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IDENTIFICATION OF THREE CHROMOSOMAL INTERCHANGES IN COMMON WHEAT, *TRITICUM AESTIVUM* L.

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Analyzing the F_1 P.M.C.s of the crosses between Solo and the 21 monosomic lines of Chinese Spring three chromosomal interchanges involving six wheat chromosomes were identified. 5B/7B involves the longest segments and is already known in other varieties. 7A/7D involves a powdery mildew resistance gene, probably Pm 1 on the distal end of the long arm of chromosome 7A. An attempt is made to explain the deviating segregation ratios of these two aneuploid F_2's in the mildew tests. 2A/4D probably involves very short segments since only one single cell out of 1,400 P.M.C.s showed three quadrivalents.

Introduction

Chinese Spring was introduced as a standard variety for chromosome constitution of common wheat (Sears, 1953). A chromosomal interchange will be present when part of a chromosome is exchanged with part of another one. A number of translocations were already identified by several authors (Table I). Most frequent varieties having one single reciprocal translocation relative to Chinese Spring were analyzed. Three varieties have shown two translocations each involving two chromosomes. One strain designated as Eligulate was described being homozygous for two translocations involving three chromosomes.

In the strain W 70 a 86 (Blaukorn) 10 different chromosomes have undergone translocations.

This investigation was conducted to determine the interchanges of the variety Solo in relation to the standard variety Chinese Spring.

Materials and Methods

Solo is a short strawed wheat variety bred at the Bayerische Landesanstalt für Bodenkultur und Pflanzenbau at Weihenstephan. It shows field resistance to stem rust and carries three genes for mildew resistance (Baier, 1972; Baier *et al.*, 1973). Chromosome pairing in pollen mother cells (P.M.C.) at first meiotic metaphase was analyzed in hybrids between monosomic plants of each of the 21 Chinese Spring monosomic lines used as female parents with Solo. The F_1 plants were grown in the green house at approximately 18°C with halogen illumination. The somatic chromosome number of the monosomics of Chinese Spring and the monosomic F_1 crosses were determined using the Feulgen method. Two or more anthers were taken from each spike in the first meiotic metaphase stage, fixed in Carnoy's solution and stained by basic fuchsin. The pairing configurations were observed in several cells of each anther.

Results and Discussion

Frequently one or two quadrivalents were observed in the crosses of Solo with the euploid and monosomic lines of Chinese Spring. In one single cell out of 1,400 three quadrivalents appeared (Table II). Trivalents were observed in

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some crosses with or without the presence of univalents. Appearance of trivalents and absence of univalents in cells showing trivalents was used to identify the critical crosses. As is evident from Table II, chromosomes 2A, 7A, 5B, 7B, 4D and 7D are involved in translocations; in all other crosses the appearance of trivalents was accompanied by at least two univalents.

The meiotic cells of the monosomic crosses with 5B and 7B developed trivalents without univalents in more than 50% and a trivalent with or without univalents in more than 70% of the cells analyzed (Table II). Taking into account the lower number of P.M.C.s with a trivalent in the other four critical monosomic crosses it is assumed that chromosomes 5B and 7B are involved in one reciprocal translocation. This conclusion is supported by the results of Law and Worland (1972) with concern to the 5B/7B translocation in wheat cultivar Bersee which also appeared in high percentage as quadrivalents and trivalents in P.M.C.s of disomic and monosomic hybrids with Chinese Spring lines. In Table I several other cases of mainly European varieties are listed which are characterized by a 5B/7B translocation. Presumably Solo and all these varieties carry the same chromosomal interchange.

Comparing chromosomes 2A, 4D, 7A and 7D there are indications that 7A and 7D are involved in another reciprocal translocation based on the percentage of P.M.C.s with trivalents with or without univalents. Furthermore the trivalent in the crosses involving monosomic 7A as well as 7D in most cases showed a 'frying pan' configuration. This configuration was not observed in the other four critical

TABLE I

Summary of identified chromosomal interchanges in *Triticum*

Variety/Stock	Chromosomes involved	No. of interchanges	Authority
Indian	3B-7B	1	Sears, 1953
Thatcher	4A-6B	1	Sears, 1953
Poso	5B-7B	1	Sears, 1953
S 615	2B-3B, 4A-6B	2	Larson, 1954, cited by Riley *et al.*, 1967
ssp. carthlicum (tetraploid)	2A-3A	1	Dalal and Sadanaga, 1963
Sonora	3A-7B	1	Baker and McIntosh, 1966
S 2303	4A-1B	1	,,
Eligulate	4A-6A-7B	2	,,
Holdfast	3B-3D	1	Riley *et al.*, 1967
Cappelle-Desprez	5B-7B, 3B-3D	2	Riley *et al.*, 1967
Wachtel	1D-6D	1	Röbbelen, 1968
Poros	7B-2D	1	Mettin, 1969
Vilmorin 27	5B-7B	1	The and Baker, 1970
Bersee	5B-7B	1	Law, 1971
Hybride du Joncqois	5B-7B, 3B-3D	2	Law, 1971
Maris Ensign	7B-2D	1	Larsen, 1973
Synthetic hexaploid	6B-7D	1	Larsen, 1973
W 1007/53	3A, 2B and two unidentified	2	Zeller, 1973
W70 a 86 (Blaukorn)	1A, 2A, 5A, 6A, 3B, 7B, 1D, 3D, 6D, 7D	5	Zeller and Baier, 1973

monosomic crosses. 2A and 4D most probably represent the third reciprocal interchange.

The percentage of trivalents allows an assessment of the relative length of the interchanged segments. The data in Table II justify the conclusion that the 5B/7B translocation includes a relatively long, the 7A/7D and 2A/4D translocations

TABLE II

Chromosome configurations at metaphase I in F_1 plants from crosses of Chinese Spring monosomics with Solo

	Number of cells in each pairing configuration																	
	II		IV					III				III+IV						
Monosomic cross	20'' + 1'§	19'' + 3'	18'' + 1'' ' + 1'	17'' + 1'' '' + 3'	16'' + 2'' '' + 1'	15'' + 2'' '' + 3'	14'' + 3'' '' + 1'	19'' + 1'' '	18'' + 1'' ' + 2'	17'' + 1'' ' + 4'	17'' + 2'' ' + 1'	17'' + 1'' '' + 1'' '	16'' + 1'' '' + 1'' ' + 2'	No. of P.M.C.	No. of plants	% of P.M.C. with a triv. without univalents.	% of P.M.C. with a trivalent, with or without univalents.
1A	83	40	77	17	1				17	2			2	239	4		
1B	14	11	19	10	8					1				62	2		
1D	2	1	11	5	3									23	1		
2A	42	1	35	1				14	5			8		106	3	20,7	25,5
2B	8	4	18	13	3	1							1	48	1		
2D	9	4	27	3	3									46	1		
3A	11	3	12	8	2								1	36	2		
3B	5	1	7	3	3	1	1		2					23	2		
3D	3		14	4						1				22	1		
4A	13	7	25	5		2			1					53	2		
4B	10	7	9	11	5					2			2	46	2		
4D	20	7	41	7	2	1		5	8			2	3	96	3	7,3	18,8
5A	12	11	21	8	8	1			1	1				63	3		
5B	12	5	4					34	13			2		70	3	51,4	70,0
5D	31	12	32	9	1				2					87	2		
6A	8	1	7	2	2									20	1		
6B	25	15	30	4	3				3				1	81	4		
6D	19	1	24	7	3				2				2	58	2		
7A	15		20	8	1			13	6		1	21	2	87	2	39,3	49,4
7B	15	8	1	2				40	16		1	9	2	94	2	52,1	72,3
7D	21	4	36	10				10	14	4	1	12	2	114	3	19,3	36,8

'CS' disomic × 'Solo'

4 cells with 21''§
5 cells with 20'' + 2'
11 cells with 19'' + 1'' ''
6 cells with 18'' + 1'' '' + 2'
3 cells with 17'' + 2'' ''
3 cells with 17'' + 1'' '' + 4'

§ ' = univalents
'' = bivalents
'' ' = trivalents
'' '' = quadrivalents

shorter segments. 2A/4D appears to involve a very short segment because of the low frenquency of trivalents in the appropriate monosomic crosses. Futhermore in the euploid and noncritical monosomic crosses only one cell appeared to show three quadrivalents.

Figure 1 demonstrates the chromosome configuration in the monosomic F_1 hybrid of Chinese Spring monotelosomic $7A^L$ with Solo. The trivalent in this figure which is monosomic for 7A and presumably involves 7D of Chinese Spring and the corresponding reciprocally interchanged chromosomes of Solo appears to be smaller than the quadrivalent. The quadrivalent may be formed either from 2A/4D or 5B/7B. On the basis of both the frequency of trivalent formation and size of chromosomes more probably the 5B/7B translocation showed up.

The gene Pm 1 for resistance to powdery mildew is located on the distal end of chromosome 7A (Sears and Briggle, 1969). In separate studies to locate this gene in Solo by means of the F_2 monosomic analysis (Baier, 1972; Baier *et al.*, 1973) it was observed that the 7D cross had the highest deviation from normal segregation but did not fit the expected ratio in the critical monosomic cross. This can be explained by possible pairing of the 7A translocation segment from Solo chromosome 7D with the normal 7A chromosome from Chinese Spring which may occur when a trivalent is formed. Table II shows that a trivalent occurred in 39% of the observed P.M.C.s.

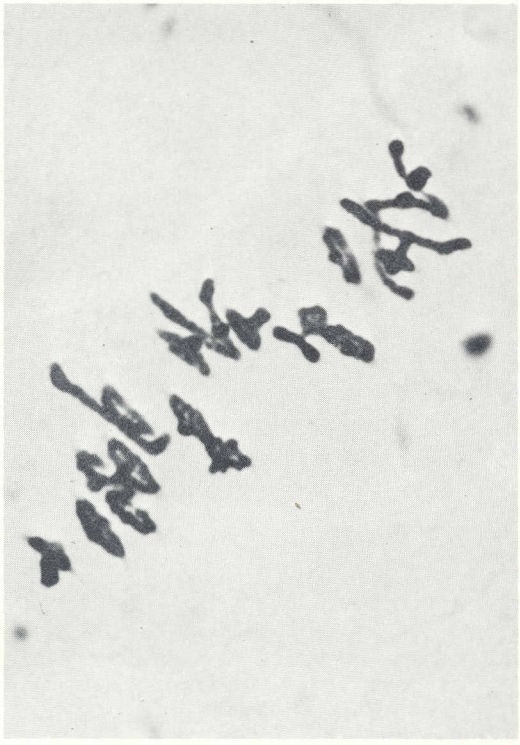

Fig. 1. Chromosome configuration at first metaphase of a PMC of the monosomic F_1 hybrid from the cross Chinese Spring monotelosomic $7A^L \times$ Solo, showing 17 bivalents, on quadrivalent and one trivalent.

A significant deviation from the normal segregation ratio also was observed in the F_2 of the monosomic cross with 7A. This deviation possibly is caused by irregular distribution of the three chromosomes from a trivalent. Sears (1953) reported that the two translocated chromosomes from a trivalent commonly go to one pole and the normal one to the other. From a P.M.C. with a trivalent it will be expected that two types of pollen grains are generally formed: type 1 with n-1 chromosomes but without a translocated chromosome and a second type which contains the two translocated chromosomes. In this case the latter type also would carry the resistance gene on the translocated chromosome. Since Morris and Sears (1967) pointed out that 96% of the ovaries are pollinated from pollen with "n" chromosomes, it seems highly probable that segregation from mildew resistance will deviate rather strongly as observed in the 7A cross. The cytogenetic problems which may arise from this situation have been extensively described by Sears (1953) and by Unrau *et al.* (1956).

The deviation of segregation ratios in chromosomes 7A as well as 7D indicates that the terminal end of the long arm of 7A participates in the assumed translocation and lends further support to the earlier conclusion that 7A/7D are involved in one of the three reciprocal translocations in Solo.

The genes involved in the 5B/7B and 2A/4D translocations had no detectable influence on segregation of other characters analysed in this study.

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