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Original article

Study of Morphogenesis Relationships between the Racinary System and the Aerial Part in the Wheat (*Triticum Durum* Desf.) under the Different Hydric Regimes

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Abstract

The water deficit is considered as one of the main abiotic stresses affecting cereal productivity, especially durum wheat (*Triticum durum* Desf.) due to the scarcity of water resources, which is a staple food in our daily diet. The objective of this study is to assess the performance of two systems, root and aerial, under three water situations (100, 60 and 30 % RC) in five genotypes (Waha, Acsad 1361, Mexicali 75, Oued Zenati, Langlois), in order to establish a growth model for both parts under deficient conditions.

Collected data showed variations for each measured characteristics. These variations depended on the water regime and genotype considered. Structural modifications were measured for both adventitious and seminal root types. These changes relate to root elongation, which has been accompanied by a reduction in the rate of adventitious rhizogenesis. Anatomical transformations have also been recorded, such as the reduction in root diameter, which is explained by a decrease in the thickness of the cortical parenchyma. This transformation would favor a better circulation of the sap during its horizontal transport.

Keywords: Durum wheat, water deficit, morphogen relationship, Carpentry.

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INTRODUCTION

Wheat and particularly durum wheat occupies a predominant place in agriculture and consequently in the Algerian economy. Nevertheless, the production provided by the sowing areas of this species remains low to satisfy the expressed needs, which are increasing annually (Chennafi et al, 2010). As a result, our country considers itself to be one of the main importers of durum wheat products in the world (Benbelkacem et al., 2000), while low production levels are largely reflected in the low and irregular yields recorded over the agricultural years, and durum wheat cultivation in our country faces many constraints, including climatic ones (Hazmoune et al., 2006). Indeed, climatic stresses are the main variables that greatly influence the expression of the species' productive potential. Drought through variations in intensity and reporting periods is the main climatic factor whose effects are most damaging (Adda et al, 2013), thus severely limiting the development of yield in this species. Any attempt to improve yield levels in this species depends on the quality of the solutions provided to this environmental stress and the use of water-deficit-tolerant plant material is the most effective. However, the creation of such material inevitably depends on the study of the mechanisms involved in this tolerance and the determination of the criteria conditioning them: the weight and quality of the grain are the reference characteristics for evaluating yield (Gate, 1995).

The work initiated in this research attempts to elucidate the impact of water deficit on under different water regimes. To achieve this objective, genotypes different in their origins, functioning and behavior towards drought are used. In order to evaluate the impact of the water deficit on the activity of the various bodies involved in the filling process, different water regimes are used.

MATERIALS and METHODS

Experiment objective

Water stress is one of the most important environmental stresses, affecting agricultural productivity around the world (Boyer, 1982), it results in a series of changes in the plant that affect morphological, physiological (Brisson, 2008) and biochemical characteristics when the plant's water requirements exceed the available quantities (Mefti et al., 2000). The work presented attempts to evaluate the contribution of the study of morphogenesis relationships between the aerial and underground portions of durum wheat (*Triticum Durum* Desf.) under different water deficit regimes.

Plant material

The plant material used is composed of five durum wheat genotypes where the choice of the latter is managed by origin and drought tolerance.

Test installation

Seeds of the five genotypes are disinfected with commercial bleach solution diluted to 50% and rinsed several times with distilled water. They are then germinated in Petri dishes on absorbent paper soaked in water and placed in an oven set at 25ºC for 48 hours. The transplanting of the sprouted grains is carried out in PVC cylinders 100cm long and 10cm in diameter filled with a homogeneous substrate of sawdust with a water retention capacity (289%) at the rate of one plant in cylinder, knowing that the first block is irrigated at 30%, the second at 60% and the last at 100% at field capacity.

Results and discussion:

The substrate used for the tests of this work allowed a moisture evolution along the profile (Fig. 1) adequate to the expected objectives. Indeed, the application of irrigation to the field capacity allows the maintenance of a humidity with equivalent distribution across the different horizons of the cylinder. Under these water conditions (100%RC), the humidity was sufficient and close to the easily usable reserve (80%RC). This distribution ensures optimal water supply across all horizons of the culture substrate profile.

The application of the water deficit under its two levels of intensity (30%RC, 60%RC) caused a different distribution. Indeed, an increasing profile of the surface moisture profile was obtained at the depth of the cylinder, the importance of which depends on the acuity of the water deficit. In these two water situations, it has been observed that the deepest layers remain the most humid.

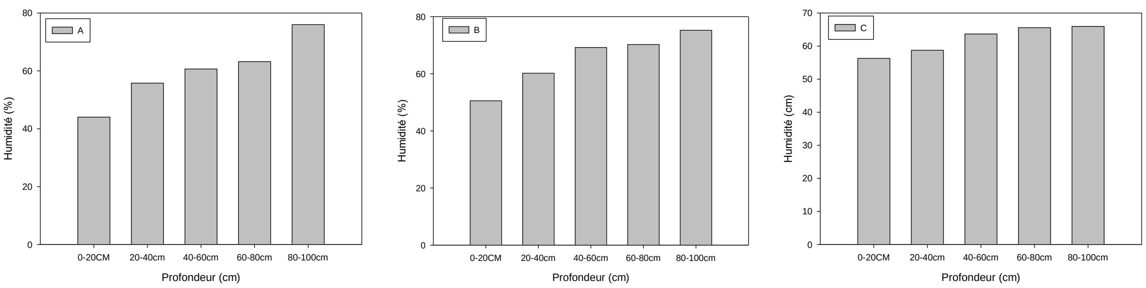

Figure 1. Evolution of humidity by weight in the three water stress situations A: 30%RC, B: 60%RC and C: 100%RC

The results obtained from this research indicate that variations in plant water supply levels in durum wheat have been accompanied by profound morphological and anatomical changes in both the aerial and root parts. These modifications, referred to as morphogenesis remodelling, are believed to be responsible for drought tolerance in this species. This deduction is confirmed by certain studies (BENLARIBI et al., 1990; ALI BID et al., 1992) which demonstrate the importance of morphological remodelling of the plant to control water deficit.

Among the morphological modifications concerning the root system, the results indicate that the water deficit favours the elongation of both seminal (r=0.64***) and adventitious (r=0.59**) roots. This lengthwise growth occurs according to the progressive decrease in humidity along the profile of the growing medium.

This remodelling allowed the roots to reach the deep layers of the substrate, which remained wetter after the onset of drought. This transformation is part of the mechanisms that allow the plant to tolerate drought while maintaining a high water potential. These results are confirmed by the work of Sahnoune et al (2004) and Adda et al (2005) which indicate that root length growth following drought declaration is a reference criterion for the selection of durum wheat genotypes tolerant to the effects of this abiotic stress.

Root elongation was accompanied by a reduction in the number of adventitious roots. These two results therefore indicate a tolerance strategy based on compensation for rhizogenesis operations. The proposed model is then defined by a reduction in the number of roots associated with greater root elongation. This model therefore provides water nutrition under conditions of scarcity of water resources in the growing substrate. Some studies (EL FAKHRI et al., 2011) favor this model by proposing a reduction in the number of roots and an increase in their length.

Table 1. Correlation between morphological parameters

	SH	TRE	NT	NFAP	TS	NFT	NRA	LRA	LRS	SF
TRE	-0,44**									
NT	-0,08	0,07								
NFAP	0,02	-0,20	-0,45**							
TS	0,46**	-0,06	-0,01	0,08						
NFT	0,10	-0,17	0,71***	-0,17	0,01					
NRA	-0,08	-0,20	0,21	0,27*	0,10	0,49**				
LRA	0,59**	-0,35*	-0,09	-0,06	0,10	0,04	0,09			
LRS	0,64***	-0,39*	-0,07	-0,11	0,14	0,15	0,13	0,66***		
SF	-0,24*	0,08	0,08	-0,05	-0,48**	0,20	0,22	-0,03	0,02	
MSA / MSR	-0,05	0,04	0,21	-0,09	-0,10	0,24*	0,12	-0,15	-0,15	0,09

TRE: Relative moisture content, **NT**: Number of talles, **NFAP**: Number of sheets on the main axis. **TS**: Senescent rate. **NFT**: Total number of sheets. **NRA**: Number of adventitious roots, **LRA**: Adventitious root length., **LRS**: seminal root length. **SF**: Foliar surface. **MS** : Aerial dry matter. **MSR**: Root dry matter. **SH**: Water deficit.

The lengthwise growth of the roots is ensured by the simultaneous multiplication and cell growth. The extent to which either process contributes to root elongation would depend on environmental conditions. So, according to these results, the higher growth in length is caused by the declaration of water deficit results from cell growth instead of cell multiplication. This deduction is confirmed by the fact that the lengths of the cortical parenchyma cells increase with the declaration and intensity of the water deficit.

Contrary to what some studies (Labdelli et al., 2013) show that water deficit reduces cell growth, the exception was observed according to these results for root cells. The effect of the water deficit on the aerial part resulted in a reduction in the surface area of the last leaf (r=-0.24*). No effect of stress on the tillering capacity of the plants was found. The anatomical transformations of the aerial part estimated through the dimensions of the parenchymal cells seem to be weakly involved in the variations in organ sizes at this level. This is justified by the small effect of variations in water supply levels on these dimensions and also by the absence of any significant relationship between the development of leaf area and the dimensions of these cells.

Table 2. Correlation between anatomical root parameters

	SH	EPAD	DVA	EPS
EPAD	-0.73***			
DVA	-0.76***	0.49**		
EPS	-0.73***	0.59**	0.51**	
DVS	-0.68**	0.53**	0.53**	0.79***

Table 3. Correlation between the dimensions of parenchymal cells in roots.

	SH	LCPRS	DCPRS	CPRA	DCPRA	LCPCF
LCPRS	-0.14					
DCPRS	-0.32*	0.31*				
LCPRA	0.13	0.10	0.03			
DCPRA	0.21	-0.05	-0.17	0.47**		
LCPCF	0.18	-0.01	-0.25*	-0.14	-0.23*	
DCPCF	-0.00	-0.11	-0.12	-0.04	-0.04	0.42**

The roots are the site of important structural transformations. Most of these are carried out in a context of promoting the transport and circulation of water on the one hand and the preservation of water in soil that tends to become dehydrated on the other. These transformations concern both types of roots, seminal and adventive. The main transformations concern the reduction of the thickness of the cortical parenchyma of the seminal (r = -0.739***) and adventitious (r = -0.738) roots. This reduction would be a consequence and is imposed by drought for the reduction of the vegetative mass.

This reduction would also be part of a remodelling strategy by reducing the importance of the cortical parenchyma and consequently a decrease in the importance of the path to be covered by the sap during its horizontal transport. The consequences of such a transformation would be a better use of the energy required to regulate the water potential during this process. Some research results (Adda et al., 2013) confirm this transformation by indicating that under the limiting water supply conditions, one of the consequences of which is the reduction in root diameter.

Another consequence of drought on root remodelling relates to transformations that increase the hydraulic resistance of the roots and ensure better sap circulation. It concerns the reduction of the diameter of the woody vessels of the metaxime.

Figure 2. Demonstrating the appearance of the root system in the Oued Zenati genotype in all three situations waterborne

This reduction is significant for both adventitious (r=-0.767***) and seminal (r=-0.767***) root types. This reduction is a criterion used to improve the efficiency of the circulation of raw sap. Among the strategies developed by the plant in water deficit conditions refers to the increase in the leaf senescence index (r=0.46**). Based on this result, it can be seen that the effects of water deficit on slowing down morphogenesis are more likely to occur in the aerial part than in the root part.

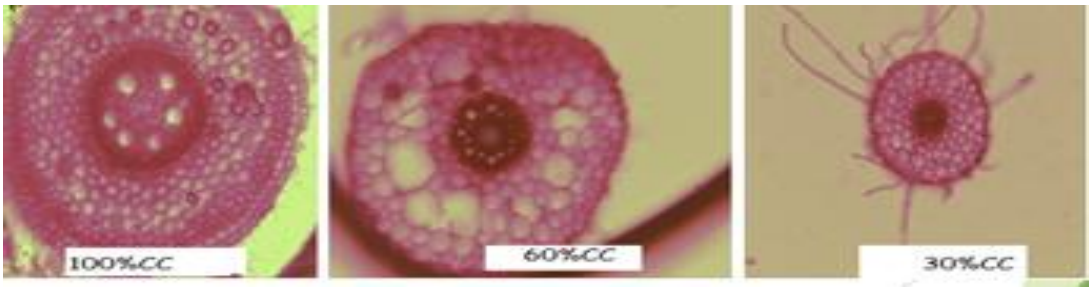

Figure 03. Cross-section at the piliferous zone of the adventitious root in the Mexicali75 genotype in the three water (30, 60, 100% RC).

The results obtained show that among the main reactions of tolerant plants are related to changes in rhizogenesis. Among these modifications are related to root elongation. Indeed, the increase in the intensity of the water deficit was accompanied by a greater growth in length. This reaction concerned both adventitious and seminal root types. This root cell elongation has allowed the preservation of the water content of the plants by showing tolerance with the maintenance of a high water potential. Root elongation was accompanied by a reduction in the rate of adventitious rhizogenesis.

CONCLUSION

The creation and selection of variability for water deficit tolerance in durum wheat requires the screening and study of the mechanisms involved in the morphogenesis process.

The substrate used has made it possible to better enhance the remodelling externalized by the plant in response to the water deficit.

The results obtained show that among the main reactions of tolerant plants are related to changes in rhizogenesis. Among these modifications is the root elongation. Indeed, the increase in the intensity of the water deficit was accompanied by a greater growth in length. This reaction concerned both adventitious and seminal root types, the latter being explained by greater cell growth and a decrease in cortical parenchyma thickness.

Also a reduction in the diameter of the woody vessels of the metaxylme. This transformation would favor a better circulation of the sap during its horizontal transport.

There is a small effect of variations in water supply levels on the dimensions of leaf chlorophyll parenchyma cells and the absence of any significant relationship between leaf area development and leaf cell dimensions.

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