Transferring useful rye genes to wheat, using Triticale as a bridge

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Rye has already proved to be a good donor of genes for improving important traits and diversity in wheat breeding

- Many wheat cultivars carrying wheat-rye translocations have proved successful worldwide (Lukaszewski, 1990, Rabinovich, 1998, Schneider and Molnár-Láng, 2009).

- Wheat-rye translocations determine a number of useful characteristics such as:
  - disease resistance:
    - powdery mildew,
    - stem rust,
    - leaf rust and
    - stripe rust
  - tolerance to barley yellow dwarf virus
  - insect resistance (Hessian fly, Russian wheat aphid, green bug)
  - yield potential,
  - stress tolerance, and adaptation

(Friebe *et al*. 1990, Carver and Rayburn, 1994, Friebe *et al*. 1995 McKendry *et al.* 1996, Kim *et al.*2003, etc.).

CONTINUED EFFORT FOR INTROGRESSION OF RYE GENES INTO WHEAT IS JUSTIFIED

- The agronomic advantages of the wheat-rye translocations, as well as their pleiotropic detrimental effects depend on:
  - the **wheat genetic background**,
  - wheat class and environmental condition,
  - **the source of the transferred rye chromatin** and its position in the wheat genome (Kumlay *et al.,* 2003, Kim *et al.,* 2004).
- There are still many genes of interest for wheat improvement, not yet transferred, that are available in the rye genome

Triticale has many advantages as a bridge for transferring useful genes from the rye genome to wheat

Triticale

x

Wheat

Sterile F1
Fertility can be improved

by back-crossing

-Hybridizing Triticale with wheat is relatively easy

-Selection of potentially useful rye genes can be more efficient if based on their expression in the presence of two wheat genomes

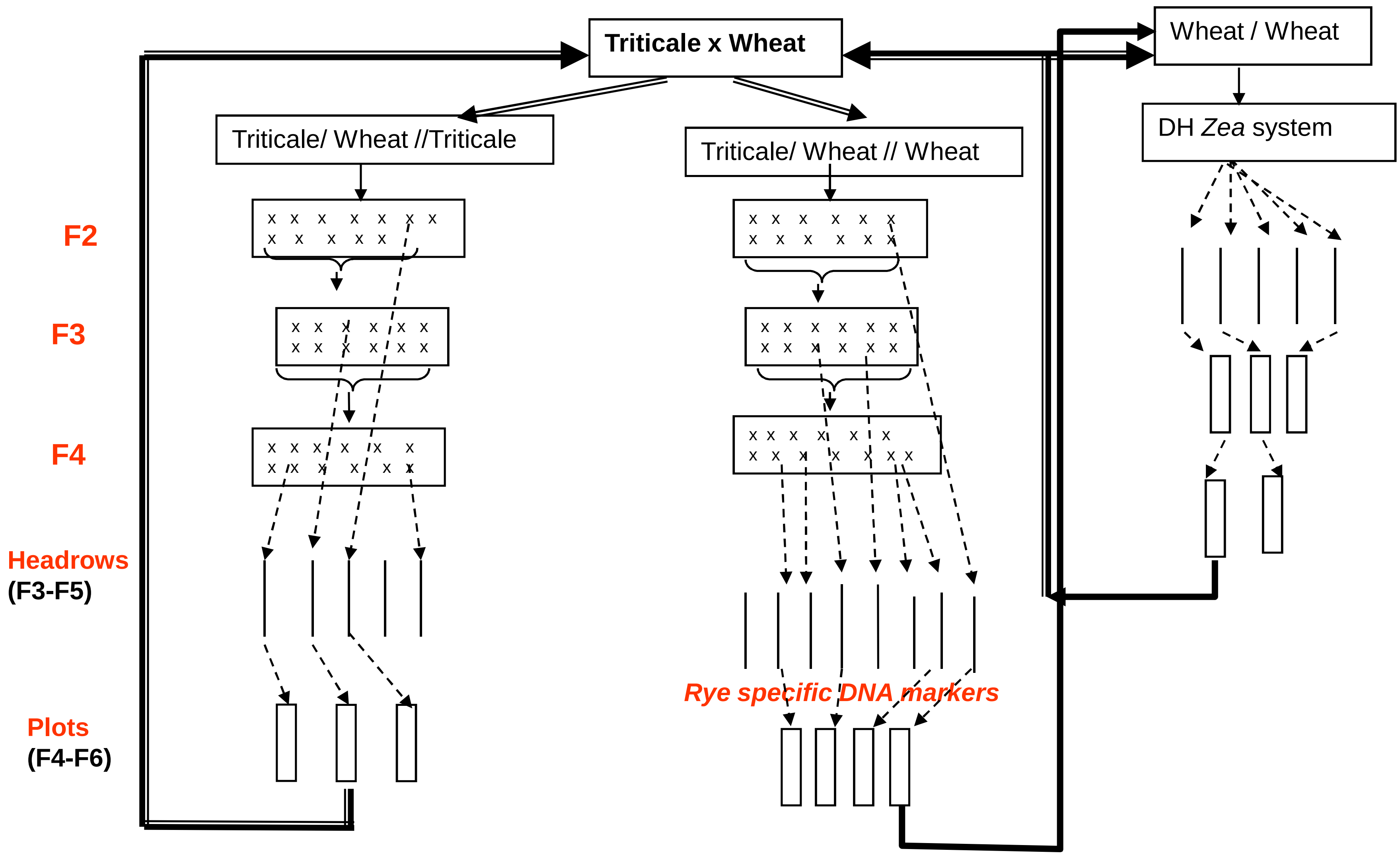
-Triticale has long been used as a bridge to facilitate rye gene introgressions into wheat (Sebesta *et al.*, 1978, Sethi, 1989)

BUT

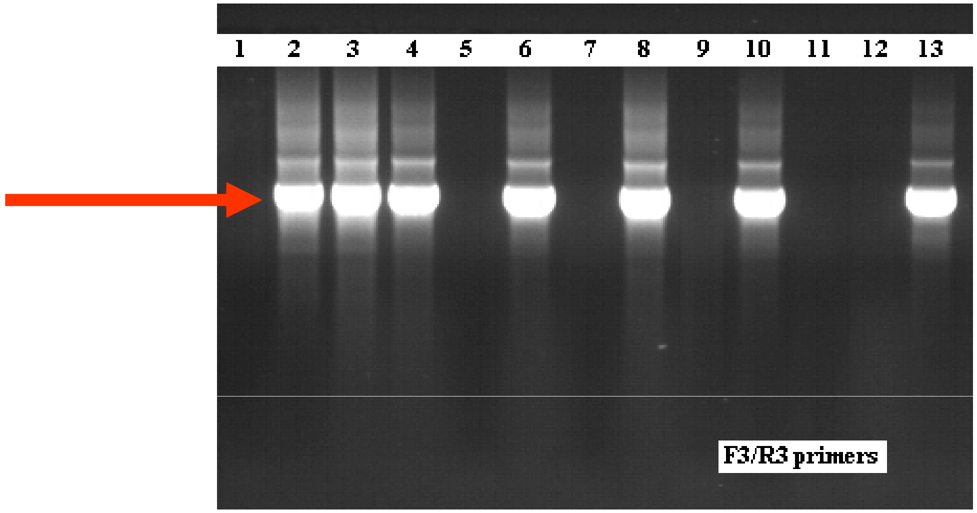
- Important progress has been made since in Triticale breeding

- At NARDI Fundulea there are aggresive breeding programs in both wheat and Triticale

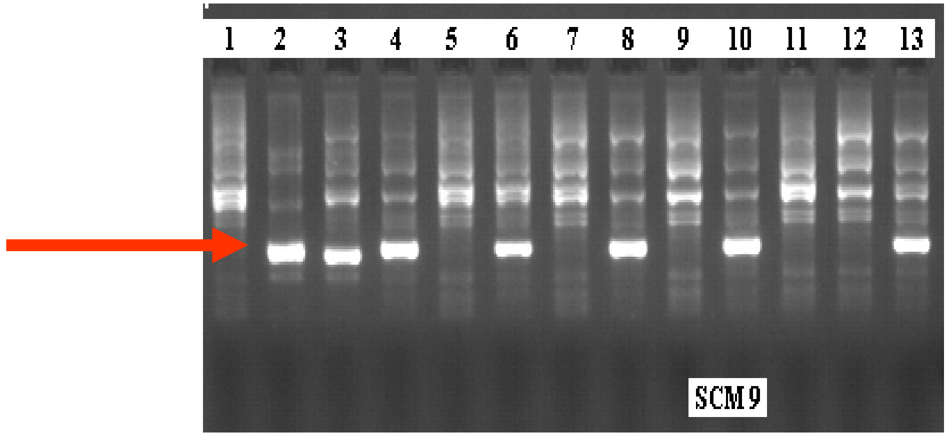
Simplified scheme of breeding for introgression of useful rye genes into wheat and wheat genes into triticale



Marker detection of rye genes introgressions



1. Introgressions detected by set of primers F3/R3, described by Katto *et al*. (2004) as “universal marker” for rye chromatin.

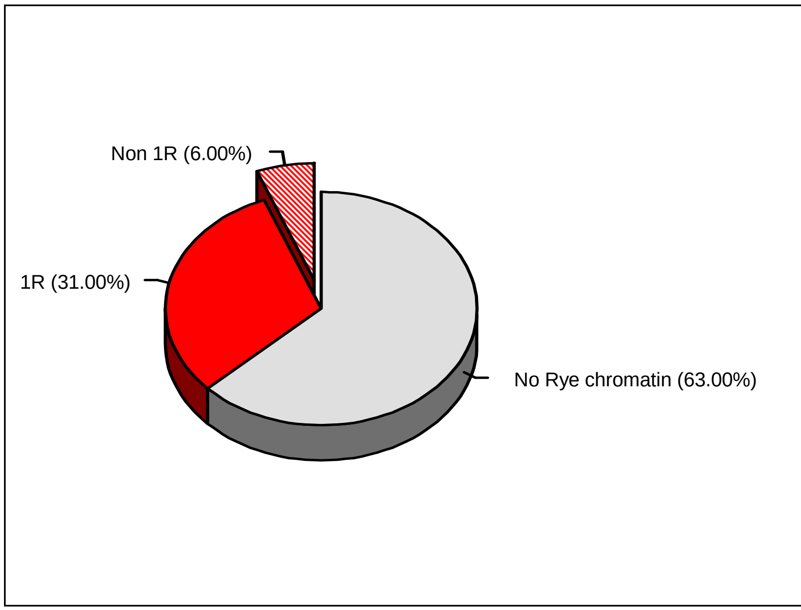


2. Introgressions detected by primers for SCM9, specific to the 1RS rye chromosome

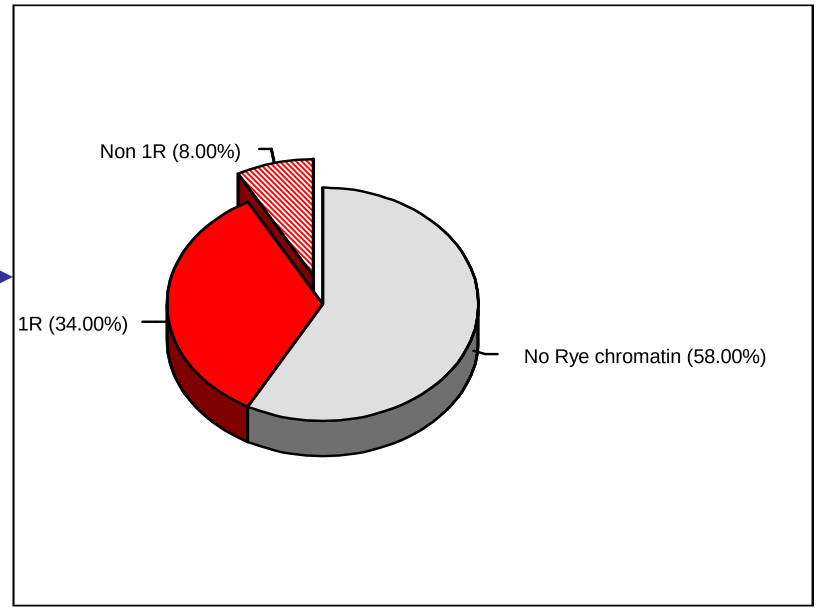
3. Markers for other rye chromosomes

PRESENCE OF RYE CHROMATIN IN PLANTS OR ROWS SELECTED PHENOTYPICALLY FROM TRITICALE/2*WHEAT CROSSES

Plants selected in F2



Headrows selected in F3



Results obtained so far:

1. Diversification of disease resistance genes:
   a) Bunt resistant lines – Line F00628G34-1
   b) BYDV resistant lines

2. Improved early vigour in seedlings

3. Increased plant albedo

1a Results of testing bunt resistance of line F00628G34-1

In ROMANIA

Location	Inoculum	2005		2006	
		% bunt			
		Susc. check	F00628G	Susc. check	F00628G
RO Fundulea	**Mix**	45.4	**0**	46.8	**0**
(1)	FUN			66.7	**0**
	SIM			83.5	**0**
	SUA			80.3	**0**

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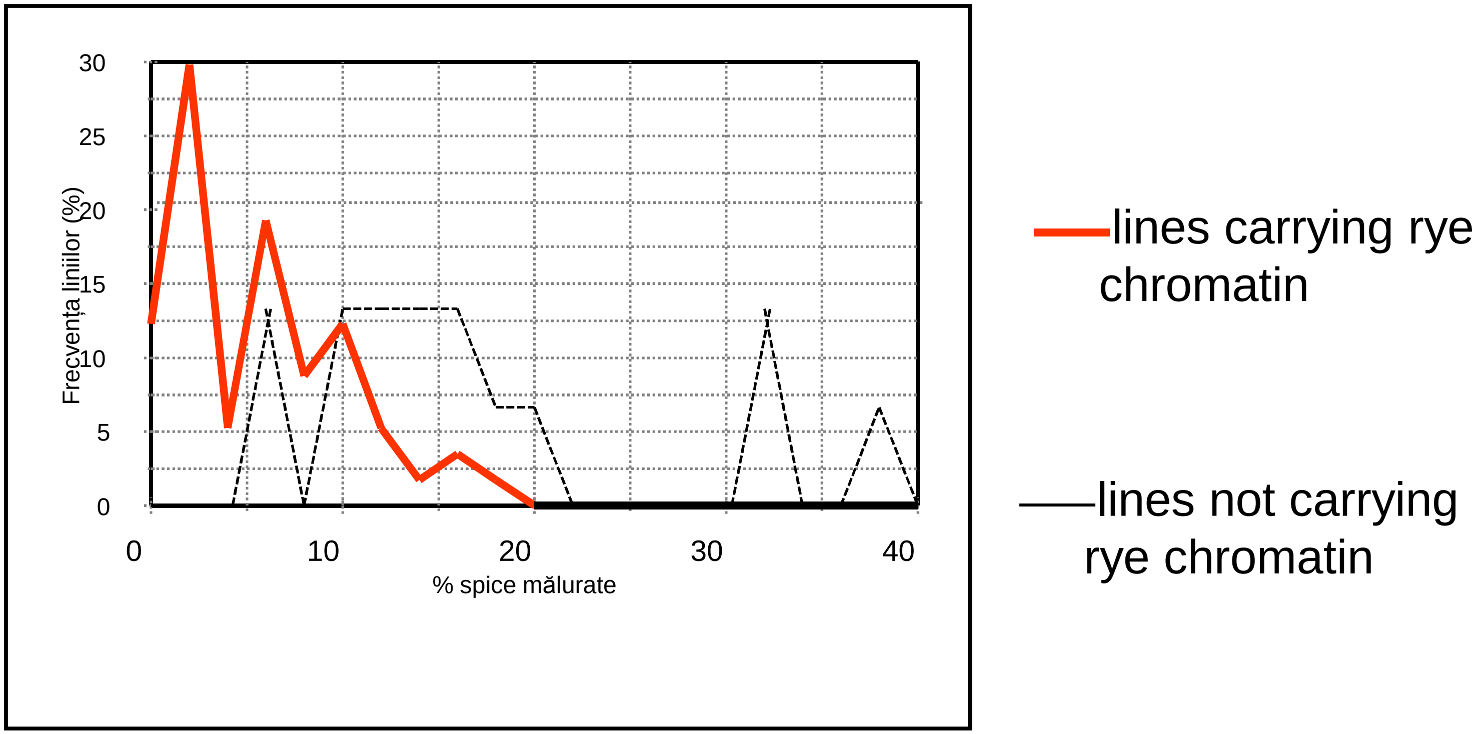
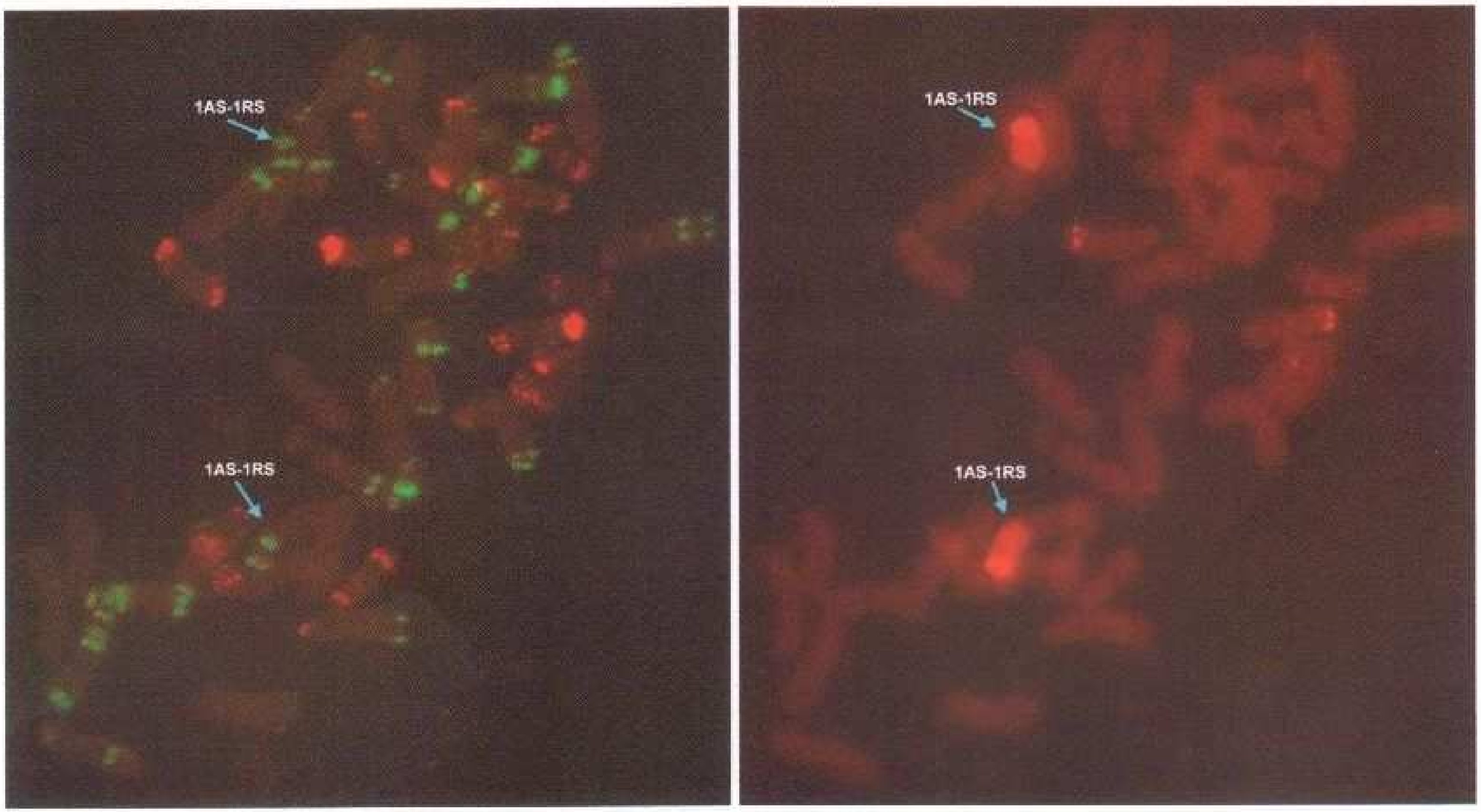
In the European *Tilletia* Ring test

Location	Inoculum	2007		2008	
		% bunt			
		Susc. check	F00628G	Susceptible check	F00628G
RO, Fundulea (1)	**Mix**	59.9	**0**	97.6	**0**
Austria, Tulln (2)	Mix	50.4	**11.5**	64.0	**0**
CH, Nyon (3)	Mix	83.7	**2.7**	29.7	**2.6**
	Wilch.	90.9	**0.5**	29.7	**3**
Denmark, Slagelse (4)	Mix	24.8	**1.5**		
Germany, Dottenfelderhof (5)	Local	48.6	**0**		
G, Darzau (6)	Mix	8.3	**0**	91.6	**15.5**
F, Le Subdray (7)				24.8	**0**
Ukraine, Odessa (8)	Race T7	100	**7.4**		
	Race T9	91.5	**4.2**		
	RaceT17	98.3	**9.3**		
	Race T02	95.6	**4.7**		

Distribution of F3 lines from the cross F00628G34-1/Litera, according to frequency of bunted spikes



FISH and GISH analysis show that line F00628G34-1 carry a 1AS-1RS translocation



(results obtained by Constantina Banica during a stage at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár, Hungary)

1b. BARLEY YELLOW DWARF VIRUS (BYDV) – AN INCREASING THREAT TO WHEAT

• Climate changes bring higher autumn and winter temperatures

• Autumn temperature is a critical factor for BYDV epidemiology, with a small increase in autumn temperature leading to greatly increased infection rates. (LOWLES et al. 1996)

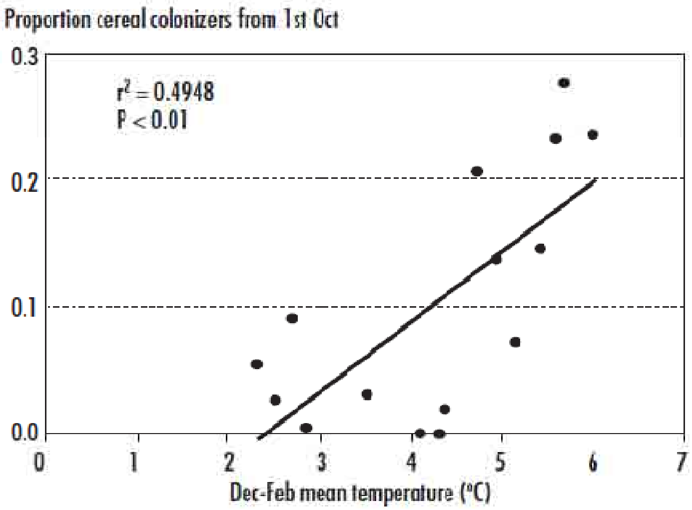


Figure 1. Relationship between previous winter temperature and proportion of cereal-colonizing forms of the aphid *Rhopalosiphum padi* trapped at Rothamsted in the fall, 1986-2000.

•BYDV resistance in wheat is not sufficient

• Relying only on resistance transferred from ***Thinopyrum intermedium*** could not be a durable solution

GENETIC DIFERENCES FOR BYDV RESISTANCE IN TRITICALE

Wheat lines obtained from Triticale/2*Wheat crosses, selected for resistance to BYDV

Differences among lines selected from Triticale crosses, in the early planted nursery in 2010

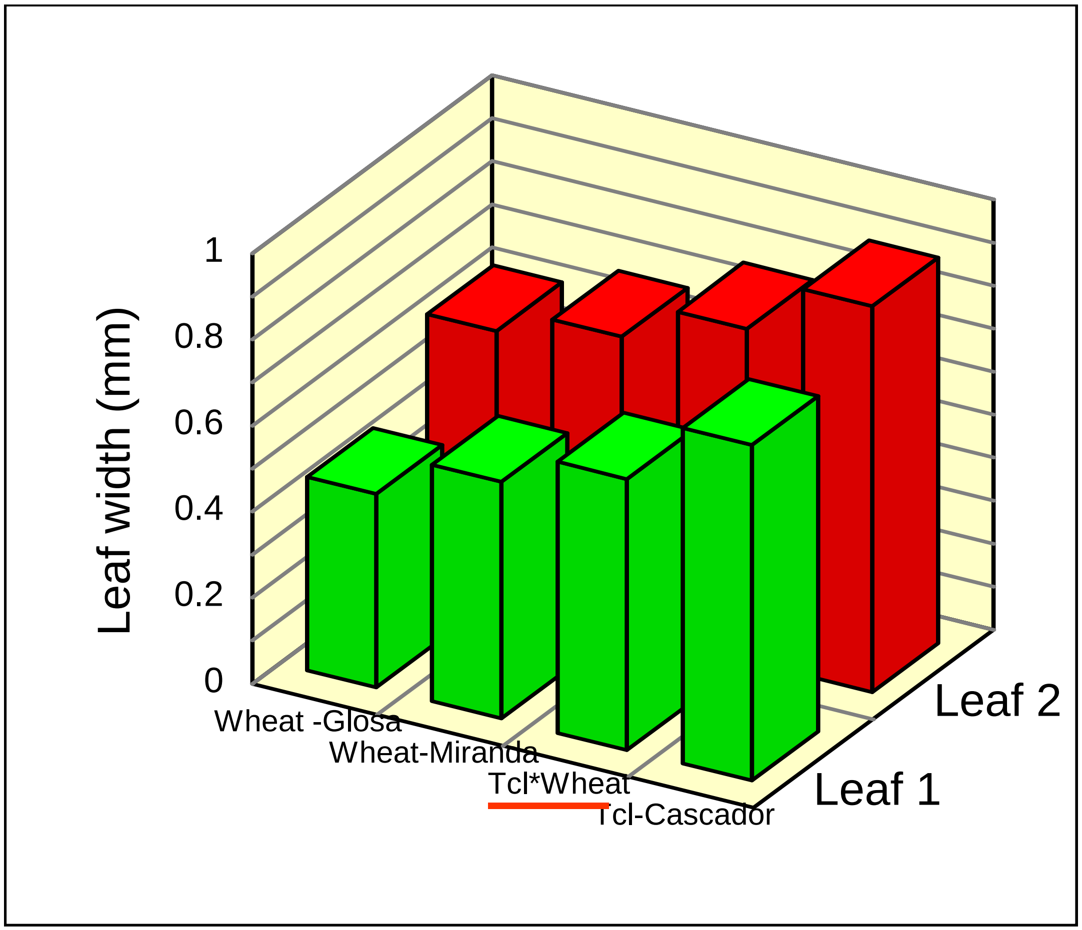
Scores under early sowing dates in 2009

Line	Genealogy	BYDV score 1	BYDV score 2
F04294T1-2	Triticale 93161T2-2201/2*wheat	2	3
F06659G4	Triticale 94896T2-1011/2*wheat	3	2
F05901G3-3	*Thinopyrum intermedium* derivative	3	3
Wheat	Susceptible check	6	6

2. Improving early vigour in seedlings:

- can improve stand establishment
- can increase water use efficiency, by reducing water loss through evaporation (Rebetzke and Richards, 1999)
- Genetic variability for this character in semidwarf wheat is small (Richards *et al.,* 2001), but rye and Triticale have much better early vigour.
- Width of first leaves are a good indicator of seedling vigour (Richards *et al.,* 2001).

Width of first and second leaves in a line derived from Triticale/2*Wheat crosses, as compared with Triticale and wheat cultivars

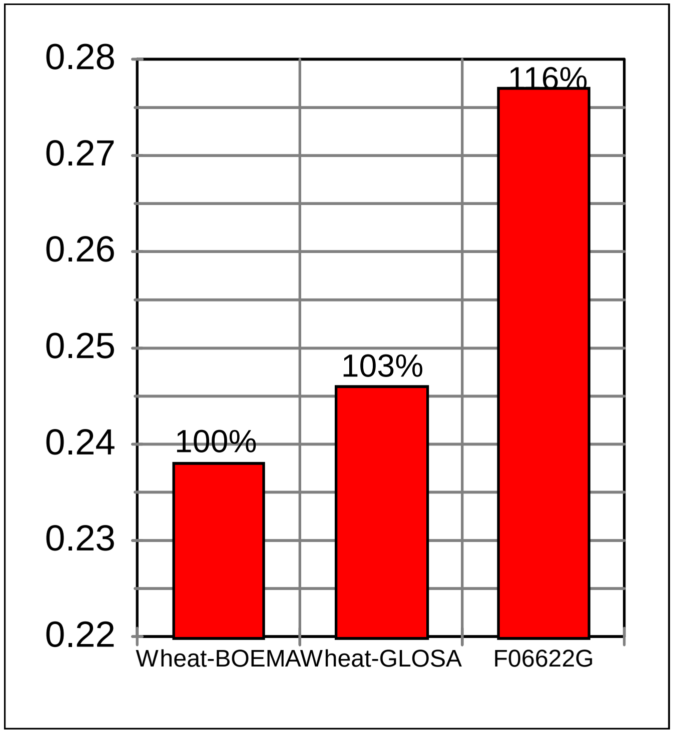


3. Increasing plant albedo

- A reduction in transpiration can be achieved by reducing net radiation by way of reflection, namely increasing crop albedo (Blum, 2005).
- The cropland albedo is of primary importance for determining the magnitude of the global temperature change (Matthews *et al*. 2003).
- Increasing canopy albedo by 20% (0.04) drives a >1ºC reduction in summertime surface air temperatures in a wide latitudinal band spanning North America and Eurasia (Ridgwell *et al*., 2009).

Triticale has higher waxiness than most wheat cultivars

Some wheat lines selected from crosses with *Triticale* have higher albedo.



What about QUALITY ?

- **Rye chromatin transfers to wheat can have detrimental effects on bread-making quality;**

Robert A. Graybosch (2001) - **Uneasy Unions: Quality Effects of Rye Chromatin Transfers to Wheat**

- These effects proved to be dependent on :
  - On the specific translocation and
  - On the background.

- **We have observed large variation of quality in progenies carrying Rye chromatin**

CONCLUSIONS

- To take advantage of the large genetic progress made in triticale breeding, we used hexaploid Triticale as a bridge in transferring useful rye genes to wheat.
- Results obtained so far include:
  - Bunt resistant lines
  - BYDV resistant lines
  - Lines with improved early vigour in seedlings
  - Lines with increased albedo