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Morphological Characterization and Structural Features for High Drought Tolerance in some Omani Wheat Landraces

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Abstract. The study was conducted to characterize seven wheat (*Triticum aestivum* L. and *T. durum* L.) accessions from the arid and semi-arid areas of Oman using morpho-anatomical characteristics. Omani wheat germplasm had a great magnitude of variation in qualitative and quantitative morphological characteristics, and stem, leaf sheath and leaf blade anatomical characteristics. Modifications in the structural features related to drought tolerance were thick epidermis and cuticle, highly developed bulliform cells and dense covering of epidermal hairs for preventing water loss. Another feature is highly developed mechanical tissues with intensive sclerification, for providing a mechanical strength to soft tissues and preventing tissue collapse. All these structural modifications are of ecological importance, which can be extremely helpful in combating extreme aridity in these Omani wheat landraces.

Keywords: Omani land races, drought, tolerance, morpho-anatomy, bulliform cells

1. Introduction

Knowledge about germplasm diversity and genetic relationships among breeding materials could be an invaluable aid in crop improvement strategies. A number of methods are currently available for analysis of genetic diversity in germplasm accessions, breeding lines and segregating populations. These methods have relied on pedigree, morphological, agronomic performance, biochemical, and molecular data [1].

The Sultanate of Oman have an ancient cultivation history of bread wheat (*Triticum aestivum* L.), but little is known about the morphological variation, genetic structure, the agronomic properties (such as tolerance against heat, drought and salinity) and quality characteristics of these traditional wheat landraces [2]. Growing on arid to semi-arid climate with low annual precipitation, these wheat landraces can provide excellent genetic material that can enhance the tolerance potential of wheat crop against multiple environmental stresses.

Like any other crop species the first step in wheat improvement is full assessment of the local materials, including collection, evaluation and molecular characterization of germplasm lines. Often, local varieties of crops are of excellent quality and flavour, have a good level of resistance to pests and diseases and may be superior to exotic materials [3].

Anatomical characteristics are the good indicators of plant adaptation to environmental stresses like drought [4]. Thick epidermis and larger size of bulliform cells can play a key role in improving degree of drought tolerance in plants subjected to drought stresses [5], which prevent water loss through plant surface. Furthermore, water deficit conditions result in reduced stomatal density and area in most plants that can play a critical role in reducing transpirational rate [6]. Increased xylem vessel area, especially under drought stress, can aid in efficient translocation water and nutrients [7]. The present studied are, therefore, focused on the

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morphological characterization of Omani wheat landraces and to identify specific anatomical markers for the high drought tolerance in these genetic stock.

2. Methodology

An experiment was conducted to evaluate morphological characterization of primitive Omani wheat germplasm and to examine some specific anatomical characteristics important for drought tolerance. Seven wheat (*Triticum aestivum* L. and *T. durum* L.) landraces from the arid and semi-arid areas of the Sultanate of Oman were sown at Botanical Garden Research Area, University of Agriculture, and Faisalabad. The material was sown in earthen pots filled with clay, sand and peat in equal quantities. Data for day to maturity shoot height leaves per plant, and awn and seed characteristics were recorded at the time of harvesting.

For anatomical studies, all wheat species were selected for root, stem and leaf free-hand sectioning as presented in Table 1. Plant material used for anatomical studies included stem, leaves and leaf sheaths. For stem anatomy one cm piece from the nodal region of the stem was selected. For leaves one cm piece from the leaf centre along the midrib was taken and for leaf sheath one cm piece from the nodal region surrounding the stem was selected. The material was preserved in FAA (formalin acetic alcohol) solution for fixation, which contained v/v formalin 5%, acetic acid 10%, ethyl alcohol 50% and distilled water 35%. The material was then transferred in acetic alcohol solution (v/v 25% acetic acid and 75% ethyl alcohol) for long-term preservation. Double-stained standard techniques were used for staining. Comparative anatomy of leaf, stem and roots structures from the permanent slides and camera photographs were taken by Carl-Zeiss camera microscope.

The experiment was conducted in completely randomized design with four replications. The data were subjected to Analysis of Variance (ANOVA) in completely randomized design (CRD) for the comparison of mean [8]. The anatomical data were also subjected to multivariate analysis to assess the significance of anatomical characteristics in taxonomy of grass species recorded from the Faisalabad region

3. Results

3.1. Morphological Characterization

Stiff stems were recorded in two Omani landraces, Hamira and Shwairaa, whereas all the other landraces had intermediate stiffness (Table 1). Lodging did not occur in two Omani landraces (J-305 and Sarraya), while other landraces showed low to medium stem lodging. Flag leaf attitude was recurved in Hamira and Missani, and semi-erect in Cooley; however, the other landraces /cultivars showed erect flag leaves. Only one landrace depicted strong twist of flag leaf (Senain), but medium twist was recorded in Cooley and Shwairaa, whereas the other landraces showed weak twist.

Two Omani landraces, Cooley and Sarraya, were awnless (Fig. 1). Awns were distributed all over the ears in all Omani wheat landraces. Long awns were recorded in J-305 and Shwairaa and very long in Missani. Horizontal habit of awns was recorded in Missani and Senain, while the other landraces had erect awns. Seed shape was ovate in J-305, Hamira and Senain, whereas elliptic in Missani and Shwairaa, and oval in Cooley and Sarraya. Short seed brush was recorded in Cooley, Missani and Shwairaa, while long in J-305, S-24 and Senain. Seed groove was shallow in Missani and deep in Cooley, J-305, Senain and Sarraya.

J-305, Missani and Cooley were the tall wheat landraces, whereas Shwairaa, Sarraya and Senain were dwarf. Number of leaves per plant was high in Senain and Shwairaa, and low in Missani.

Sarraya and Cooley were the late maturing landraces, while J-305, Missani and Senain were early ear emerging wheats. Number of seeds per plant was high in Hamira and low in Sarraya. 100 seed weight was exceptionally high in Cooley, whereas Missani and J-305 showed higher yield as compared to other landraces, and Shwairaa was the poorest in relation to seed yield production.

3.2. Anatomical Studies

Epidermis thickness was the maximum in Shwairaa and minimum in J-305 (Fig. 2). Epidermal cell area, in contrast, was highest in Sarraya and lowest in Shwairaa. Collenchyma was recorded in four landraces/cultivars, where the maximum collenchymas area was recorded in Sarraya. Collenchyma cell area, on the other hand, was lowest in two landraces, Senain and Sarraya. The largest cortical area was recorded in S-24, which was about two times larger than that recorded in the second best landrace J-305. Lowest cortical area was recorded in Sarraya. Cortical cell area, on contrary, was highest in Cooley, which was closely followed by that recorded in two other Omani landraces, Shwairaa and Missani.

Vascular bundle area on the stem periphery was lowest in Shwairaa. However, central vascular bundle area was maximized in Cooley, which was considerably higher than that recorded in the second best landrace Shwairaa. The minimum of this parameter was recorded in J-305. Cooley possessed the widest metaxylem vessels. Two other Omani landraces, Shwairaa and Sarraya, had significantly wider vessels than those recorded in other landraces/cultivars. This characteristic was the minimum in Senain. Phloem area was highest in Cooley, which was almost double as compared with that recorded in the second best landrace J-305. The minimum of this parameter was recorded in Sarraya.

Table 1: Morphological Characteristics of Some Omani Wheat Landraces from Arid/Semi-Arid Area

Characteristics		Cooley	J-305	Hamaira	Missani	Sarraya	Senain	Shwairaa
Days to maturity	Early		■		■		■	
	Medium			■				■
	Late	■				■		
Plant height	Dwarf		■				■	■
	Medium	■		■	■			
	Tall					■		
Leaf number	Low				■			
	Medium	■	■	■		■		
	High						■	■
Ear size	Small	■		■		■		
	Medium		■					■
	Large				■		■	
Ear shattering	Low							■
	Resistant	■	■	■	■	■	■	
Stem stiffness	Intermediate	■	■		■	■	■	
	Stiff			■				■
Stem lodging	Absent		■			■		
	Low	■						■
	Medium			■	■		■	

Characteristics		Cooley	J-305	Hamaira	Missani	Sarraya	Senain	Shwairaa
Flag leaf attitude	Semi-erect	■						
	Erect		■			■	■	■
	Recurved			■	■			
Flag leaf twist	Weak		■	■	■	■		
	Moderate	■						■
	Strong						■	
Awn distribution	Absent	■				■		
	Whole ear		■	■	■		■	■
Awn habit	Erect	■	■	■		■		■
	Horizontal				■		■	
Seed shape	Oval	■				■		
	Ovate		■	■			■	
	Elliptic				■			■
Seed groove	Shallow				■			
	Intermediate							■
	Deep	■	■	■		■	■	
Seed number	Low					■		
	Moderate	■	■		■		■	■
	High			■				

Fig. 1: Ear structure of some Omani wheat landraces from arid/semi-arid area

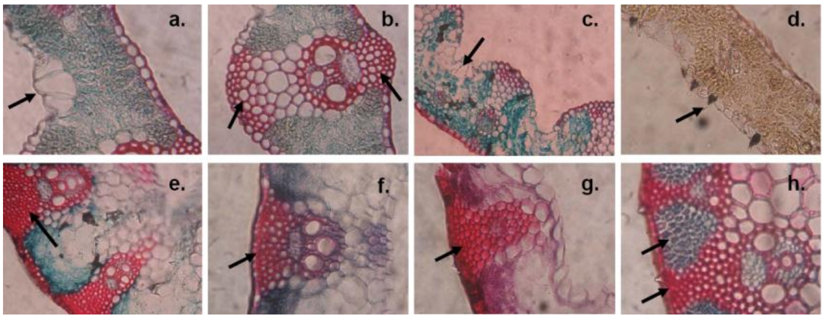

Fig. 2: Transverse sections of stem, leaf sheath and leaf blade of some Omani wheat from arid/semi-arid areas (a. Large bulliform cells in leaf blade of Hamira, b. Intensive sclerification around the vascular bundles in leaf bade of Hamira, c. Deeply grooved bulliform cells in leaf blade of Missani, d. Intensive hairiness on adaxial leaf surface of J-305, e., f., g. Intensive sclerificaion outside the vascular bundles in leaf sheath of Hamira, Cooley and Senain, and h. Intensive sclerification and prominent chlorenchyma in stem of J-305

Omani landrace Shwairaa showed the thickest epidermal layer in leaf sheat, whereas its minimum was noted in J-305. However, epidermal cell area was highest in Shwairaa and lowest in Senain. Collenchyma cells in the leaf sheath were recorded in only one landrace, i.e. Cooley. Aerenchyma in the leaf sheath was recorded in all cultivars and landraces; however, the largest aerenachyma was recorded in Missani, which was more than two-fold than that recorded in second best Cooley. This parameter was the minimum in J-305, which had very much reduced aerenchyma in its leaf sheath as compared with that in the other landraces/cultivars. Large-sized cortical cells were recorded in Hamira and Sarraya, which were closely followed by that recorded in Cooley and Missani. Three Omani wheat landraces, Senain, J-305 and Shwairaa, had very much reduced cortical cells. Omani landrace Hamira showed extraordinarily large sclerenchymatous region, which was about double as compared to that recorded in the second best performer Missani. Sclerechymatous cell area, in contrast, was the maximum in J-305 and the minimum in Missani.

Cooley showed more than two-times larger bundle sheath cells than that recorded in the second best. Vascular bundle area was the maximum in Missani, and this was significantly higher than that recorded in the second best performer Hamira. The minimum of this characteristic was noted in J-305. Metaxylem area was the maximum in Hamira, and this was closely followed by that recorded in Cooley. Phloem area was the maximum in Cooley. Its minimum was recorded in Shwairaa, whereas another Omani landrace J-305 also exhibited very much reduced phloem area as compared with those recorded in the other landraces/cultivars.

Adaxial epidermal cell area in leaf blade was the maximum in Shwairaa, whereas J-305 showed the minimum of epidermal cell area on adaxial leaf surface. Epidermal cell area on abaxial side was the maximum in Cooley and the minimum in Hamira. Sclernchyma thickness was the maximum in Missani its cell area was the maximum in Sarraya. The minimum of this character was recorded in J-305. Total bulliform area was the maximum in Cooley, which was closely followed by that recorded in Missani. The minimum of this character was recorded in Senain, while in two Omani landraces, J-305 and Shwairaa bulliform cells were not formed in the adaxial epidermis.

4. Discussion

Omani wheat landraces are best known for their high tolerance to heat and drought stresses [2], and more likely to salinity stress, as dryland salinities are the characteristic feature of arid and semi-arid lands [9]. In the present study a complete morpho-anatomical characterization of some widely cultivated Omani wheat landraces was conducted for the first time. On the basis of seed yield per plant, Missani, and J-305 were rated as high yielding among all landraces/cultivars, whereas Cooley, Sarraya and Senain the medium, and Hamira and Shwaira the low yielding landraces.

Stem characteristics like stiffness, straw colour, and degree of lodging were among the least variable characteristics in these wheat landraces/cultivars. In general, Omani wheat landraces were more susceptible to lodging, even the stiff-stem bearing landraces like Hamira and Shwairaa. Drought stress is the major constraint in crop yield, and lodging can further aggravates this problem, thereby resulting in total crop failure [10], and this may be one of the potential factors for low seed yields in both Hamira and Shwairaa.

Ear characteristics like shape, density, and awnedness had significant variation in these wheat landraces; however, characteristics like colour at maturity and shattering showed very much consistency. Ear characteristics seemed to be not related to seed weight or grain yield in the present study; however, awnedness is reported to be important in increasing grain yield as this may provide additional photosynthetic capacity to developing grains [11]. However, not much variation was recorded in awn characteristics like distribution, length, and colour at maturity and habit. The high-yielding Missani and J-305 wheat landraces had horizontal habit of awn and the low yielding had erect awn.

Parameters relating to glumes like size, attachment, internal impression and surface roughness had little variation among these landraces/cultivars. Glume may contribute towards grain yield significantly, as an abnormality in glume structure, e.g. glume blotch can greatly reduce yield [12]. Glume characteristic, particularly length and width in our case seemed to affect the grain yield as all the high yielding landraces (Missani and J-305) had long and wide glumes. High yielding J-305 had oval seeds. Seed shape and size are found to be related to grain yield [13], and in addition, in the same study several genomic positions on the genome were found to be related to kernel size and shape. Variation in relation to quantitative morphological characteristics was quite considerable. However, the high yielding landraces/cultivars generally had dwarf to semi-dwarf habit, high tillering capacity, large flag leaf area, early ear emergence, longer and wider ears, and larger and heavier seeds [14].

Modifications in the structural features can support the high degree of drought tolerance in Omani wheat germplasm. Water conservation as well as its efficient translocation seems to be an important strategy in Omani wheat landraces. Structures related to drought tolerance were thick epidermis and cuticle, highly developed bulliform cells and dense covering of epidermal hairs can minimize water loss from a plant surface [15]. Intensive sclerification, that will provide a mechanical strength to soft tissues and can prove to be of high significance, as it can prevent collapse of parenchymatous tissues, which are metabolically active [16]. All these structural modifications are of ecological importane, which can be extremely helpful in combating extreme aridity in these Omani wheat landraces.

5. References

[1] S. A. Mohammadi and B. M. Prasanna. Analysis of genetic diversity in crop plants-Salient statistical tools and considerations. *Crop Sci.* 2003, **43:** 1235-1248.

[2] Al-Maskri, et al., A note about *Triticum* in Oman. *Genet. Resour. Crop Evol.* 2003, **50:** 83-87.

[3] Williams et al., Vegetable production in the tropics. In: intermediate tropical agriculture series. Longman Sci. Tech: Essex, 1991.

[4] M. Hameed, M. Ashraf, M. S. A. Ahmad, and N. Naz. Structural and functional adaptations in plants for salinity tolerance. In: Ashraf M et al. (eds.), *Plant Adaptation and Phytoremediation*, Springer Science+Business Media B.V., 2010.

[5] A. Bahaji, I. Mateu, A. Sanz, and M. J. Cornejo. Common and distinctive responses of rice seedlings to saline- and osmotically-generated stress. *Plant Growth Regul.* 2002, **38:** 83-94.

[6] N. Naz, M. Hameed, M. Ashraf, M. Arshad, and M. S. A. Ahmad. Impact of salinity on species association and phytosociology of halophytic plant communities in the Cholistan desert, Pakistan. *Pak. J. of Bot.* 2010, **42:** 2359-2367.

[7] M. Hameed, S. Batool, N. Naz, T. Nawaz, and M. Ashraf. Leaf structural modifications for drought tolerance in some differentially adapted ecotypes of blue panic (*Panicum antidotale* Retz.). *Acta Physiol. Plant.* 2012, **34:** 1479-1491.

[8] R. G. D. Steel RGD, J. H. Torrie, and D. A. Dickie. *Principles and procedures of statistics: A biometrical approach*. McGraw-Hill, New York, 1997.

[9] B. R. Scanlon, K. E. Keese, A. L. Flint, L. E. Flint, C. B. Gaye, W. M. Edmunds, and I. Simmers. Global synthesis of groundwater recharge in semiarid and arid regions. *Hydrol. Processes*. 2006, **20:** 3335-3370.

[10] H. Kebede, P. K. Subudhi, D. T. Rosenow, and H. T. Nguyen. Quantitative trait loci influencing drought tolerance in grain sorghum (*Sorghum bicolor* L. Moench). *Theor. Appl. Genet.* 2001, **103:** 266-276.

[11] M. Rosella and G. Francesco. Giunta Awnedness affects grain yield and kernel weight in near-isogenic lines of durum wheat. *Aust. J. Agric. Res.* 2002, **53:** 1285-1293.

[12] S. C. Melville and J. L. Jemmett. The effect of glume blotch on the yield of winter wheat. *Plant Pathol.* 2007, **20:** 14-17.

[13] F. Breseghello, M. E. Sorrells. QTL analysis of kernel size and shape in two hexaploid wheat mapping populations. *Field Crops Res.* 2007, **101:** 172-179.

[14] A. Karagoz, N. Pilanali, and T. Polat. Agro-morphological characterization of some wild wheat (*Aegilops* L. and *Triticum* L.) species. *Turkish J. Agric. For.* 2006, **30:** 387-398.

[15] Grigore and C. Toma. Ecological anatomy investigations related to some halophyte species from Moldavia. *Romanian J. Biol.-Plant Biol.* 2008, **53:** 23-30.

[16] J. M. Alvarez, J. F. Rocha, and S. R. Machado. Bulliform Cells in *Loudetiopsis chrysothrix* (Nees) Conert and *Tristachya leiostachya* Nees (*Poaceae*): Structure in relation to function. *Braz. Arch. Biol. Technol.* 2008, **51:** 113-119.