# Genetic diversity for morphological traits and seed storage proteins in Spanish rivet wheat

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## Abstract

The objective of the current work was to analyse the variability of high and low molecular mass (HMM and LMM) glutenin subunits, along with some morphological characteristics in sixty Spanish accessions of rivet wheat (*Triticum turgidum* L. ssp. *turgidum*). The lines were grouped in sixteen botanical varieties and five additional types, according the morphological criteria. Up to 13 allelic variants (four alleles for the *Glu-A1* locus and nine alleles for the *Glu-B1* locus) and 34 B-LMMGs patterns were found in the evaluated lines. The current data indicated a clear reduction of morphological variability, along with an asymmetric distribution of the alleles and patterns for seed storage proteins. This polymorphism could be useful for enlarging the genetic background of modern durum wheat.

*Additional key words*: genetic resources, glutenin subunits, tetraploid wheats, *Triticum turgidum* ssp. *turgidum*.

## Introduction

The modern agriculture interest in high-yield cultivars has borne a great reduction in the genetic diversity of main crops, because it is based on uniform crops with a reliable production. This situation has given rise to a narrowing of the genetic base of plant breeding programmes, which along with the loss of local traditional cultivars, caused an irreversible loss of their genetic diversity. Many of them disappeared of farmlands and are only found in Germplasm Banks (Esquinas 2005). In this context, the search of species that can contribute to enlarge the genetic base of crops such as wheat, is very important (Jauhar 1993). In this respect, the documentation, evaluation and characterization of old collections stored in Germplasm Banks could play a notable role in wheat breeding (Brown *et al*. 1989).

For wheat quality, endosperm storage proteins, which are divided in two main groups (gliadins and glutenins) according to their molecular characteristics (Payne 1987) are very important. Glutenins are further divided in high-molecular mass (HMMGs) and low molecular mass (LMMGs) subunits (Singh and Shepherd 1988, Pogna *et al*. 1990). Among these proteins, the best studied are the HMMGs coded at the *Glu-1* loci located on the long arm of group-1 homoeologous chromosomes (Payne 1987); whereas the LMMGs are coded for the *Glu-3* loci on the short arm of the same homoeologous group. Diverse studies suggest that these latter proteins play an important role in the gluten strength of durum wheat (for review see Oak and Dexter 2006).

The tetraploid wheats (2n=4x=28, AABB), are represented by several species including well known durum wheat [*Triticum turgidum* ssp. *durum* (L) Thell em. Desf.]. Other species, popular in the last, were progressively depleted during the twentieth century. One of these neglected wheat is the rivet wheat (*T. turgidum* L. ssp. *turgidum*), also called poulard wheat, which was often cultivated in the Mediterranean region (Balkans, Italy, South of France, Spain), United Kingdom, Germany and Switzerland. This disappearance was in part stopped by their inclusion in Germplasm Banks. Nowadays, these species are again interesting in wheat breeding programmes. Tellez-Molina and Alonso-Peña (1952) described the diversity of rivet wheat based on morphological traits.

The objective of the current work was to analyse the variability of HMM and LMM glutenin subunits, together with the morphological characteristics in Spanish accessions of rivet wheat.

*Received* 1 May 2008, *accepted* 21 December 2008.
*Abbreviations*: Glu - glutenin; HMM - high molecular mass; LMM - low molecular mass.
*Acknowledgements*: This research was supported by grant AGL2007-65685-C02-02 from the Spanish Ministry of Education and Science and the European Regional Development Fund (FEDER) from the European Union. The first author is grateful to the Spanish Ministry of Education and Science (FPI programme) and European Social Fund for a predoctoral fellowship.
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## Materials and methods

Sixty rivet wheat (*T. turgidum* L. ssp. *turgidum*) lines developed from the identical accessions number obtained from Centro de Recursos Fitogenéticos INIA (Alcalá de Henares, Spain) and National Small Grain Collections (Aberdeen, USA), were analysed in this study (Table 1). These lines were grown during 2005/2006 and 2006/2007 in a 1 m, one row-plot of an un-replicated trial in the Guadalquivir River Valley (Cordoba, Spain) with standard agronomic practice for the region at the CIFA-IFAPA experimental station at Cordoba, Spain.

Eight qualitative morphological traits elected among the descriptors of the International Union for the Protection of New Varieties of Plants (UPOV 1994), were measured on the collected material. These traits were: spike shape, section of stem, hairiness in spike neck, presence or not awns, glumes-beak shape, glumes-beak length, glumes shoulder shape and glumes shoulder width. Additionally, several traits: glumes colour, glumes types, glumes with or without pigmented edge, awn colour and grain colour were measured to group these materials according to the classification of Lagasca and Clemente (Tellez-Molina and Alonso-Peña 1952).

Proteins were extracted from single crushed seed according to protocol, described by Alvarez *et al.* (2001). Reduced and alkylated glutenin subunits were fractionated by electrophoresis in vertical SDS-PAGE slabs in a discontinuous Tris-HCl-SDS buffer system (pH 6.8/8.8) at 8 % polyacrylamide. LMM glutenin subunits were analysed by 10 % gels. The Tris-HCl/glycine buffer system of Laemmli (1970) was used. Electrophoresis was performed at a constant current of 30 mA and temperature of 18 ºC for 45 min after the tracking dye migrated off the gel. All the gels were stained overnight with 12 % (m/v) trichloroacetic acid solution containing 5 % (v/v) ethanol and 0.05 % (m/v) Coomassie Brillant Blue R-250. De-staining was carried out with tap water.

Allelic frequencies and the effective numbers of alleles per locus (Ne) at the *Glu-A1* and *Glu-B1* loci, together with the B-LMMGs were calculated. The genetic diversity was estimated using Nei's diversity index (He; (Nei 1972, 1973).

Table 1. Origin of the 60 lines of rivet wheat used in this work. No. UCO - line number of the Germplasm Bank of the Department of Genetics at the University of Cordoba.

| No. UCO | Accession | No. UCO | Accession | No. UCO | Accession |
|---|---|---|---|---|---|
| TRG-002 | BGE-013083 | TRG-214 | BGE-013076 | TRG-234 | BGE-013735 |
| TRG-003 | BGE-013090 | TRG-215 | BGE-013077 | TRG-235 | BGE-018620 |
| TRG-004 | BGE-013093 | TRG-216 | BGE-013078 | TRG-236 | BGE-018622 |
| TRG-005 | BGE-013096 | TRG-217 | BGE-013079 | TRG-237 | BGE-018625 |
| TRG-006 | BGE-013097 | TRG-218 | BGE-013081 | TRG-238 | BGE-018626 |
| TRG-007 | BGE-013717 | TRG-219 | BGE-013084 | TRG-239 | BGE-018643 |
| TRG-008 | BGE-013721 | TRG-220 | BGE-013089 | TRG-240 | BGE-018678 |
| TRG-009 | BGE-018621 | TRG-221 | BGE-013091 | TRG-241 | BGE-019290 |
| TRG-010 | BGE-018627 | TRG-222 | BGE-013099 | TRG-242 | BGE-019291 |
| TRG-011 | BGE-018628 | TRG-223 | BGE-013100 | TRG-243 | BGE-020946 |
| TRG-012 | BGE-018653 | TRG-224 | BGE-013101 | TRG-244 | PI-190932 |
| TRG-013 | BGE-018655 | TRG-225 | BGE-013103 | TRG-245 | PI-190948 |
| TRG-014 | BGE-018677 | TRG-226 | BGE-013718 | TRG-246 | PI-190978 |
| TRG-045 | PI-191203 | TRG-227 | BGE-013719 | TRG-247 | PI-191104 |
| TRG-047 | PI-191445 | TRG-228 | BGE-013722 | TRG-248 | PI-191145 |
| TRG-071 | PI-352518 | TRG-229 | BGE-013724 | TRG-249 | PI-221424 |
| TRG-210 | BGE-012534 | TRG-230 | BGE-013725 | TRG-250 | PI-352520 |
| TRG-211 | BGE-012555 | TRG-231 | BGE-013726 | TRG-251 | PI-352521 |
| TRG-212 | BGE-012557 | TRG-232 | BGE-013729 | TRG-252 | PI-352526 |
| TRG-213 | BGE-013074 | TRG-233 | BGE-013733 | TRG-253 | PI-352530 |

## Results

The glumes colour was mainly white (39 lines), while the red glumes were present in 19 lines and the black glumes were present in two lines. Twenty-five lines possessed pubescent glumes, whereas thirty-five lines showed glabrous glumes (Table 2). The lines with glumes with pigment edges were fifteen. So, the white awns (34 lines) were predominant and the other two awn types, fifteen lines presented red awns and eleven ones had the black awns. Approximately, half of the lines showed red grain (29 lines), whereas the other half were white grain.

Using these traits, the lines were grouped in sixteen botanical varieties and five additional botanical types, according to the criteria indicated by Lagasca and Clemente in their 'Ceres Hispanica' herbarium

Table 2. Lines of rivet wheat grouped according to the classification of Lagasca and Clemente (Tellez-Molina and Alonso-Peña 1952). GC - glumes colour, GT - glumes type, GED - glumes with edge, AC - awn colour, GRC - grain colour.

| GC | GT | GED | AC | GRC | Botanical variety | Lines |
|---|---|---|---|---|---|---|
| black | glabrous | yes | white | white | var. *herrerae* Körn | TRG-237 |
| | | | | red | var. *nigro-glumaceum* Flaks | TRG-226 |
| red | glabrous | yes | red | white | not identified (type I) | TRG-213, TRG-246 |
| | | | | red | not identified (type II) | TRG-242 |
| | | no | red | white | var. *dreischianum* Körn | TRG-221, TRG-007, TRG-012 |
| | | | | red | var. *speciosum* Alef | TRG-249, TRG-227, TRG-253 |
| | pubescent | yes | black | red | var. *triste-rubro-atrum* Al. | TRG-011, TRG-222 |
| | | | red | white | not identified (type III) | TRG-010 |
| | | | | red | not identified (type IV) | TRG-239, TRG-252 |
| | | | white | white | not identified (type V) | TRG-243 |
| | | no | black | white | var. *rubroalbum* Flaks | TRG-225 |
| | | | red | red | var. *dinurum* Alef | TRG-233, TRG-071, TRG-250 |
| white | glabrous | yes | black | white | var. *miscibile* Haçid | TRG-003, TRG-047 |
| | | | white | white | var. *nigroglumarum* Haçid | TRG-009, TRG-219 |
| | | no | black | white | var. *melanatherum* Körn | TRG-008 |
| | | | white | white | var. *lusitanicum* Körn | TRG-210, TRG-214, TRG-215, TRG-216, TRG-232, TRG-235, TRG-002, TRG-217, TRG-0045 |
| | | | | red | var. *gentile* Alef | TRG-220, TRG-228, TRG-234, TRG-231, TRG-236, TRG-238, TRG-013, TRG-241, TRG-244, TRG-218 |
| | pubescent | no | black | white | var. *salomonis* Körn | TRG-212, TRG-006, TRG-014 |
| | | | | red | var. *pseudosalomonis* Papad | TRG-230, TRG-005 |
| | | | white | white | var. *megalopolitanum* Körn | TRG-240, TRG-248, TRG-247 |
| | | | | red | var. *buccale* Alef | TRG-211, TRG-224, TRG-229, TRG-245, TRG-251, TRG-223, TRG-004 |

Table 3. Frequency distribution [%] of spike qualitative characters in rivet wheat which did not use above (spike shape: 1 - tapering, 2 - parallel side, 3 - fusiform; stem section: 1 - thin, 2 - medium, 3 - thick; glumes beak shape: 1 - straight, 2 - moderately curved; glumes beak length: 1 - short, 2 - medium, 3 - long, 4 - extremely long; glumes shoulder shape: 1 - sloping, 2 - straight, 3 - elevated; glumes shoulder width: 1 - narrow, 2 - broad).

| Botanical varieties | Spike shape | | | Stem section | | | Glumes beak | | | | | | Glumes shoulder | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | shape | | length | | | | shape | | | width | |
| | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 1 | 2 |
| var. *buccale* | 3 | 3 | 1 | 6 | 1 | 0 | 4 | 3 | 5 | 1 | 0 | 1 | 6 | 0 | 1 | 7 | 0 |
| var. *dinurum* | 2 | 1 | 0 | 3 | 0 | 0 | 2 | 1 | 0 | 0 | 2 | 1 | 2 | 1 | 0 | 2 | 1 |
| var. *dreischianum* | 3 | 0 | 0 | 0 | 2 | 1 | 3 | 0 | 2 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 3 |
| var. *gentile* | 4 | 5 | 1 | 7 | 1 | 2 | 4 | 6 | 2 | 3 | 5 | 0 | 5 | 5 | 0 | 7 | 3 |
| var. *herrerae* | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| var. *lusitanicum* | 5 | 4 | 0 | 5 | 2 | 2 | 7 | 2 | 6 | 2 | 1 | 0 | 7 | 1 | 1 | 7 | 2 |
| var. *megalopolitanum* | 1 | 2 | 0 | 0 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 2 | 1 |
| var. *melanatherum* | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| var. *miscibile* | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 2 | 0 |
| var. *nigro-glumaceum* | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| var. *nigroglumarum* | 0 | 2 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 1 | 1 |
| var. *pseudosalomonis* | 1 | 1 | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 2 | 0 |
| var. *rubroalbum* | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| var. *salomonis* | 1 | 2 | 0 | 0 | 2 | 1 | 0 | 3 | 0 | 1 | 2 | 0 | 2 | 1 | 0 | 2 | 1 |
| var. *speciosum* | 1 | 2 | 0 | 0 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 2 | 1 | 0 | 2 | 1 |
| var. *triste-rubro-atrum* | 2 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 2 | 0 | 1 | 1 |
| type I | 1 | 1 | 0 | 2 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| type II | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| type III | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| type IV | 1 | 1 | 0 | 2 | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 1 |
| type V | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |

Table 4. Distribution of allelic variants.

| Botanical varieties | N | *Glu-A1* Null | 1 | 2* | 2' | *Glu-B1* 6+8 | 7+8 | 13+16 | 17'+18' | 17'+18* | 6 | 7 | 8' | 13**+8* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| var. *buccale* | 7 | 0 | 7 | 0 | 0 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| var. *dinurum* | 3 | 0 | 3 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| var. *dreischianum* | 3 | 1 | 1 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| var. *gentile* | 10 | 1 | 3 | 5 | 1 | 4 | 0 | 2 | 1 | 0 | 2 | 0 | 1 | 0 |
| var. *herrerae* | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| var. *lusitanicum* | 9 | 0 | 4 | 4 | 1 | 4 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 0 |
| var. *megalopolitanum* | 3 | 1 | 0 | 2 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| var. *melanatherum* | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| var. *miscibile* | 2 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| var. *nigro-glumaceum* | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| var. *nigroglumarum* | 2 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| var. *pseudosalomonis* | 2 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| var. *rubroalbum* | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| var. *salomonis* | 3 | 1 | 0 | 2 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| var. *speciosum* | 3 | 0 | 1 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| var. *triste-rubro-atrum* | 2 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| type I | 2 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| type II | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| type III | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| type IV | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| type V | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

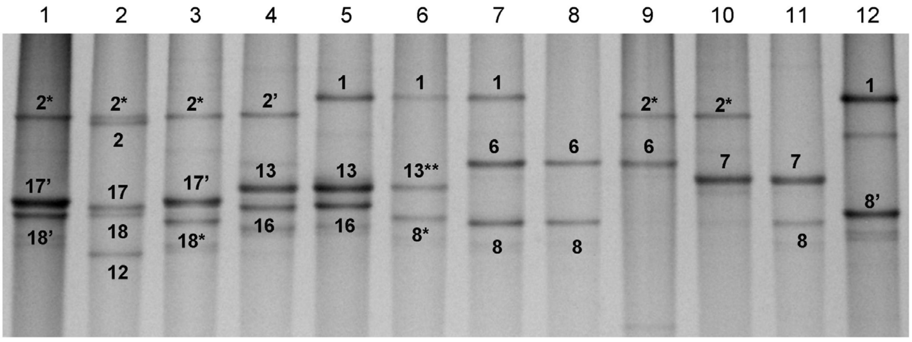


Fig. 1. SDS-PAGE (8 %) patterns of HMMGs from some Spanish lines of rivet wheat, representative of the different allelic variants detected at the *Glu-A1* and *Glu-B1* loci. *Lanes* are as follow: 1 - TGR-214; 2 - cv. *Gabo*; 3 - TGR-2246; 4 - TGR-218; 5 - cv. *Alaga*; 6 - TGR-003; 7 - TGR-007; 8 - cv. *Langdon*; 9 - TGR-220; 10 - TGR-222; 11 - cv. *Mexicali*; and 12 - TGR-244.

(unpublished work), collected during the nineteenth century (Tellez-Molina and Alonso-Peña 1952). The five botanical types included seven lines that were not associated to any botanical varieties indicated by these Spanish botanists (Table 2).

The botanical varieties with a greater number of lines were the var. *gentile* Alef (10 lines) and *lusitanicum* Körn (9 lines) with white glumes and awns and red and white grain, respectively; follow of the var. *buccale* Alef (7 lines), similar to var. *gentile* but with pubescent glumes. Of the other botanical varieties, five (var. *dreischianum* Körn, var. *speciosum* Alef, var. *dinurum* Alef, var. *salomonis* Körn, and var. *megalopolitanum* Körn) had three lines each. For the botanical types, two of them presented two lines each (type I and IV).

The botanical varieties and types were characterised for the additional traits elected above. Two of these traits did not show variation; all lines presented awns and did not show glaucosity in spike neck. Only the TGR-225 line (var. *rubroalbum* Flaks) presented hair in spike neck. In Table 3 the rest of spike traits are shown. For spike shape, three different types were detected; being the fusiform spikes the less frequent in all lines (3 lines). The other two spike shape (tapering and parallel side) showed similar number of lines among them (29 and 28, respectively). Only the var. *gentile* and *buccale* presented the three spike types (Table 4). For the section of stem three classes were detected, being the most frequent the thin stem that appeared in half of the lines. Glumes beak shape was measured two types which showed similar number of lines. Out of the four possible types for glumes beak length it is the extremely long beak that is the less frequent, detected only in the var. *dinurum* and *buccale*. Glumes with sloping shoulder were the most frequent overall lines (39 lines), for the contrary elevated shoulder was the less frequent, appearing in only 4 botanical varieties. Two possible types were detected by the glumes shoulder width, 42 lines showing narrow shoulder.

The HMMGs of several rivet wheat lines representative of the variation detected are shown in Fig. 1. Up to 13 allelic variants (four alleles for the *Glu-A1* locus and nine alleles for the *Glu-B1* locus) were found in the evaluated lines. The effective number of alleles obtained for these loci (Ne = 2.70 and 3.40, respectively) was lower than the number of alleles detected. This suggests that, although the genetic diversity was high (He = 0.600 and 0.700, respectively), great part of this diversity is in clear danger of erosion. Five novel allelic variants were detected (one for the *Glu-A1* locus and four for the *Glu-B1*). For the *Glu-A1* and *Glu-B1* loci, 15 allelic combinations were found. The allelic combination 1, 6+8 was the most frequent (26.7 %) followed by the combination 2*, 6+8 with 15.8 %. The five novel alleles were presented in six combinations.

Table 4 shows the distribution of allelic variants among the botanical varieties and not identified lines. For the *Glu-A1* locus, the alleles with higher number of lines were *Glu-A1a* (subunit 1) and *Glu-A1b* (subunit 2*), which presented similar number of lines (26 and 25, respectively). The other two allelic variants showed a lower number of lines. The novel allele (subunit 2’) was found in four botanical varieties.

The allelic variant more frequent for the *Glu-B1* locus was the *Glu-B1d* allele (subunits 6+8) followed by of the *Glu-B1a* allele (subunits 7+8). Among the novel alleles, the allelic variant 17’+18* and 8’ presented the less number of lines (Table 4). The latter allelic variant was detected in a unique variety (var. *gentile*) that presented the most number of lines. The allelic variant 13**+8* was detected in two varieties (var. *melanatherum* and *miscibile*). Allelic variant 17’+18’ was presented in the var. *dreischianum*, *lusitanicum* and *gentile*, likewise in the TGR-242 line.

Thirty-four patterns were identified in the LMM glutenin subunits, which presented between three and five bands (Fig. 2). The patterns with four bands were the most frequents, appearing in 21 lines, followed by the patterns with 3 bands that appeared in 19 lines. The effective number of alleles (Ne = 21.20) and the genetic diversity (He = 0.900) indicated that the danger of genetic erosion in these loci is minor to that detected in the *Glu-1* loci.

The most frequent patterns were 15 and 6, that appeared in seven and five lines respectively; gave out in six botanical varieties and two botanical types. Ten patterns had among two and four lines and the other 22 patterns appeared in unique line. The patterns had similar structures with small changes in the mobility in some of their bands (*e.g.* patterns 3 and 4 or 19 and 21). Overall patterns were separated as LMM-1 type associated to soft gluten strength and LMM-2 type with strong gluten strength (Carrillo *et al*. 1990, Payne *et al*. 1984). Four LMM-1 (patterns of 1 to 4) and thirty LMM-2 patterns (patterns of 5 to 34) were detected. The LMM-1 patterns were observed in two botanical varieties and BGE 018643. Most lines with LMM-1 patterns belong to var. *buccale*.

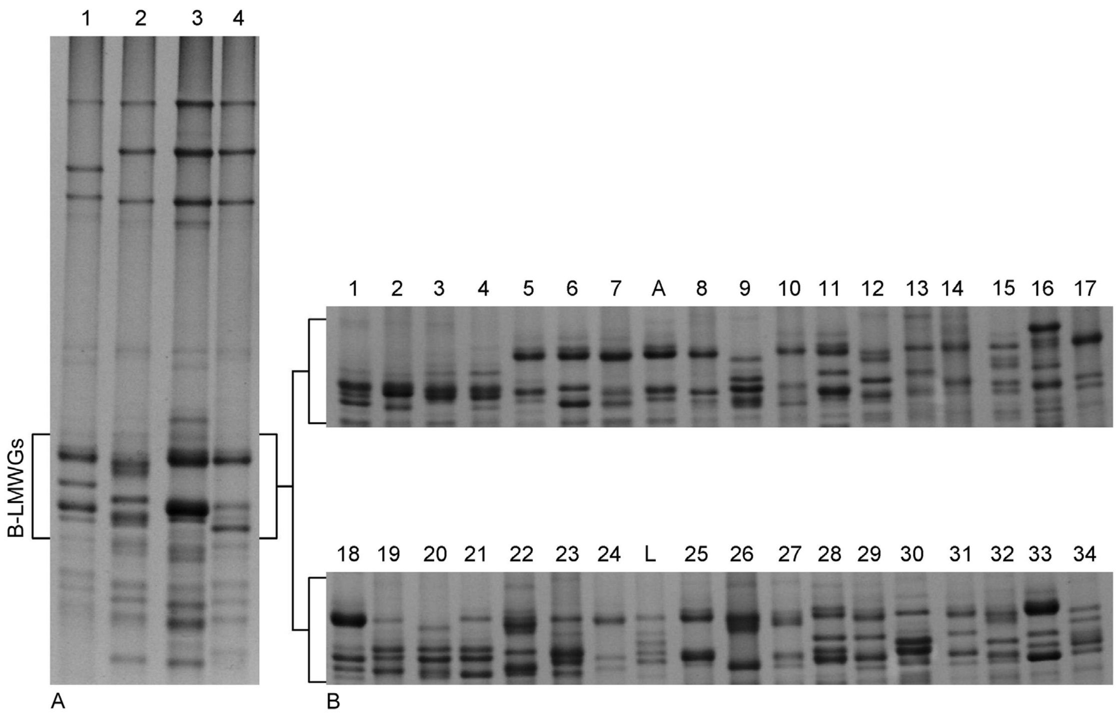


Fig. 2. SDS-PAGE (10 %) from several lines of rivet wheat. Each lane corresponds to the different pattern found. A - cv. Alaga and L - cv. Langdon. *A* - complete gel; *B* **-** only the lower part of the gel corresponding to the LMM-Gs is shown**.**

## Discussion

The ultimate aim of exploring the genetic potential of the neglected crops stored in Germplasm Banks is to make an informed decision on their conservation, given that the genetic erosion of these materials could be higher than expected (Virchow 1999, Hammer 2003). Diverse tools have been used for the evaluation of the genetic diversity in cultivated and wild species, the most widely used being the seed storage proteins together with the microsatellites (Stoilova *et al*. 2006, Mirali *et al*. 2007, Yao *et al*. 2008, Yüzbaşioğlu *et al*. 2008). Furthermore, because the lack of genetic diversity is an important burden on future breeding advances, they could be used to develop new germplasm.

Only 16 of 39 botanical varieties found by Lagasca and Clemente, were detected in the current materials, which implies a great loss of the diversity. Additionally, five botanical types which were not included in the "Ceres Hispanica" herbarium (Tellez-Molina and Alonso-Peña 1952) were found. These types presented two traits in common: red glumes and glumes with pigment edge.

With respect to other morphological traits measured (UPOV 1994), the current materials showed a high variation. However, these traits could not be used to define the botanical varieties because any botanical varieties showed a specific UPOV's trait. The same occurred for HMMGs and B-LMMGs: any relationship was not found between allelic variants and patterns and botanical varieties.

The composition of the HMMGs and B-LMMGs of this subspecies (rivet wheat) has not been previously described. The results indicated a high variability for the HMMGs with up to 13 allelic variants, similar to those found in previous studies on Spanish emmer wheat (Pflüger *et al*. 2001, Alvarez *et al*. 2007) and Turkish and Italian durum wheat (Turchetta *et al*. 1995), although higher than that was found in others studies in durum wheat cultivars (Carrillo *et al*. 1990, Lerner *et al*. 2004). A similar fact occurs for the B-LMMGs, where up to 34 patterns were detected. This was higher variability than detected by Nieto-Taladriz *et al*. (1997) in 88 durum wheat cultivars (18 patterns) or Pflüger *et al*. (2001) in 97 emmer wheat accessions (23 patterns).

The current data of rivet wheat indicated a clear reduction of morphological variability, along with an asymmetric distribution of the alleles and patterns found for seed storage proteins. The low frequencies in the new allelic variants and patterns show the necessity to protect and maintain of this species, because the possibility of finding the same alleles or patterns in other materials is very low. This confirms the importance of the evaluation of materials included in Germplasm Banks, which could be an important source of genes.

This material is being recuperated and multiplied to maintain this variability. Later, an analysis of the agronomic characteristics, including their qualities, must be undertaken. This variability could be used to enlarge the genetic base for seed storage proteins of durum wheat, along with the use of this species as a crop *per se*.

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## Giles W.: **Encyclopedia of Exotic Plants for Temperate Climate -** Timber Press, Portland 2007. 440 pp. USD 49.95. ISBN-13: 978-0-88192-785-6.

For years, growing of exotic plants in the climatic conditions of temperate zone has been an unrealizable ambition of many gardeners. Will Giles brings this dream into a reality in his new book.

The "Encyclopedia of Exotic Plants for Temperate Climate" is a comprehensive publication, which describes more than 1500 plant species and cultivars including bromeliads, succulents, palms, aroids, bamboos, ferns and many others. Text is richly replenished with over 500 colour photographs most of which is the work of the author. Individual entries contain Latin and English botanical names, description of given plant, information of its geographic origin, preferred microclimatic conditions, as well as detailed growing procedure. Some entries are also accompanied by interesting remarks, *e.g.*, where the botanical name "passionflower" (*Passiflora*) came from. This book also includes contact information about recommended nurseries and seed companies in the United Kingdom, North America and Central Europe.

The author is a head of The Exotic Garden in Norwich and an internationally recognized expert in gardening of exotic plants in climatic conditions of Great Britain. Initially, he was working as an illustrator and photographer for botanical books and magazines. Over the past ten years, Will Giles has been leading tours to outlying parts of the world, *e.g.*, Sri Lanka, Caribbean, or Madeira Island, all with a botanical theme. Nowadays, he is a regular contributor to several television and radio gardening programs. His passion and invaluable first-hand experience with growing of exotic plants is noticeable throughout this book.

This book is written in a clear, very readable style, which makes it accessible to both non-specialists and professionals. The encyclopedia is destined for all enthusiastic gardeners of all levels, who will find in it inspiration and courage to carry out experiments with new plants, and create extraordinary flowerbeds in their gardens. Excellent photographs even enhance this inspiring and reliable resource. Last but not least, recommended price of the publication seems surprisingly low comparing to its quality.

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