Identification of chromosomes involved in translocations in wild Emmer

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ABSTRACT

With the aid of telocentric lines of Emmer wheat, the chromosomes involved in seven chromosome types (one standard type and six translocation types) in wild Emmer, *Triticum dicoccoides*, were identified. Type E1a was of almost the same chromosome structure as that of *durum* LD 222 with a small reciprocal translocation between chromosomes 4B and 2B. Type E1b had a major translocation between 2A and 2B and a minor one probably between 2B and 3B. Type E2 had a major translocation between 2B and 3B. Type E3 had a major translocation between 5B and 7B. Type E4 had a major translocation between 4B and 3B and a minor one between 2B and 4B or 3B. Type E5 had a major translocation between 6B and 7B. Type E6 had a major translocation between 1A and 5A. We discussed the result in comparison with the previously reported data on the same translocations.

1. INTRODUCTION

Five major and one minor types of translocation in wild Emmer, *T. dicoccoides* Körn. were reported by Kawahara and Tanaka (1983) and Kawahara (1984, 1986, 1987), who carried out the extensive studies on intraspecific variation, fundamental chromosome structure, and geographical distribution of the translocation types. Kawahara (1984), based on the chromosome pairing in the F₁'s between translocation testers and Einkorn wheat, estimated the genomes to which the chromosomes involved in the translocations belonged, but did not identify the translocation chromosomes themselves. As *T. dicoccoides* is a good source of the genes for agronomically important traits such as disease resistance, identification of chromosomes involved in the different types of translocation is desired from a viewpoint of cytogenetics and wheat breeding. Using telocentric lines of *durum* wheat, Nishikawa et al. (1986) identified the chromosomes involved in translocations among cultivated forms of Emmer wheat. The method was applied in this study to investigate the translocations found by Kawahara (1984).

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2. MATERIALS AND METHODS

Seven tester strains of *Triticum turgidum* (L.) Thell. ssp. *dicoccoides* Körn., each representing Kawahara's seven chromosome structures (KU-1978B for Type E1a, KU-108-3 for E1b, KU-109 for E2, KU-195 for E3, KU-8915A for E4, KU-1945 for E5, KU-1952 for E6), were kindly provided by Dr. T. Kawahara, Plant Germ-plasm Institute, Faculty of Agriculture, Kyoto University.

Double ditelosomics ($13'' + t'' + t'''$) or ditelo-monotelosomics ($13'' + t'' + t'$) for the A and B genome chromosomes of a *durum* wheat [*Triticum turgidum* (L.) Thell. ssp. *turgidum* conv. *durum* (Desf.) MK] cv. LD 222, which had been developed by the senior author, were crossed to the tester strains, and the chromosome pairing in PMC's of the F_1 's was observed.

3. RESULTS AND DISCUSSION

The telocentric chromosomes tended to fall apart from their homologous chromosome arms at metaphase I. This resulted in variations in the meiotic pairing of the telosomes. For example, a meiotic pairing $(t+t)1'''$ (trivalent consisting of one whole and two telocentric chromosomes) dissociated into $t1'' + t'$ and $2t' + 1'$, and the critical pairing $(t+t)3^V$, which indicated the involvement of the telocentric chromosomes in the translocation, dissociated into $t3^{IV} + t'$, $t2''' + t1''$, $1'' + 2t'$ and so on. In the monotelodisomic F_1 's, the critical pairing, $t3^{IV}$ occasionally dissociated into $t1'' + 1''$, which can not be distinguished from normal pairing in non-critical F_1 's. So, this pairing type was recognized as critical in the lines which showed $t3^{IV}$ in the other PMC's. The normal chromosomes were rarely formed two univalents or $1''' + 1'$. For the sake of brevity, the desynaptic pairing of the telosomes were scored as the complete pairings in Table 1: for example, $t1'' + t'$ and $2t' + t'$ were scored as $(t+t)1'''$. Among telocentric chromosomes of LD222, the 1B and 6B telosomes showed a considerable degree of desynapsis in the F_1 's of all the testers. In the non-critical F_1 's, the quadrivalents occurred in a ring-of-four or chain-of-four configuration. The percentage of the ring-of-four was more than 60% in the F_1 's of the E2, E4, E5 and E6 testers, but it was about 20% in those of the E1a tester.

(a) E1a tester (KU-1978B)

Chromosome pairing in the F_1 's of the E1a tester was generally stable, with a small portion of PMC's showing precocious dissociation of the telocentric chromosomes. The fact that all the F_1 's formed no quadrivalent in at least 93% of the PMC's and no univalent indicated the similarity of this tester to LD 222 in chromosome structure. However, the critical pairing $[(t+t)3^V + 12'']$ was observed in the F_1 's containing 2B telosomes and 4B telosomes by 6.7% and 4.2% of PMC's, respectively. Therefore, it is concluded that the E1a translocation type is almost the same, but a little differentiated from LD 222 by a reciprocal

Table 1. Frequencies(%) of PMC's with multivalents in the F_1 's between Kawahara's translocation testers of *T. dicoccoides* and doubleditelosomics or ditelo-monotelosomics for the A and B genome chromosomes of Emmer wheat

F ₁ telo- somic for	No. of PMC's	Multivalents						
		observed	(t+t)1 ³ [t1 ²	(t+t)1 ³ +1 ⁴ t1 ² +1 ⁴	(t+t)1 ³ +2 ⁴ t1 ² +2 ⁴	(t+t)3 ⁵ t3 ⁴	(t+t)3 ⁵ +1 ⁴ t2 ⁴ +1 ⁴	(t+t)5 ⁷ t5 ⁶
(a) E1a tester (KU-1978) (2AL, 3BL, 5BL, 6BS)**								
2BLS	163	93.3	0	0	6.7	0	0	0
4Bαβ	71	95.8	0	0	4.2	0	0	0
others***	143	95.4	4.6	0	0	0	0	0
(b) E1b tester (KU-108-3) (2AL, 3BL, 5BL, 6BS)**								
2AL	134	71.6	0	0	28.4	0	0	0
2BLS	136	54.4	0.7	0	42.6	0	2.2	0
3BL	150	48.0	50.0	0	2.0	0	0	0
others	158	60.0	39.4	0	0	0	0	0
(c) E2 tester (KU-109) (2AL, 5AL, 6AL, 1BS, 3BL, 4Bα, 5BL)**								
2BLS	108	0	0	0	100.0	0	0	0
3BL	108	0	0	0	100.0	0	0	0
others	105	1.9	97.7	0	0	0	0	0.3
(d) E3 tester (KU-195) (2AL, 5AL, 3BL, 5BL)**								
5BL	119	0	0	0	100.0	0	0	0
7BLS	100	0	0	0	100.0	0	0	0
others	105	6.4	91.6	2.0	0	0	0	0
(e) E4 tester (KU-8915A) (2AL, 3AS, 1BS, 5BL, 6BS)**								
2BLS	107	0	77.6	0.6	1.3	20.0	0	0
3BLS	107	1.9	0	0	96.3	1.9	0	0
4Bαβ	146	2.1	0	0	95.9	2.1	0	0
others	142	1.9	86.9	11.1	0	0	0	0
(f) E5 tester (KU-1945) (2AL, 3AL, 5AL, 3BL, 5BL, 6BS)**								
7ALS	165	0	97.2	1.8	0	0	1.2	0
2BLS	146	1.4	96.6	0.7	0	0	1.4	0
6BS	183	4.4	0	0	95.6	0	0	0
7BLS	138	1.4	0	0	97.1	0	1.4	0
others	170	1.6	96.8	1.5	0	0	0	0.1
(g) E6 tester (KU-1952) (2AL, 6AS, 3BL, 5BL)**								
1ALS	120	0	0	0	100.0	0	0	0
5ALS	107	0	0	0	93.5	6.5	0	0
others	109	5.6	90.8	3.6	0	0	0	0

* Multivalents in monotelodisomic F_1 's were in brackets.

** F_1 's were monotelodisomic for the chromosome arms in parentheses.

*** Pooled data of all the non-critical F_1 's.

translocation of small segments between 2B and 4B. Nishikawa (1967) showed that LD 222 has almost the same A and B genome as those of Chinese Spring. Kawahara (1984) pointed out that there are minor chromosomal variations among the strains of type E1. Kawahara (1991) also reported that the F_1 of the E1a tester and Chinese Spring rarely formed a quadrivalent.

(b) E1b tester (KU-108-3)

A quadrivalent, mostly in a chain of four configuration, was formed in 22.4–65.9% (40% on the average) of the PMC's in the non-critical F_1 lines. The critical pairing was observed in three F_1 's, respectively containing 2A telosome, 2B telosomes and 3B telosome. The F_1 with the 2B telosomes formed $(t+t)3^V$ the most frequently and also formed a septivalent $(t+t)5^{VII}$ in 2.2% of the PMC's. Then, it seems reasonable to consider that 2A, 2B and 3B are comprised in the sexivalent, and that 2B and 2A are included in most of the quadrivalent. Therefore, the E1b tester is concluded to be different from *durum* LD222 by two translocations, the small one between 2B and 3B and the large one between 2A and 2B.

(c) E2 tester (KU-109)

A quadrivalent was formed in almost all (97.7%) PMC's in the non-critical F_1 's of the E2 tester. The quadrivalent occurred in a ring of four configuration in 63% of the PMC's. The F_1 's containing 2B telosomes and 3B telosome showed the critical pairing in all the PMC's. Evidently long segments must have been interchanged between 2B and 3B in the E2 tester. Very rare occurrence of $1^{VI}+11''$ indicated that there was another small translocation involving 2B or 3B. Considering that there were one major and one minor translocations with one chromosome in common between E1b and E2 (Kawahara 1984), 2B seems more likely involved than 3B.

(d) E3 tester (KU-195)

One major quadrivalent occurred in 93.6%, and two quadrivalents in 2.0%, of the PMC's in the non-critical F_1 's, nearly half of the major quadrivalent being ring. The major quadrivalent rarely dissociated into $1''' + 1'$. The critical pairing occurred in the F_1 's respectively containing 5B telosome and 7B telosomes. This indicated that there was a major translocation between 5B and 7B in the E3 tester. No information was obtained on the minor translocation. Kawahara (1984) also observed two quadrivalents in 6.1% of the PMC's in the F_1 between the E1 tester and the E3 tester.

(e) E4 tester (KU-8915A)

The F_1 between this tester and 5A telosomic line was not available. Almost all the PMC's in the non-critical F_1 's had at least one quadrivalent, and about 11% of them had another quadrivalent. Over 60% of quadrivalents were ring. In the PMC's with only one quadrivalent the ring-of-four configuration was predominant over the chain-of-four configuration. The critical pairing occurred in 21.3%, 98.2% and 98.0% of the PMC's of three F_1 's containing the telosomes of 2B, 3B

and 4B, respectively. In the three F_1 's the second quadrivalent was observed in 20%, 1.9% and 2.1% of the PMC's, respectively. It was evident that chromosomes 3B and 4B were involved in the major translocation and 2B was involved in the smaller translocation.

(f) E5 tester (KU-1945)

A quadrivalent was formed in nearly all the PMC's in the non-critical F_1 's, but two quadrivalents were found rarely. About half of the quadrivalents were in a ring configuration. A chain of six chromosomes was, although very rarely, observed in non-critical line of 4A telosomes. The critical pairing was formed in almost all the PMC's of F_1 's containing 6B telosome and 7B telosomes, respectively, and $(t+t)5^{VII}$ pairing occurred rarely in the F_1 's respectively containing the telosomes of 7A, 2B and 7B. With regard to chromosome pairing, lines 7A and 2B were similar to the non-critical lines, with exception of rare occurrence of $(t+t)5^{VII}$. These facts suggested that the fairly long segments were interchanged between chromosomes 6B and 7B, and that a small translocations occurred among 7A, 2B and 7B.

(g) E6 tester (KU-1952)

About 95% of PMC's in the non-critical F_1 's had at least one quadrivalent, over 60% of which was in a ring of four. The critical pairing was formed in all the PMC's in the F_1 's of the 1A and 5A telocentric lines. This indicated that the fairly long segments were reciprocally translocated between chromosomes 1A and 5A. The results described above is summarized in Table 2.

Table 2. Chromosomes involved in Kawahara's six types of translocation in *Triticum dicoccoides* in relation to LD 222

Translocation type	Major	Minor
E1	- - - -	2B- 4B
E1b	2A- 2B	2B- 3B
E2	2B- 3B	2B- ?
E3	5B- 7B	?- ?
E4	3B- 4B	2B- ?
E5	6B- 7B	7A- 2B- 7B
E6	1A- 5A	?- ?

Kawahara (1984) inferred genomes to which the chromosomes involved in his six types of translocation belonged. Types E2, E3 and E5 had translocations between the B genome chromosomes, type E4 between the A and B genome chromosomes, and type E6 between the A genome chromosomes. He also showed that E1b was different from E1a by a minor translocation between the A and B genome chromosome. The present result completely agreed with Kawa-

hara's inference except for type E4. Our result evidently showed the presence of a translocation between chromosomes 3B and 4B in type E4. There is no likely explanation for this discrepancy. From the result in Table 2 a sexivalent would be expected to occur in the F_1 's between E2 and E4 and between E3 and E5. This was observed by Kawahara (1984).

The chromosome structure of LD 222 is prevailing in cultivated form of Emmer group (Nishikawa et al., 1986). This implies that E1a, the most common translocation type among wild Emmer, is also the major type among cultivated Emmer, though the two forms are differentiated by a minor translocation. Although Nishikawa et al. (1986) identified three translocation types other than LD 222 type in cultivated form of Emmer group, they were not found in wild Emmer.

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