Structural differentiation of chromosomes between 
*Triticum dicoccoides* Körn. and *T. araraticum* 
Jakubz., showing high meiotic pairing homology

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ABSTRACT

Tetraploid wheats were divided into the Emmer (genomic constitution, AABB) and the Timopheevi (AAGG) groups based on the low level of meiotic chromosome pairing and sterility in their hybrids. *Triticum dicoccoides* lines KU8821A and KU8821C and *T. araraticum* line KU8821B, which show a high level of meiotic chromosome pairing in the hybrids, have been considered to be intermediate types between the Emmer and the Timopheevi wheats. These intermediate types may play an important role in the differentiation of tetraploid wheats. Chromosome structural differentiation was examined by the N-banding technique. These lines showed either the banding patterns of the Timopheevi or of the Emmer groups, and were not intermediate plants between the two groups based on the chromosome structure. The present results suggest that the Emmer and the Timopheevi groups were derived diphyletically in the evolution of tetraploid wheats.

1. INTRODUCTION

Tetraploid wheats have been divided into two different groups, the Emmer (2n=4x=28, AABB) and the Timopheevi (2n=4x=28, AAGG) groups based on the sterility and low level of meiotic chromosome pairing in their hybrids (Lilienfeld and Kihara, 1934). The Emmer group includes a wild species *Triticum dicoccoides* and several cultivated species such as *T. dicoccum*, *T. turgidum*, and *T. durum*. The Timopheevi group also contains a wild member, *T. araraticum* and the cultivated *T. timophevi*.

Two different hypotheses on the origin of the B and G genomes of the tetraploid wheats have been proposed. Lilienfeld and Kihara (1934) and Bozzi and Giorgi (1969) suggested that each of these genomes had a distinct origin. In their studies on the isozymes of alpha-amylase and DNA contents of tetraploid wheats, Nishikawa and Furuta (1978) and Nishikawa et al. (1979), proposed a diphyletic origin for the Emmer and the Timopheevi groups. Also, Ogihara and Tsunewaki (1982) and Tsunewaki and Ogihara (1983) analyzed the restriction patterns of
chloroplast DNA of tetraploid wheats and putative donor species of their cyto-
plasms. They suggested that the cytoplasms of the Emmer and the Timopheevi
groups were derived from different diploid species, *Aegilops longissima* and *Ae.
aucheri*, respectively.

On the other hand, Wagenaar (1961) suggested that the Timopheevi group arose
from *T. dicoccoides* through desyanptic gene mutations. Feldman (1966) also
mentioned the possibility of the monophyletic origin of the Emmer and the Timopheevi
groups. Tanaka et al. (1978) and Tanaka and Sakamoto (1979), during their botanical expedition to the Near East, observed that *T. dicoccoides*
and *T. araraticum* grew sympatriically at several collection sites. Tanaka et
al. (1978) found that two *T. dicoccoides* lines KU8821A and KU8821C and one *T.
araraticum* line KU8821B, which had been collected at the same location, showed
a high level of meiotic chromosome pairing in the hybrids between *T. dicoccoides*
and *T. araraticum* lines. They suggested that these lines were intermediate
types between the Emmer and Timopheevi groups and the tetraploid wheats had
originated monophyletically.

We compared the N-banding patterns of *T. dicoccoides* lines KU8821A and
KU8821C and *T. araraticum* line KU8821B and analysed the chromosome structural
differentiation between the B and G genomes.

2. MATERIALS AND METHODS

*typicum* Zhuk. line KU107-1 and *T. araraticum* Jakubz. var. *nachitchevanicum*
Jakubz. line KU8821B were stained by the N-banding technique. Root-tips
about 2 cm long were pretreated with ice-cold water for 18 h and fixed in 1:3 acetic
alcohol. Chromosomes of the meristematic cells were spread by the squash
method. The cover glasses were removed after freezing in dry ice. The slides
were then air dried overnight, treated with 45% acetic acid at 60°C for 2 min, and
air-dried again. Chromosome bands were differentiated by the N-banding tech-
nique reported by Gerlach (1977).

3. RESULTS AND DISCUSSION

Spikes of *T. dicoccoides* KU8821A and KU8821C and *T. araraticum* KU8821B
were so similar that they could not be distinguished from one another. Tanaka et
al. (1978) reported a high level of meiotic chromosome pairing in hybrids between
KU8821A and KU8821B (univalent frequency 1.26), and between KU8821C and
KU8821B (univalent frequency 2.46), compared with the other hybrids between
the Emmer and Timopheevi wheat groups (univalent frequency 5.0–6.0). Tanaka
et al. (1978) speculated that these hybrids were intermediate types between the
Emmer and the Timopheevi groups, and that tetraploid wheats originated monophyletically from an amphidiploid such as SSAA between Ae. speltoides and T. boeoticum or urartu (AA), and differentiated into the two groups, i.e. the Emmer and the Timopheevi groups.

The N-banding analysis showed that T. durum var. reichenbachii had eight pairs of banded chromosomes (Figs. 1 and 2). Flavell et al. (1978), in a review of wheat chromosomes, reported that the N-banding patterns of wheat chromosomes is similar to the C-banding patterns and the recognition of homologous chromosomes was not usually prevented by variations in the size, number and distribution of the C-bands and N-bands. Present banding patterns of T. durum var. reichenbachii are similar to the N-banding and C-banding patterns of the B genome chromosomes and chromosome 4? (according to the new chromosome designation adopted at the 7th Int. Wheat Genet. Symp.) reported in the other Emmer wheats and T. aestivum (AABBDD) (Gerlach, 1977; Iordansky et al., 1978; Van Niekerk and Pienaar, 1983; Lukaszewski and Gustafson, 1983; Endo and Gill, 1984). T. dicoccoides KU8821A and KU8821 also showed eight banded chromosomes, whose banding patterns were similar to those of the B genome chromosomes and chromosome 4? of T. durum var. reichenbachii, although some minor variations were observed (Figs. 2 and 3). These results indicate that KU8821A and KU8821C had the A and B genomes.

On the other hand, T. timopheevi line KU 107-1 had eight pairs of well-banded chromosomes (Fig. 4) as reported by Hutchinson et al. (1982) and Noda (1983). Hutchinson et al. (1982) distinguished chromosomes belonging to the A genome from those belonging to the G genome, and labeled them a to n. The present N-banding patterns of T. timopheevi line KU 107-1 were similar to those of the G genome chromosomes observed by Hutchinson et al. (1982). However, the

Fig. 1. Chromosome banding patterns of T. durum var. reichenbachii (AABB) revealed by the N-banding technique.
correspondence of the band patterns and karyotypes of Timopheevi chromosomes to those of the Emmer and *T. aestivum* wheats was not analysed by Hutchinson et al. (1982). The present banded chromosomes of *T. timopheevi* KU107-1, which appeared to correspond to the B genome chromosomes were numbered 1 to 7 (Fig. 5). To the remaining chromosome number 8 was tentatively given.

Similarity in the karyotype and banding patterns of the B genome and the G genome chromosomes was observed to some degree in the case of the 1B and 1, 4B and 4, 5B and 5, 6B and 6 chromosomes. However, the correspondence in the other chromosome was not clear. The present results suggest that banded karyotypes of the B and G genomes were not similar enough to consider that two genomes have the same origin.

A comparison of the chromosome banding patterns of *T. araraticum* line KU8821B with those of *T. timopheevi* line KU107-1, revealed that the banding patterns of KU8821B were similar to those of *T. timopheevi*, compared with those of the Emmer wheat. Therefore, this line appears to have the A and G genomes.

None of KU8821A, KU8821B and KU8821C lines showed an intermediate banding pattern between *T. durum* and *T. timopheevi*. These results did not
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support the speculation of Tanaka et al. (1978, 1979), regarding the monophyletic origin of the tetraploid wheats. Recent electron microscopic studies of meiotic chromosomes in wheats showed that homoeologous chromosomes as well as homologous chromosomes paired into a synaptonemal complex at the zygotene stage, but that only homologous chromosome pairing remained until metaphase I (Hobolth, 1981; Jenkins, 1983; Holm, 1986; Gillies, 1987). In wheats, the Ph gene on chromosome 5B controls the chromosome pairing at meiosis, and mutation or suppression of the Ph gene resulted in the increase of homoeologous pairing (Riley and Law, 1965; Wall et al., 1971 Sears, 1977, 1982). The high level of meiotic pairing observed in the hybrids between KU8821B and KU8821A, or KU8821B and KU8821C, may be due to the suppression of the Ph gene, as observed in the

Fig. 3. Chromosome banding patterns revealed by the N-banding technique. a) *T. dicocoides* var. *aaronsohni* line KU8821A. b) *T. dicocoides* var. *aaronsohni* line KU8821C.
The present study indicates that chromosome structural differences were not necessarily reflected in the degree of chromosome pairing. Also, it is suggested that the Emmer and Timopheevi groups may have originated from different amphidiploid ancestors.
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Fig. 5. Idiogram with chromosome banding patterns of A) T. timopheevi var. typicum line KU107-1 (AABB), and B) T. araraticum var. nachichevanicum line KU8821B.

REFERENCES


