GENETICAL AND CYTOLOGICAL STUDIES IN *ALLIUM*.

II. DISTRIBUTION OF FREQUENCIES OF CHROMOSOME NUMBER IN POLLEN GRAINS OF F_1 PLANT OF *A. CEPA* $\times$ *A. FISTULOSUM*

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1. Material

Since the rediscovery of mendelism much effort has been devoted by plant cytogenetists to the breeding of intervarietal, interspecific and intergeneric hybrids, especially in plants already under cultivation, in order to obtain those kinds which would be better suited for practical use, or for purposes of cytological as well as genic analytical investigations. The breeding of F_1 plant from the cross of *Allium Cepa* and *A. fistulosum* had been carried out previously by various cytogeneticists, e.g. Emsweller and Johns (1934, 1935), Levan (1935), Maeda (1937-1948), etc. The writer's material used in this report was obtained through crossing flowers of *A. Cepa* with pollen of *A. fistulosum* in 1951.

This hybrid plant, after flowering in 1952, was unable to produce seeds (F_2), whose meiotic division proceeded with some disorder. Although virtually devoid of the ability for sexual reproduction, this perennial F_1 plant multiplies by bulbs from year to year, as will be found in other species of the genus *Allium*. In 1953, several germinative seeds were produced from this hybrid plant.

2. Observation

The external characters of the hybrid plant—the forms of the leaf, stem, flower and bulb—are almost intermediate between the parent alliums. Its flowering time is also in between those of the parent species—May in Tokyo, while that of *A. fistulosum* being late March to June and that of *A. Cepa*, June. The height of the hybrid plant, however, sur-

Fig. 1. External forms of *A. Cepa* (left), *A. fistulosum* (right) and their hybrid plant (center), the latter's height being taller than that of the parent plants (sketched in early May in Tokyo).

Fig. 2. Flowers and stamens of parent plants and their hybrid. The order of arrangement is the same as in Fig. 1.

passes even a taller parent plant, *A. Cepa*, which is a case of heterosis.

The shapes and the haploid numbers of chromosome of alliums can be exactly and easily observed at the first vegetative division in the pollen grains of the materials. The distribution of frequencies of chromosome number confirmed by the writer in 1952 from metaphase plates of 352 pollen grains in the hybrid plant is as follows:

Chromosome number	3	4	5	6	7	2	9	10	11	12	Total
Pollen grains	1	0	0	0	12	256	69	11	2	0	352
%	0.56				3.4	72.72	19.6	3.13	0.56	—	99.97

As for the size of pollen, the writer often encountered one about twice as large as the normal one. Accordingly, there must be cells consisting of diploid or nearly diploid chromosomes, although no metaphase figures of these cases were observed by the writer.

The distribution of frequencies of chromosome number reexamined by him in 1953 turned out almost the same percentage in each class of chromosome number, confirming 92 metaphase plates in pollen of the same plant, as shown in the table below.

Chromosome number	6+f	7	8	9	10	Total
Pollen grains	1	3	68	20	0	92
%			73.91	21.73		

It is apparent as referred to in the tables above, that the spontaneous chromosome variation in this material may be found to prevail to about the same extent yearly, if not influenced by abnormal conditions like extremely high or low temperatures, as described in the writer's paper I of this series. In the present paper only the former table, however, was dealt with statistically.

According to the two tables, it is obvious that the frequencies of chromosome numbers less than the normal number, $n=8$, are of rarer occurrence as compared with those of chromosome numbers greater than the normal. In regard to the chromosome number, nevertheless, an even distribution should be expected on both sides of the normal case. In the first paper of this series, the writer reported upon the cytology of the phylogenetically tetraploid *A. odorum*, $n=2x=16$, in which the frequency of the chromosome number in pollen grains was found to distribute evenly in cases of chromosomes in excess of the normal complement and also in cases below the normal number. It may be inferred, therefore, that in this diploid plant, an interspecific hybrid allium, the pollen grains containing the chromosomes insufficient for one genome ($n=8$) perished after meiosis before the first pollen mitosis. Even the germ cells with the chromosomes less than the normal haploid number, in the former tetraploid case, appear to be viable, while in the latter diploid case the possibility of their survival is very small.

Based upon the observation stated above, the writer classified the frequencies of chromosome number into groups of chromosome numbers of 8-8, 9-7, 10-6,....., as the following table shows, doubling each frequency of the chromosome number more than 8 and neglecting the real frequency less than the normal. The same comparative ratio as above may be

obtained by dividing into two, the frequency of chromosome 8, leaving untouched those of chromosome numbers 9, 10, 11,.....

Chromosome number	8-8	9-7	10-6	11-5	12	Total
<i>i</i> (variable)	0	1	2	3	4	
Frequency observed	256	133	22	4	0	420
Frequency expected (<i>f_i</i>)	264.2	112.3	23.3	4.4	0.5	419.7

$$f_i = 420 \times \frac{0.462^i e^{-0.462}}{i!} \quad \chi^2 = 4.192, P > 0.30.$$

By computing the average value of distribution of frequencies of chromosome number in the former table (0.462) and by applying the formula of Poisson distribution, the writer obtained the expectant frequencies (*f_i*) tallying in approximation with the observed data, as seen in the table above.

Regarding the shape of chromosomes of parent plants of this hybrid, both species have a pair of chromosomes with satellites, viz. SAT-chromosomes in the vegetative cells, which are distinguishable from each other. The satellite of SAT-chromosome in *A. fistulosum* is usually distinct, while on the contrary that of *A. Cepa* is small and often indiscernible.

In the 49 metaphase plates of normal chromosome number, where-

Fig. 3. Five side views of chromosomes at meiotic metaphase of *F₁* plant. Cases of a pair (upper two and middle) and two pairs (lower left) of chromosomes existing as univalents. $\times 1,900$.

Fig. 4. Examples of metaphase plates in the first pollen mitosis containing chromosomes 6 to 11. In cases of 6 and 7 the SAT-chromosome is unrecognizable. $\times 1,900$.

Fig. 5. A curve showing distribution of frequencies of chromosome number in the pollen grains; abscissa, chromosome number and ordinate, percent.

rein the shape of each member could be told, 25 pollen grains contained a SAT-chromosome derived from *A. fistulosum* and 24 pollen grains that derived from *A. Cepa*.

Résumé

1) The distribution of frequencies of the chromosome number contained in the pollen grains of the hybrid plant ($n=16$) of *A. Cepa* × *A. fistulosum* was investigated. According to the writer's ob-

servations for a two year period, over 70 percents of all the pollen has the normal chromosome number ($n=8$) and ca. 20 percents, $n=9$. This ratio occurred annually.

2) In cases with chromosomes above the normal, the distribution of frequencies of chromosome number in this material coincides with Poisson distribution, regardless of the observed frequencies of pollen containing chromosomes less than one genome, which seems to perish for the most part prior to arriving at the first pollen mitosis. This hybrid plant multiplies mainly by bulbs, seed production being of rare occurrence.

3) The pollen with a SAT-chromosome derived from *A. fistulosum* and with that from *A. Cepa* amounted to about half and half in the normal metaphase plates of this hybrid plant.

Literature

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