Identification of chromosomes involved in translocations in wild Emmer

Kozo Nishikawa1,*, Shima Mizuno2 and Yoshihiko Furuta2

1Aichi Sangyo University, 12-5 Harayama, Okamati, Okazaki 444
2Faculty of Agriculture, Gifu University, 1-1 Yanagido, Gifu 501-11, Japan

(Received 19 November 1993)

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).

* Corresponding author.
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 F1’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)3V, which indicated the involvement of the telocentric chromosomes in the translocation, dissociated into t3IV + t', t2" + t1", 1" + 2t' and so on. In the monotelodisomic F1’s, the critical pairing, t3IV occasionally dissociated into t1" + 1", which can not be distinguished from normal pairing in non-critical F1’s. So, this pairing type was recognized as critical in the lines which showed t3IV 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 F1’s of all the testers. In the non-critical F1’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 F1’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 F1’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 F1’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)3V + 12"] was observed in the F1’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 F₁’s between Kawahara’s translocation testers of *T. dicoccoides* and doublediteloosomics or diteleotetrasomics for the A and B genome chromosomes of Emmer wheat.

<table>
<thead>
<tr>
<th>F₁ telosomic for PMC’s observed</th>
<th>(t₁t)²</th>
<th>(t₁t)² + 1²</th>
<th>(t₁t)² + 2²</th>
<th>(t₁t)³</th>
<th>(t₁t)³ + 1⁴</th>
<th>(t₁t)³ + 2⁴</th>
<th>(t₁t)³ + 3⁵</th>
<th>(t₁t)³ + 3⁵ + 1⁴</th>
<th>(t₁t)³ + 3⁵ + 2⁴</th>
<th>(t₁t)³ + 3⁵ + 3⁶</th>
<th>(t₁t)³ + 3⁵ + 4⁶ + (t₁t)³</th>
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<td>(a) E₁a tester (KU-1978) (2AL, 3BL, 5BL, 6BS)**</td>
<td>2BLs</td>
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<td></td>
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<tr>
<td></td>
<td>others***</td>
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<td>4.6</td>
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<tr>
<td></td>
<td>2BLs</td>
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<td>0</td>
<td>42.6</td>
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<td></td>
<td>3BL</td>
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<td>0</td>
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<td></td>
<td>7BLs</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
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<td>others</td>
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<td>0</td>
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<td></td>
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<tr>
<td>(e) E₄ tester (KU-8915A) (2AL, 3AS, 1BS, 5BL, 6BS)**</td>
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<td>(f) E₅ tester (KU-1945) (2AL, 3AL, 5AL, 3BL, 5BL, 6BS)**</td>
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<td>96.6</td>
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<td>7BLs</td>
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<td>(g) E₆ tester (KU-1952) (2AL, 6AS, 3BL, 5BL)**</td>
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* Multivalents in monotelosomic F₁’s were in brackets.
** F₁’s were monotelosomic for the chromosome arms in parentheses.
*** Pooled data of all the non-critical F₁’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 F₁ 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 F₁ lines. The critical pairing was observed in three F₁'s, respectively containing 2A telosome, 2B telosomes and 3B telosome. The F₁ with the 2B telosomes formed (t + t)₃V the most frequently and also formed a septivalent (t + t)₅VII 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 F₁'s of the E2 tester. The quadrivalent occurred in a ring of four configuration in 63% of the PMC's. The F₁'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 1₁⁺ 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 F₁'s, nearly half of the major quadrivalent being ring. The major quadrivalent rarely dissociated into 1" + 1' The critical pairing occurred in the F₁'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 F₁ between the E1 tester and the E3 tester.

(e) E4 tester (KU-8915A)

The F₁ between this tester and 5A telosome line was not available. Almost all the PMC's in the non-critical F₁'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 F₁'s containing the telosomes of 2B, 3B
and 4B, respectively. In the three F₁’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 F₁’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 F₁’s containing 6B telosome and 7B telosomes, respectively, and (t + t)5[VII] pairing occurred rarely in the F₁’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 fairy 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 F₁’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 F₁’s of the 1A and 5A telocentric lines. This indicated that the fairy 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

<table>
<thead>
<tr>
<th>Translocation type</th>
<th>Major</th>
<th>Minor</th>
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<tr>
<td>E1</td>
<td>-</td>
<td>2B- 4B</td>
</tr>
<tr>
<td>E1b</td>
<td>2A- 2B</td>
<td>2B- 3B</td>
</tr>
<tr>
<td>E2</td>
<td>2B- 3B</td>
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<td>E3</td>
<td>5B- 7B</td>
<td>?- ?</td>
</tr>
<tr>
<td>E4</td>
<td>3B- 4B</td>
<td>2B- ?</td>
</tr>
<tr>
<td>E5</td>
<td>6B- 7B</td>
<td>7A- 2B- 7B</td>
</tr>
<tr>
<td>E6</td>
<td>1A- 5A</td>
<td>?- ?</td>
</tr>
</tbody>
</table>

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 Kawahara's inference.
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 trans-
location 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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