The impact of 5B:7B translocation on molecular-genetic mapping of wheat chromosomes

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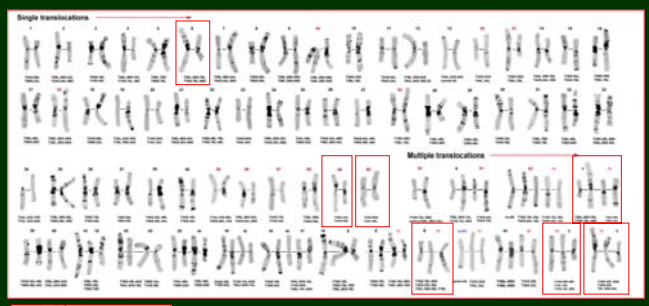


Figure 1. Variants of chromosomal rearrangements in wheat

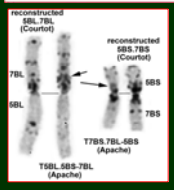


Figure 2. The structure of T7B:5B translocated chromosomes.

Translocation T5B:7B was earlier considered as centromeric (Riley et al. 1967; Friebe and Gill 1994; Miura et al. 1994; Schlegel 1996); however, some mapping results (Le Gouis and Bernard, unpublished) contradicted this suggestion. Precise analysis of the structure of rearranged chromosomes indicates that this translocation is not centromeric. The breakpoints are located in the short arm of chromosome 5B distally to the pericentromeric C-band complex (Figure 2) and in the long arm of 7B between centromeric C-band and proximal C-band complex).

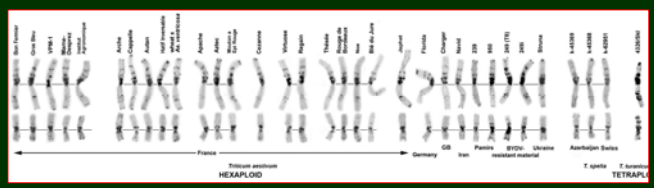


Figure 3. C-banding patterns of T7B:5B translocated chromosomes in different wheat genotypes

Although the structure of T5B:7B translocated chromosomes in different wheat genotypes was identical, we found polymorphism of the C-banding patterns (Figure 3). This rearrangement was found in bread wheat cultivars from Europe and Iran, landraces from Pamirs, spelt from Azerbaijan and Switzerland. Probability of genetic interchanges between them is very low. Thus, the 5B:7B translocation could have multiple origin.

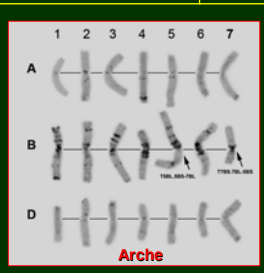
Wheat cultivars carrying 5B:7B translocation were used in France to develop several mapping populations (Table 1, red). When the parents were heterozygous for 5B:7B translocation (Figure 4), the genetic maps were distorted. For example, building the map of the Arche x Recital population using the standard Mapmaker program revealed 20 linkage groups instead of 21 because the 5B and 7B fused together.

In order to understand the cytogenetic nature of disturbances in the construction of genetic maps we analyzed the chromosomal constitution of lines constituting the Arche x Recital (ARE) mapping population using the C-banding method.

Chromosomal rearrangements play an important role in plant evolution. The emergence of many species was accompanied by species-specific translocations. Chromosomal rearrangements also occur during the intraspecific divergence of many cereal species including wheat. In polyploid wheat we identified more than 70 variants of reciprocal translocations (Figure 1), most of which were rare, while only few types had broad distribution. In *Triticum aestivum* translocation T5B:7B was the most frequent chromosomal rearrangement. It was found in 31 cultivars from seven countries, and 26 more cultivars were described by other authors (Schlegel, 1996, Friebe and Gill, 1994). High frequency of T5B:7B can be due to the adaptive value of this rearrangement as the chromosomes 5B and 7B carry some important genes controlling plant growth and development: vernalization response (*Vrn1, Vrn2, Vrn3*), frost resistance (*Fr1*), hybrid necrosis (*Ne1*), chromosome pairing (*Ph1*), resistance to *Septoria* leaf blotch (*Stb1, Stb8*), yellow rust (*Yr2, Yr3, Yr6, Yr19*), and others (McIntosh et al 1998). At the same time, T5B:7B translocation being abundant in Western Europe is poorly represented or absent in wheat cultivars from countries with more continental climate, such as Russia and Ukraine. T5B:7B translocation is especially common in France (22 of 58 cultivars) and Great Britain (9 of 13 cultivars).

Distribution of 5B:7B translocation in common wheat cultivars from Europe

With5B:7B translocation	Without 5B:7B translocation	
Apache	Automne Rouge Barbu	Isengrain
Arche	Blé de Crepi	Melbor
Autan	Blé de Barbu	Moisson
Aztec	Blé Barbu de l'Aveyron	Opata
Blé de Jura	Blé de Pays de Langogne	Ornicar
Bon Fermier	Blé de Redon de Roux ½ LacheBle	Oligoculm
Cappelle-Desprez	Blé de Redon type Progres 1	Parcel
Cezanne	Blé de St. Siergue	Prince Albert
Florida	Blé de la Valloise	Recital
Gros Bleu	Blé du Lot	Renan
Hâtif Inversable	Blé Seigle	Rouge de Marchissy
Institut Agronomique	Caphorn	Soisson
Japhet	Chiddam Blanc de Mars	Touzelle Anone
Marne-Desprez	Courtot	Touzelle Blanche de Provence
Mouton a epi Rouge	Dattel	ULi13
Noe	Etoile de Choisy	Victoria d'Automne
Regain	Hybride 80-3	Vilmorin 23
Roazon	Hybride de Grosse Tête	Voltige
Rouge de Bordeaux		Yga Blondeau
Thesee		
Virtuose		
VPM-1		



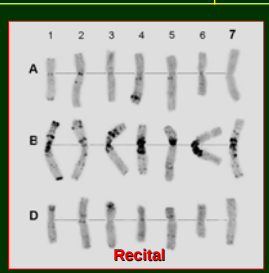


Figure 4. Karyotypes of wheat cultivars Arche (left) and Recital (right) used as parental forms in ARE population. A T7B:5B translocation was identified in cv Arche.

In total, 237 androgenethic dihaploid lines produced from the F1 hybrids of Arche x Recital were studied. Eighty nine (89) lines had normal 5B and 7B chromosomes, including ARE082 that contained normal 5B + tel7BL + tel7BS and ARE014 (chromosome 2A was represented by telocentrics of the short and long arms). Four lines carried translocations, other than T5B:7B: ARE247 - T4B:5A (Fig. 1, 59), ARE041 – T4B:7D; ARE029 – T5D:6B (Fig. 1, 60), and ARE006 with more than 9 different translocations (Figure 9). The deletion of the distal part of the short arm of chromosome 6B including satellite was identified in ARE032, and translocation of an unidentified fragment to the telomeric part of the long arm of chromosome 1B was found in ARE116.

147 lines possessed translocated chromosomes T5B:7B. Of them ARE219 had T5BS:7BS + telocentric 5BL + second translocation T1B:4B (Figure 8). ARE087and ARE166 had T5BL:7BL + 1 or 2 telocentrics 7BS (Figure 5). In some lines one of the translocated 5B:7B chromosomes was modified further (Figure 6, 7). Secondary translocations involving other chromosomes were identified in ARE219 (Figure 8),
ARE093 – T5B:7B+T4A:4B (Fig. 1, 64),
ARE163 – T5B:7B+tel7Al+T7AS:?,
ARE159 – T5B:7B+T1B:3B,
ARE008 – T5B:7B+T3B:?B, and
ARE085 – line had 2*n*=48 and contained numerous translocations and 14 telocentric chromosomes (Figure 10).
In ARE022 (T5B:7B:2D, Figure 6), ARE046 (T5B:7B:3B-1), ARE220 (T5B:7B:3B-2) and ARE224 (T5B:7B:7A, Figure 7) the secondary translocation involved one of the previously rearranged chromosomes.

Figure 5. ARE087.

Figure 6. ARE022.

Figure 7. ARE224.

Figure 8. ARE219.

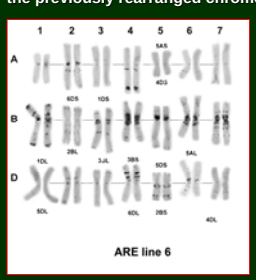


Figure 9. ARE006 (2n=42).

Figure 10. ARE085 (2n=48).

The results of our analysis suggest that segregation of chromosomes in a progeny of plants heterozygous for 5B:7B translocation is not random: (1) there is strong selection against genotypes with non balanced chromosome constitution and (2) the lines with translocation significantly prevails in the progeny (147:89), thus, translocated 5B:7B chromosomes are capable of preferential transmission through the pollen. Although we found cytogenetic evidences (Figure 11) of recombination between normal and translocated chromosomes, the prevalence of, on one hand, Recital molecular makers alleles in DH lines containing normal 5B and 7B chromosomes, and, on the other hand, Arche alleles in DH lines with translocated 5B:7B chromosomes, indicates that recombination between normal and translocated chromosomes in meiosis of hybrids heterozygous for translocation is significantly reduced.

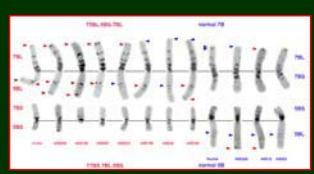


Figure 11. Distribution of C-bands on translocated 5B:7B and normal chromosomes 5B and 7B in Arche, Recital, and some of the ARE lines. Bands typical for Arche parent are indicated with red arrows, that of Recital with blue arrows.

Future prospectives:
To target the translocation breakpoint using molecular markers.
By comparing morphological, physiological, and agronomical characteristics of DH lines that carried normal and those containing translocated chromosomes to analyze agronomical impact of 5B:7B translocation.
To develop a mathematical model for construction of the genetic map in the presence of translocations.

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