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INDUCED CHROMOSOME ASYMMETRY AND ITS EFFECT ON INTERCHROMOSOMAL CORRELATIONS FOR CHIASMA FORMATION IN RYE, *SECALE CEREALE* L.

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ABSTRACT

The effect of induced chromosome asymmetry on the interchromosome correlations for chiasma formation was studied in the interchange heterozygotes of rye, *Secale cereale* L. Correlation for chiasma formation between two groups of chromosomes were observed only in 2 out of 18 plants studied. The estimates of between and within nuclear variances indicated negative correlation in these plants. The remaining 16 plants did not show interchromosome effect for chiasma formation.

Key words: Interchange heterozygote, chiasma, correlation, *Secale cereale*.

Basak and Jain [1] developed a hypothesis according to which total chiasma frequency of a cell can be partitioned into an autonomous fraction and a correlated fraction. It was suggested that each chromosome pair in a cell is capable for forming a certain minimum number of chiasmata independently of other pairs. This combined minimum capacity of all the chromosome pairs to form chiasmata constituted the autonomous fraction. The correlated fraction, on the other hand, is one which is left after the autonomous fraction is accounted. The hypothesis, thus, suggested that the relative magnitudes of the two fractions of chiasma frequency in an organism plays an important role in determining the type of interchromosome correlations. In rye, the studies on interchromosomal chiasma formation were first initiated with the open-pollinated lines [2]. Later the study was extended to inbred rye materials with drastically reduced chiasma frequency per cell [3]. Also, distribution of chiasmata in the normal chromosomes of rye, on one hand, and a pair of accessory chromosomes, on the other, was studied [4, 5]. The present study reports another approach of creating variations artificially in otherwise symmetrical karyotype of rye and its effect on chiasma formation.

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MATERIALS AND METHODS

Due to their similarity in size, it is not possible to identify the individual rye chromosomes or to classify them into different groups during meiotic metaphase I. It was, thus, considered necessary to induce the size differences artificially in different chromosomes. This was done by irradiating dry seeds of the rye line 7379 with 5, 10, 15, 20, 25, 30 and 35 kR doses of gamma rays. Irradiation was carried out in ^{60}Co gamma cell at the dose rate of 3000 rads per min.

The interchange heterozygotes, screened cytologically using 1.5% acetocarmine from a large irradiated population, were found to have two groups of chromosomes: 1) normal bivalents, and 2) a multiple interchange involving more than two chromosomes. Total number of chiasmata in each group as a whole were recorded on 20 well spread PMCs in each plant following the method of Darlington [6]. The correlation for chiasma formation per cell between the two groups of chromosomes was studied using the method of Mather [7].

RESULTS AND DISCUSSION

Total 18 plants from the treatments of 25 kR and above were found to have reciprocal translocations between two different chromosome pairs. The mean number of chiasmata per cell in these plants is given in Table 1. Figure 1 shows chiasma formation in the PMCs with two groups of chromosomes. The inter-and intranuclear variances for chiasma frequency in the interchange heterozygotes (Table 2) revealed that only 2 out of 18 plants analysed had significant variance ratio, indicating the presence of correlation for chiasma formation between two groups of chromosomes. The magnitudes of variances between and within nuclei in these plants suggested that the correlation was of negative type. In the remaining 16 plants, the variance ratios are nonsignificant. These plants did not show any correlation with regard to chiasma formation between two groups of chromosomes.

Table 1. Mean chiasma frequency in translocation heterozygotes in *Secale cereale*

Plant No.	No. of chiasmata per cell	Plant No.	No. of chiasmata per cell
VI-13-6	13.89	VIII-11-2	13.44
VI-13-5	13.54	VI-15-8	13.04
VII-8-5	13.29	VIII-14-5	13.04
VI-9-7	13.34	VII-9-2	13.04
VII-10-5	13.00	VIII-5-6	12.79
VII-12-1	12.84	VIII-10-4	13.14
VIII-5-7	13.09	VIII-15-6	13.50
VIII-8-5	13.29	VIII-9-5	13.39
VII-5-2	13.14	VII-5-4	13.09

In order to test the applicability of the hypothesis proposed by Basak and Jain [1], a group of rye plants with induced changes in the karyotype were studied. In these plants it

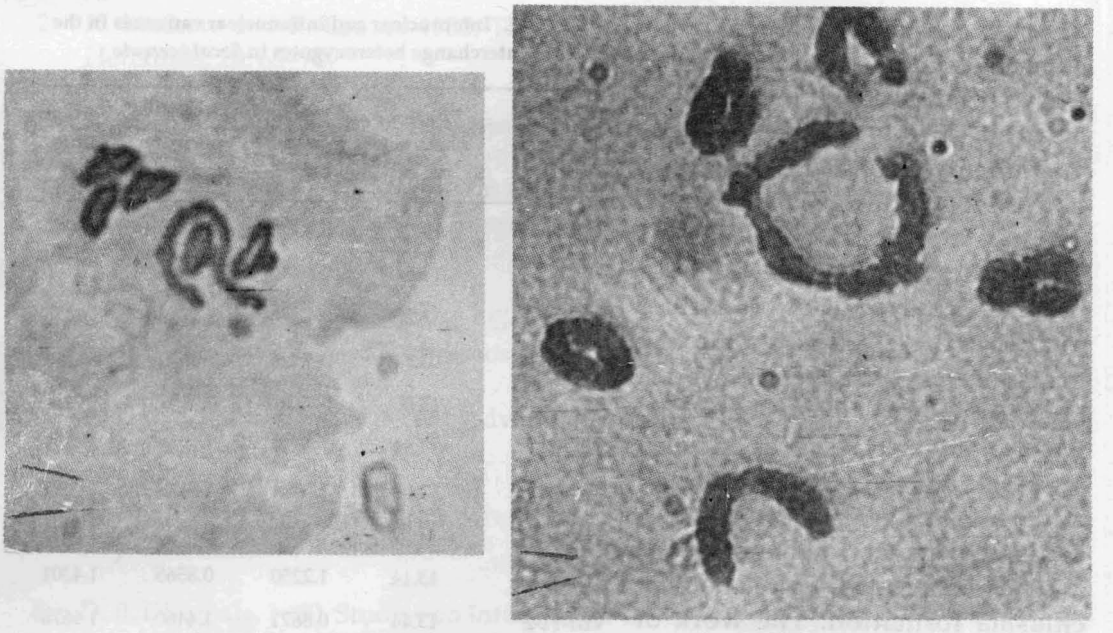

Fig. 1. Chiasma formation at PMC metaphase I in two different translocation heterozygotes of rye.
(1) One multiple interchange involving four chromosomes with 3 chiasmata (long rod shaped structure), and five bivalents (ring shaped) with 3+3+3+2+2 chiasmata.
(2) One multiple interchange heterozygote involving four chromosomes (large structure in centre) with chiasmata, and five bivalents (on periphery) with 3+2+2+1+1 chiasmata.

was possible to get a better estimate of the inherent (intranuclear) variance by deducting the variance due to grouping of chromosomes into the multivalent and bivalents forming types. The distribution of chiasmata in the nucleus of the interchange heterozygotes (Table 2) revealed a different pattern of interchromosome effects from that of the normal diploids [8] in which majority of plants exhibited significant negative correlations for chiasma formation.

The absence of any correlation for chiasma formation among chromosome pairs in majority of the plants observed in the present study indicated that the artificially induced changes in chromosome morphology of these interchange heterozygotes have influenced the magnitudes of internuclear and intranuclear variances and so the nature of chiasma distribution in chromosome pairs of these plants. Absence of competition for the formation of chiasmata in these plants suggests that chiasmata were formed more in an autonomous way than in the correlated way.

These results are in contradiction to the assumptions of the hypothesis being examined in the present study. The asymmetry of paired chromosomes created in present material is

expected to favour formation of a large number of chiasmata in a correlated way and therefore presence of negative correlation between the multivalents and bivalents. Deviations from these expectations as observed in the present study may, however, be due to various other factors which also influence intranuclear distribution of chiasmata. One of the factors affecting this correlation is the average chiasma frequency per cell. If this is artificially reduced, it would result, as assumed by Basak and Jain, in reduction of number of chiasmata formed in a correlated manner and consequent absence of negative correlation for chiasma formation. The work of Lamm [3] in inbred rye material having low chiasma frequency showed that there was no interchromosome competition for chiasma formation which was usually observed in open-pollinated rye having higher chiasma frequency.

Table 2. Internuclear and intranuclear variances in the interchange heterozygotes in *Secale cereale*

Plant No.	No. of chiasmata per cell	Intra-nuclear variance	Intra-nuclear variance	Variance ratio
VI-13-6	13.89	0.4684	0.5315	1.1347
VI-13-5	13.54	0.8671	0.6565	1.3206
VII-8-5	13.29	0.4789	0.4210	1.1375
VI-9-9	13.34	0.8565	1.8670	2.1798*
VII-10-5	13.00	0.4736	0.9157	1.9232
VII-12-1	12.84	1.8039	1.2249	1.4726
VIII-5-7	13.09	1.8894	1.8473	1.0227
VIII-8-5	13.29	1.1631	0.8736	1.3313
VII-5-2	13.14	1.2250	0.8565	1.4301
VIII-11-2	13.44	0.8671	1.4460	1.6676
VI-15-8	13.04	0.4986	1.2776	2.5623*
VIII-14-5	13.04	1.3407	1.2776	1.0494
VII-9-2	13.04	0.9723	0.8881	1.0948
VIII-5-6	12.79	0.7157	0.7947	1.1103
VIII-10-4	13.14	1.6460	1.3934	1.1813
VIII-15-6	13.50	0.9736	1.2052	1.2371
VIII-9-5	13.39	0.8105	0.6631	1.2222
VII-5-4	13.09	0.6789	0.5999	1.1316

*Significant at 5% level.

In the present study the number of chiasmata per cell in the interchange heterozygotes was considerably reduced as compared to the normal diploid plants [8]. It seems logical that under these circumstances, where a cell is not able to realize its full potential of chiasma formation, most of the chiasmata would form only autonomously and only a small fraction of the total chiasma frequency would be available for competition among the different chromosome pairs.

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