

"Renval". This finding corresponds with data of Vlasak (1995), Lacko-Bartošová, Antala (?...), Lacko-Bartošová et al. (1999). Cultivar "Renval" had in majority of hybrid combinations in F1 generation positive influence on values of experimental traits.

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## POSSIBILITIES OF SYNTHETIC AMPHIPOID USE FOR ENLARGEMENT OF GENETIC DIVERSITY IN WHEAT

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## Summary

The world-wide gene pool of common wheat is descended from a very small number of spontaneous interspecific hybrids, which originated as a result of two natural amphiploidisation events. In the more recent event, plant(s) of emmer wheat (*Triticum dicoccoides*), which were cultivated at the time by early Neolithic farmers, were fertilised by weedy diploid goatgrass (*Aegilops tauschii*), producing primitive common wheat. Because of the rarity of this event, today's common wheat (*T. aestivum*) has extremely low levels of polymorphism at enzyme, storage protein, and DNA marker loci, compared with its parent species, especially *Ae. tauschii*. In fact, the bulk of evolutionary evidence suggests that common wheat began its existence as a highly monomorphic species and that its genetic variation was reduced further by domestication. Despite its narrow genetic base, human-guided evolution has produced a profusion of distinct landraces over a period of 5 or more millennia, and modern breeding has maintained steady genetic improvement throughout the current century. Interspecific hybridisation has shown to be a useful tool in the breeding of cultivated species of *Triticeae* tribe. This technique has been mainly used for transferring some interesting characters, such as resistance to biotic and abiotic stresses and other traits of agronomic interest. We present an overall survey of amphiploids created with the utilisation of wheat genomes. Potential uses of synthetic amphiploids to introgress genetic material into *Triticeae* species and amphiploidisation to expand the wheat gene pool are discussed.

**Key words:** amphiploid, synthetic, wheat, triticale, tritordeum, tritinaldia, agrotana, agroticum, diversity, gene pool

Wild forms from regions of their natural occurrence are still an undervalued source of the genetic diversity, which will have to be incorporated into the present breeding programmes and used in agriculture. The increasing requirements for the performance of wheat varieties make the breeders use a limited range of approved parental forms (varieties) for hybridisation. The result is an increasing proportion of genetic similarities of the newly formed varieties, which has a negative impact on their longevity. In pure cultures, where the diversity of resistance genes is limited, we see a rapid selection of new virulent pathotypes of fungal diseases, which could soon overcome the resistance of their hosts. This is the reason why the search for new donors of resistance against biotic and abiotic stress factors, which would be potentially effective for a long time, is so urgent. The use of the so-called "non-host resistance", which occurs in some genetically distant wild species, has lately been frequently mentioned.

During the evolution of the *Triticeae* tribe, which includes *Triticum*, *Hordeum* and *Secale*, i.e. genera most frequently used in agriculture, spontaneous amphiploidy played an important role. Induced amphiploidy allows building up completely different genomes into the common organism. Table 1 presents a survey of amphiploidies.

Synthetic wheat:

*Ae. tauschii* (2n = 2x = 14,DD) is a generally acknowledged donor of the D genome of hexaploid wheat with a high degree of homology, even though the present study of genetic diversity within the framework of *Ae. tauschii* showed that the D genome of wheat could be of polyphyletic origin. Some authors also maintain that amphiploid hexaploid wheat with the AABBDD genome is not a product of unique hybridisation, but that its origin could occur more times through recurrent hybridisation of various tetraploid and diploid parents. Within the *Ae. tauschii* species a high degree of variability in many characters and properties can be assumed, which could also be the source of desirable genes of resistance to fungal diseases of wheat. Successful translocation of resistance to diseases and pests and resistance to stress have been recorded and *Ae. tauschii* is also considered to be the source of new alleles for storage proteins of genes localised on the 1D chromosomes. There is a sufficient degree of recombinant interchanges between the D genomes of *Ae. tauschii* and *T. aestivum*, made possible by pairing the chromosomes in meiosis, which facilitate the translocation of required properties from the diploid donor species into the genome of cultivated wheat. Therefore, there are no problems, such as can be seen in products of wide hybridisation of species with unrelated and also related, but non-homologous genomes.

Table 1 – Survey of some amphiploidy forms produced using wheat

Name		Type of hybridisation	Genomes (2n)	Reference
synthetic wheat		<i>(Triticum turgidum</i> conv. <i>durum</i> , <i>T. carthlicum</i> ) x <i>Aegilops tauchii</i>	AABBDD	Mujeeb et al. (1996, 1997)
		<i>(T. boeoticum</i> , <i>T. monococcum</i> , <i>T. ururu</i> ) x <i>T. turgidum</i> conv. <i>durum</i>	AAAABB	Ma et al. (1997)
other synthetic forms		<i>T. durum</i> x <i>Ae. caudata</i>	AABBCC	Aghaee-Saebarzeh et al. (2000)
		<i>T. durum</i> x <i>Ae. umbellulata</i>	AABBUU	
		<i>(T. turgidum</i> , <i>T. aestivum</i> ) x <i>Ae. variabilis</i>	AABBUUSS, AABBDDUUSS	William, Mujeeb (1996)
		<i>Ae. tauchii</i> x <i>Agropyron cristatum</i>	DDPP	Martin et al. (1998)
triticale	x <i>Triticosecale</i> Wittmack	<i>Triticum</i> spp. x <i>Secale cereale</i> L.	AARR, AABBRR, AABBDDRR	extensive literature
tritordeum	x <i>Tritordeum</i> Ascherson et Graebner	<i>Triticum</i> spp. x <i>Hordeum chilense</i> Roemer et Schultese	AABBH <sup>ch</sup> H <sup>ch</sup> , AABBDDH <sup>ch</sup> H <sup>ch</sup>	Martin, Cubero (1981)
tritinaldia		<i>(T. turgidum</i> , <i>T. aestivum</i> ) x <i>Haynaldia villosa</i> Schur ( <i>Dasypyrum villosum</i> L.) (synthetic amphiploid)	AABBVV, AABBDDVV	Pace. et al. (1985); Yao-JingXia et al. (1995)
	x <i>Haynaldoticum sardoum</i> Meletti et Onnis	<i>T. spp</i> x <i>Haynaldia villosa</i> Schur ( <i>Dasypyrum villosum</i> L.) (spontaneous amphiploid)	AABBVV	Meletti et al. (1996)
agrotana		<i>T. aestivum</i> x ( <i>T. bessarabicum</i> / <i>Elymus farctus</i> subsp. <i>bessarabicus</i> or <i>Thinopyrum ponticum</i> / <i>E. elongatus</i> /)	AABBDDJJ	Chen-Quin et al. (1995)
agrotricum (wheat x wheatgrass)		<i>T. aestivum</i> x <i>Thinopyrum intermedium</i> ( <i>Agropyrum intermedium</i> , <i>Elymus hypsidus</i> )	AABBDDEE <sup>+</sup>	Chen-Quin et al. (1999); Liu-Bao et al. (1999)
		<i>T. aestivum</i> x <i>Thinopyrum ponticum</i> ( <i>Lolopyrum elongatum</i> /Host/ A. Love, <i>Elymus elongatus</i> )	AABBDDEE <sup>+</sup>	Colmer et al. (1995); Kasai et al. (1998); Chen-Quin et al. (1998)
		<i>T. aestivum</i> x <i>Elymus sibiricus</i>	AABBDDEE <sup>+</sup>	Motsnyi et al. (2000)
		<i>Triticum aestivum</i> x <i>Thinopyrum intermediatum</i> ( <i>Elymus hypsidus</i> )	AABBDDE <sup>1</sup> E <sup>1</sup> or AABBDDE <sup>2</sup> E <sup>2</sup>	Gao-Zhi et al. (1998); Limin et al. (1995)
(wheat x lymegrass)		<i>(T. aestivum</i> , <i>T. carthlicum</i> ) x ( <i>Leymus arenarius</i> , <i>L. mollis</i> )	hexaploid, octoploid	Anamthawat-Jonsson (1996)
		<i>T. spp.</i> x <i>Leymus mollis</i>	hexaploid	Anamthawat-Jonsson (1999)

<sup>+</sup>) Amphiploid forms differ in their genomes due to different species of the *Elymus* genus.

Under conditions of Central Europe it is necessary to consider its use particularly for creating sources of resistance to *Puccinia recondita* f.sp. *tritici* and to powdery mildew *Blumeria graminis* (DC) Speer f.sp. *tritici* (= *Erysiphe graminis* (DC) f.sp. *tritici* Marchal).

Translocation of resistance to diseases and pests and resistance to stress have been successful and *Ae. tauschii* is considered to be the source of new alleles for storage proteins of genes localised on the 1D chromosomes.

#### Triticale

In 1875, Wilson described the first spontaneously formed sterile form. Rimpau obtained the first fertile triticale amphiploid in 1888. After the production of the first triticale variety in 1968, it was the object of keen breeding attention leading to the application of many varieties in practice. The presence of the rye genome is responsible for the specific properties of the crop, particularly its potential use in poorer conditions of growing and worse feeding quality of the grain. Great attention has recently been devoted to the possible improvement of some triticale properties by means of purposefully created amphiploids and induction of translocations. A good example is e.g. to transfer a segment of chromosome 1D from bread wheat possessing the Glu D1 (5+10) allele to hexaploid triticale through a centric break-fusion using 5D/5B translocation conditioned by the absence of the *Ph* gene (Lukaszewski, Curtis, 1992, 1994). That enabled to obtain the recombinant chromosome 1R having a small segment of 1D with the glutenin allele Glu D1 (5+10). Two types of translocation of 1R chromosome, 1R.1D5+10 differing in a size of transferred segment of chromosome from 1D were obtained. They were designated by symbols 1R.1D5+10-1 and 1R.1D5+10-2 (1 and 2 indicate these translocations differing in the length of the 1D chromosome segment). Both described translocation chromosomes in hexaploid triticale with Glu D1 (5+10) lead to a considerable increase in bread volume and breadmaking quality of triticale (personal communication, Lukaszewski, 2000).

#### Tritordeum

The production of tritordeum, created in Cordoba in Spain where it is intensively studied and bred, is considered to be a significant success in the area of genetics. According to literary data increasing the yield potential has been progressing in the present forms. Tritordeum is also a potential source for the translocation of some important properties of barley to wheat and, in some cases, also into other cereal species. *Hordeum chilense* is resistant to rust, especially to leaf rust (*P. recondita* f.sp. *tritici*, *Blumeria graminis* /= *Erysiphe graminis*/), septoria leaf blotch (*Septoria tritici* /*Mycosphaerella graminicola*/), common bunt (*Tilletia caries*), loose smut of barley (*Ustilago nuda*), loose smut of wheat (*U. tritici*), net blotch (*Pyrenophora teres*) and scald (*Rhynchosporium secalis*). It is also considered to be a source of resistance to some insect pests, i.e. *Diuraphis noxia*, *Rhopalosiphum padi* and *Schizaphis graminum*, and also to *Meloidogyne* spp.

The existence of a wide genetic variability of tritordeum resistance to diseases of the ear (*F. culmorum*, *F. graminearum* [*Gibberella zeae*], *Stagonospora nodorum*) is the prerequisite for the finding of resistance donors, which could be applied in wheat breeding. Hexaploid tritordeum has a very high content of proteins. We can therefore assume that it could be used for feeds.

#### Tritinaldia, *xHaynaldoticum sardoum*

Several stable hexaploid lines (2n = 42), with the genome AABBVV, were obtained from the cross *T. durum* cv. Modoc x *D. villosum* (*Haynaldia villosa*) and these synthetic amphiploids are potential donors of resistance to powdery mildew (Pace et al., 1985; Yao-Jing Xia et al., 1995). In addition to these synthetic forms there are also spontaneous amphiploid forms, which are known as „Denti de cani“ (dog's teeth) and are considered to originate from crosses between durum wheat and *D. villosum*, common in durum wheat fields in Italy. Two pure lines, one with a hollow stem CV (winter) and the other with a solid stem CP (spring), were selected from populations growing in Sardinia. Since 1987, these 2 lines have been grown and evaluated in Pisa and other areas of Italy. Both lines are tall and give a grain yield of only 0.8-1 t.ha<sup>-1</sup>, they have good resistance to *Fusarium* wilt and produce flour of excellent baking quality and high protein content. The CP line has rheological properties equal to or superior to bread wheat. The lines are considered useful in their own right as low-input crops and as sources of useful genes for wheat improvement. They did not differ greatly in accumulation of the various protein classes, but they differed in the banding pattern of the prolamins and glutelins (Meletti et al., 1996).

#### Use of perennial Triticeae species for wide hybridisation

Perennial *Triticeae* species comprise some of the most valuable grasses in the temperate regions of the world. In addition, they have been a source of genes for pest resistance and other traits in wide hybridisation programmes to improve cultivated cereal crops. Intense breeding efforts have been restricted primarily to species of *Agropyron*, *Psathyrostachys*, *Thinopyrum*, *Leymus*, *Elymus*, and *Pseudoroegneria* [*Elymus*]. Crested wheatgrass (*Agropyron* spp.) has received the most attention in breeding programmes as evidenced by the release of several improved cultivars. Stand establishment vigour of *Psathyrostachys juncea* has been substantially increased through breeding, and selection for improved forage quality and

disease resistance has been effective in intermediate wheatgrass, *Thinopyrum intermedium* [*Elymus hispidus*]. Interspecific hybridisation is a promising breeding procedure in the perennial Triticeae, or with cultivated wheat species.

The wheat streak mosaic rymovirus (WSMV), vectored by the wheat curl mite (WCM; *Aceria tosichella*), is one of the most important viral diseases of wheat (*T. aestivum*) in the world. Genetic resistance to WSMV and the WCM does not exist in wheat. Resistance to WSMV and the WCM was evaluated in five different partial amphiploids, namely Agrotana, OK7211542, ORRPX, Zhong 5 and TAF 46, which were derived from hybrids of wheat with decaploid *Thinopyrum ponticum* [*Elymus elongatus*] ( $2n = 10x = 70$ ) or with hexaploid *Th. intermedium* [*E. hispidus*] ( $2n = 6x = 42$ ). Although the amphiploids signed as Agrotricum [*Agropyron x Triticum*] - lines C115321, C115322, OK9387A are resistant to streak mosaic virus (WSMV).

Wide-hybrids between wheat (*Triticum aestivum* and *T. carthlicum*) and lymegrass (*Leymus arenarius* and *L. mollis*) can serve as a bridge to increase genetic diversity both of wheat (with respect to biotic and abiotic stress tolerance) and of lymegrass (with respect to end-use quality). The hybrids have been developed further by: (1) direct backcrossing with the parental species; and (2) chromosome doubling to produce fertile amphiploids (Anamthawat-Jonsson 1996, 1999). Simultaneously, lymegrass characters such as stress tolerance and disease resistance may be introgressed into wheat, making the cultivation more reliable in many different production regions.

### Discussion

As a rule, the direct use of synthetic amphiploids is limited, due to its negative properties, which inhere to the wild forms from which they are created. The use of triticale in agricultural practice and the relative chance of tritordeum being used in practice in the future are more or less exceptions. It is interesting that a more marked breeding progress was reached in cereals with a high degree of ploidy. In this association we can assume that rapid breeding progress of hexaploid wheat and triticale could also be based on the homoeologous chromosome, which could fix the heterosis effect in the amphiploid condition.

From this point of view the amphiploid forms could have a good chance to be successful in breeding.

One of the limiting factors when translocating genes from wild forms is the incidence of genetical systems determining the crossability, and/or the incidence of hybrid necrosis. While the use of *Ae. tauschii* by means of synthetic hexaploid wheat with the AABBCC genome is relatively easy, the transfer of genes from other unrelated genomes using synthetic amphiploids with wheat could be considerably difficult due to problems of meiotic pairing of non-homologous chromosomes. It is desirable to build the required genes in wheat using the induction of translocation. The homoeologous pairing suppressor gene Ph1 is localised on the long arm of the 5B chromosome in wheat. The forms with a lack of the Ph1 gene should cause homoeologous chromosome pairing in meiosis. This makes the translocation line very useful for the induction of homoeologous chromosome pairing between alien chromosomes and wheat chromosomes in interspecific and intergeneric hybrids.

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#### DETECTION OF LOCUS GLU 1D5+10 IN WHEAT GENE RESOURCES WITH MRS AND LG MORFOTYPES OF SPIKE

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#### Summary

In selected gene resources of *Triticum aestivum* L. with MRS (multirow spike) morphotype of spike and long glumes, using technics of molecular biology the locus Glu 1D5+10 was detected. The presence of this allelic variant, as a genetic marker, predicts high bread-making quality. The genomic DNA from the young wheat leaves by DNasy Plant Mini Kit (Qiagen) was isolated. The presence of glutenin subunits 1D5+10 by SPLAT (D'Ovidio, Anderson, 1994) method was detected. The used primers were JEDL11 and JEDL12, the resulting product had 450 bp. The allelic variant Glu 1D5+10 was verified in all MRS and LG genotypes .

**Key words:** gene resources, wheat, Glu 1D5+10, SPLAT

#### Introduction

Progress in field of biochemistry and molecular biology allows application of genetic markers based on DNA polymorphism (Williams et al., 1990). Markers on DNA level – RAPD, SPLAT, RFLP, AFLP – are representing the groups of molecular markers used in breeding programmes. Bread-making quality of gluten is determined with proteins gliadin and glutenin. Glutenin markers of improved bread-making quality of wheat are allelic variants Glu 1A1, Glu 1B7+9 (Chloupek, 2000) and locus Glu 1D5+10. These allelic variants during determination of „Glu score“ shows the highest value (4). The value of „Glu score“ correlates with SDS test, the indicator of gluten swelling. In contrary, the markers of poor bread-making quality are glutenin locuses Glu 1B6+8 and Glu 1D2+12. The prediction of bread-making quality cannot be realise without qualitative analysis of the other protein fraction – of gliadins. In case of gliadins the main manifesting influence is of rye translocation