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Effect of Water Stress on Some Morphological and Biochemical Characteristics of Purple Basil (*Ocimum basilicum*)

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Abstract: Basil (*Ocimum basilicum*) is an annual herb plant belonging to the Lamiaceae family that is used as a drug, spice and fresh vegetable. In order to study the effects of different levels of water stress on some morphological and biochemical characteristics of purple basil, a pot experiment was conducted in randomized complete block design with six treatments and three replications in growth chamber. The different levels of water stress were 100 (control or non-stress), 90, 80, 70, 60 and 50% of field capacity. The results of statistical analysis showed that water stress has significant effects on morphological and biochemical characteristics. As the soil water content decreased, the plant height, stem diameter, number and area of leaves, Leaf Area Index (LAI), herb yield and leaf chlorophyll contents (a,b and total chlorophyll) decreased but the amounts of anthocyanin and proline increased.

Key words: Basil (*Ocimum basilicum*), water stress, anthocyanin, chlorophyll, proline, morphological characteristics

INTRODUCTION

The amount of water supply for the root of plant is known to be an important ecological factor affecting the distribution of different species of plants in the earth. Nearly all plantal reactions are affected by the amount of soil water directly or indirectly. Drought stress is one of the important limiting factors of plant growth that has limited the production of 25% of world lands (Levitt, 1980). While a lot of intensive and comprehensive researches are done on the relationship between the water stress and land productions, the behavior of plants haven't been studied well in such circumstances. Basil (*Ocimum basilicum*) is one of the important plants belonging to the Lamiaceae family. It is aromatic leaves are used fresh or dried as a drug in traditional medicine and as a flavoring agent for foods, confectionary products and beverages (Rhizopoulou and Diamantoglou, 1991). The origin of this plant is reported to be Iran, Afghanistan and India (Prakash, 1990). The cultivation of this plant is prevalent in the most parts of these areas but we have little information about the it is responses to environmental conditions (especially stressful conditions). Therefore the aim of this study was to find out the effects of water stress on some morphological and biochemical characteristics of purple basil.

MATERIALS AND METHODS

The experiment was conducted in a growth chamber at the Department of Biology, Urmia University (Iran), during winter of 2004. The seeds of basil were sown in pots (15 cm diameter, 20 cm depth), filled with a sandy-loam soil (with 19.6% field capacity). The growth chamber temperature Rangel between 20-28 (mean minimum and maximum) and plants were grown under 10000 lux of light density. After germination the seedling were thinned to four plants per pot. When the plants had reached the four to six true-leaf stages, water stress treatments (100% control or non-stress), 90, 80, 70, 60 and 50% of Field Capacity (FC) were imposed and these percentage of soil FC were kept at constant level by daily weighting and watering of pots. The amounts of chlorophyll (a, b and total) (Arnon, 1946), proline (Bates, 1973) and anthocyanin (Fuleki and Francis, 1968). of leaves were measured after six weeks of treatments were imposed. Also, at the end of the experiment, growth parameters such as plant height, stem diameter, number and area of leaves, Leaf Area Index (LAI), fresh and dry weight of herb yield were measured (Tarner, 1981). Data were analyzed using statistical software available from MSTATC (Nissen, 1989).

RESULTS

According to the results of statistical analysis, water stresses have significant on growth parameters. The results of means (Table 1) shows that when the level stress increases, the height of plant decreases so that the maximum height (56/46 cm) is in control treatment (non-stress) and the minimum height (14/42 cm) in treatment 50% of field capacity is observed. The means on stem diameter shows that between control treatment and T2 there is non signification difference but between control treatments with other treatments signification difference there is about 5%. In other words, with increasing level stress, the stem diameter decreased. With increasing level stress the number of leaves decreased and the difference between treatments become signification. The number of leaves in control treatment in comparison to the others treatments 1/16, 1/28, 1/89, 3/36

Table 1: Effect of water stress on growth parameters of purple basil

Treatment	Plant height (cm)	Stem diameter (mm)	Leaf No.	Leaf area (cm ²)	Leaf area index	Fresh herb yield (g plant ⁻¹)	Dry herb yield (g plant ⁻¹)
Control (%)							
100f.c	56.46a	187.3a	2.81a	269.2a	6.090a	38.69a	4.573a
90f.c	49.96a	160.7b	2.730ab	164.6b	3.693b	30.94b	3.743b
80f.c	45.83a	145.3b	2.53b	130.8c	2.953bc	24.60c	3.220b
70f.c	28.29b	59.00c	2.50bc	99.83d	2.243cd	18.79d	2.363c
60f.c	26.82b	55.67d	1.70c	42.51e	1.160dc	8.563e	1.133d
50f.c	14.42b	31.33d	1.10d	16.33f	0.3693e	2.310f	0.040e

Means followed by similar letters in each column are not significantly different at 5% level (Duncan's Multiple Range Test)

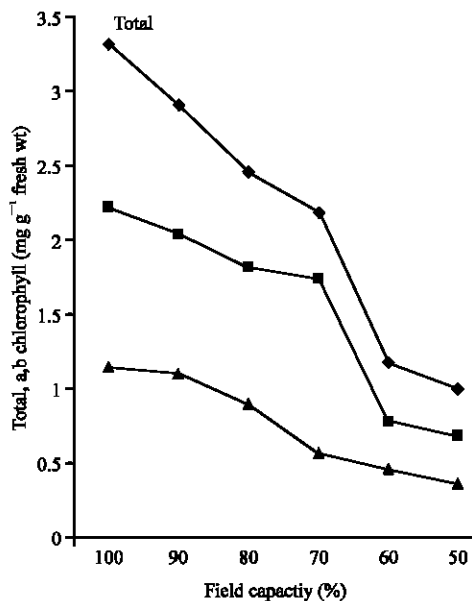


Fig. 1: Effects of water stress on the amount chlorophyll a, b and total

and 5/97, respectively time to the number of leaves in stresses, 90, 80, 70, 60 and 50% of field capacity. The leaf level in stresses, 90, 80, 70, 60 and 50% of field capacity is 38/85, 51/41, 62/91, 80/89 and 93/93%, respectively which in comparison to control treatments has been decreased. With increasing (level stresses) the amount of Leaf Area Index (LAI) become less and showed that there is a significant difference (in 5% level) among control treatment and other treatments. With becoming the decrease of water the fresh herb yield in the vase and dry herb yield in the vase become less and the difference between different treatments was significant (in level 5%). The fresh herb yield in stresses 90, 80, 70, 60 and 50% of field capacity were decreased 20/03, 36/15, 51/43, 77/86 and 94/02%, respectively, with comparison to non-stress treatment. The dry herb yield in 90, 80, 70, 60 and 50% of field capacity decreased 18/15, 29/58, 48/32, 75/22 and 91/13%, respectively in comparison to non-stress treatment

When the wetness of soil decreased, the content of chlorophylls total, a and b and decreased in the leaves (Fig. 1). The maximum contents chlorophylls total, a and b were 0/998, 0/685 and 0/361 which were got in 50% of field capacity. With decreasing amount of water, the proline accumulation increased in the leaves (Fig. 2). The amount of proline in 50% treatment of field capacity are 1/15, 1/30, 1/35, 1/63 and 1/69, respectively time with the amount of proline in 60, 70, 80, 90 and 100% treatment of field capacity. With decreasing amount of water, the anthocyanin accumulation increased in the leaves (Fig. 3). The amount of anthocyanin in 50% of field capacity are

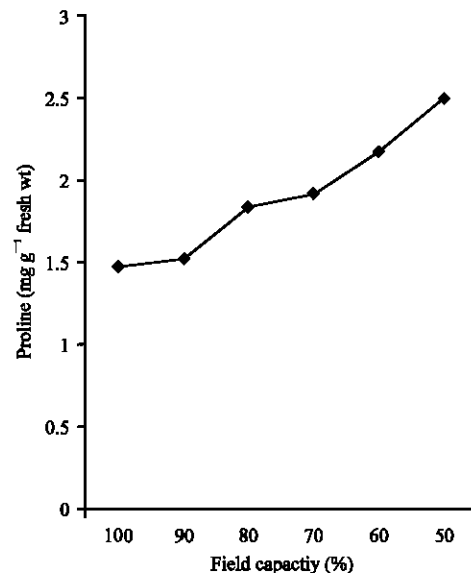


Fig. 2: Effects of water stress on the amount proline

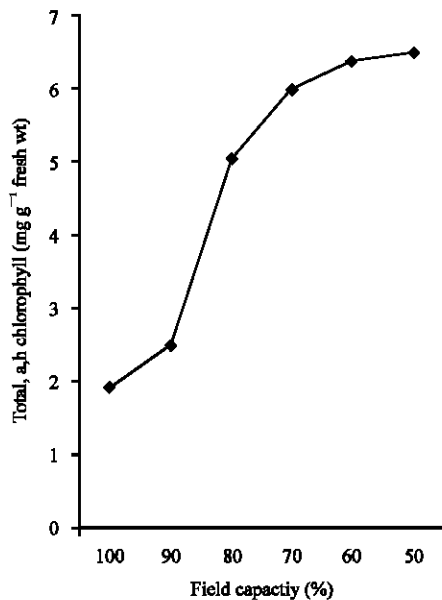


Fig. 3: Effects of water stress on the amount anthocyanin

1/16, 1/33, 1/76, 2/61 and 3/39, respectively time with the amount of anthocyanin in 60, 70, 80, 90 and 100% treatment of field capacity.

DISCUSSION

One of the first signs of water shortage is the decrease of turgor and it will result in decrease of growth and development of cell especially in stem and leaves. The growth of cell is the most important process that is affected by water stress. We can recognize the size of plant through the decrease in height or smaller size of leaves when there is a decrease in the growth of cells (Hsiao, 1973). The decreasing of height plant because of water stress in this research is done on plant purple basil in *Origanum majorana* (Rhizopoulou and Diamantoglou, 1991), *Cymbopogon martini* (Fatima *et al.*, 1999) and *Mentha arvensis* (Misra and Srivastava, 2000), is reported.

When the pressure of inflammation is decreased in a plant cell because of water shortage, the development of cell is decreased because of lack of pressure inside cell. So there is a relationship between the size cell decrease and the rate of water decrease on the tissue plants. When the development of cells decreases because of water shortage, it first leads to the decreasing growth of leaves. Also, in effect water shortage material absorption so decrease and it will result in decrease of growth and development leaves. When the leaves level decreases, the plants lose less water through perspiration. So, the restriction of leave level can be called the first mechanism

against drought (Levitt, 1980). The number of decreasing and leaves levels in accordance to less water condition is like the *Cymbopogon martini* (Fatima *et al.*, 1999), *Cymbopogon winterianus* (Farooqi *et al.*, 1998) and in the *Mentha arvensis* (Misra and Srivastava, 2000). The amount of LAI parameter has a relationship with the leaf level and the changes are related to the leaf level changes. So the loss of LAI relates to the low performance of purple basil especially in treatments with high stress. There is a report of LAI loss because of water stress in soybean (Cox and Jolliff, 1987) and mustard (Begum and Paul, 1993). When the leaf level becomes less, the light attraction becomes less too and the capacity total of photosynthesis becomes less and it is clear that with restriction of photosynthesis in water shortage conditions, the growing of plant becomes less and plant performance is decreasing (Hsiao, 1973). The loss of amount of photosynthesis in drought stress conditions shows the loss of amount of dry matter production on the leaf level and it leads to low performance which shows the effect drought stress, the less performance of leaf level (Cox and Jolliff, 1987). The report of researches done in *Cymbopogon martini* (Fatima *et al.*, 1999) and in the *Cymbopogon winterianus* (Farooqi *et al.*, 1998) a which shows the production loss of fresh and dry matter because of loss of water, which approves the results of present research. The drought stress made chloroplast break and the amount of chlorophyll decrease. Therefore formation of chlorophyll a, b are decreased and ratio of chlorophyll a to chlorophyll b has changed. In water deficit condition the concentration of amino acid proline increased. As chlorophyll and proline are both syntheses from the same substance. Therefore we can say the increase in synthesis proline leads to the decrease in synthesis chlorophyll in drought stress conditions (Aspinal and Paleg, 1981). The decreasing leaf chlorophyll of the effect water shortage in soybean (Cox and Jolliff, 1987) and mustard (Begum and Paul, 1993) and maize (Sepehri and Modarres, 2003) are reported. When the plants are affected by drought and other parameters that decrease of water potential in cytosol, the concentration of osmolites should be increase so that the absorption of water continued under stress conditions osmoregulation. Among organic osmolites, proline probably is the most frequently and the commonly substance that accumulate in response to water potential decrease (Kuznetsov and Shevyakova, 1999; Yoshida *et al.*, 1997).

The increase of density of proline because of water shortage has been reported in wheat (Bajji *et al.*, 2001), mustard (Begum and Paul, 1993), Alfalfa (Irigoyen *et al.*, 1992) and *Cymbopogon winterianus* (Farooqi *et al.*,

1998). Anthocyanins are with the secondary metabolites which have protection against plants stresses. Anthocyanins are pigments that dissolved in water and produced by a series of environmental factors such as seen light, cold temperatures, water stress in plants so that the plant can defend against environmental stress. Anthocyanins accumulation may allow plants to respond quickly and temporarily to environmental variability rather than through more permanent anatomical or morphological modifications (Chalker-Scott, 1999). The influence of less of water in size of fruit and anthocyanin has been investigated in grapes. The results have shown that with the decrease of size of fruits because of water shortage, the amount of anthocyanin in the fruits increases significantly (Roby *et al.*, 2004). The increase of amount of anthocyanin in the leaves of purple basil in response to the drought stress has been observed in this paper, this result is in agreement with the researches of *Photinia, continus* (Beeson, 1992) and corn (Habben, 2004).

The results of this study shows that the growth of basil is very sensitive water stress, because it has shown striking negative reaction in water stress treatments. We also can conclude that decrease in the soil water content causes the decrease in chlorophyll (a, b and total) and basil regulated the osmosis for defending with the effects of water stress with accumulation a series of compatible solutes such as proline and anthocyanin that is costly regarding metabolism. Because it uses a lot of carbon that can be used to supply the growth.

Regarding the findings of present study, the planting and growth of basil in drought conditions is not economical and advisable because of weak growth of bush and decrease of herb yield.

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