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Artificial alloploids like triticale can theoretically be obtained with the cytoplasm of either of its parental species depending on the direction of the cross by which the initial hybrid is produced. The chromosome number of this hybrid being subsequently doubled.

The hexaploid triticales so far produced at I. N. I. A. all have the cytoplasm of the tetraploid cultivated wheat as we have always used these wheats as female parents for our crosses.

Production of triticales with rye cytoplasm could be of interest for two reasons. Firstly because a triticale with rye cytoplasm may be a better agricultural crop than the one produced with the same chromosomes with wheat cytoplasm. Secondly because a change of cytoplasm may induce male sterility and if male sterile lines of triticale can be obtained they could be used for the production of triticale hybrid seed.

With this last purpose in mind we have also attempted the transfer of the chromosome complement of the hexaploid triticale to other cytoplasms that behave as male sterilizers for wheat, such as those of *Aegilops ovata, Ae. caudata* and *Triticum timopheevi.*

MATERIAL AND METHODS

As donors of cytoplasm we used:

For *Secale cereale* cytoplasm a tetraploid variety *Gigantón* obtained in 1952 (Tjio J. H., Sánchez-Monge E., and Alvarez Peña M., 1953) and still in cultivation in Spain.

(1) Paper read at the «Symposium Breeding of Triticale». Section Cereals of EUCARPIA, Leningrad, July 1973.

For *Ae. ovata, Ae. caudata* and *T. timopheevi* cytoplasms a collection of alloplasmic tetraploid and hexaploid wheats with such cytoplasms.

The hexaploid triticales, used as nuclear donors, were:

— JM lines from our programs of triticale production and breeding at the I. N. I. A.
— CACHIRULO lines derived from our firs released variety *Cachirulo* by back-cross breeding or mutagenic treatments.
— JK lines selected from segregating material that were sent to us by Prof. B. C. JENKINS.
— New synthesized triticales having *T. turgidum* (T-236) and *T. dicoccoides* (T-202) as female parents.
— Mexican triticales from CIMMYT (Armadillo and Bronco series) and the Canadian cultivar Rossner.

The transfer of the triticale chromosome from one cytoplasm to the other was made by the substitution back-cross technique described by KIHARA (1954). The types of crosses that have been used are recorded in Table 1.

RESULTS

Rye cytoplasm.—The female parent in the substitution back-crosses has always been our tetraploid rye *Gigantón* in crosses of the type

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

were $b = 8$ has already been reached. Our attempts to obtain seed by pollinating diploid rye with triticale pollen failed.

Chromosome substitution in these back-crosses in relatively quick and we obtained progenies with 42 somatic chromosomes and 21 bivalents at meiosis as early as the fourth back-cross.

Hexaploid triticale lines with rye cytoplasm showed different degrees of flower fertility (Table 2), but full fertility is much more frequent than male-sterility, and it was difficult to obtain triticale lines with rye cytoplasm breeding true for male-sterility.

Two JM lines showing a high degree of fertility with rye cytoplasm (JM-130 and JM-135) were used in a comparative study with their counterparts with wheat cytoplasm. Meiotic instability measured in terms of univalent per P. M. C. and micronuclei per tetrad were practically identical in each line for both cytoplasms (Table 3). Some agronomic characteristics were also compared and the results are given in Table 4.

TABLE 1

TYPES OF SUBSTITUTION BACK-CROSSES

Secale cereale 4n × Triticale^{b}	(b = 8)
(Aegilops ovata × Triticum aestivum^{b}) × Triticale$^{b'}$	(b = 11, b' = 7)
[(Ae. ovata × T. dicoccum^{b}) × T. turgidum$^{b'}$)] × Triticale$^{b''}$	(b = 8, b' = 4, b'' = 2)
(Ae. caudata × T. aestivum^{b}) × Triticale$^{b'}$	(b = 12, b' = 3)
[(Ae. caudata × T. aestivum^{b}) × T. turgidum$^{b'}$] × Triticale$^{b''}$	(b = 7, b' = 4, b'' = 2)
(T. timopheevi × T. aestivum^{b}) × Triticale$^{b'}$	(b = 16, b' = 7)
(T. timopheevi × T. turgidum^{b}) × Triticale$^{b'}$	(b = 12, b' = 4)

TABLE 2

FLOWER FERTILITY IN HEXAPLOID TRITICALE LINES WITH RYE CYTOPLASM

Male-steriles	(*S. cereale* 4n × JM- 78^{4})* × T-236^{2}
	(*S. cereale* 4n × JM-130^{5}) × JK-138
5 to 30 % fertility	(*S. cereale* 4n × JM-130^{5}) × JK-138^{2}
	(*S. cereale* 4n × JM-130^{5}) × JK-124
	(*S. cereale* 4n × JM- 74^{6})
30 to 60 % fertility	(*S. cereale* 4n × JM-130^{5}) × JK-124^{2}
	(*S. cereale* 4n × JM- 78^{6})
60 to 100 % fertility	(*S. cereale* 4n × JM-130^{5}) × JM- 87
	(*S. cereale* 4n × JM-130^{5}) × JM-139
Fertility 100 %	(*S. cereale* 4n × JM-130^{7})
	(*S. cereale* 4n × JM-135^{7})
	(*S. cereale* 4n × JM-130^{5}) × JK-147^{3}
	(*S. cereale* 4n × JM-130^{5}) × JK-5/1^{2}
	(*S. cereale* 4n × JM-130^{5}) × JK-5/6^{2}
	(*S. cereale* 4n × JM-130^{5}) × JK-122^{2}
	(*S. cereale* 4n × JM-135^{5}) × T-202

TABLE 3

COMPARISON OF THE MEIOTIC STABILITY OF TRITICALE LINES WITH WHEAT AND RYE CYTOPLASM

LINE	JM-130		JM-135	
Cytoplasm	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

TABLE 4

COMPARISON FOR MORPHOLOGICAL CHARACTERS AND YIELD BETWEEN TRITICALE LINES WITH WHEAT AND RYE CYTOPLASM

CHARACTER	WHEAT VS. RYE CYTOPLASM	
	JM-130	JM-135
Plant height	5 % higher*	4 % higher*
Tillering	32 % higher*	21 % higher*
Maturity date	identical	identical
Flag leaf lenght	12 % lower*	5 % lower
Flag leaf breadth	4.6 % higher	1.1 % higher
Flag leaf weight per cm²	12 % higher*	identical
Ears per plant	56 % higher**	39 % higher**
Spikelets per ear	5.5 % higher*	0.9 % higher
Glume length	6.4 % lower**	identical
Glume breadth	identical	1.8 % lower
Rachis length	2.7 % higher	3.1 % lower
Rachis internode length	0.9 % lower	4.2 % lower
Kernel length	5.9 % lower**	0.8 % higher
Chlorophyll *a* content	15 % higher*	0.7 % higher
Chlorophyll *b* content	13 % higher*	identical
Flower fertility	2.9 % lower	5.8 % higher
1000 kernels weight	10.7 % lower**	3.2 % lower*
Kernel protein content	8.4 % higher*	6.3 % lower
Yield	42.8 % higher*	43.6 % higher*
Protein per Ha	54.8 % higher	34.6 % higher

* Significant at the 5 % level.
** Significant at the 1 % level.
The values for rye cytoplasm were taken as 100 for comparison.

The data of Table 4 indicate a lack of practical value for these hexaploid triticales with wheat cytoplasm, but no definitive conclusion can be made until more triticale lines with both cytoplasms have been compared.

Aegilops ovata cytoplasm.—Of the two types of substitution back-crosses attempted (Table 1) only the first one could be extended past the second back-cross. The fourth back-cross was obtained with the line JM-74 and the cross combination:

$$(Ae.\ ovata \times T.\ aestivum^{6}) \times Triticale^{4}$$

From this material the chromosomes of other triticale lines have been easily transferred to the *Ae. ovata* cytoplasm, and we have reached the seventh substitution back-cross. So far all the pollinations made with JM, JK and Mexican lines have given only male sterile progenies.

The effects of the *ovata* cytoplasm on triticale seem to be less drastic than with wheat (SÁNCHEZ-MONGE, 1973) and there is very little reduction in tallness and only a small difference is earliness.

Aegilops caudata cytoplasm.—Two types of substitution back-cross were used (Table 1) and only the first one has given viable seeds after three substitution back-crosses. This was with the line JM-130 in the combination

$$(Ae.\ caudata \times T.\ aestivum^{12}) \times Triticale^{3}$$

With other triticale lines (JM, JK and Cachirulo) no seed was obtained.

T. timopheevi cytoplasm.—The two types of substitution back-crosses used (Table 1) have given viable seed and we have reached the 5th and 4th back-cross for the first and second type, respectively. Values of the *b* exponent from 6 to 13 have given good results for the crosses:

$$(T.\ timopheevi \times T.\ aestivum^{b}) \times Triticale^{5}$$

and values from 6 to 12 for the crosses:

$$(T.\ timopheevi \times T.\ turgidum^{b}) \times Triticale^{4}$$

All the progenies so far obtained (Table 5) have been completely male sterile.

TABLE 5

TRITICALE LINES USED IN SUBSTITUTION BACK-CROSSES WITH T. TIMOPHEEVI CYTOPLASM WITH TWO CYTOPLASM DONORS

CYTOPLASM DONOR	T. timopheevi × T. aestivum^{b}	T. timopheevi × T. turgidum^{b}
Triticale lines (all giving male sterile progenies)......................	Armadillo 130 Armadillo 135 Armadillo 1524 Cachirulo 1642 Cachirulo 1643 Cachirulo 1647 Cachirulo 1810 JK-5/10 JM-78 JM-87 JM-130 JM-135 T-236	Armadillo 130 Armadillo 135 Armadillo 1524 Bronco 90 Cachirulo 1463 Cachirulo 1464 Cachirulo 1495 Rossner

SUMMARY AND CONCLUSIONS

Using the substitution back-cross technique hexaploid triticale forms with the cytoplasms of rye and of *Aegilops ovata* have been produced and other triticale forms with the cytoplasms of *Ae. caudata* and *T. timopheevi* are being produced.

The triticale forms with rye cytoplasm so far obtained do not compare favourably with their counter-parts with wheat cytoplasm from the point of view of agricultural utilization.

The production of male-sterile lines of triticale with different cytoplasms could be of practical interest. We are convinced that triticale offers more possibilities for hybrid seed production by means of male-sterility and restoration than wheat, because it is a better pollen producer and the flowers of the male sterile forms are more open during stigma receptivity (SÁNCHEZ-MONGE, 1971).

Rye citoplasm has not, as yet, given rise to any line breeding true for male-sterility but if some could be obtained it would probably be useful because fertility restoring lines with rye cytoplasm already exist (cf. Table 2).

The other cytoplasms, *Ae. ovata, Ae. caudata* and *T. timopheevi,* seem to be strongly male-sterilizing for hexaploid triticale and could be used for hybrid seed production. The cytoplasm of *Ae. caudata* is probably the least useful because lower seed set values are always obtained.

Only male sterile progenies have been obtained with these last three cytoplasms. More lines will need to be evaluated in order to locate a source of fertility restoration.

RESUMEN Y CONCLUSIONES

Por medio de la técnica de los retrocruzamientos de sustitución se han obtenido formas de triticale con los citoplasmas de centeno y de *Aegilops ovata* y están en vías de obtención los triticales con citoplasmas de *Ae. caudata* y *Triticum timopheevi.*

Las formas de triticale con citoplasma centeno obtenidas hasta el momento tienen menor interés práctico que sus equivalentes genéticos sobre citoplasma trigo.

La producción de líneas androestériles de triticale sobre diferentes citoplasmas podría ser de interés práctico. El triticale ofrece mejores posibilidades que el trigo para la producción de semilla híbrida mediante androesterilidad y restauración, ya que es mejor productor de polen y además las flores de las formas androestériles se abren más durante el tiempo que dura la receptividad de los estigmas (SÁNCHEZ-MONGE, 1971).

El citoplasma centeno no ha dado origen, hasta el momento, a ninguna línea que mantenga la androesterilidad. La obtención de alguna de tales líneas sería del mayor interés, puesto que existen ya líneas restauradoras (v. Tabla 2).

Los otros citoplasmas de *Ae. ovata, Ae. caudata* y *T. timopheevi* han resultado fuertemente androesterilizantes para el triticale hexaploide y podrían ser utilizados para la producción de semilla híbrida. Probablemente el citoplasma *caudata* es el menos útil, porque siempre se obtienen con él menores producciones de semilla.

Con estos tres tipos de citoplasmas solamente se han obtenido descendencias androestériles. Se necesitará evaluar más líneas para localizar alguna fuente de restauración de la fertilidad.

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