MEMOIRS OF THE COLLEGE OF SCIENCE, KYOTO IMPERIAL UNIVERSITY, SERIES B.
VOL. IV, NO. 3, Article 10, 1929.

Chromosome Arrangement.

II. The Meiotic Divisions in Pollen Mother Cells of *Phaseolus chrysanthos*, SAV. and *Cassia occidentalis*, L.

By

AITARO MUTO.

With 3 Text-figures.

(Received January 26, 1929)

DONCASTER[1] (1924) points out the fact that when the chromosomes are short and of nearly uniform size, the figures of equatorial plates have a remarkable resemblance to those given by physists of the groupings of various numbers of magnets floating in a confined space. In *Phaseolus chrysanthos*, SAV. and *Cassia occidentalis*, L., the chromosomes in the meiotic divisions in pollen mother cells were found in polar view round in shape and nearly uniform in size, and some observations were made with the view of comparing the chromosome arrangements with the stable forms of floating magnet arrangements. Materials were fixed in the case of *Phaseolus* with LICENT'S chromo-acetic-formalin mixture, a previous treatment with CARNOY'S alcohol-chloroform-acetic mixture for a few minutes having been given, and in the case of *Cassia* simply with NAWASCHIN'S mixture.

1. ***Phaseolus chrysanthos***, SAV.

The number of chromosomes was determined in pollen mother cells and cells in root-tips to be 11 and 22 respectively in all the cultivated forms examined, as listed in Table I (see also Figs. 1, 2).

1) DONCASTER, L. (1924), An Introduction to the Study of Cytology. London.

TABLE I.

Name of cultivated forms of the plant	Chromosome Number in		
	Pollen Mother Cells		Cells of Root-tips
	Heterotype metaphase	Homotp. metaph.	
" Maruba "	11 (Fig. 2, *a*, *i*)	11 (Fig. 1, *m*)	22 (Fig. 1, *a*)
" Kensaki "	11 (Fig. 2, *j*)	11 (Fig. 1, *n*)	22 (Fig. 1, *b*)
" Dainagon "	11 (Fig. 2, *b*)	11 (Fig. 1, *o*)	22 (Fig. 1, *c*)
" Kon adzuki "	11 (Fig. 2, *e*)	11 (Fig. 1, *p*)	22 (Fig. 1, *d*)
" Midori-yogore "	11 (Fig. 2, *d*, *h*, *k*)	11 (Fig. 1, *q*)	22 (Fig. 1, *e*)
" Yogore "	11 (Fig. 2, *g*)	11 (Fig. 1, *r*)	22 (Fig. 1, *f*)
" Wase-maruba "	11 (Fig. 2, *f*)	11 (Fig. 1, *s*)	22 (Fig. 1, *g*)
" Kuro-adzuki "	11 (Fig. 2, *c*)	11 (Fig. 1, *t*)	22 (Fig. 1, *h*)
" Natsu-adzuki "	11 (Fig. 2, *l*)	——	22 (Fig. 1, *i*)
" Chiba-urumi "	——	——	22 (Fig. 1, *j*)
" Beni-adzuki "	——	——	22 (Fig. 1, *k*)
" Shirosaya-aka "	——	——	22 (Fig. 1, *l*)

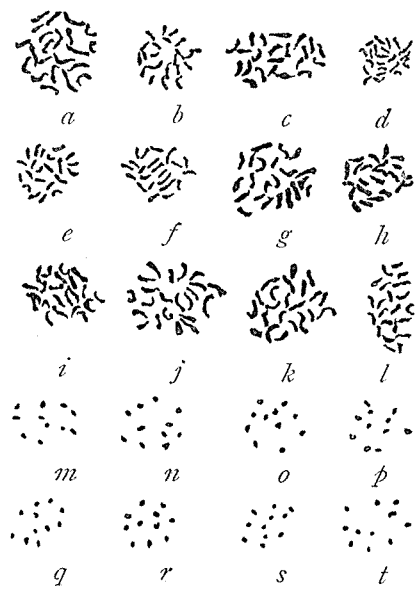

Fig. 1.

Phaseolus chrysanthos, SAV. *a*—*l*. Nuclear plates in cells of root-tips, *m*—*t*. Homotypic nuclear plates in pollen mother cells. *a*. " Maruba," *b*. " Kensaki," *c*. " Dainagon," *d*. " Kon-adzuki," *e*. " Midoriyogore," *f*. " Yogore," *g*. " Wasemaruba," *h*. " Kuro-adzuki," *i*. " Natsuadzuki," *j*. " Chiba-urumi," *k*. " Beni-adzuki," *l*. " Shirosaya-aka," *m*. " Maruba," *n*. " Kensaki," *o*. " Dainagon," *p*. " Kon-adzuki," *q*. " Midori-yogore," *r*. " Yogore," *s*. " Wasemaruba," *t*. " Kuro-adzuki." (ZEISS $^1/_{12}$ × comps. oc. 12)

In *Phaseolus vulgaris* WEINSTEIN[1] has observed the same number of chromosomes in pollen mother cells as well as in root-tips as the number found in our cultivated forms of *Phaseolus chrysanthos*, SAV. In *Phaseolus chrysanthos* the chromosomes in the meiotic divisions of pollen mother cells are nearly round in shape and of small size, though there is recognizable a slight difference in size between these chromosomes. They are distributed in the equatorial plate, generally evenly apart from one another, so that counting of the chromosomes was very easy. The chromosome arrangements were observed in the metaphase of the heterotype as well as of the homotype division of pollen mother cells. The arrangement configurations are generally of a form which may be diagramatically expressed as a chromosome ring having some small number of chromosomes inside it. The results obtained are summarized in Table II, the result from each cultivated form of the plant not being respectively distinguished, but the forms of chromosome arrangement where the same number of chromosomes is inside the ring being taken together in one group. From the same view point as discussed by KUWADA in his paper on the same thesis, two cases are distinguished here in the table; in the one case all the chromosomes are found arranged strictly on the equatorial plate (Case A), and in the other they have not yet completely formed the nuclear plate, some being found slightly above or below the others (Case B).

From Table II it is seen that in both cases A and B, the forms of arrangement in which 3 chromosomes occupy inner positions are the most numerous, and the forms having 2 and 4 inside chromosomes respectively come next in frequency of occurrence and those with 1 and 5 respectively are least numerous. It is a very significant fact that of the forms that occur most frequently, or the forms in which 3 chromosomes are found inside the ring, those forms in which the 3 chromosomes are arranged in the form of a regular triangle, surrounded by a circular ring of chromosomes (Fig. 2, *g* and *h*), that is, an arrangement form

---

[1] WEINSTEIN, A., (1926), Am. Journ. Bot. Vol. XIII. No. 4.

TABLE II.

Number of inner chromosomes	Example	Case A		Total	Per cent.	Case B		Total	Per cent.
		Heterotp. metaph.	Homotp. metaph.			Heterotp. metaph.	Homotp. metaph.		
1	Fig. 2, *a*	4	—	4	2.7	3	—	3	2.0
2	„ „ *b* „ „ *c*	10	14	24	16.7	30	4	34	22.6
3	„ „ *d*[1] „ „ *e* „ „ *f* „ „ *g* „ „ *h*	57	34	91	63.2	71	8	79	52.0
4	„ „ *i* „ „ *j* „ „ *k*	16	9	25	17.4	26	1	27	18.0
5	„ „ *l*	—	—	—	—	7	—	7	4.6
Total				144	100.0			150	99.2

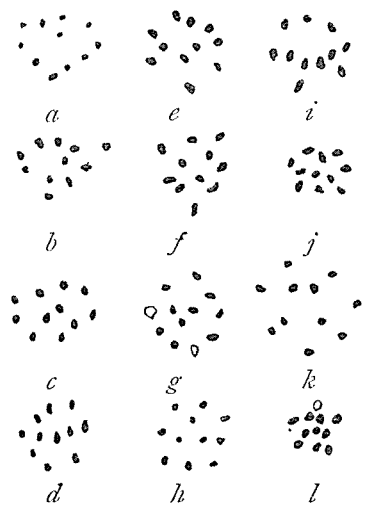

Fig. 2. Heterotype nuclear plates representing various forms of arrangements in pollen mother cells of *Phaseolus chrysanthos*, Sav. Hollow circles indicate that the chromosomes are slightly out of the nuclear plate. *a*. "*Maruba*," *b*. "*Dainagon*," *c*. "*Kuro-adzuki*," *d*. "Midori-yogore," *e*. "Kon-adzuki," *f*. "Wase-maruba," *g*. "Yogore," *h*. "Midori-yogore," *i*. "Maruba," *j*. "Kensaki," *k*. "Midori-yogore," *l*. "Natsu-adzuki." (ZEISS $^1/_{12}$ × comps. oc. 12)

[1] This form of chromosome arrangement was relatively infrequent, there being 18 out of 91 observed cases having 3 inner chromosomes in Case A, and 21 out of 79 in Case B.

of chromosomes which corresponds to the stable form of arrangement of floating magnets[1] are of frequent occurrence (46 out of 91 in Case A, and 34 out of 79 in Case B).

2. ***Cassia occidentalis,*** L.

The haploid number of chromosomes in *Cassia tomentosa*, is reported by SAXTON (1907), and in *C. Fistula*, by TISCHLER (1921), each to be 12[2]. In the case of *C. occidentalis*, L., in which the counting was carried out at the nuclear plate stage in the heterotype division of pollen mother cells, the number was found to be 13.

As the chromosomes in the heterotype metaphase are all of nearly uniform size and shape, the plant was taken as material for observation for the same purpose as in the case of *Phaseolus*. The results obtained are given in Table III, the two cases A and B being distinguished here again.

TABLE III.

Number of inner chromosomes	Example	Case A	Per cent.	Case B	Per cent.
		Heterotype metaphase		Heterotype metaphase	
2	Fig. 3, a	2	2.5	1	1.6
3	„ „ b „ „ c „ „ d	13	16.3	10	16.2
4	„ „ e „ „ f „ „ g „ „ h „ „ i	47	58.8	35	56.5
5	„ „ j „ „ k	15	18.7	11	17.7
6	„ „ l	3	3.7	5	8.0
Total		80	100.0	62	100.0

1) MIZUNO (1916), Theory of the Atom, Part. II, Tokyo, and CANNON, H. G. (1923), Journ. Genetics. Vol. XIII.

2) TISCHLER, G. (1922), Allgemeine Pflanzenkaryologie. Berlin.

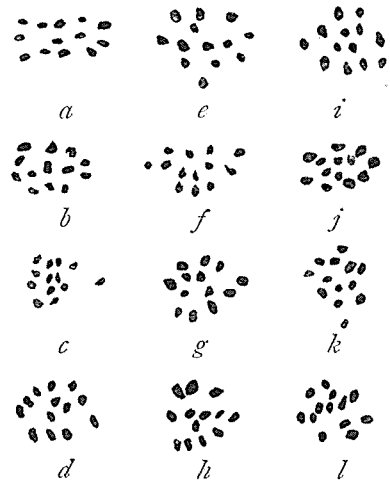

Fig. 3. Heterotype nuclear plates representing various forms of arrangement in pollen mother cells of *Cassia occidentalis*, *L.* (ZEISS $^1/_{12}$ × comps. oc. 18)

Table III shows that there exists in this plant practically the same relation as in the case of *Phascolus* between the number of chromosomes occupying the inner positions and the frequency of occurrence of the forms having that number of inside chromosomes. According to MIZUNO, in the case of 13 floating magnets, 4 take up their positions inside the ring. Thus we see here again a remarkable resemblance to the stable form of arrangement of floating magnets in the forms which are of far more frequent occurence than any of the other forms differing from the arrangement of floating magnets.

SUMMARY.

1. The haploid number of chromosomes in the heterotype division in pollen mother cells was found to be 11 in some cultivated forms of *Phaseolus chrysanthos*, *Sav.* and 13 in *Cassia occidentalis*, L.

2. The forms of the arrangement of the chromosomes were examined in 294 cases in *Phaseolus*, and in 142 cases in *Cassia*.

3. In *Phaseolus*, all the cultivated forms examined being taken together, we find that cases where the number of chromosomes occupying positions inside the ring is the same as that of the inside floating magnets are the most numerous, being 63.2 per cent. in frequency of occurrence when all the chromosomes are arranged strictly in the equatorial plate, and 52.6 per cent. when some of them are scattered slightly above or below that plate.

4. In the case of *Cassia*, these frequencies were found to be 58.8 per cent. and 56.5 per cent. respectively, results which are nearly similar to those obtained in *Phaseolus*.

5. In the case of both *Phaseolus* and *Cassia*, the most frequently occurring forms of arrangement are those which resemble the stable forms of arrangement of floating magnets.

In conclusion I wish to express my sincere thanks to Professor Y. KUWADA, under whose direction this investigation was carried out. My thanks are also due to Mr. K. ABIKO, Director of the Hokkaido Agricultural Experiment Station for kindly placing material at my disposal.