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EFFECT OF WATER STRESS AND WATERLOGGING STRESS ON LEAF WATER RELATIONS IN A MEDICINALLY IMPORTANT PLANT *BASELLA ALBA* L. (BASELLACEAE)

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Abstract

Plant water relations of the medicinally important plant *Basella alba* subjected to water stress and waterlogging conditions are summarized in the present research article. It was found that the aspects related with plant water relations viz. relative water content, osmotic potential and electrolyte leakage get influenced negatively due to the water stress and waterlogging conditions.

Keywords: *Basella,* water stress, waterlogging, RWC, osmotic potential, electrolyte leakage.

Introduction

The popular best tropical spinach i.e. *Basella alba* L. show easy adaptability to varied climatic conditions and soil types also has ethnomedicinal importance, bioactive potential some of the important activities exhibited are androgenic, anti ulcer, anti inflammatory, antioxidant, sex reversion, etc. (Palada and Crossman, 1999; Deshmukh and Gaikwad, 2014).The unpredictable environmental condition leads to the acute water stress or waterlogging conditions which directly affects the crop productivity throughout the world (Huaqi *et al.,* 2002, Gambrell and Patrick, 1978). Both such circumstances result an alterations in the biochemical and physiological status at cellular levels in plants. Plant water relations can be studied at different levels viz. relative water content, osmotic potential and electrolyte leakage. All these parameters are interlinked with water status at cellular level in plant body. Relative water content is percentile water content at full turgor (Taiz and Zeiger, 2006). If the relative water content reduces it affects negatively the stomatal conductivity and photosynthetic efficiency, henceforth it is directly interlinked to the plant's growth and development (Cornic, 2000; Alexieva *et al*., 2001; Atteya 2003). Osmotic potential relates to the energy absence in the solution as of interactions in solvent and solute in comparison with pure water and is allied with cell vacuole solution. Osmotic potential affects hydrostatic pressure, solute concentration and water concentration which negatively influences the physiochemical processes (Mok, 1979; Devlin and Witham, 1986). Cell membranes first senses the stresses especially the water stresses which results in membrane damage affecting the membrane permeability leading to membrane leakage (Levitt, 1980; Chavan, 1995).

Material and Methods

Pot culture experiments were conducted to study plant water relations aspects during water stress and waterlogging stress. The seeds of *Basella alba* red form and green form were sown in plastic pots containing garden soil and compost mixture in the ratio of 3:1. After seed germination, the seedlings were carefully grown for 60 days and then the plants were subjected to water stress and waterlogging stress for 6, 12 and 18 days respectively. The plants from each treatment were randomly selected for the study of plant water relation parameters viz. RWC, OP and electrolyte leakage as mentioned below

a. Relative water content (RWC)

RWC was calculated as per the Slatyer (1955). One gram leaf discs from the unstressed control and treated plants were immersed in distilled water in petriplates. After three hours the turgid leaf discs were removed and blotted to surface dry and weighed. In the similar way another set of leaf discs was kept in an oven at 60^0C to obtain the constant dry weight. Relative water content was calculated with the help of following formula.

$$RWC = [(W1-W3) / (W2-W3)] \times 100$$

Where, W1, W2 and W3 are weight of fresh leaf discs, weight of turgid leaf discs and weight of oven dried leaf discs respectively.

b. Osmotic potential of cell sap

Osmotic potential was determined as per Janardhan and Krishnamurthy (1975). One gram leaf tissue from the unstressed control and treated plants were thoroughly washed and blotted to dry afterwards crushed in 10 ml of distilled water and filtered through four layered muslin cloth and the final volume of the extract was adjusted to 20 ml with distilled water. The electrical conductivity of the extract was measured on conductivity meter (Elico model PE-133). From the dry plant tissue the moisture content was measured which was employed for the use of dilution factor and the osmotic potential (-bars) was calculated with the help of following formula

$$\text{Osmotic potential} = (0.36\times EC\times DF) / 0.987$$

Where,

EC = Electrical conductivity

DF = Dilution Factor

0.36 = Constant for converting EC to OP

0.987 = Factor used for converting atmospheric pressure to bars

c. Electrolyte Leakage

The method of Kurup *et al.*, (1993) was employed to determine the electrolyte leakage from the plant leaf tissue. 1 g leaf tissue discs from the unstressed control and treated plants were taken, immersed in 50 ml distilled water and after 10 minutes the initial conductivity was measured. Then the discs were again kept in the solution and the set was kept in boiling water bath for 10 minutes and the solution was used to measure the final conductivity and the electrolyte leakage was expressed in percentage change over the initial conductivity.

Result and Discussion

In both the forms of *Basella,* water stress and waterlogging stress resulted in decrease of the LRWC (Fig. 1). The effect of water stress as compared to waterlogging was significant which will ultimately disturb the water balance in the studied plants. Water stress tends to increase the hydraulic resistance in the plants leading in decrement of water potential and stomatal conductance (Alvarez *et al*., 2014). Likewise the osmotic potential was also decreased with increase in water stress and waterlogging conditions (Fig. 2). The water stress leads in an increase in the amount of ammonium compounds, organic acids, amino acids, proteins, sugars which lowers the osmotic potential for maintaining the turgor potential (Ingram and Bartels, 1996; Tyree and Jarvis, 1982; Bray, 1993). It was found that the electrolyte leakage was simultaneously increased with increase in the water stress conditions (Fig. 3). The increase in electrolyte leakage indicates the leaky nature of the membrane. Electrolyte leakage procedure can be used to determine the cell membrane stability and it is always associated with the generation of reactive oxygen species leading to the programmed cell death in plants (Youssef and Awad, 2008; Demidchik *et al.*, 2014). The net results of all the above plant water related parameters are tabulated in Table 1.

Summary and Conclusion

Leaf relative water content (LWRC) balances water intake in the form of absorption and loss of water in the form of transpiration and is related with the water potential and osmotic potential and also indicates the stress intensity (Lugojan and Ciulca, 2011; Mullan and Pietragalla, 2012; Alizade, 2002). Water stress cause cell dehydration resulting in membrane cleavage and cytoplasmic sedimentation (Blackman *et al*., 1995). In drought, the plant tissue turgor is maintained by the osmotic potential, bulk modulus of elasticity and turgor loss point (Saito and Terashima, 2004). Membrane stability is a parameter to recognize the plant vigour to sustain under adverse environmental situations. Electrolyte leakage concerns with membrane damage leading to the cell death (Osterhaut, 1922; Dexter, 1932). Bajii *et al.* (2001) stated that the cell membrane damage due to the biotic or abiotic stresses can be determined by estimating the electrolyte leakage.

Water stress leads to the dehydration and compartmentation of the cytoplasm while waterlogging causes hypoxic and anoxic conditions. Both the stresses affect negatively the crop productivity throughout the world (Lone *et al.,* 2015). The anoxic or hypoxic conditions raised due to the waterlogging conditions affects the soil pH, redox potential and soil oxygen levels. Plants tends to shift their life cycle from aerobic to anaerobic respiration during severe waterlogging conditions also the plants exhibit increase in reactive oxygen species, formation of lateral roots and aerenchyma in anatomical details and decrease in root hydraulic conductivity, stomatal conductance, availability of mineral nutrients (McNamara and Mitchell, 1989; Asharaf, 2012). Plants attempt to overcome such adverse conditions by making an osmotic adjustment by maintaining the balanced state with respect to relative water content, osmotic potential and electrolyte leakage. All these ultimately help the plants to overcome the adverse environmental conditions. Thus plant water relation parameters are very important to know the water stress and waterlogging stress stability index of a plant.

Table 1: Effect of water stress and waterlogging stress on relative water content, osmotic potential, electrolyte leakage (% over control) of *Basella alba.*

***Basella alba* varieties**	**Treatment**	**Relative Water Content (RWC) %**	**Osmotic Potential (–bars)**	**Electrolyte Leakage (% over control)**
BAR	**Control**	**88.00**	**5.67**	**100**
	6 WS	81.37 (-7.53)	7.38 (+ 30.15)	111.55 (+12.69)
	12WS	78.53 (-10.77)	8.56 (+ 50.97)	123.83 (+23.83)
	18WS	75.00 (-14.78)	10.35 (+82.53)	155.77 (+55.77)
	6WL	86.13 (2.13)	6.58 (+16.04)	109.79 (9.79)
	12WL	84.07 (-4.47)	7.85 (+38.44)	117.03 (+7.030
	18WL	83.00 (-5.69)	8.52 (+50.26)	134.81 (+34.81
BAG	**Control**	**86.00**	**5.59**	**100**
	6 WS	82.82 (3.70)	7.78 (+39.17)	111.55 (+11.55)
	12WS	81.63 (5.09)	9.07 (+62.25)	126.85 (+26.85)
	18WS	77.77 (-9.57)	10.51 (+88.01)	168.18 (+68.18)
	6WL	86.80 (+0.93)	6.99 (+25.04)	108.82 (+8.82)
	12WL	84.77 (-1.44)	8.90 (+59.21)	117.46 (+17.46)
	18WL	82.33 (-4.27)	9.18 (+64.22)	135.36 (+35.36)

BAR= *Basella alba* with reddish purple stem BAG= *Basella alba* with green stem
WS= water stress WL= waterlogging stress
Each value is mean of three determinations.
Values in parenthesis indicate percent increase (+) or decrease (-) over the percent control.

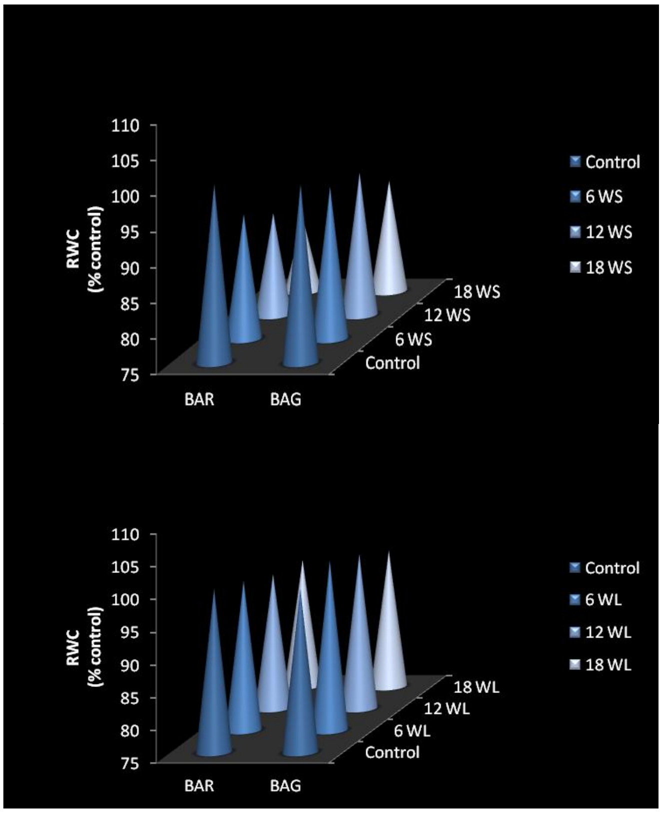

Fig. 1 : Effect of water stress and waterlogging stress on relative water content in *Basella alba*.

BAR= *Basella alba* with reddish purple stem
BAG= *Basella alba* with green stem
WS= water stress WL= waterlogging stress

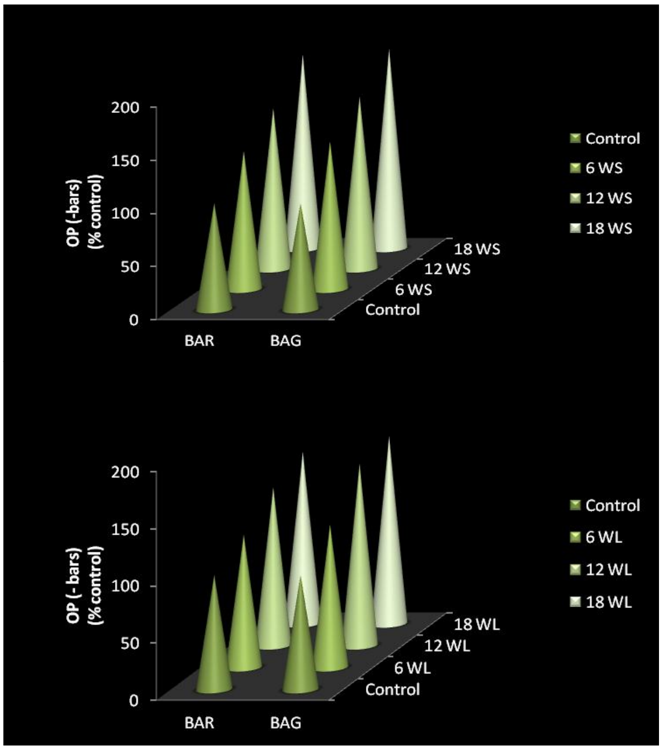

Fig. 2 : Effect of water stress and waterlogging stress on osmotic potential in *Basella alba*.

BAR= *Basella alba* with reddish purple stem
BAG= *Basella alba* with green stem
WS= water stress WL= waterlogging stress

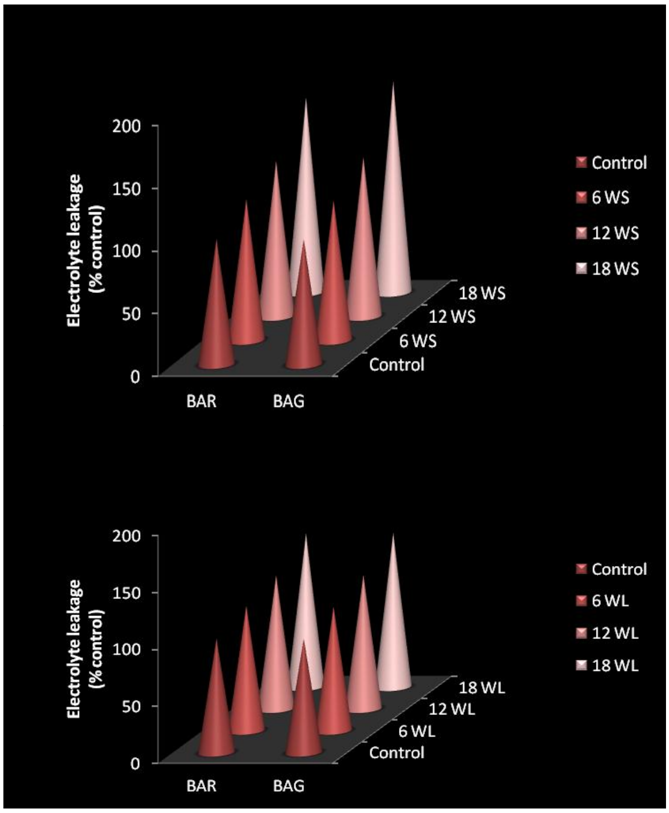

Fig. 3 : Effect of water stress and waterlogging stress on electrolyte leakage (% over control) in *Basella alba*.

BAR= *Basella alba* with reddish purple stem
BAG= *Basella alba* with green stem
WS= water stress WL= waterlogging stress

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