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Tolerance of *Moringa* Oleifera to water stress

Boumenjel A.[1], Pantera A.[2,*], Ammari Y.[1]

[1]National Institute of Research in Rural Engineering, Waters and Forests (INRGREF), Forest Ecology Lab
[2]Agricultural University of Athens

*corresponding author: e-mail: pantera@aua.gr

Abstract

Moringa oleifera (Lam) is a fast growing tree that is gradually getting more attention for it numerous uses. It is often called "natural gift" or "miracle tree" because of its many nutritional, forage, medicinal and industrial potentialities. *Moringa oleifera* appears to be a promising multipurpose species for use under a changing climate. To test possible adaptation potential and / or tolerance of *Moringa oleifera* to water stress, an experiment was conducted under semi controlled conditions. Stress was induced in the semi-controlled experiment by the application of different concentrations of polyethylene glycol (PEG-6000), to cause different levels of water potential stress for twenty days. The effect of water stress to plant growth was evaluated based on chlorophyll (a and b) and carotenoid compared to controls. Water stress resulted to a 70% gain in chlorophylls b, 44% losses in chlorophyll a and 45% in carotenoids. These results testify the tolerance ability of *Moringa oleifera* plants to water stress.

Keywords: Climate change, Tunisia, water potential, multipurpose tree, agroforestry

1. Introduction

Water deficit is one of the most common environmental constraints that affect plant growth and development (Aslam et al., 2006). This drought or lack of water that can occur at different times in the life cycle of the plant is closely related to the stage of development of the plant (Chaves et al., 2002); (Jaleel et al. 2008) and may affect biomass and grain yield of crops (Araus et al. 2002); Tester and Bacic (2005).

A strategy to cope with this problem could be the use of tolerant plant species that have a high economic value. Many researchers have highlighted to need to choose plant species that can be adapted to such conditions as an effective economic and ecological option (Shannon 1985, Alonso et al 1999, Ghoulam et al 2002).

Moringa is a fast growing plant of tropical, subtropical and temperate climatic regions. All the parts of the tree are been used in traditional medicine and modern medicine of developing countries (Sharma et al., 2011). Its seeds provide numerous provisional services highlighting its economic and evological value (Rashid et al., 2008; Silva et al., 2010).

Within the framework of this research, the species *Moringa oleifera* (Lam.) was evaluated on its response to increasing water drought as expressed by physiological parameters (photosynthetic pigments), in a controlled experiment.

Table 1. Variation of the content of photosynthetic pigments according to different water potentials

Treatment in MPa	chlorophylls a in µg/ gMF*		chlorophylls b in µg/gMF**		carotenoids in µg/gMF***	
	Average	Effect rate %	Average	Effect rate %	Average	Effect rate %
0	$0,93 \pm 0,03^a$		$0,31 \pm 0,01^c$		$0,47 \pm 0,01^a$	
-0,5	$0,86 \pm 0,02^a$	-8,23	$0,4 \pm 0,007^b$	+ 28,4	$0,42 \pm 0,006^a$	-11,32
-1	$0,59 \pm 0,03^b$	-36,63	$0,41 \pm 0,01^b$	+ 30,41	$0,3 \pm 0,01^b$	-36,98
-1,5	$0,52 \pm 0,014^b$	-44,37	$0,53 \pm 0,02^a$	+ 70,44	$0,26 \pm 0,01^b$	-45,07

* DDL = 3; Pr = 0.0001 < 0.001: Very highly significant, ** DDL = 3; Pr = 0.0009 < 0.001: Very highly significant, *** DDL = 3; Pr = 0.0001 < 0.001: Very highly significant. The values are denoted by the mean ± SE (n = 3). The values followed by different letters are significantly different (P ≤ 0.001) according to Duncan's test. The treatments are control (0MPa), low stress (- 0.5MPa) and average stress (-1MPa), while the strong treatment (-1.5MPa).

2. Materials and Method

A number (160) of disinfected *Moringa* seeds were randomly selected and placed in glass *Petri* dishes (20 seeds per dish). Seeds were moistened by distilled water and the dishes were then placed in a culture chamber under controlled environmental conditions (mean temperature 26 °C and 60% relative humidity) in the absence of light. Seeds sprouted began immediately from the second day of the experiment. A total of 48 seedling were then planted in especially prepared hydroponic pots and were provided with a Hoagland nutrient solution (Hoagland and Arnod 1950) for 36 days. Water stress was applied increasing concentrations (gl-1) of polyethylene glycol 6000 (PEG 6000), to induce decreasing water potentials (MPa) of 0 MPa (control), -0.5 Mpa, -1 MPa and -1.5 MPa. The experiment lasted for 20 days. Determination of the leaf content of photosynthetic pigments was done according to the method of Wellburn (1994):

CHa = (12, 21 x DO663-2.81 x DO646) V / W
CHb = (20, 13x DO646 - 5, 03 x DO663) V / W
CHT = Cha + CHb

Caro = (1000 x DO470 - 3, 27 x CH a - 104 x CH b) /198) V / W

With: V = volume of the solution and W = weight of the sheets used.

3. Results

Based on our results in Table 1, the µg / gMF content, a (Cha) chlorophylls and carotenoids (Cr), is significantly affected by water stress. In fact, it drops 44% and 45% respectively in the highest -1.5 MPa. The opposite behavior is observed in Chlorophylls b, which shows a gain of 70%.

4. Discussion

The health of the *Moringa* plant and its level of nitrogen nutrition were evaluated in this experiment. The determination of photosynthetic pigments, would be a quantitative indicator of chloroplasts thus an index on the chlorophyll activity of the plant (Jones et al., 2004). Thus, our results in Table 1 suggest a decrease in chlorophyll a (44%) and carotenoid (45%), but with a significant increase in chlorophyll b (70%). Our results are in agreement with the work of (Galle et al., 2011), two evergreen tree species from the Mediterranean (*Q. ilex*) and another semi-deciduous tree (*C. albidus*) and those of (Berka et al., 2009) on *Argania spinosa*. Thus, with those of (Kim et al., 2000), which assume that the decrease in photosynthesis has consequences on carbon metabolism, and certain enzymes involved in the circulation of assimilates are regulated in response to the water deficit. According to Galle et al. (2011), this phenomenon is due to the low values of stomatal conductance and due to a high mesophyll conductance. The lower resistance of the mesophyll to the diffusion of CO_2 caused resistance of the stomata, as a main limiting factor of the photosynthesis. The reduction of chlorophyll a and carotenoids can be explained as a photoinhibition due to the degradation of the D1 protein in the reaction centers (Julia et al., 2011). In conclusion, the water stress induced changes over time on the content of photosynthetic pigments, which is probably reflected in the nitrogen nutrition of *Moringa* plants and, hence, the change in growth of stems and roots. Thus, we agree by the hypothesis of Rebeca et al. (2012) that stomatal control relates to the growth rate in plant species, even under conditions where soil water availability may fluctuate.

5. Conclusion

Despite the severe water stress applied for a long time period, *Moringa oleifera* tolerate water shortages by maintaining a respectable aerial and root growth, with increased activity of the photosynthetic system b, in hydroponic condition. Also, disruption of chlorophyll a and carotenoids and reduced leaf area of the leaves helped the plants to overcome the long stress period more effectively. This testifies the ability of *Moringa* to be used for the rehabilization of degraded areas but also as an excellent choice for dry or of water-deficit regions.

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