

CROSSABILITY OF HEXAPLOID WHEAT (*TRITICUM AESTIVUM* L.) WITH DIPLOID RYE (*SECALE CEREALE* L.)¹

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Summary. Six varieties (Chinese Spring, Roazon, Aurora, Kaukaz, Zorba, Liwilla) and two breeding strains (CHD 374/77 and CHD 503/76) of the common wheat (*Triticum aestivum*) were pollinated with two varieties (Donar and Chodan) and one inbred line (601) of the diploid rye (*Secale cereale*). Our studies supported the previously displayed high crossability of the wheat Roazon. The group of wheats with the genotype $Kr_1Kr_1Kr_2Kr_2$ was found to have a somewhat better crossability of the cv. Aurora in comparison with other forms and a low crossability of the following varieties: Kaukaz, Zorba, Liwilla and the strains CHD 374/77 and CHD 503/76. It was found that the degree of hybrid seed setting is different depending on rye components. Pollination of wheats with the rye cv. Donar resulted in a higher percentage of set seeds than in the case of using the cv. Chodan as a pollinator. The least effective pollinator appeared to be the inbred rye line 601.

Crossing of wheat and rye in the case of the majority of European varieties meets with large difficulties. However, there are wheat varieties readily crossable with rye, such as Chinese Spring (Backhouse 1916), American strains 79-72S, CI 12632 and a number of other (Falk, Kasha 1981). Lein (1943) found that the ability of wheat to seed setting after pollination with rye pollen is a result of the presence of two pairs of additively acting genes. Basing himself on the percentage of hybrid seed setting he proposed to separate 4 genotypes:

$Kr_1Kr_1Kr_2Kr_2$ (0 - 10%)

$Kr_1Kr_1kr_2kr_2$ (10 - 30%)

$kr_1kr_1Kr_2Kr_2$ (30 - 50%)

$kr_1kr_1kr_2kr_2$ (over 50%).

The genes *kr* in their dominant form inhibit crossability, Kr_1 acting more strongly than Kr_2 . Wheats easily crossable with rye have these genes in the recessive form. The genes Kr_1 and Kr_2 were localized by Riley and Chapman (1967) on the chromosomes 5B and 5A, respectively, and their action was the subject of many studies.

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Lange, Wojciechowska (1976), Wojciechowska, Lange (1977) revealed that dominant alleles of these genes cause inhibition of the pollen tube growth in rye. Jalani and Moss (1980) showed that wheat forms with a large crossability, and, therefore, having *kr* genes in the recessive form, possess more pollen tubes attaining micropyles than forms which are difficult to cross with rye. Abnormalities occurring during fertilization and development of the embryo and endosperm of hybrid seeds displayed by many authors (Tozu 1966, Nakamura 1966, Jalani, Moss 1981) are probably also related with the action of these genes. It cannot be excluded that there exist some other factors (genes) besides the *kr* system, which affect crossability of these two kinds; such suggestions were made by many authors (Krolow 1970, Marais, Pienaar 1977, Falk, Kasha 1981, Jalani, Moss 1981). Tanner, Falk (1981) found that genetic system controlling crossability occurs also in rye. It probably has the monomeric character, a high degree of crossability dominating over a low one.

The purpose of the present paper was to find the degree of crossability in several varieties of hexaploid *Triticum aestivum* wheat and to try to analyze the influence of rye components (*Secale cereale*) on that trait.

MATERIAL AND METHODS

Six varieties of common wheat (Chinese Spring, Roazon, Aurora, Kaukaz, Zorba, Liwilla) and two breeding strains (CHD 374/77 and CHD 503/76) were crossed with two varieties of diploid rye (Donar selected in the Pektus firm in the GDR and Polish Chodan) and with the inbred line 601. The inbred rye line was selected from the population of Hungarian rye at the Station of Plant Breeding in Clermont-Ferrand in France. The cv. Chinese Spring, known for its recessive *kr* genes, was used as an easily crossable standard. The cv. Roazon was obtained in France as a result of intergeneric crossing of (*Aegilops ventricosa* × *Triticum turgidum* ssp. *carthlicum* conv. *rubiginosum*) × (*Triticum aestivum* Marne³ × *Triticum aestivum* Moisson (Bougeois et al. 1978). That variety was used for crossing on account of its previously found high crossability with the Petkus rye. Wheat varieties used a maternal form had a small fragment of the genetic rye material or the entire chromosome of rye. Aurora and Kaukaz are varieties, in which the short arm of 1B chromosome was substituted by the arm of the rye chromosome 1R (Met tin et al. 1978), whereas the cv. Zorba has the entire 1B chromosome substituted by 1R (Zeller, Fischbeck 1971). The cv. Liwilla and the breeding strains CHD 374/77 and CHD 503/76 are of Polish origin; their crossability with rye has not been studied until now.

Crossing was performed under glass-house conditions.

RESULTS AND DISCUSSION

The cv. Chinese Spring set on the average 68.15% of hybrid seeds, seed setting after pollination with rye pollen of Chodan being about 20% higher than that in the case of using the cv. Donar as a pollinator (Table 1).

The wheat cv. Roazon pollinated with rye pollen of Chodan showed the crossability level (45.90%) referring it to a group with the genotype $kr_1kr_1Kr_2Kr_2$. This result is very similar to that previously obtained (Stefanowska, Cauderon 1983) in the case of pollination with the Petkus pollen (43.79%). The cause of such a high crossability of the French wheat variety is unknown until now and may have its source in the *kr* system originating probably from *Triticum turgidum* ssp. *carthlicum*. May be this cultivar, besides the genetic material and cytoplasm originating from *Aegilops ventricosa*, also has other factors (genes) absent in the remaining European wheat varieties. The cv. Roazon pollinated with pollen of the inbred rye line 601 set significantly less hybrid seeds (29.25%).

The wheat cv. Aurora pollinated with rye pollen of Chodan and Donar displayed a significantly higher degree of seed setting (9.76 and 7.63%, respectively) than the cv. Kaukaz and others with a similar genotype. If the rye inbred line 601 was used as a pollinator, nearly a four-fold decline was observed in the degree of hybrid seed setting (Table 1).

Table 1. Hybrid seed setting after pollination of selected varieties and breeding strains of hexaploid wheat with pollen of several varieties and inbred lines of diploid rye

Cross combination (wheat × rye)	Percentage of seeds set	Number of	
		pollinated flowers	seeds set
cv.Chinese Spring × cv.Chodan	86.11	36	31
cv.Chinese Spring × cv.Donar	66.28	347	230
cv.Roazon × cv.Chodan	45.90	122	56
cv.Roazon × line 601	29.25	506	148
cv.Aurora × cv.Donar	9.76	205	20
cv.Aurora × cv.Chodan	7.63	380	29
cv.Liwilla × cv.Chodan	6.71	149	10
strain CHD 503/76 × cv.Donar	6.34	410	26
cv.Zorba × cv.Donar	5.36	167	9
cv.Kaukaz × cv.Chodan	4.79	292	14
cv.Liwilla × cv.Donar	3.35	239	8
strain CHD 503/76 × cv.Chodan	2.45	652	16
strain CHD 374/77 × cv.Donar	2.30	304	7
cv.Aurora × line 601	2.21	544	12
strain CHD 374/77 × cv. Chodan	2.14	513	11
cv.Kaukaz × cv.Donar	1.73	173	3
strain CHD 374/77 × line 601	0.72	418	3
cv.Liwilla × line 601	0.64	312	2
cv.Zorba × cv.Chodan	0.57	174	1
cv.Kaukaz × line 601	0.57	351	2
strain CHD 503/76 × line 601	0.26	376	1
Mean	9.58	6670	639

The influence of the paternal form of rye on the seed setting was observed and analysed by many authors. Sapro et al. (1977) pollinating the hexaploid wheat cv. Arthur with the rye cv. Snoopy obtained 28% of set seeds, whereas when using the rye cv. Rymin as the paternal form, they obtained only 7% of hybrid seeds. Oettler (1982) as a result of pollination of *Triticum aestivum* cv. Jubilar and cv. Kormoran with 20 inbred lines of rye obtained on the average 1.1% of set seeds. Depending on

the paternal component this percentage ranged from 0 to 6.4. A still higher variation of crossability was obtained by him as a result of pollination of wheats with a higher crossability, i.e. *Triticum turgidum* and *Triticum durum*, by inbred rye lines; the mentioned percentage in that case ranged from 0.9 to 37.3% and from 2.0 to 51.8%, respectively, depending on the line.

The degree of seed setting in the cv. Kaukaz, Zorba, Liwilla, CHD 374/77 and CHD 503/76 qualified them to a group having the genotype $Kr_1Kr_1Kr_2Kr_2$. The cv. Kaukaz and Zorba, despite the presence of rye genetic material in their genome, did not show a higher degree of crossability. Kaukaz, as well as the remaining wheat cultivars with dominant Kr genes, pollinated with pollen of an inbred rye line, had significantly lower percentage of set seeds (Table 1).

CONCLUSIONS

1. Crossability of the French wheat cv. Roazon with rye is at the level of a group having the genotype $kr_1kr_1Kr_2Kr_2$.

2. The wheat cv. Aurora has probably dominant genes Kr , nevertheless it is better crossed with rye than the remaining forms from the same group of wheats.

3. Crossability of the wheat cv. Kaukaz, Zorba and Liwilla, as well as that of the strains CHD 374/77 and CHD 503/76 with rye was from 0.26% to 6.71%, which suggests that they have the genotype $Kr_1Kr_1Kr_2Kr_2$.

4. The rye cv. Chodan and Donar are more effective pollinators of wheat than the inbred line 601 and that is both in the case of wheat with a high and low crossability with rye, the cv. Donar giving a somewhat higher percentage of hybrid seeds than the cv. Chodan in the majority of analyzed cross combinations.

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ZDOLNOŚĆ DO KRZYŻOWANIA HEKSAPLOIDALNEJ PSZENICY (*TRITICUM AESTIVUM* L.) Z DIPLOIDALNYM ŻYTEM (*SECALE CEREALE* L.)

Streszczenie

Zapylano 6 odmian (Chinese Spring, Roazon, Aurora, Kaukaz, Zorba, Liwilla) oraz 2 rody hodowlane (CHD 374/77 i CHD 503/76) pszenicy zwyczajnej (*Triticum aestivum*) dwoma odmianami (Donar i Chodan) i jedną linią wsobną (601) diploidalnego żyta (*Secale cereale*). Potwierdzono wykazaną wcześniej dobrą krzyżowalność pszenicy Roazon. W grupie pszenic o genotypie $Kr_1Kr_1Kr_2Kr_2$ wykazano nieco lepszą od innych form krzyżowalność odmiany Aurora oraz stwierdzono niską zdolność do krzyżowania z żytem odmian: Kaukaz, Zorba, Liwilla, a także rodów CHD 374/77 i CHD 503/76. Wykazano zróżnicowany stopień zawiązywania nasion mieszańcowych w zależności od komponentów żytnich. W wyniku zapylania pszenic żytem odmiany Donar uzyskano wyższy procent zawiązaných nasion niż w przypadku użycia jako zapylacza odmiany Chodan. Najmniej efektywnym zapylaczem okazała się linia wsobna żyta 601.

СПОСОБНОСТЬ К СКРЕЩИВАНИЮ ГЕКСАПЛОИДНОЙ ПШЕНИЦЫ (*TRITICUM AESTIVUM* L.) С ДИПЛОИДНОЙ РОЖЬЮ (*SECALE CEREALE* L.)

Резюме

Шесть сортов пшеницы обыкновенной (*Triticum aestivum* L.) — Chinese Spring, Roazon, Aurora, Kaukaz, Zorba, Liwilla, а также две селекционные линии — CHD 374/77, CHD 503/76 опылялись двумя сортами диплоидной ржи (*Secale cereale*) — Donar, Chodan и одной инбредной

линией 601. Подтверждено установленную ранее хорошую скрещиваемость пшеницы Roazon. В группе пшениц с генотипом $Kr_1Kr_1Kr_2Kr_2$ обнаружено несколько лучшую, чем у других форм, скрещиваемость сорта Augora, а также низкую способность к скрещиванию с сортами ржи Kaukaz, Zorba, Liwilla и линий CHD 374/77 и CHD 503/76. Установлено, что завязывание гибридных семян отличается различной степенью в зависимости от компонентов ржи. В результате опыления пшениц рожью Donar получен высший процент завязанных семян, чем при использовании сорта Chodan в качестве опылителя. Наименее эффективным опылителем оказалась инбредная линия ржи 601.