levels of water.

Materials and Methods

Planting materials and experimental design: The experiments were carried under greenhouse condition at Department of Horticulture, Sikkim University, Sikkim, India. India. The experimental site lies between 27^0 00'46" to 28^0 07'48" North Latitude and 88° 00'58" to 88° 55'25" East Longitude with an altitude of 1230 m above M.S.L. The one month old seedlings of *S. aethiopicum* were transplanted in the pots filled with a mixture of top soil, sand and well decomposed farmyard manure in the ratio of 4:2:1 weighing approximately 6-7kg per pot. Completely randomised design was employed in experiment with four treatments and six replications.*viz.* T_0 (100% pot capacity); T_1 (75% PC of T_0); T_2 (50% PC of T_0), and T_3 (25% PC of T_0).

Growth Analysis: A growth measurement was done every week till the end of the experiment by following the methods suggested by Muthomi and Musyimi (2009) [9]. Growth parameters like leaf number, leaf area, plant height, plant spread, root dry weight, shoot dry weight, root shoot ratio and fruit yield were studied.

Chlorophyll concentration: Chlorophyll concentration was determined as per the method described by Thimmaiah (2009) [10]. The young fully expanded leaves weresampled from the shoot apex from all the treatments. 1g leaf sample was grinded in 20ml (80 %) acetone using mortar and pestle and the mixture was centrifuged at 5000 rpm. The resulting supernatant was read at 663 and 645 nm using UV-visible spectrophotometer (Model no.: Lambda 35, Make: Perkin Elmer).

Leaf water content: Leaf water content was measured using gravimetric method according to Farnsworth and Meyerson (2003) [5], taking fresh and dry weight of leaves.

Physiological parameters: A young and fully expanded leaf of each replicate from each treatment was used for measurement of gas exchange parameters. Physiological parameters (photosynthetic rate (*Pn),* transpiration rate *(E)* and stomatal conductance *(gs)*) were recorded by using Infra Red Gas Analyser (Model no.: CI-340, Make: CID). Water-use efficiency (*WUE*) was calculated as ratio of *Pn*and*E*.

Results and Discussion

Leaf number, leaf area, plant height and plant spread: The effects of different levels of water stress on the growth parameters like leaf number, leaf area, plant height and plant spread was recorded maximum in the plants grown at 100% PC. Treatments T_1 and T_2 (75% PC and 50% PC) did not show the significant difference, though there was drastic reduction in growth at 25% PC. Highest recording of all the parameters in 100% PC probably attributed to the optimum supply of water required for the growth of plants. This finding is in line with the findings of Muthomi & Musyimi (2009) [9] where lowered irrigated *S. scabrum* MILL plants showed 97% reduction in leaf area compared to full water irrigated plants

Shoot dry weight, root dry weight, root shoot ratio and leaf water content: There was gradual decrease in shoot dry weight with decrease in water stress levels but, on the other hand, maximum root dry weight and root shoot ratio were showed by the plants irrigated with lowest level (25% PC) of water. This finding is partial agreement with Kirnak *et al.,* (2001) [8] where they had found the highest root dry weight at 40% PC in tomato plants. Leaf water content was found highest and lowest in 100% PC and 25% PC respectively.

Chlorophyll *a*, Chlorophyll *b*andtotal Chlorophyll: The plants at 50% PC and 75% PC were at par regarding Chlorophyll content (Chlorophyll *a*, Chlorophyll *b* and total Chlorophyll). However, there was drastic decrease in 25% PC plants and it might occurred due to the statements given by Fang and Xiong (201) [4]; Armand *et al.,* (2016) [1].

Photosynthetic rate, transpiration rate, stomatal conductance and water use efficiency: During the present investigation, the level of performance of plantin terms of photosynthetic rate, transpiration rate, stomatal conductance and water use efficiency was found non significant difference when there was successive reduction of pot capacity from 100% to 75%, however there was declining trend in 50% PC and 25% PC, except for water use efficiency where highest value was in 50% PC.Result found to be parallel agreement with the statement as under the limited water availability in the soil, the capability of plants to perform its normal photosynthetic activities (with less reduction) by closing the stomata to avoid the excess amount of water loss increase the water use efficiency (Chaves *et al,*. 2009) [2].

Yield: Fruit yield was statistically high under treatments 100% PC, 75% PC, and 50% PC, however, the yield was significantly low at 25% PC. In reference to the results obtained for the parameters like leaf number and area, plant height and spread, photosynthetic activities, etc., it was expected that low irrigated plants will have significant decreased in fruit yield. It is in line with the findings of Gaveh *et al.* (2011) [6] who reported that reduced yield in reduced level of irrigation in *S. macrocarpon.*

Table 1: Effects of different levels of water stress on leaf number, leaf area, plant height, plant spread, shoot dry weight, root dry weight, root shoot ratio and leaf water content of *S. aethiopicum.* Means with different letters indicate the significant differences among the treatments.

Treatments	100% PC	75% PC	50% PC	25% PC
Leaf Number	112 ± 1.79^a	105 ± 1.79^b	103 ± 1.26^b	92 ± 2.28^c
Leaf Area (cm^2)	188.03 ± 1.56^a	180.34 ± 1.07^b	179.04 ± 1.84^b	174.03 ± 1.91^c
Plant Height (cm)	114.15 ± 1.53^a	111.70 ± 1.23^b	110.47 ± 0.99^b	97.78 ± 1.10^c
Plant Spread (cm)	90.32 ± 1.26^a	86.23 ± 2.37^b	85.63 ± 1.59^b	76.50 ± 3.21^c
Shoot Dry Weight (g $plant^{-1}$)	40.15 ± 1.61^a	35.95 ± 0.78^b	34.62 ± 1.09^c	26.67 ± 0.67^d
Root Dry Weight (g $plant^{-1)}$	7.68 ± 0.18^a	6.47 ± 0.19^c	7.48 ± 0.25^b	7.75 ± 0.16^a
Root Shoot Ratio (g $plant^{-1}$)	0.19 ± 0.01^c	0.17 ± 0.02^d	0.21 ± 0.03^b	0.29 ± 0.02^a
Leaf Water Content (%)	94 ± 2.28^a	80 ± 2.76^b	78 ± 2.10^b	37 ± 1.41^c

Table 2: Effects of different levels of water stress on net photosynthetic rate (*Pn*), transpiration rate (*E*), stomatal conductance (g_s)and fruit yield of *S. aethiopicum*. Means with different letters indicate significant differences among the treatments.

Treatments	*Pn* (μmol $m^{-2}s^{-1}$)	*E* (mmol/ m^{-2} (H2O) s^{-1})	g_s (mmol/ m^{-2}/s^{-1})	WUE (mmol $m^{-2}s^{-1}$)	Fruit yield (kg/plant)
100% PC (T_1)	16.65±1.66^a	4.05±0.64^a	0.78±0.33^a	4.11±0.08^c	2.75±0.18^a
75% PC (T_2)	15.40±1.99^{a,b}	3.77±0.50^a	0.75±0.23^a	4.08±0.04^c	2.65±0.14^a
50% PC (T_3)	14.30±1.87^{b,c}	1.90±0.52^b	0.38±0.17^b	7.53±0.14^a	2.54±0.08^a
25% PC (T_4)	12.22±1.77^c	1.75±0.26^b	0.30±0.14^b	6.94±0.21^b	0.65±0.05^b

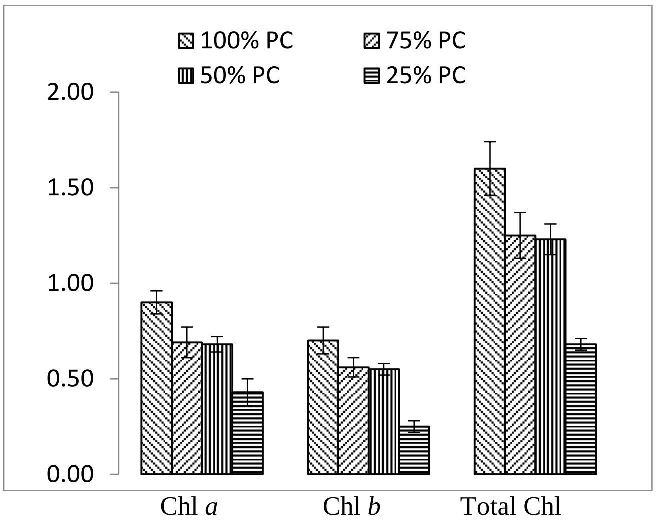

Fig 1: Effects of different levels of water stress on Chlorophyll *a* (Chl*a*), Chlorophyll *b* (Chl*b*) and total Chlorophyll content (Total Chl) of *S.,* expressed as mg g-^{1}.

Conclusion

Plant grown at 100% pot capacity was superior to all the treatments for leaf number, leaf area, plant height and plant spread. However, plants at 75% PC and 50% PC were statistically at par with least growth at 25% PC. *S. aethiopicum* plants increased its root dry weight and root shoot ratio with decreasing shoot dry weight under reduced water levels. Plants irrigated at 75% PC and 50% PC retained satisfactory amount of Chlorophyll content and leaf water content to withstand the water stress. Plants treated with 75% PC and 50% PC had much higher photosynthetic rate than 25% PC. Under water stress levels, *S. aethiopicum* reduced its transpiration and stomatal conductance significantly in compared to 100% PC. Water use efficiency was highest at 50% PC while it was least in 75% PC and 100% PC. Fruit yield had no significant differences due to variation in water levels i.e., 100%, 75%, 50%, and 25% pot capacity depicts the higher tolerance of *S. aethiopicum* for water stress. The result of this study showed that *S. aethiopicum* could perform its satisfactory growth and photosynthetic activities even under limited soil water condition, so it indicates that the plant can be grown with lower supply of irrigation water. Detail studies on crop physiology and the mechanism of drought tolerance can be explored to establish more facts.

References

1. Armand N, Amiri H, Ismaili A. The effect of methanol on photosynthetic parameters of bean (*Phaseolus vulgaris* L.) under water deficit. Photosynthetica. 2016; 54(2):288-294
2. Chaves MM, Flexas J, Pinheiro C. Photosynthesis under drought and salt stress: regulation mechanisms from whole plant to cell. Annals of Botany. 2009; 103:551-560.
3. Diop TA, *Krasova-Wade* T, Diallo A, Diouf M, Gueye M. Solanum cultivar responses to arbuscular mycorrhizal fungi: growth and mineral status. African Journal of Biotechnology. 2003; 2(11):429-433.
4. Fang Y, Xiong L. General mechanisms of drought response and their application in drought resistance improvement in plants. Cellular and molecular life sciences. 2015; 72(4):673-689.
5. Farnsworth EJ, Meyerson LA. Comparative ecophysiology of four wetland plant species along a continuum of invasiveness. Wetlands. 2003; 23(4):750-762.
6. Gaveh EA, Timpo GM, Agodzo SK, Shin DH. Effect of irrigation, transplant age and season on growth, yield and irrigation water use efficiency of the african eggplant. Hort. Environ. Biotechnol. 2010; 52(1):13-28.
7. Houghton JT, Ding YD, Griggs DJ, Noguer M, van der Linden PJ, Dai X *et al*. Climate change 2001: the scientific basis. The Press Syndicate of the University of Cambridge, 2001.
8. Kirnak H, Kaya C, Tas I, Higgs D. The influence of water deficit on vegetative growth, physiology, fruit yield and quality in eggplants. Bulg. J. Plant Physiol. 2001; 27(3-4):34-46.
9. Muthomi J, Musyimi DM. Growth responses of African nightshades (*Solanum scabrum*Mill) seedlings to water deficit. ARPN Journal of Agricultural and Biological Science. 2009; 4(5):24-31.
10. Thimmaiah SR. Ascorbic acid content: Standard method of biochemical analysis, Kalyani Publishers, New Delhi. 2009.