*Asian Jr. of Microbiol. Biotech. Env. Sc. Vol. 22 (3) : 2020 : 567-572*

***ISSN-0972-3005***

# MORPHOLOGICAL AND PHYSIOLOGICAL RESPONSE OF NAKED AND COVERED BARLEY GENOTYPES TO WATER STRESS IN EASTERN ALGERIA

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(Received 25 December, 2019; accepted 30 September, 2020)

***Key words :*** *Covered barley, Morphological traits, Naked barley, Physiological traits, Water stress.*

**Abstract** – Drought stress is the major limiting factor in agriculture production worldwide and is the main problem limited barley production in Algeria. In order to elucidate the impact of Water stress on morpho-physiological traits of barley genotypes, two genotypes of barley "covered" and "naked" were subjected to two treatments, The first group of plants are regularly irrigated, the second group, At the 5rd leaf stage treated plants are subjected to water stress by stop irrigation for 15 days. Results of Analyze de la variance showed significant differences among varieties for all characters exception of Leaf Area, Vegetative Dry Matter and chlorophyll pigments .Water stress caused decrease of Chlorophyll pigments and relative water content. Barley varieties differ notably in their response to water stress, Overall performance of covered barley cultivars was superior to naked barley cultivars under both water stress. Among covered barley genotypes, 'Saida' and 'El fouara' cultivars were the most drought tolerant and naked barley cultivar was the most sensitive genotype to water stress.

## INTRODUCTION

Barley (*Hordeum vulgare* L.), very important cereal crop worldwide and classified into two major categories according to the grain type: hulled barley and naked barley (Taketa *et al*., 2004). It is widely grown in a wide range of environmental conditions.

Water deficit is one of the most severe restraint for productivity of the crops and food security around the world (Hessini *et al*., 2009). It is among the most widespread abiotic stresses limiting cereals productivity in the Mediterranean environment (Mastrangelo *et al*., 2000). Water stress affects morphological and physiological processes in plants resulting photosynthetic inhibition and reduces plant growth and production (Cao *et al*., 2011). plant responses to drought are different mechanisms include drought tolerance for maintaining turgor to maintain growth under water stress, drought avoidance is the capacity of plants to preserve higher tissue water by lessening of leaf area and stomatal conductance and Drought escape mechanism which allows plants to complete their cycle before severe water stress (Levitt, 1980).

Generally, Plants make up 95% of water, and any loss of water content produces changes in cell biochemical and physiological interactions (Sawhney and Sing, 2002). Understanding how plant's biochemical, physiological and morphological respond to drought can play a major in the stability of crop performance and its resistance to drought stress (Pinhero *et al*., 1997).

The productivity of current crops in many regions is only partly due to the genetic potential of plants. The purpose of research was to evaluate the effect of degree of Water Stress on morphological and physiological traits, with the aim of identifying the best genotype(s) water deficit-resistant barley in arid and semi-arid regions of the world.

## MATERIALS AND METHODS

### Plant Materials and Growth Conditions

Seeds of 10 barley varieties, Six Covered barley ('Saïda', 'El fouara', 'Rihan', 'Dingo, Barbarous' and 'Tichedrett') and one Naked barley were sown in pots (10L). Experiment was conducted in greenhouse situated in the university under ambient environment. At emergence, eight seedlings per pot were left growing while others were thinned out. Plants were exposed to two treatments, T0 no stress (plants are regularly irrigated, 100% field capacity), T1 (At the 5$^{rd}$ leaf stage, treated plants are subjected to water stress by stop irrigation for 15 days) and then the plants were separated into roots for further studies. There were four replications in each treatment.

### Morphological measurements

During 5rd leaf stage, eight plants per treatment were harvested and Plant height and Length of longest root measurements were taken. Leaf area was then calculated based on a formula suggested by (Belkharchouche *et al.*, 2009), Vegetative Dry Matter and root dry matter were obtained after drying samples at 70 °C.

### Physiological measurements

Relative water content Determined by method of (Ritchie *et al.*, 1990). Photosynthetic pigments, fresh leaf samples (100 mg) were used for the extraction of pigments in 80% acetone. Chlorophyll a, b and carotenoid contents were determined and expressed in µg/mL (Lichtenthaler, 1987).

### Statistical analysis

All collected data were subjected to the statistical analysis (ANOVA) by R software. Deference between genotypes and the treatment were determined by means of two-factor analysis of variance.

## RESULTS AND DISCUSSION

The water stresses have remarkable influence on physiological and Morphological traits of barley cultivars to a different degree. Results of Analyze de la variance showed significant differences among varieties for all characters exception of Leaf Area, Specific Leaf Weight, Vegetative Dry Matter and chlorophyll pigments significant differences among Genotype × treatment interaction for all traits with the exception of Leaf Area, Vegetative Dry Matter, Length of longest root, chlorophyll b and Carotenoids (Table 1).

### Physiological responses to water stress

In all the varieties, studied RWC was significantly ($p<0.001$) decreased when subjected to water-stressed as compared to not stressed (Table 1). The mean values of the RWC across genotypes under well watered and water deficit treatments were 90.5 ± 0.58% and 57 ± 2.76%, respectively. Cultivars Saida and El fouara maintained higher RWCs at treatments, whereas Naked barley had the lowest RWC values (Figure 1). Reductions in RWC of

**Table 1.** Effect of genotype, stress and their interactions on the physiological and morphological parameters measured in the 07 genotypes

| Variables | Genotype | treatment | Genotype × treatment |
|---|---|---|---|
| pH | <0.001*** | 0.001*** | 0.042* |
| LA | 0.094 ns | 0.517 ns | 0.557 ns |
| RDM | <0.001*** | <0.001*** | 0.004** |
| VDM | 0.305 ns | 0.04* | 0.37 ns |
| L LR | 0.018* | 0.028* | 0.877 ns |
| RWC | 0.001*** | <0.001*** | <0.001*** |
| Ca | <0.001*** | <0.001*** | 0.008** |
| Cb | 0.146 ns | 0.301 ns | 0.844 ns |
| Cds | 0.026* | 0.176 ns | 0.866 ns |

P < 0.05 * = significant
p > 0.05ns= non significant
P < 0.01 **= significant
P < 0.001***= highly significant
PH= Plant height; RDM= root dry matter; VDM= Vegetative Dry Matter; LA= Leaf Area; LLR= Length of longest Root; chlorophyll a= Ca ;chlorophyll b= Cb; Carotenoids= Cds; RWC= The Relative Water Content%

genotypes Barbarous, Dingo, El fouara and Saida was non-significant.

Comparatively low RWC was found in genotypes Naked barley, Rihane and Tichedrett. RWC was decreased up to 12% in Barbarous. Other varieties such as El fouara(17.1%), Naked barley (34.7%), Tichedrett (34.9%), Saida (17%) , Dingo (9.1%) and Rihane (22.3%). RWC decreased with water stress in all the varieties however Saida variety retained maximum RWC under stressed condition (Figure 1). Similar study have been reported by (Akram, 2011),Water stress caused reduction in RWC, which affected the growth and yield of the plants (Molnár *et al.*, 2002). According to Clavel *et al.*, (2005), RWC was a good indicator of plant water status. Changes in the RWC of leaves are considered as a sensitive indicator of Water stress.

Water stress has significant effect on the amount of chlorophyll a. The maximum amount of chlorophyll a (91.7 ± 5.56 and 90.8 ± 13.5 µg/mL) were obtained from control treatment in El fouara and Saida varieties respectively (Figure 2). The minimum amount of chlorophyll a (27.7 ± 2.62 µg/mL) obtained from control treatment in Barbarous variety. Stress resulted in a decrease of chlorophyll a, chlorophyll b (Figure 3) and Carotenoids (Figure 4) contents. The decrease in chlorophyll content under drought stress results in chlorophyll degradation (Anjum *et al.*, 2011).

Our results are in agreement with the findings of many studies have shown that in drought condition chlorophyll content decrease and then decreased photosynthetic activity (Nikolaeva *et al*. 2010). Tolerant genotypes with high chlorophyll would devote more of its photosynthetic production.

### Morphological responses to water stress

In the current study, the results showed that Naked barley and Covered barley cultivars varied

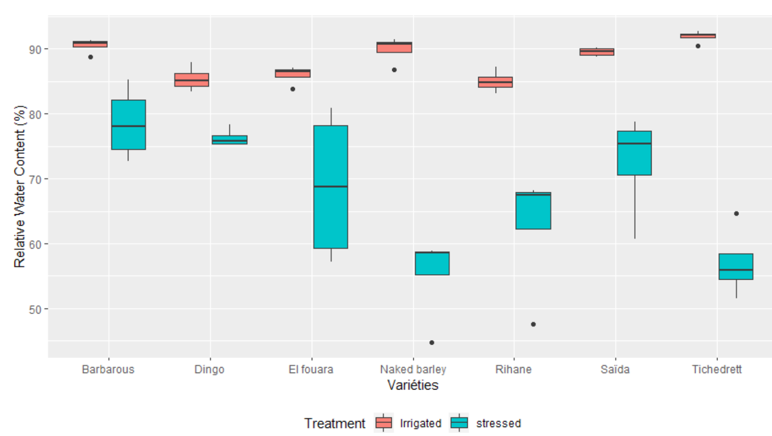


**Fig. 1.** Relative water content % of seven barley cultivars under water stress.

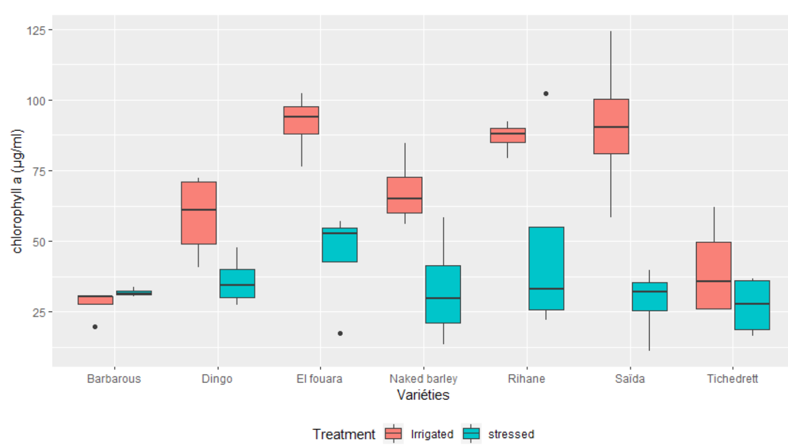


**Fig. 2.** chlorophyll a of seven barley cultivars under water stress.

significantly for Plant height under water stress conditions, were Covered barley (El fouara and Saïda) genotypes had higher Plant than the Naked barley genotypes (Table 1). El fouara variety Produced the tallest plants (31 ± 1.16) against the Dingo that had the shortest plants (12.4 ± 0.9). Naked barley had equal plant height and occupied the middle position. The height of the plant decreases with increasing water stress (Bouazzama *et al*., 2012). Water stress causes reduces stem length by inhibiting the internodal elongation of plants and lowers leaf area (Ashraf *et al*., 1996). The Leaf Area increased did not significantly ($P < 0.05$) due to drought stress (Table 1).

Barley cultivars varied not significantly for Leaf Area under water stress conditions were Covered barley (El fouara and Saïda) genotypes had higher leaf area than naked barley genotypes. Mean leaf area was observed in control treatment of all wheat varieties such as El fouara (13.4 ± 2.64 $cm^2$), Saïda (12 ± 0.81 $cm^2$), Dingo (9.04 ± 0.48 $cm^2$), Naked barley (7.65 ± 0.67$cm^2$), Barbarous (6.39 ± 1.3 $cm^2$), Tichedrett (6.75 ± 0.56 $cm^2$) and Rihane (3.38 ± 0.38 $cm^2$). Saïda and El fouara genotype lowered its leaf area under drought stress conditions and it may use this mechanism to tolerate those conditions..

Leaf area was decreased when two week water stress was given in some varieties such as Saida (7.68 ± 1.57$cm^2$), Tichedrett (5.22 ± 0.70$cm^2$), Barbarous (6.21 ± 0.94 $cm^2$). According to the study of Mc Cree (1986) and Rucker *et al.* (1995), drought can reduce leaf area which can consequently lessen photosynthesis. Akinci *et al* (2009) reported that the water stress caused major reductions in height, leaf number, leaf area. Under drought stress conditions, reduced water availability decreases cell growth and subsequently reduces the leaf area index

The tendency of the plant roots were grow to lower, more moist soil layers until the water supply is exhausted in the environment (Da Rosa *et al.*,

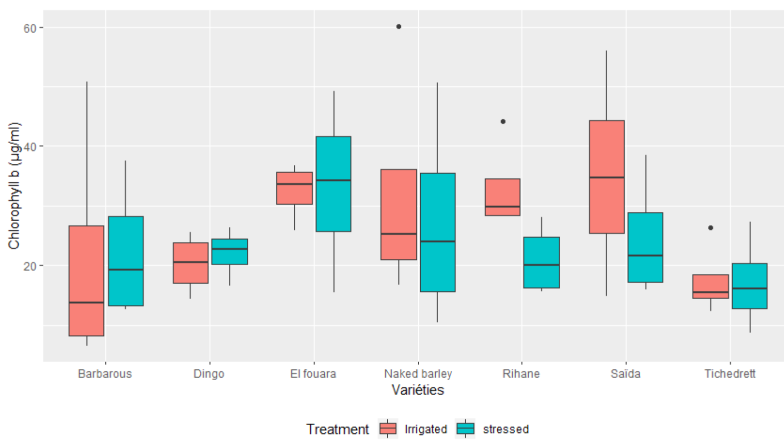


**Fig. 3.** Chlorophyll b of seven barley cultivars under water stress.

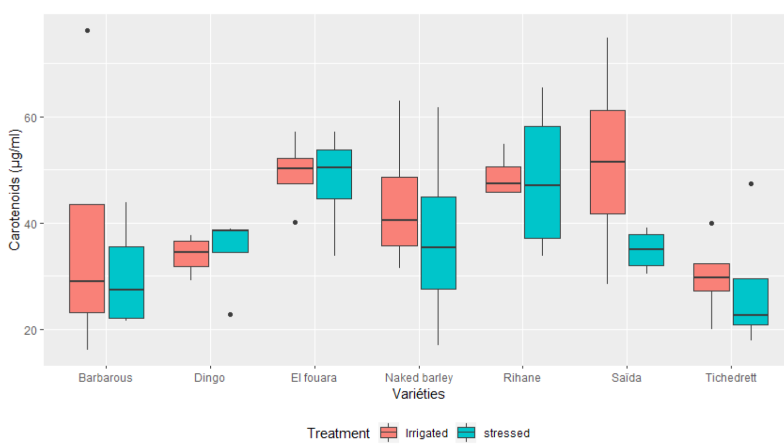


**Fig. 4.** Carotenoids of seven barley cultivars under water stress.

2011). Drought-induced reduction in leaf area is ascribed to suppression of leaf expansion through a reduction in photosynthesis (Rucker *et al.*, 1995). Tichedrett produced the tallest root (44.1 ± 2.74 cm) against the Dingo that had the shortest root (29 ± 6.72 cm). In another study of ( Anjum *et al.*, 2003) observed that water stress curtailed leaf area, water contents (WC), fresh weight, stem length, of both the barley cultivars, Jau-87 and S-84728. In drought stress, drought tolerance genotypes produce more leaf area and total dry matter (Nouri-Ganbalani *et al.,* 2009).

## CONCLUSION

The results revealed a high degree of variation between different barley genotypes in terms of how their traits responded to water stress conditions. Different barley genotypes have some advantages in morphologic and physiological traits, which can reduce the damage caused by water stress. Physiological studies on barley genotypes can be useful for identification of drought resistant genotypes. Barley varieties differ notably in their response to water stress. Covered barley (Saïda) showed higher water use efficiency, it could the most drought tolerant varieties.

The Saïda cultivar proved to be the most water economic when subjected to water stress, evidenced by reservation of more water contents in the plant tissue. Overall, it is advised to grow this cultivar of barley in land areas with limited supply of irrigation water. Barley cultivar Saïda showed relatively more tolerance to drought. The performance of Covered barley cultivars under both normal and drought stress conditions was superior to that of naked barley cultivar (Chair Ennabi). The drought tolerance superiority of Covered barley cultivars under water-restricted conditions could be associated with their leaf area.

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