Meiotic Chromosome Behavior in *Rhoeo spathacea* (Swartz) Stearn

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Abstract

Each of the 12 chromosomes of the tropical monocot, *Rhoeo spathacea*, is involved in a translocation with two other chromosomes. This unusual chromosome constitution results in unique synaptic arrangements of the chromosomes in prophase I and metaphase I of meiosis and atypical chromosome segregation at anaphase I. Using the acetocarmine squash technique, 5436 pollen mother cells from 16 *Rhoeo* plants were examined, including 281 at diakinesis/metaphase I, 1,310 at anaphase I, and 3,845 at telophase I. Data on the frequencies of rings of 12 chromosomes and various chromosome chain configurations at diakinesis were determined. Similarly, the frequencies of 6:6, 5:7, 5:1:6, and 5:2:5 anaphase I chromosome segregation patterns were recorded. Telophase I cells were studied to determine the frequency of those containing micronuclei and excluded chromosomes.

Meiotic chromosome behavior in pollen mother cells (PMCs) of *Rhoeo spathacea* (Swartz) Stearn [synon. *Rhoeo discolor* (L'Heritier) Hance] has fascinated cytologists since Belling (2) first reported that the chromosomes of this plant form a ring of 12 during meiosis I. This synaptic relationship is produced because no two chromosomes in *Rhoeo* are identical. Rather, every chromosome is involved in a translocation with two others. A number of investigators, beginning with Darlington (3), have reported on the consequences of these multiple translocations on meiotic chromosome behavior in *Rhoeo*. Among these consequences are ring and chain formation at diakinesis, alternate *vs.* adjacent chromosome alignment at metaphase I, and atypical segregation patterns, such as 5:7, 5:1:6, and 5:2:5 at anaphase I.

The Study

In the process of investigating the cytology of a greenhouse population of 16 *Rhoeo* plants of unknown origin, 5,436 PMCs were examined, including 281 at diakinesis/metaphase I, 1,310 at anaphase I, and 3,845 at telophase I. Using the acetocarmine squash technique to examine PMCs, each of the 16 plants was shown to have $2n = 12$ and all plants were found to exhibit chromosome behavior consistent with the hypothesis of multiple translocations, as generally reported in the literature.

Cytological Data

Table 1 gives a concise account of the numbers and frequencies of the various chromosome configurations observed in the 5,436 PMCs, while Table 2 compares the data obtained for 281 PMCs at diakinesis/metaphase I with similar data reported earlier (3, 6, 7). Data for 489 PMCs from Lin's unpublished study (5) are not included.

Table 3 summarizes data concerning chromosome segregation patterns observed in 1,310 anaphase I cells in the present study and compares these data to those obtained in less extensive studies (1, 3, 4, 6, 7).

Table 3 indicates that in some cases chromosome distributions were determined during meiosis II rather than in metaphase I or anaphase I. Lin (5) reported additional data on chromosome segregation patterns in 240 PMCs at metaphase I or anaphase I.

TABLE 1. *Data obtained on meiotic behavior of chromosomes in 5436 PMCs of* Rhoeo spathacea.

Meiotic Stage	No. PMCs	%	Specific Types (and Frequencies) of Indicated Configurations
Diakinesis			
Ring of 12	88	31.32	
Chain of 12	99	35.23	
Two Chains	65	23.13	11+1 (15); 10+2 (21); 9+3 (11); 8+4 (9); 7+5 (7); 6+6 (2).
Three Chains	18	6.41	10+1+1 (1); 9+2+1 (1); 8+3+1 (1); 7+4+1 (1); 7+3+2 (3); 6+5+1 (3); 6+4+2 (1); 6+3+3 (1); 5+5+2 (3); 5+4+3 (3).
Four Chains	10	3.56	9+1+1+1 (1); 5+3+3+1 (4); 5+3+2+2 (2); 4+4+3+1 (2); 4+3+3+2 (1).
Five Chains	1	0.36	4+4+2+1+1
Total	281	100.01	
Anaphase I			
6:6	779	59.47	
5:7	280	21.37	
5:1:6	200	15.27	
5:2:5	32	2.44	
Others	19	1.45	4:1:7 (7); 4:3:5 (2); 4:2:6 (4); 9:3 (1); 4:8 (2); 4:6:2 (1); 4:2:1:5 (1); anaphase bridge (1).
Total	1310	100.00	
Telophase I			
Normal	3606	93.8	
Abnormal	239	6.2	
Total	3845	100.0	

Among the 3,845 telophase I cells studied, 239 or 6.2% were classified as abnormal because they contained excluded chromosome or micronuclei. Since 40.53% of the 1,310 anaphase I cells were found to exhibit abnormal segregation (*i.e.*, 5:7, 5:1:6, 5:2:5, etc.), an explanation of the relatively low frequency of abnormal telophase I cells would seem to be required. Three possible causes of this difference may be suggested: 1) Cytoplasmic enzymes may destroy chromosomes excluded at anaphase I so they do not appear in telophase I cells; 2) Chromosome lagging at anaphase I, and therefore producing 5:1:6 and 5:2:5 configurations, may finally be included in one of the daughter nuclei at telophase I; 3) An abnormal 5:7 distribution recognized at anaphase I with no difficulty will not be readily detected as abnormal at telophase I.

TABLE 2. *Frequency of ring and chain formation reported in several studies of meiosis in* Rhoeo.

Diakinesis Chromosome Configuration	Darlington (3)	Simmonds (6)		Walters and Gerstel (7)	Mertens
		Coll. 1	Coll. 2		
Ring of 12					
No.	—	6	5	32	88
Freq.	30%	15.0%	16.7%	32%	31.32%
Chain of 12					
No.	—	9	10	38	99
Freq.	45%	22.5%	33.3%	38%	35.23%
2 Chains					
No.	—	7	8	15	65
Freq.	20%	17.5%	26.7%	15%	23.13%
3 Chains					
No.	—	3	2	14	18
Freq.	5%	7.5%	6.7%	14%	6.41%
4 Chains					
No.	—	—	—	1	10
Freq.	—	—	—	1%	3.56%
5 Chains					
No.	—	—	—	—	1
Freq.	—	—	—	—	0.36%
Not Specified					
No.	—	15	5	—	—
Freq.	—	37.5%	16.7%	—	—
Total No. Cells	—	40	30	100	281

TABLE 3. *Summary of data reported in several studies of the frequency of various anaphase I chromosome distributions in* Rhoeo.

Chromosome Segregation Pattern	Darlington (3)	Kato (4)		Akemine (1)		Simmonds (6)		Walters and Gerstel (7)	Mertens
Stage	A II	A I	M II	M I	A I	A I	A I	M II	A I
6:6									
No.	37	59	86	72	107	8	37	35	779
Freq.	93%	62.8%	65.7%	72%	77.5%	66.7%	56.1%	70%	59.47%
5:7									
No.	3	30	45	23	20	1	11	15	280
Freq.	7%	31.9%	34.3%	23%	14.4%	8.3%	16.7%	30%	21.37%
5:1:6									
No.	—	3	—	5	9	2	12	—	200
Freq.	—	3.19%	—	5%	6.52%	16.7%	18.3%	—	15.27%
5:2:5									
No.	—	2	—	—	2	—	2	—	32
Freq.	—	2.1%	—	—	1.44%	—	3%	—	2.44%
Others									
No.	—	—	—	—	—	1[1]	4[2]	—	19[3]
Freq.	—	—	—	—	—	8.3%	6%	—	1.45%
No. Cells	40	94	131	100	138	12	66	50	1310

[1](6:3:3); [2](6:2:4), (7:1:4), and (5:3:4), [3](8:4), (9:3), (7:1:4), (5:3:4), (6:2:4), and (4:2:1:5)

Commentary

The present study revealed a number of diakinesis and anaphase I configurations not previously reported in the literature or by Lin (5). These include the three-chain diakinesis configurations of 7+3+2, 6+3+3, and 5+4+3 and all of the four-chain and one, five-chain configuration listed in Table I. Two previously unreported anaphase I distributions, 9:3 and 4:2:1:5, were also noted in the present study. These data suggest that the discovery of various infrequent chromosome configurations only awaits the study of a sufficiently large population of PMCs. Finally, the telophase I data obtained in this study, showing approximately 6% PMCs having lagging chromosomes or micronuclei, are not inconsistent with results reported by Walters and Gerstel (7), who found 4 abnormal telophase I PMCs in a population of 100.

Literature Cited

1. AKEMINE, T. 1937. Nondisjunction of the meiotic chromosomes in *Rhoeo discolor* Hance. Japan. J. Genet. 13:31-36.

2. BELLING, J. 1927. The attachment of chromosomes at the reduction division in flowering plants. J. Genet. 18:177-205.

3. DARLINGTON, C. D. 1929. Chromosome behavior and structural hybridity in the Tradescantiae. J. Genet. 21:207-286.

4. KATO, K. 1930. Cytological studies of pollen mother cells of *Rhoeo discolor* Hance with special reference to the question of the mode of syndesis. Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B. 5:139-161.

5. LIN, Y. J. 1972. Position and frequency of chiasma failure and adjacent distribution in *Rhoeo spathacea* (Swartz) Stearn. Unpublished M. S. thesis, The Ohio State University, Columbus. 46 p.

6. SIMMONDS, N. W. 1945. Meiosis in tropical *Rhoeo discolor*. Nature 155:731.

7. WALTERS, M. S., and D. U. GERSTEL. 1948. A cytological investigation of a tetraploid *Rhoeo discolor*. Amer. J. Bot. 35:141-150.