STUDIES ON THE SYNCYTE FORMATION INDUCED BY X-RAYS IN RICE PLANTS

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Received June 22, 1964

At metaphase-I of meiotic division in some types of abnormal plants there often appear giant cells in which polyploid numbers of chromosomes are counted. These giant cells are formed either by nuclear division without cytoplasmic division (coenocyte) or by cell fusion (cyncyte). The distinction between coenocyte and syncyte can only be made by a detailed study of meiotic division, especially of the early stage.

The purpose of this paper is to report the processes of cyncyte formation during male sporogenesis in an abnormal plant induced by X-rays (Katayama 1953).

Acknowledgement is made to Dr. Nagamatsu, Professor of Plant Breeding Laboratory, Faculty of Agriculture, Kyushu University, for his guidance and valuable suggestions in the preparation of this manuscript.

MATERIAL AND METHODS

A completely sterile rice plant (K-127) secured in the X_2 generation of variety "Aikoku" in 1951 was used as the material in this study.

Morphologically, it is difficult to distinguish this sterile plant from the normal plant. When it blooms, however, the glumes fail to open naturally; the anthers and pistils develop very poorly, and there is a great variation in the size of pollen grains. Pollen grains are not stainable by acetocarmine. Self-pollination or crossing with normal pollens does not produce any seed. This sterility has made the genetical study of this plant very difficult.

PMCs and roop-tip cells were observed by aceto-carmine squashes after fixing with acetic alcohol. To determine the starting stage of cell fusion, permanent preparations were made by the usual paraffin method with young buds.

HISTORICAL REVIEWS

Gaines and Aase (1926) first noted the formation of large syncytes in the haploid *Triticum compactum*. Giant multinucleate "pollen grains" were sometimes formed as a result of the coalescence of contiguous pollen mother cells; the fusion of somatic nuclei in pairs also occurred in ovaries and anthers.

An extreme case of syncyte formation was observed by Levan (1939) in *Petunia* stamens after colchicine treatment of young growing points. All of the tapetum cells and pollen mother cells of each locule were found to have been fused to form plasmodia, in which as many as 1500 chromosomes were counted in an extreme case. He also reported that two haploid *Phleum pratense* ($2n=3x=21$) obtained from two twin pairs showed a frequent cell fusion at the meiotic prophase (1941).

A recessive factor in barley (Smith 1942) was discovered which interferes with the normal development of a portion of microsporocytes, the number of bivalents at metaphase-I varying from fewer than 7 to more than 100.

Tsuchiya (1959) observed several sporocytes consisting of two nuclei in a X-ray induced desynaptic barley and four types of syncyte formations in some trisomic plants and their progeny.

In *Phleum* (Levan 1941), the fusion of neighbouring cells was observed during the early preleptotene stage; and from the relation between the numbers of univalents and bivalents at metaphase-I, the cell fusion was believed to take place after the last division of the archesporial cell without nuclear fusion prior to the zygotene.

OBSERVATIONS AND CONCLUSIONS

In the root-tip cells 24 chromosomes were counted. There was no difference in karyotypes between the sterile and normal plants. At the early stage of meiosis, the number of nuclei per cell varied from 0 to 21 (Table 1). The cells showed a large variation in size as shown in Figures 1-6 (Katayama 1963). At the early stage of prophase, the fusion of cells was started to produce giant cells. From this observation it is believed that the giant cells observed in this plant are not coenocytes but syncytes.

As shown in Table 1, the number of nuclei per PMC was 0 to 21 at early prophase, 1 to 6 at diakinesis and 1 to 3 at metaphase-I, respectively. At diakinesis, the frequencies of chromosome configurations of 12_{II} and 11_I+2_I were 46 (67%) and 13 (19%), respectively (Table 2). Nevertheless, in all but a very few cases, all the bivalents present were arranged on an equatorial plate, the size of which varied with the chromosome number contained at the metaphase-I (Figures 1 and 2). As shown in Table 2, the various types of chromosome configuration, namely $8_{II}+8_I$ to $69_{II}+3_I$, were observed at metaphase-I.

From the facts mentioned above, it may be assumed that the bivalents contained in each nucleus of a cell at diakinesis gradually migrate and are arranged on one regular equatorial plate at metaphase-I. Such a migration of chromosomes during the first division has been noted in *Phleum* (Levan 1941) and in barley (Smith 1942). In *Phleum* these syncytes behave as large cells that develop into one bipolar spindle, and all the bivalents present are arranged on a regular equatorial plate.

Of 46 PMCs observed, 45 (98%) formed one regular equatorial plate at metaphase-

Table 1. Number of nuclei per cell at various stages of syncyte formation

No. of nuclei per cell	Early stage		Diakinesis		Metaphase- I	
	Frequency	%	Frequency	%	Frequency	%
0	1	0.90				
1	72	64.86	18	48.65	49	96.08
2	22	19.82	6	16.22	1	1.96
3	4	3.60	3	8.11	1	1.96
4	3	2.70	3	8.00		
5	1	0.90	3	8.11		
6	3	2.70	4	10.81		
7	1	0.90				
12	1	0.90				
14	1	0.90				
17	1	0.90				
21	1	0.90				
Total	111	99.98	37	100.00	51	100.00

I. Some univalents were observed at diakinesis and metaphase-I as shown in Table 2 and Figure 2. During anaphase-I, these univalents became lagging chromosomes and resulted in the unequal distribution. At micro-spore stage, haploid number of chromosomes was often observed. In general, various stages of meiosis from early stage of first division to microspore stage were observed simultaneously in each anther. The maximum chromosome number counted was about 220 per cell (Figure 6).

SUMMARY

1. It was found from a cytological observation that the giant cells formed in a completely sterile rice plant induced by X-rays are syncytes and not coenocytes.

2. There was not observed any morphological difference that distinguished the syncyte-forming and normal plants.

3. Twenty-four chromosomes were counted in the somatic cells of the sterile plant.

4. The cell fusion to form syncytes was found to have started already at the early stage of meiosis.

5. Number of nuclei per PMC varied from 0 to 21.

6. Chromosome configurations per nucleus varied from $8_{II} + 8_I$ to $69_{II} + 3_I$.

7. The maximum chromosome number counted was about 220.

8. No data on the genetic behavior of syncyte formation were obtained because of the complete sterility of this plant.

9. There was a great variation in the size of pollen grains.

Table 2. Chromosome configurations at diakinesis and metaphase-I

Chromosome configuration	Diakinesis		Metaphase-I	
	Frequency	%	Frequency	%
8 _{II} + 8 _I	1	1.45		
9 _{II} + 6 _I			1	2.17
10 _{II} + 2 _I	1	1.45	1	2.17
10 _{II} + 4 _I	1	1.45		
10 _{II} + 6 _I			1	2.17
11 _{II}	1	1.45	1	2.17
11 _{II} + 1 _I	1	1.45		
11 _{II} + 2 _I	13	18.84	4	8.70
11 _{II} + 3 _I	1	1.45		
12 _{II}	46	66.67	17	36.96
12 _{II} + 1 _I	1	1.45	1	2.17
12 _{II} + 2 _I	1	1.45	2	4.35
13 _{II}	1	1.45	2	4.35
14 _{II}			1	2.17
17 _{II} + 14 _I			1	2.17
18 _{II} + 8 _I			1	2.17
20 _{II} + 8 _I			1	2.17
21 _{II}			1	2.17
22 _{II}			1	2.17
22 _{II} + 3 _I			1	2.17
22 _{II} + 4 _I			2	4.35
23 _{II}			1	2.17
24 _{II}	1	1.45	2	4.35
45 _{II} + 6 _I			2	4.35
52 _{II} + 6 _I			1	2.17
69 _{II} + 3 _I			1	2.17
Total	69	100.01	46	99.96

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Figs. 1-6. Various irregularities of meiosis in syncyte formation (K-127).

1. M-I, showing 12 bivalents.
2. M-I, showing about 10 bivalents and many univalents.
3. M-II, showing about 27 univalents.
4. One cell, showing 24 somatic-like chromosomes at the stage corresponding to diakinesis.
5. One cell containing two nuclei, showing somatic-like chromosomes.
6. One cell, showing about 220 somatic-like chromosomes.