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# Study of the Mechanismsinvolved Inthetoleranceof Durum Wheat(Triticum durumdesf.) to Droughtto Improveproductivity

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**Abstract**

Research and study of adaptation parameters to water deficit is a key work in any attempt to improve the safety and productivity of wheat governed by water deficits areas. The proposed work attempted to explain the adaptive functioning of ten genotypes of durum wheat (Triticum durum Desf.) under different water regimes. It attempted to elucidate the relationships and skills offered by the variability of the species cultivated in the process, the morphological remodeling of root and stem parts in drought tolerance and their relationship with productivity. The effect of water deficit on the strength of the meristem part was very variable depending on its intensity, the nature of the genotype and the parameter considered. The process of transmission and viability of tillers were more sensitive to water deficit statement in the different intensities. The results showed that all levels of water deficit adopted (55%, 52%) (ADH1, ADH2) in this study lead to a reduction in the length among all genotypes tested. The results obtained in this study showed that the number of tillers formed and preserved closely depended on the morphological characteristics of the adventitious roots.

**Keywords:** Durum wheat, drought tolerance, productivity.

## Introduction

Drought is the most abiotic stress factor limiting crop productivity. This is particularly true in the Mediterranean region. In this area, the climate is characterized by erratic and unpredictable precipitations. As water available for agricultural uses becomes more restrictive, the release of drought-tolerant genotypes will become increasingly important (Loss et al. 1994; Grando et al. 1995). Algeria, where the cultivation of cereals is located in the interior plains and highlands, semi-arid, constitutes a reference area of this region (Adda et al., 2005).

The understanding of the physiological and the genetic adaptive mechanisms controlling drought tolerance is a crucial aspect in plant biology. The response of root growth to water deficit conditions is one aspect contributing greatly to drought tolerance. It represents the first organ in sensing water stress (Shimazaki et al., 2005). Several studies on root growth during water stress in plants of economical importance, such as wheat (Pritchard et al., 1991), barley (Sahnoune et al., 2004) and maize (Wu and Cosgrove, 2000; Shimazaki et al., 2005) have been reported. Experiments have been done on adventitious roots for which differences between cultivars have been observed in some cereals (Teulat, 1997). However, few studies have focused on the relationship between morphological variations roots and tiller formation under drought conditions.

A large root system can result in rapid soil water consumption, which may not be favorable in non-irrigated arid and semiarid areas. There is evidence that breeding of wheat varieties has unknowingly increased water use efficiency (WUE) by reducing the size of the root system (Siddique et al. 1990). It is evident that the interest roots morphological traits are those that allow tolerance to water deficit but associated with better productivity of the aerial part of the plant.

Our study focuses on the harmful effects of water deficit on durum wheat root growth. The pattern of root growth is investigated at various levels of soil water content and depth. The impact of water deficit on tillering capacity is prospected. The relationship between root morphology and the tillers formation in ten durum wheat genotypes were determined.

## Materials and Methods

### The plant material

Ten durum wheat genotypes (Triticum durum Desf.) from different geographic origins and differing in response to drought were chosen for this study (Table 1).

### Experimental Approach

Sprouts are transplanted into cylinders PVC, filled with a substrate consisting of a mixture of sand, soil and organic matter in the respective proportions of 8: 3: 1. The tests were conducted in a semi-automatic greenhouse temperature, diurnal and nocturnal respectively maintained at 20 ° C and 15 ° C, the relative humidity was 70% and photoperiod was maintained at 12 hours / day, at the Institute of Agricultural and Biological Sciences at the University of Tiaret. The cylinders are arranged in three batches. A batch continues to be irrigated until the end of the experiment (SDH), in the other two were performed by a progressive watering stop 38 and 49 days corresponding to the lots ADH1 and ADH2. At each level of treatment, the genotypes are repeated ten times 05 arranged randomly. The dose is determined irrigation practiced daily by weighing the cylinders. The irrigation water is replaced every three days by a commercial nutrient solution ACTIVEG kind.

### The measurements

The earth is separated from the roots by a moderate stream of tap water. Roots were then washed in a tank prior to measurements. The different parameters are estimated during the shooting stage. The parameters studied are:

- The number of total roots (NTR) and newly formed (NRNéof) determined by counting the roots concentrated in the top soil, in the neck.
- The report, root dry matter / air dry matter (RDM/ADM) was determined after drying in an oven at 80 ° C for 48 hours.
- The number of tillers per plant (NT) is determined at the aboveground biomass.
- The report, number of tillers / total number of roots.

## Statistical Analyses

All data were processed using the STATISTICA software package (StatSoft, Tulsa, USA). Comparisons between water treatments and between genotypes, within each water treatment, were based on the Duncan test at 5% probability level.

Table 01**:** The main features of the genotypes used in the study

| Genotype | Origin | Genotype | Origin |
|---|---|---|---|
| OUED ZENATI | Algeria | OFANTO | IEC (Italy) |
| GLOIRE DE MONGOLFIER | Algeria | SIMETO | IEC (Italy) |
| MOHAMED BEN BACHIR | Algeria | GTA DUR | CYMMYT/ICARDA |
| HEDBA3 | Algeria | WAHA (CHAM1) | ICARDA (Syria) |
| VITRON (HOGGAR) | Spain | CHEN'S | ICARDA (Syria) |

(Boufenar et Zaghouane, 2006).

## Results

The results obtained (Table 2) show a significant genetic variability of the characteristics of the varieties tested in roots. The analysis of variance showed a highly significant effect of the treatment regime or hydrique.et genotypic variations. The effect of interaction between genotype and water regime is statistically significant.

### Morphological parameters of the root system

**Number of roots per plant:** Gains and losses (Table 03) show that at moderate water deficit (ADH1), these numbers are greatly reduced in most genotypes, except Simeto and Chen'S who have shown an increase in the number of roots. In terms of more prolonged water deficit (ADH2), the number of roots has undergone a significant reduction in this and all of the tested genotypes.

**The newly formed roots:** The results show (Table 03) that the number of newly formed roots in the control treatment was higher than that recorded in the batches conducted under conditions of water deficit. It essentially been a reduction in the rooting in the ADH1 treatment among all genotypes except Gta drive. In the ADH2 treatment, the reductions are even greater and in all genotypes. They are understood by the limits of 96.43% recorded by Mohamed Ben Bachir and 50% shown by Viton.

**The dry matter ratio root / aerial dry matter:** The application of the deficit of the first intensity (ADH1) causes variable changes in the report where they show that genotypes Glory Mongolfier and MBB are distinguished by the increase in this ratio in response to water deficit.

The action of water deficit at the ADH2 treatment, is expressed on the report. The emphasis of the water deficit has been accompanied by a marked decrease in ratio values in all genotypes.

**Number of tillers (NT):** The average results (Table 03) show that across the ADH1 treatment, genotype Simeto stands out among the collection conduct, by its greater sensitivity to water deficit by scoring rate of reduction in the value of this feature of 37.1%. While under the same conditions, genotype Waha is more resistant registering only 8.93% reduction. Unlike these behaviors, genotype, Chen'S has been an increase in the number of tillers (16.22%). In terms of more prolonged water deficit (ADH2), reductions in numbers of tillers are more pronounced.

Table 02**:** Analysis of variance of root morphological parameters of the ten genotypes

| **Trait** | **Genotype effect** | **Water treatment effect** | **Genotype × water treatment effect** |
|---|---|---|---|
| Number of total roots | 9,11*** | 101,934*** | 4,302*** |
| Number of roots newly formed | 3,323** | 94,544*** | 1,828* |
| RDM/ADM | 3,614*** | 16,921*** | 0,98ns |
| Number of tillers | 2,701** | 117,073*** | 1,87* |

*,**,*** : Significance level of 5.1 and 0.1%, respectively.

**Table 03:** Change in total number of roots, newly formed, report of root dry matter / air dry matter and number of tillers in 10 genotypes under different water regimes

| **Variety** | **N TR** | | **N RNéof** | | **RDM/ADM** | | **NT** | |
|---|---|---|---|---|---|---|---|---|
| | Evolution 1(%) | Evolution 2(%) | Evolution 1(%) | Evolution 2(%) | Evolution 1(%) | Evolution 2(%) | Evolution 1(%) | Evolution 2(%) |
| **OZ** | -47,52 | -69,50 | -51,52 | -75,76 | 43,59 | 29,49 | -14,55 | -50,91 |
| **G-Mong** | -32,85 | -72,99 | -60,00 | -66,67 | -13,33 | 80,00 | -27,42 | -54,84 |
| **MBB** | -13,98 | -67,74 | -67,86 | -96,43 | -1,87 | -2,80 | -28,85 | -44,23 |
| **H3** | -36,52 | -66,09 | -35,14 | -75,68 | 6,98 | 38,37 | -27,27 | -53,03 |
| **OFANTO** | -30,99 | -49,30 | -22,22 | -81,48 | 10,00 | 88,00 | -17,31 | -38,46 |
| **SIMETO** | 7,14 | -46,43 | -9,52 | -80,95 | 10,45 | 82,09 | -37,10 | -54,84 |
| **Gta-Dur** | -2,90 | -43,48 | 7,41 | -74,07 | 12,33 | 45,21 | -16,36 | -41,82 |
| **WAHA** | 0,00 | -50,51 | -13,33 | -73,33 | 23,08 | 67,95 | -8,93 | -58,93 |
| **VITRON** | 0,00 | -46,15 | -12,50 | -50,00 | 52,94 | 96,08 | -12,90 | -50,00 |
| **CHEN S** | 41,18 | -23,53 | -18,52 | -77,78 | 68,89 | 113,33 | 16,22 | -21,62 |

**Discussion**

Optimization of water absorption is related to a complex set of morphological roots, mass, volume, depth and branching (Soar et al., 2007). Changes in root formation during the entire period of operation of the experiment indicates that it is closely related to changes in humidity in the growth substrate. Generally, this increase indicates that the gradual drying of the substrate strongly inhibits the issue of adventitious roots (r = -0.71 **). These results demonstrate that the process of issuing root would not depend only on the water environment and it is the result of an interaction between the variability and the respective water supply adopted. The reduction recorded at the end of the experiment, corresponding to ADH2, is the result of a functional disorder of the plant involved in the severity of a relatively high intensity of water deficit. According Benlaribi (1990), Ali dib and Monneveux (1992), and ARora Mohan (2001), the formation of lateral roots in wheat is one of the most affected by water deficit characteristics. Thus Bingham (2001), and Kara Zoghmar (2011) argue that changes in root formation is a factor of variability and inter intarspécifique very important in the function of drought tolerance of crops. The action of this strain on this parameter can be regulated by inhibiting the appearance of roots on the one hand and their regression after onset other. The conduct of one or the other phenomenon depends on the time of the declaration of water stress.

The effects of different levels of water supply on both sides, shoot and root are different levels. These results demonstrate a sensitivity to water deficit, the more pronounced the aerial vegetative root mass. These reports tend to express increasing the ratio of the masses of both parties with the acuteness of the water deficit (r = 0.24 **). Before the imposed water stress, we find that the reduction of vegetative mass mainly concerns the aerial part of the root system. This indicates that the plant spends availability of growth factors for the protection of roots that ensure its water and mineral nutrition under conditions of water deficit. This trend would favor tolerance mechanisms to water deficit, while it would be detrimental to the maintenance of the productivity of the species whose expression is dependent on the strength of the aerial part.

Changes in the number of tillers in a deficient water regime depends on their number formed under optimal water conditions. The impact of water deficit results in a marked decrease in tillering capacity among all genotypes tested (r = -0.57 **). Among these genotypes, Chen'S showed better tillering capacity and maintaining tillers formed under conditions of water deficit. These results demonstrate that genotypes having demonstrated a higher tillering capacity under optimal water conditions, are those who have shown levels of regression of tillers formed the highest. It would be better to select the basis of an average force of tillering capacity, genotypes for a culture in limiting water conditions.

Table 04**:** Relations between water regime and root formation with tillers

| **Trait** | **Number of tillers** | **Number of total roots** | **Number of newly formed** |
|---|---|---|---|
| Water Situation | -0.57** | -0.44** | -0.35** |
| Number of tillers | | 0.73** | 0.42** |
| Number of total roots | | | 0.55** |

**Tableau 05** : Variation de rapport de nombre de talles/ nombre de racines totales chez 10 génotypes et sous les différents régimes hydriques

| **Variety** | **NT/NTR** | | |
|---|---|---|---|
| | SDH | ADH 1 | ADH2 |
| **OZ** | 0,48 | 0,74 | 0,58 |
| **G-Mong** | 0,49 | 0,55 | 0,73 |
| **MBB** | 0,59 | 0,49 | 1,17 |
| **H3** | 0,58 | 0,66 | 0,79 |
| **OFANTO** | 0,75 | 0,89 | 0,85 |
| **SIMETO** | 0,92 | 0,67 | 0,99 |
| **Gta-Dur** | 0,74 | 0,65 | 0,77 |
| **WAHA** | 0,67 | 0,54 | 0,53 |
| **VITRON** | 0,69 | 0,71 | 0,75 |
| **CHEN S** | 0,71 | 0,63 | 0,67 |

The results obtained (Table 04) show that adventitious root formation strongly influences the formation and preservation of tillers. A positive and highly significant between the number of roots formed and the number of tillers (r = 0.73 **). A high number of tillers also cause a new formation of adventitious roots in water deficit conditions (r = 0.42 **). These results demonstrate that the formation and maintenance of tillers are conditioned by the ability of the formation and operation of adventitious roots, a positive trophic interaction is established between the two types of body. Although root formation has a morphogenetic priority species. Under conditions of water deficit, the species maintains its operation for the formation of a high number of roots allowing a trend to a balanced nutrition essential water to maintain the development of the aerial part.

***Conclusion***

Many studies have been devoted to the morphological parameters and including the root system dominate (Gregory, 2006; Richards et al, 2007;. Palta and Watt, 2009; LILLEY and Kirkegaard, 2011). Lopes and Reynolds (2010) and Lilley and Kirkegaard (2011) show that the improvement in water conditions is determined by a dynamic of growth in length and branching of roots in deep horizons, wetter conditions in prolonged drought. The results obtained show that the implementation of the various root traits is highly dependent on environmental conditions. The water factor is one of the main culprits of parameters which determine the root formation in durum wheat. The data indicate that the changes caused by this constraint rather lead to a reshaping of the organs for better operational efficiency.

The results obtained in this study show that the number of tillers formed and preserved directly depend on morphological characteristics of adventitious roots. Thus, a high number of tillers is favored by a high number of adventitious roots and root neoformation process occurred after the declaration of the water deficit in the growth substrate. These results are confirmed by the work of Duggan et al. (2005), Watt et al. (2005) and Asseng and Turner (2007) showing that genotypes with stronger tillers also had deeper roots. These same studies show that positive and significant interactions may occur between the numbers of adventitious roots and tillers in environments that have undergone a water deficit during the tillering stage.

The study shows that the drought of the substrate induces a significant reduction of the vegetative mass of the two parts of the plant, shoot and root. He demonstrated that genotypes having demonstrated a significant effect of the aerial part are those who show a greater sensitivity to water deficit for maintaining growth at this stage of morphogenesis.

Durum offers existing genetic variability in tolerance to water deficit, important. Creative work of variability is essential for the creation of more productive and tolerant genotype.

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