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WHEAT AND TRITICALE WITH RYE CYTOPLASM

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This study was undertaken in order to investigate the possible use of the cytoplasm of rye, an allogamous species, as a source of male sterility in tetraploid wheat, hexaploid wheat and triticale, with the ultimate aim of hybrid wheat and triticale production. We also decided to study the effects of rye cytoplasm on the yield and quality of triticale lines, which up to now have been obtained only with tetraploid wheat cytoplasm.

MATERIAL

As donors of cytoplasm we used two sources: A population of indigenous diploid rye and a tetraploid variety Gigantón obtained in 1952 (TJIO *et al.*, 1953) and still in cultivation in Spain.

The tetraploid and hexaploid wheats used as male parents were either our own varieties or foreign introductions.

The hexaploid triticales involved were:

1) Breeding lines from our own program of triticale production and breeding (JM-lines).
2) Breeding lines selected in our Department from segregating material sent to us by Prof. B. C. Jenkins (JK-lines).
3) Two recently synthesized triticales having *Triticum turgidum* (T-236) and *T. dicoccoides* (T-202) as female parents.

THE PRODUCTION OF WHEAT AND TRITICALE WITH RYE CYTOPLASM

The triticale in rye cytoplasm was obtained by backcross-substitution (KIHARA, 1954) using as female parent our tetraploid rye Gigantón:

$$\textit{Secale cereale}\ 4n \times \textit{Triticale}^{b}$$

where b is the number of backcrosses (b=7 has been reached). Our attempts to obtain seed by pollinating diploid rye with triticale pollen failed.

Chromosome substitution in these backcrosses is relatively quick, and we obtained progenies with 42 somatic chromosomes and 21 bivalents at meiosis as early as the fourth backcross. Practically all the plants from the fifth backcross on showed cytological characteristics similar to the triticale in wheat cytoplasm; i.e., 42 somatic chromosomes and 21 bivalents at meiosis.

Hexaploid wheat in rye cytoplasm was obtained from two types of backcrosses. In one of the backcrosses we obtained first some seeds from the cross:

Secale cereale 2n x *Triticum aestivum*,

using as pollen parent a wheat variety, GH-400, which was sent to us by Dr. K. B. Porter as a restorer for the male-sterility of wheat in *Aegilops ovata* cytoplasm. From this first hybrid we obtained all the substitutions by successive backcrosses:

Secale cereale 2n x *Triticum aestivum*^{b},

with b=6 having already been reached. Substitution backcrosses of this type were used by MAAN and LUCKEN (1971) for the production of 'Selkirk' wheat in rye cytoplasm.

In the other backcross series we used, as rye cytoplasm donors, progenies of the triticale backcrosses:

(*Secale cereale* 4n x *Triticale*^{b}) x *Triticum aestivum*$^{b'}$

and with b=2 we have reached b'=4.

For the production of tetraploid wheat in rye cytoplasm, we used as female parents progenies from the hexaploid wheat and triticale backcrosses:

(*Secale cereale* 2n x *T. aestivum*^{b}) x *T. turgidum*$^{b'}$

(*Secale cereale* 4n x *Triticale*^{b}) x *T. turgidum*$^{b'}$

and with b=3 for the first and b=5 for the second we have reached b'=3.

RESULTS

Hexaploid triticale lines in rye cytoplasm showed different degrees of flower fertility (Table 1). Full fertility is much more frequent than male-sterility, which was found only in two lines and even then was lost in one of these in the next backcross generation. We have not yet obtained triticale lines in rye cytoplasm breeding true for male-sterility.

Table 1. Flower fertility in hexaploid triticale lines with cytoplasm from tetraploid rye, compared with the same lines in wheat cytoplasm. Superscripts show number of generations backcrossed, using, in most cases, two triticale lines in succession.

Triticale lines used	% fertility
JM-78^{4} + T-236^{2}	0 (♂-sterile)
JM-130^{5} + JK-138^{1}	"
JM-130^{5} + JK-138^{2}	5-30
" " JK-124^{1}	"
JM-74^{6}	"
JM-130^{5} + JK-124^{2}	30-60
JM-78^{6}	"
JM-130^{5} + JM-87^{1}	60-100
" + JM-139^{1}	"
JM-130^{7}	>100
JM-135^{7}	"
JM-130^{5} + JK-147^{2}	"
" + JK-5/1^{2}	"
" + JK-5/6^{2}	"
" + JK-122^{2}	"
JM-135 + T-202^{1}	"

The high level of fertility shown by two of the lines obtained, 143% for JM-130 and 139% for JM-135, induced us to make a comparative study between these two lines and their counterparts with wheat cytoplasm. The comparison of the characters studied is shown in Tables 2 (cytological characters) and 3 (morphological characters and yield).

The only significant difference among the cytological characters was for number of micronuclei per tetrad, which was higher with wheat cytoplasm (Table 2).

Two of the components of yield, "ears per plant" and "spikelets per ear," were consistently higher with wheat cytoplasm (Table 3). Flower fertility was higher in one line and lower in the other, but the differences were not significant. Thousand-kernel weight was always significantly higher for rye cytoplasm. Grain yield and protein per hectare were superior for wheat cytoplasm.

Table 2. Comparison of the meiotic stability of triticale lines with wheat and rye cytoplasms

	Line, cytoplasm, and ave. no. obs'd.			
	JM-130		JM-135	
	Wheat	Rye	Wheat	Rye
Univalents per PMC	1.46	1.46	1.08	1.20
Bivalents per PMC	20.27	20.27	20.46	20.40
Micronuclei per tetrad	0.97	0.67	0.85	0.52

These results, and especially those regarding yield of grain and protein, seem to indicate a lack of practical value of hexaploid triticale with rye cytoplasm. However, no definitive conclusion can be made until more triticale lines with both cytoplasms have been compared.

Hexaploid wheats with rye cytoplasm were easily obtained with diploid rye as donor, and the sixth substitution backcross has been reached for several varieties. By using as cytoplasm donors the progenies of the "tetraploid rye x triticale" backcrosses, viable progeny were obtained only in two crosses of the type:

(Secale cereale 4n x *Triticale*^{2}*)* x *T. aestivum*^{4}

with the hexaploid wheat cultivars Ariana 8 and Florence-Aurore 588. Both progenies were completely male-sterile.

Complete male-sterility has also appeared in the progenies of the fifth and sixth substitution backcrosses of the type:

Secale cereale 2n x *Triticum aestivum*^{b}

with the Spanish hexaploid cultivars Aragón 03, Cabezorro 2, Calatrava, Canti, Catalán de Monte, Ebro II, Montjuich, Pané 3, Pané 247 and San Bruno and the foreign introductions Dimas, Florence-Aurore 588, Florence-Aurore 2511, GH-400, Mara, Pitic 62 and Yactana.

With the same type of substitution backcrosses, several hexaploid cultivars showed from 6 to 27% fertility. These cultivars were the Spanish Aradi (27%), Pané 2 (26%), Saria (14%), Toroña (7%) and Gredos (6%), and the foreign introductions Tobari 66 (10%) and Terminillo (6%).

The phenotypic characteristics of these hexaploid wheats were similar to the ones described by MAAN and LUCKEN (1971) for 'Selkirk' wheat with rye cytoplasm. There was a low seed set in the backcrosses, and poor germination in both incubator and greenhouse and almost no germination under field conditions. Greenhouse plants were stunted, slow growing and showed chlorophyll deficiencies in the first leaves.

With the tetraploid wheats we found the same difficulties of low seed setting in the backcrosses and poor germination. Third backcross progenies have been obtained in two types of crosses:

(Secale cereale 2n x *Triticum aestivum*^{3}*)* x *Triticum turgidum*^{3}
(Secale cereale 4n x *Triticale*^{5}*)* x *Triticum turgidum*^{3}

Some viable plants were obtained with the Spanish tetraploid cultivars Fartó Blanco, Jerez 36 and Jerez 37 for the first type of cross and with the Italian cultivar Senatore Capelli for the second. More backcrosses will be needed before the material can be evaluated.

Table 3. Comparison for morphological characters and yield between triticale lines with wheat and rye cytoplasm, with the values for rye cytoplasm taken as 100

Character	Wheat vs. rye cytoplasm JM-130	JM-135
Plant height	+5%*	+4%*
Tillering	+32%*	+21%*
Maturity date	identical	identical
Flag-leaf length	-12%*	-5%
Flag-leaf breadth	+4.6%	+1.1%
Flag-leaf weight per cm^2	+12%*	identical
Ears per plant	+56%**	+39%**
Spikelets per ear	+5.5%*	+0.9%
Glume length	-6.4%**	identical
Glume breadth	identical	-1.8%
Rachis length	+2.7%	-3.1%
Rachis-internode length	-0.9%	-4.2%**
Kernel length	-5.9%**	+0.8%
Chlorophyll *a* content	+15%*	+0.7%
Chlorophyll *b* content	+13%*	identical
Flower fertility	-2.9%	+5.8%
1000-kernel weight	-10.7%**	-3.2%*
Kernel-protein content	+8.4%*	-6.3%
Yield	+42.8%*	+43.6%*
Protein per Ha	+54.8%	+34.6%

*Significant at the 5% level

**Significant at the 1% level

With the results so far obtained we can conclude that rye cytoplasm is not very promising as a source of male-sterility for the production of hybrid wheat and triticale. The two fertile lines of triticale in rye cytóplasm were agriculturally inferior to their counterparts with wheat cytoplasm.

LITERATURE CITED

KIHARA, H. 1954. Restoration and substitution of nucleus. Proc. IX Int. Cong. Genet.:900-902.

MAAN, S. S., and K. A. LUCKEN 1971. Male-sterile wheat with rye cytoplasm. J. Hered. 62:353-355.

TJIO, J. H. E. SÁNCHEZ-MONGE and M. ALVAREZ-PEÑA 1953. Centenos tetraploides espanoles. Agricultura 22:138-140.