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MEIOTIC ANALYSIS IN PENTAPLOID-DERIVED ANEUPLOIDS IN WHEAT

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ABSTRACT

Meiotic analysis at metaphase I was carried out in pentaploid derived F_2 and BC_1 (pentaploid × hexaploid) generations of wheat. Chromosome number among the BC_1 aneuploids ranged from 2n = 35 to 2n = 42 as expected with 2n = 38 or 39 as the modal class. High frequency of euploid gametes indicates chromosome elimination from pentaploid egg cells or their selective advantage. Increase in intermediate numbers (2n = 38 or 39) may be due to preferential fertilization. The average number of D genome chromosomes transmitted from the female side was 3.12/gamete. Skewed distribution of aneuploids was observed in the F_2 generation and the modal D chromosome number transmitted through the female gamete was 1. It is inferred that all classes of gametes are formed but they do not function with the same frequency. One backcross followed by selfing is useful in selecting a cytologically stable plant in hexaploid × tetraploid crosses.

Key words: Aneuploid, pentaploid, meiotic configuration, wheat, tetraploid species.

Interspecific and intergeneric wheat hybrids have been extensively investigated cytologically for understanding the evolutionary relationship between species and genera [1–3] and for introducing desirable traits from alien species into hexaploid wheat. As early as 1924, Kihara [4] cytologically investigated pentaploid hybrids. Since then several workers [5–10] have carried out meiotic analysis in pentaploid F_1 and F_2 hybrids. The present studies were carried out for analysing cytologically the spectrum of aneuploids generated by selfing the F_1 pentaploid hybrids (hexaploid × tetraploid) and by backcrossing them to hexaploid parents.

MATERIALS AND METHODS

Six varieties of common wheat (*Triticum aestivum* L.), C 306, NP 824, Hy 65, NI 5439, K 65 and Kalyansona); and four tetraploid species. *T. durum* Desf. var. CPAN 1737, *T. carthlicum* Nevesk., *T. turgidum* L. var. *lucitanicum* and *T. timopheevi* Zhuk. var. *viticulosum*, were used. The hexaploid wheat varieties as female parent were crossed to the tetraploid species and pentaploid F_1 hybrids were backcrossed to the recurrent hexaploid parents. Chromosome configurations were recorded at meiotic metaphase I in pollen mother cells (PMC) of BC_1 plants. Chiasma frequency was calculated per pair of chromosome arms. Chromosome numbers were determined in F_2 and BC_1–S_1 (first selfed generation after backcrossing the pentaploid by hexaploid) generation. The PMC were stained in leucobasic fuchsine and smeared in 1% acetocarmine.

RESULTS

Pooled cytological data are presented in Table 1. The spectrum of aneuploids produced in the BC_1 generation are given in Table 2. The 2n numbers of these aneuploids vary from 35 to 42. In *T. timopheevi* hybrids fewer plants could be identified, since many plants produced abortive anthers and some exhibited hybrid lethality; no disome (2n = 42) was obtained. A low frequency of plants having 2n = 41 and 42 was observed in the hybrids involving *T. durum* and *T. turgidum*. The modal class was 2n = 38 or 39. The expected frequency of aneuploids was based on random distribution of univalents at meiosis in pentaploid F_1 hybrids (Table 2). A general trend discernible is that, with increase in chromosome number of the aneuploids, the number of univalents progressively decreases. Multivalent associations were observed in a number of crosses, particularly when hexaploid variety NP 824 was involved. Hybrids involving *T. timopheevi* showed higher multivalent associations among all the aneuploids (Table 1). In most cases either a trivalent or a quadrivalent was present, which may be due to the presence of translocation(s). Mean number of chiasmata per pair of chromosome arms did not vary in different aneuploids. A large population in BC_1-S_1 generation was not analysed but a random check indicated high frequency of plants having 2n = 42 or near this level.

Chromosome numbers in pentaploid-derived F_2 were determined in randomly chosen 34 plants of one of the crosses: *T. aestivum* var. K 65 × *T. turgidum*. The

Table 1. Frequency of different chromosomal configurations and Xta/pair of chromosome arms in progenies of pentaploid × hexaploid crosses

Hybrid	Configuration	Frequency of different chromosome number/PMC							
		35	36	37	38	39	40	41	42
(*T. aestivum* × *T. durum*) × *T. aestivum*	I	5.88	6.11	4.78	4.23	3.78	2.48	2.31	0.85
	II	13.96	14.84	15.93	16.90	17.32	18.52	19.21	20.40
	III	0.02	0.09	0.08	0.01	0.04	0.02	0.01	0.03
	IV	0.02	0.01	0.01	0.01	0.09	0.07	0.02	—
	Xta	0.82	0.81	0.87	0.88	0.87	0.91	0.91	0.98
(*T. aestivum* × *T. timopheevi*) × *T. aestivum*	I	13.43	11.56	8.00	5.50	6.22	6.25	5.08	—
	II	9.42	11.64	14.06	14.82	14.98	15.56	17.16	—
	III	0.41	0.26	0.18	0.84	0.31	0.75	0.49	—
	IV	0.20	0.08	0.08	0.03	0.17	0.07	0.03	—
	Xta	0.49	0.70	0.71	0.72	0.71	0.74	0.82	—

I—Univalent, II—bivalent, III—trivalent, IV—quadrivalent, and Xta—chiasmata per pair of arms.

chromosome number ranged from 2n = 28 to 2n = 42. High proportion of plants having 2n = 28 and 29 chromosomes were observed. Only 1 out of 34 plants was disome with 2n = 42. The frequency of intermediates (2n = 35) was high. Comparatively, in BC_1 generation, there was a clear preponderance of plants having a range of chromosomes from 37 to 40.

Table 2. Spectrum of aneuploids and their frequency in pentaploid (2n = 35) F_2 and backcross progenies between pentaploid and hexaploid wheat

Chromosome number class	T.ae × T.tu F_2	T.ae× T.du. × T.ae.	T.ae.× T.du. × T.ae.	T.ae.× T.ca. × T.ae.	T.ae.× T.ti. × T.ae.
28	5 (14.7)				
29	7 (20.6)				
30	2 (5.9)				
32	1 (2.9)				
34	1 (2.9)				
35	5 (14.7)	22 (17.3)	5 (9.6)	7 (18.4)	5 (20.5)
36	2 (5.9)	9 (7.0)	6 (11.5)	2 (5.5)	2 (8.2)
37	2 (5.9)	12 (9.2)	7 (13.4)	3 (8.3)	3 (12.3)
38	3 (8.8)	23 (18.1)	11 (21.5)	4 (11.1)	5 (20.5)
39	2 (5.9)	29 (22.8)	9 (12.4)	12 (32.4)	5 (20.5)
40	2 (5.9)	17 (13.3)	5 (9.7)	6 (16.6)	3 (12.3)
41	1 (2.9)	11 (8.6)	4 (7.5)	2 (5.5)	1 (4.1)
42	1 (2.9)	4 (3.1)	4 (7.5)	—	—
Total	34	127	51	36	24

T. ae.—*T. aestivum*, T. du.—*T. durum*, T. tu.—*T. turgidum*, T. ca.—T. *carthlicum* and T. ti.—*T. timopheevi*; Percent frequency in parentheses.

DISCUSSION

Among the BC_1 aneuploids, plants with 38 or 39 chromosomes were high in number as compared to the others. The high frequency of plants with 35 chromosomes in BC_1 generation reflects univalent elimination in pentaploid egg cells or selective advantage of euploid gametes. The chromosome number in the functional female gametes in pentaploid is expected to range between 14 and 21 based on random distribution of seven univalents. The main difference between the observed and expected numbers is the depression of intermediate numbers and excess of megaspores having 14 chromosomes. If univalent loss is the main cause of deviation in the observed frequency from the expected, the actual distribution should follow a binomial distribution, which was not observed in the studies. Alston and Jones [9] reported results which agree with binomial distribution. Factors other than univalent loss, such as, random distribution of undivided univalents at AI, reduced pairing, and competitive ability of balanced megaspore can alter the proportion of different classes. The average number of D genome chromosome univalents transmitted through female gametes was 3.12/gamete for the *T. durum* cross compared to 2.64 [11] and 3.0 [12] reported previously. The actual distributions of univalents among the BC_1

aneuploids are flatter [11, 13] than the theoretically expected and univalent chromatids do not necessarily distribute at random. Kihara [14] suggested that the unexpected flatness of the curve may be due to nonrandom distribution of univalents in meiosis II. The evidence of nonrandom univalent distribution was not obtained in this study.

High frequency (29%) of hexaploid plants was observed in BC_1-S_1 generation among the crosses involving *T. durum* and *T. turgidum*. High seed set in BC_1-S_1 also indicated that a large number of plants have attained hexaploid or near hexaploid level. Improved seed fertility was directly proportional to the increase in bivalent frequency. Thus it can be inferred that one backcross followed by selfing is sufficient to pick up desirable segregants, while there are less chances of selecting such segregants in a selfed progeny of the pentaploid hybrid.

The presence of trivalents and quadrivalents among the aneuploids may be attributed to homeologous pairing or involvement of translocations. If this is true, then the pentaploid wheat hybrids may provide material useful for breeding.

The observed frequency in F_2 generation deviated from the expected on the basis of random univalent distribution. Skewed distribution in chromosome number may be due to elimination of univalents during micro- and megasporogenesis, competition in pollen tube growth, selective fertilization, and elimination of unbalanced gametes through zygotic or endospermic media. The plants with 28 or 29 chromosomes were in high proportion (34.7%). It is assumed that all classes of gametes were formed but they did not function with the same efficiency. The frequency of 35–42 chromosome plants was quite high (53%) than those reported by Makino [11] and Kaltsikes et al. [12]. The enhanced frequency of this group was mainly due to the high proportion of plants having $2n=35$ chromosomes. The differences in results may be ascribed to selective elimination or fertilization of gametes in certain types of material. Its effect has been quite variable. Varietal differences in elimination of univalents have been observed [12]. The modal D genome chromosome number transmitted from female gametes in the F_2 generation was 1 as against 3 or 4 in BC_1 aneuploids. Similar results have been obtained [9, 12] by other workers.

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