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METHODS TO IMPROVE THE GENE FLOW FROM RYE AND WHEAT TO TRITICALE

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SUMMARY

INTRODUCTION

The superior potential of the Triticale introductions from the Canadian-Mexican improvement program and from Salinas, Cal., was immediately apparent in the Eastern Orange Free State (JORDAAN $et\ al.$, 1970) and also at Stellenbosch. They, however, lacked general adaptation and failed under adverse conditions. In 1970 it was therefore decided to start a Triticale improvement program at Stellenbosch.

Crossability with Rye

Eighty-two of the better durum introductions and other tetraploid wheats were screened for crossability with the seven best local and introduced rye cultivars. The results summarized in Table 1 were similar to those of KROLOW (1970). Only 0.6% of the crosspollinated durum florets yielded viable kernels, but by means of ROMMEL's (1958) embryo-culture technique the yield of seedlings was improved to 1.2% (Table 2).

KNOBLOCH (1968) cited various successful crosses between Triticum turgidum ssp. carthlicum and rye. Seventeen different crosses between this subspecies and rye were therefore made. Two introductions of ssp. carthlicum v. stramineum hybridized readily with the rye cultivars and yielded more than 23 viable kernels per 100 cross-pollinated florets (Table 1). It can, therefore, serve as a very effective bridge for transferring rye genes to the secondary Triticales. The other varieties of carthlicum, notably rubiginosum, were incompatible with rye. A carthlicum hexaploid strain from Sweden hybridized readily with rye to yield very fertile octaploids after colchicine treatment.

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Table 1. Seed set and viability from crosses of tetraploid and hexaploid wheats x rye without using the embryo-culture technique

or cultivars cvs. Spikes (basal) Filled elled flor.) % 4x wheats carthlicum (5)* 4 22 658 86 144 34.9 30.9 dicoccoides (3) 2 6 180 0 80 44.4 3.8 dicoccon (2) 2 3 90 0 22 24.4 0.0 durum (82) 7 211 7570 0 2577 34.0 1.7 polonicum (1) 2 3 100 0 40 40.0 0.0 pyramidale (1) 1 1 38 0 6 15.8 0.0 turgidum (3) 4 5 150 0 17 11.3 0.0 durcarth. F1 4 5 214 0 66 30.8 0.0 6x wheats vulgare (10) 7 59 1933 57 18 3.9 64.0 sph	Viable		Kernels			o. of	No		
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$									4x wheats
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	10.8	30.9	34.9	144	86	658	22	4	carthlicum (5)*
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	1.7	3.8	44.4	80	0	180	6	2	dicoccoides (3)
polonicum (1) 2 3 100 0 40 40.0 0.0 pyramidale (1) 1 1 38 0 6 15.8 0.0 turgidum (3) 4 5 150 0 17 11.3 0.0 durcarth. F1 4 5 214 0 66 30.8 0.0 6x wheats vulgare (10) 7 59 1933 57 18 3.9 64.0 sphaerococcum(4) 6 28 860 277 19 34.4 60.1 vulgsphaer. F1 5 11 376 63 18 21.5 53.1 sphaervulg. F1 4 7 226 60 6 29.2 75.8 sphaerdur. F1 4 13 490 0 0 0.0 0.0	0.0	0.0	24.4	22	0	90	3	2	dicoccon (2)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	0.6	1.7	34.0	2577	0	7570	211	7	durum (82)
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$\begin{array}{cccccccccccccccccccccccccccccccccccc$	0.0	0.0	15.8	6	0	38	1	1	pyramidale (1)
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	0.0	0.0	11.3	17	0	150	5	4	turgidum (3)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	0.0	0.0	30.8	66	0	214	5	4	durcarth. F1
$\begin{array}{cccccccccccccccccccccccccccccccccccc$									6x wheats
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	2.4	64.0	3.9	18	57	1933	59	7	vulgare (10)
sphaervulg. F1 4 7 226 60 6 29.2 75.8 sphaerdur. F1 4 13 490 0 0 0.0 0.0	20.7	60.1	34.4	19	277	860	28	6	
sphaervulg. F1 4 7 226 60 6 29.2 75.8 sphaerdur. F1 4 13 490 0 0 0.0 0.0	11.4	53.1	21.5	18	63	376	11	5	vulasphaer. F1
sphaerdur. F ₁ 4 13 490 0 0 0.0 0.0	22.1	75.8	29.2	6	60	226	7	4	
	0.0	0.0	0.0	0	0	490	13	4	
carth type 3 3 110 14 1 13.6 73.3	10.0	73.3	13.6	1	14	110	3	3	

^{*}Three compatible and two incompatible strains. The three compatible stramineum strains were subsequently found to be hexaploid.

Ten high-quality T. aestivum ssp. vulgare cultivars were crossed with 7 rye cultivars in order to transfer genes for better adaptation and quality via new primary Triticales to the introduced secondary Triticales. An average of 2.4% of the cross-pollinated florets yielded viable kernels (Table 1). Embryo culture did not significantly improve the yield of seedlings (Table 2).

According to RILEY and CHAPMAN (1967) the wheat cultivars from the East tend to hybridize more readily with rye. Since KNOBLOCH

Table 2. Seed set and viability from crosses with rye, making use of the embryo-culture technique

				Kerr	nels set	No.	No.	Seedlings	obtained
♀ parent and	No.	No	. of	(16-1)	L8 days)	kernels	embryos	% dis-	
no. culti-	rye	pollin	nations		% pol1.	dis-	trans-	sected	% poll.
vars	cvs.	Spikes	Florets	No.	florets	sected	planted	kernels	florets
4x wheats									
durum (21)	6	42	1616	600	37.1	325	282	5.8	1.2
6x wheats									
vulgare (1)	4	5	186	9	4.8	9	9	55.6	2.7
sphaerococcum	1	1	24	13	54.1	10	10	70.0	29.1

⁽¹⁹⁶⁸⁾ also cited various successful T. aestivum ssp. sphaerococcum x S. cereale crosses, it was decided to cross 4 sphaerococcum introductions with 6 rye cultivars. All sphaerococcum varieties, including

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echinatum, rotundatum and rubiginosum, hybridized readily with rye on the average 20.7% of florets yielded viable kernels (Table 1). The sphaerococcum x vulgare F1 hybrids when crossed with rye likewise gave a good set of viable kernels (Table 1). T. aestivum ssp. sphaerococcum must, therefore, be considered an efficient bridge for transferring rye genes via new primary octaploid Triticales to the secondary Triticales.

SISODIA and McGINNIS (1970b) recommended that pentaploid wheat hybrids, resulting from Dinkel X Emmer crosses, be hybridized with rye. Our sphaerococcum x durum F_1 hybrids, when crossed with 4 rye cultivars, did not set any kernels (Table 1).

Triticale Crossability

According to SISODIA and McGINNIS (1970a, b) the germplasm of 6x wheat, both at the nuclear and cytoplasmic level, is important in the improvement of hexaploid Triticale. Eight Triticale introductions from Salinas, Cal., were therefore crossed as pollen parents with 6 vulgare cultivars and 3 sphaerococcum strains. Many crosses did not yield any viable kernels and an average set of only 1 viable kernel per 100 cross-pollinated florets was obtained (Table 3). Dissection of the F_1 kernels at 16 days after pollination revealed that the endosperm was a fluid, degenerate mass and that the embryos were underdeveloped - only 1 out of 21 embryo cultures gave rise to a seedling. The methods employed by KRUSE (1967, 1969) to overcome incompatibility reactions did not improve the set of viable kernels. In the reciprocal crosses (Triticale x common wheat) 23% of the cross-pollinated florets yielded viable kernels.

All the durum \times Triticale crosses made to date yielded only inviable kernels.

Irradiation of Triticale Pollen and Eggs

BREWBAKER and EMERY (1962) stated that irradiation of mature pollen had been tested with only a minor measure of success in overcoming interspecific incompatibilities. They reported that NISHIYAMA and IIZUKA obtained a few viable kernels from two interspecific Avena crosses in 1952 when X-irradiated pollen was used. With this result in mind, and also attempting to induce haploidy in common wheat, gamma-irradiated pollen of various species was used to pollinate emasculated wheat spikes. It was found that irradiated Triticale pollen resulted in \bar{a} much improved set of viable F_1 kernels in the common wheat x 6x Triticale crosses (Table 3, Fig. 1). When pollination was effected immediately after pollen irradiation by a $^{60}\mathrm{Co}$ source, the best set of viable F_1 kernels was obtained at a gamma-ray dose of 1 kR (15 kR/hr) - at this dose nearly 36% of the crosspollinated florets yielded viable kernels. Pollination 1 and 3 days after pollen irradiation resulted in peak sets of viable F1 kernels at gamma-ray doses of 1.5 kR and 2kR, respectively (Table 3, Fig. 1). Pollination immediately after the pollen received a gamma-ray dose of 3kR yielded no viable kernels; when the pollination was effected 3 days afterwards, 14.5 per cent of the florets yielded viable kernels.

The most fertile F_1 hybrids resulted from Triticale pollen which received a gamma-ray dose of 0.1-0.5kR; they yielded as many kernels (± 4) per F_1 spike as the F_1 resulting from the control

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Table 3. The effect of pollen irradiation on the enhancement of viable kernel sets in common wheat x Triticale and common wheat x rye crosses

0.5 do. 2 2 3 80 4 55 73.8 5.1 3.7 0.75 do. 2 1 2 50 5 41 92.0 4.3 4.0 1.0 do. 2 2 4 114 11 56 58.8 23.9 14.0 1.25 do. 2 1 2 56 13 32 80.4 17.8 14.3 1.5 do. 2 2 4 114 36 58 82.5 30.9 25.4 2.0 do. 2 2 4 108 45 36 75.0 38.3 28.7 2.5 do. 2 1 3 84 25 37 73.8 25.8 19.0 3.0 do. 2 2 3 76 14 35 64.5 22.4 14.5 4.0 do. 1 1 1 26 2 19 80.8 0.0 0.0 \\ \text{Wheat x rye and controls} \\ \text{000} \text{ - 2 (selfed) 4 164 154 0 93.9 99.4 93.3 0.0 0.0 - 2 2 12 401 26 3 7.2 68.9 4.9 0.05 6-10 hr 2 2 3 103 18 1 18.4 73.7 13.6 0.1 do. 2 2 3 120 15 1 13.3 81.3 10.8 0.2 do. 2 2 3 109 27 1 25.7 75.0 19.3 0.4 do. 2 2 3 109 27 1 25.7 75.0 19.3 0.4 do. 2 2 3 109 27 1 25.7 75.0 19.3 0.4 do. 2 2 3 105 18 1 30.2 62.1 18.8 0.6 do. 2 2 3 105 18 3 20.0 52.4 10.5 10.5 do. 2 2 3 105 18 3 20.0 52.4 10.5 10.5 do. 2 2 3 105 18 3 20.0 52.4 10.5 10.5 do. 2 2 2 3 104 8 2 9.6 50.0 4.8 2.0 do. 1 1 2 70 0 9 12.9 11.1 1.4 3.0 do. 1 1 1 2 70 0 9 12.9 11.1 1.4 3.0 do. 1 1 1 1 38 0 0 0 0.0 0.0 \end{array}												
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In KR nated (wheat)	_			tivars			No.ker					
Wheat x Triticale (6x) and controls												
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0.0	whear v illicate (ox) and controls											
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lTime after irradiation	3.0					38	0	0	0.0	0.0	0.0	

lTime after irradiation

GENE FLOW TO TRITICALE

crosses of common wheat x Triticale. Triticale pollen which received a gamma-ray dose of more than lkR gave rise to sterile F_1 plants.

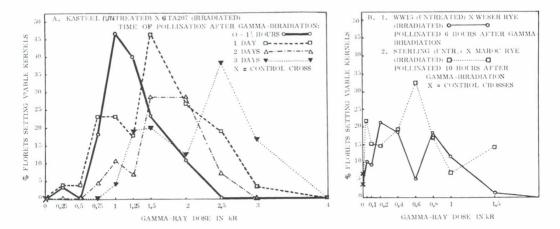


Figure 1. The effect of gamma-irradiated A) Triticale and B) rye pollen crosses with common wheat: Viable F₁ kernels as a percentage of the pollinated florets

In one family of 13 plants, obtained after the *Triticale* pollen received a gamma-ray dose of 0.05 kR, a single haploid common-wheat plant with 21 somatic chromosomes was found.

In the 6x Triticale x common-wheat crosses the production of viable F_1 kernels was not improved by irradiating the Triticale parent. The egg cells of Triticale can tolerate a much higher dose of irradiation than the pollen (ca. 7kR vs. ca. 3 kR).

Irradiation of Rye Pollen

When gamma-irradiated pollen of two rye cultivars was used in crosses with two common-wheat cultivars, a substantial increase of viable F_1 kernels was obtained over the control crosses (Table 3, Fig. 1). The best set of viable F_1 kernels was obtained at gamma-ray doses of $0.05 \mathrm{kR} - 0.4 \mathrm{kR}$. In contrast to the irradiated Triticale pollen, irradiated rye pollen resulted in an increased kernel set; the germination capacity of these kernels remained constant up to a dose of $0.8 \mathrm{kR}$.

Conclusion

Irradiation of rye and 6x Triticale pollen effectively facilitates the production of primary octaploid and secondary hexaploid Triticales, respectively.

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