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Identification of two wheat-rye translocation lines

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Abstract

By producing chromosome substitutions with Imperial rye chromosomes 4R and 7R in Chinese Spring wheat two spontaneous translocation lines were obtained. One involves segments of wheat chromosome 7B and rye chromosome 4R, the other involves parts of wheat chromosome 4A and rye chromosome 7R.

Introduction

Since homoeologous pairing between wheat and rye chromosomes in F_1 hybrids is very low in the presence of chromosome 5B (Mettin _et al_. 1976) and even in its absence (Lacadena 1967; Bielig and Driscoll, 1970a,b) or with the 5B-effect suppressed by the _Aegilops speltoides_ genome (Riley and Kimber, 1966), the most important procedure to incorporate genes from rye into wheat is the creation of chromosome substitution or translocation lines. Most of the seven rye chromosomes provide substantial compensation for the loss of single homoeologous wheat chromosomes (Gupta, 1971; Koller and Zeller, 1976). Also several wheat-rye translocation lines are known.

Translocations involving segments of rye chromosome 1R and wheat chromosomes of group 1 were reported by Mettin _et al_. (1973), Zeller (1973), Shepherd (1973), and Bartos _et al_.(1973). The transferred rye segments appear to condition rust resistance, , certain prolamin bands and resistance to the wheat curl mite, the vector of wheat streak mosaic virus (Martin _et al_. 1976). Another translocation includes segments of 2AL and 2RL (Sears 1972) and reveals a significant increase in kernel protein content (Jagannath and Bhatia, 1972). A 4A-2R translocation, called Transec, possesses resistance to powdery mildew and leaf rust (Driscoll and ~~1965~~ Jensen, 1964; Driscoll 1968). Acosta (1961) produced a 3A-3R wheat-rye translocation (analyzed by Barber _et al_. (1968) having stem rust resistance. In an attempt to transfer the stem rust resistance of rye chromosome 3R into durum wheat

after irradiation of a 3RS ditelosomic Chinese Spring/Imperial addition line Rao (1977) obtained a heterozygous durum wheat-rye translocation. In homozygous condition the interchanged chromosome which carries the gene for resistance was transmitted normally through the female gametes, however, showed no male transmission. Rao (1977, pers. communication) also found a translocation line with 20 wheat chromosome pairs and an interchanged pair involving segments of wheat chromosome 4A and rye chromosome 4R (C). The long arm of rye chromosome 5R carrying the hairy neck gene was successfully translocated to wheat chromosome 4A (Driscoll and Sears, 1965), 5BS (Sears 1967), 6BL (Sears 1973), 5DL (Muramatsu 1968) and 6D (Sears 1967), respectively. Finally a segment of 6RL that carries a gene for the restoration of pollen fertility in *Triticum timopheevii* cytoplasm has been translocated to wheat chromosome 6BS (Tuleen, 1976, pers. communication). The present report deals with the identification of two new translocation lines involving segments of rye chromosomes 4R and 7R.

Material and Methods

Two translocations, T8 and T22 were recovered in the progeny of the 42-chromosome hybrids Chinese Spring monosomic 4A x Chinese Spring/Imperial addition line 7R (D), and Chinese Spring (CS) monotelocentric 7BL x Chinese Spring/Imperial addition line 4R (C), resp. Strain T8 was analyzed cytologically by crossing with CS ditel-β monotelo-α-4A, CS ditelo-4Aα, CS/Imperial addition lines 7R (21"+1"), 7RS (21"+t") and 7RL (21"+t"). T22 was crossed with CS double ditelo-7B, CS ditelocentrics 7BS and 7DS and CS/Imperial addition line 4RS (21"+t"). Anthers from the plants studied were fixed in acetic-alcohol and stained by the Feulgen procedure.

Results

Cytology of translocation T8

From the cross T8 x CS ditelo-β-monotelo-α-4A and its reciprocal two types of offspring were obtained: those with both telocentrics and those with only telo-4Aβ (Table I). The former showed maximum pairing of 20"+t1" (telocentric + entire) + t' (Fig. I), while the latter had a maximum of 20"+t'+1'. In the cross T8 x CS ditelo-4Aα, however, mainly 20"+t1" occurred, though 20"+t'+1' was nearly as

Table I

Chromosome pairing in F_1 hybrids of translocation line T8 with various Chinese Spring aneuploids and Chinese Spring/Imperial addition lines

F_1 hybrids	No. plts.	21"+t'	20"+1"'	20"+t2"'	20"+t1"+t'	20"+t'+t'+1'	20"+t'+2'	20"+t'+1'	20"+t1"	20"+t'+t'+1'	other
T8 x DT4Aα 2n = 41+t	5	-	-	-	-	-	-	82	109	-	-
T8 x DβMTα 4A 2n = 41+t +t	2	-	-	-	41	8	-	-	-	-	-
DβMTα 4A x T8 2n = 41+t +t	1	-	-	-	28	2	-	-	-	-	-
DβMTα 4A x T8 2n = 41+t	5	-	-	-	-	-	-	46	-	-	5[1]
Add. 7R x T8 2n = 43	2	-	16	-	-	-	-	-	-	-	1[2]
Add. 7RS x T8 2n = 42+tS	4	-	-	70	21	-	2	-	-	-	-
Add. 7RL x T8 2n = 42+tL	3	92	-	-	-	-	22	-	-	-	2[3]

[1] 19"+t'+3'

[2] 21"+1'

[3] 19"+t'+4'

Table II

Chromosome pairing in F_1 hybrids of translocation line T22 with various Chinese Spring aneuploids and Chinese Spring/Imperial addition line 4RL

F_1 hybrids	No. plts.	21" +t'	20" +t2"'	20" +t' +1'	20" +t' +2'	20" +t' +t1"	20" +t1"	19" +2' +t2"'	19" +t' +2' +t1"	19" +t' +3'	18" +1"" +t1"
T22 x DDT7B 2n = 41+t+t	5	-	-	-	-	81	-	-	5	-	-
T̄22 x DT 7BS 2n = 41+t	6	-	-	144	-	-	-	-	-	16	-
T22 x DT 7DS 2n = 41+t	3*	-	-	2	-	-	25	-	-	-	14*
T22 x Add. 4RL 2n = 42+tL	7	5	31	-	2	-	-	15	-	-	-

* One T22 plant presumably possesses a wheat-wheat chromosomal translocation

Figures 1 and 2

Metaphase I in PMC's of F_1 hybrids (1) Chinese Spring di-β-monotelo-α-4A x translocation line T8, 4Aα -7RS (4Aβ), showing 20"+t1"+t' (2) Translocation line T22, 7BL - 4RL (7B$) x Chinese Spring ditelocentric-7BS with 20"+t'+1'

Figure 3

Spikes of (left) normal wheat Chinese Spring and (right) translocation line T22

frequent (Table I). These chromosome configurations indicate that a rye segment replaces most or all of the β-arm of 4A.

In hybrids of T8 with addition line 7R, 20"+1"' usually occurred. When only the 7RS telocentric was present, it mainly formed a monotelosomic trivalent which also included 4A and the translocated chromosome; whereas 7RL, when present, never paired (Table I). This leads to the conclusion that T8 is a translocation consisting of the complete -arm of wheat chromosom 4A or a part of it and the entire 7RS arm or a segment of it. The translocation line shows good fertility.

Cytology of translocation T22

In the F_1 plants from the cross CS ditelocentric 7DS x T22, the telosome mainly formed a heteromorphic bivalent (Table II). Crosses of double ditelocentric 7B with T22 showed most commonly 20"+t1"+t', while no pairing of telo-7BS occurred in the F_1 hybrid between ditelocentric 7BS and T22 (Fig. II). These results indicate that the translocated chromosome includes either an intact 7BL arm or a substantial portion of it. In the cross between the ditelocentric addition line 4RL and T22, a monotelosomic trivalent involving the translocated chromosome, the complete chromosome 7B and telo-4RL most frequently was formed (Table II). From this it is concluded that translocation T22 consists of at least part of wheat arm 7BL and rye arm 4RL. T22 is charachterized by red coleoptile conditioned by a gene on 4RL (Koller and Zeller, 1976). The line is vigorous and exhibits a fertility of approximately 80% (Fig. III).

Discussion

Several methods have been developed for the transfer of alien variation from related species to wheat: i) induction of homoeologous chromosome pairing, ii) use of ionizing radiation and iii) exploitation of the tendency of univalent chromosomes to misdivide and form an interchanged chromosome having one entire arm from each of the two parental univalents. It appears that the translocation lines described in this paper resulted through union of newly formed telocentric chromosomes.

With a univalent 4A and a univalent 7R present in the cross between CS monosomic 4A and the disomic addition CS/Imperial 7R, two telocentrics were presumably formed in the same daughter nucleus after simultaneous misdivision and united to give rise to the 4A -7RS translocation T8 that was recovered in the progeny of the F_1 hybrid. The isolation of a substitution line consisting of 40 entire wheat chromosomes, two telocentric 4A chromosomes and two telocentric rye chromosomes, presumably 7RS (Koller and Zeller, 1976), indicates some relationship between 4A and 7R, though so far no homoeoalleles are known on wheat chromosomes of group 4 and rye chromosome 7R.

Translocation T22 most likely also arose by union of telocentrics, after misdivision of ~~wheat~~ univalent 4R in the F_1 of the cross between monotelocentric 7BL and CS/Imperial addition 4R. In the translocation, part or all of chromosome arm 7BS was replaced by part or all of rye chromosome arm 4RL. Koller and Zeller,(1976) demonstrated that the long arm of rye chromosome 4R is able to compensate for the loss of chromosomes of wheat homoeologous group 7 to a considerably higher degree than the complete rye chromosome 4R. This leads to the conclusion that the exchange in line T22 involves homoeologous segments.

As the homoeologous relationships between wheat and rye chromosomes are known, it is easy to select for chromosomal translocations that have arisen by union of telocentrics after univalent misdivision in a double monosomic substitution (one wheat, one rye univalent). Since even in the absence of the 5B-effect in wheat, little or no pairing takes place between wheat and rye chromosomes (Riley and Kimber, 1966; Lacadena, 1967; Bielig and Driscoll, 1970a,b), to date incorporation of genetic material from rye into the wheat genome can only be done by the production of substitutions or by the induction of translocations through ionizing irradiation or union of telocentrics. Although union of misdivided telosomes can occur between homoeologous <u>and</u> non-homoeologous chromosomes (Muramatsu 1968; Sears 1972, 1973; Shepherd 1973), exchange of homoeologous arms should have less deleterious effects and appears to be more desirable.

Once sufficient corresponding translocation lines are available, any valuable gene in rye whose chromosomal localization is known can be transferred into wheat by simple crossingover between the rye segments in an F_1 hybrid followed by incorporation of the desirable gene into the proper translocation through crossing and backcrossing.

There are several species of *Aegilops* having genes that promote homoeologous chromosome pairing in hybrids with wheat: *Ae. speltoides* Tausch (Riley *et al.* 1961), *Ae. mutica* Boiss. (Riley and Law, 1965) and *Ae. longissima* Schweinf. et Muschl. (Mello-Sampayo 1971). Lelley (1976), in crosses of wheat-rye chromosome addition lines with *Secale cereale* L. and *Secale montanum* Guss., observed several alleles in rye that effect homoeologous pairing between wheat chromosomes. It is reasonable to assume that in rye genes can be found which permit pairing between wheat *and* rye chromosomes in appropriate hybrids.

It should also be noted that homoeologous pairing may occur between *Aegilops squarrosa* L. , the donor of the wheat D-genome, and rye (Melnyk and Unrau, 1959). If recombinants can be recovered after backcrossing to *Aegilops*, gene transfer from rye into wheat should also be feasible.

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