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Iwasa, Shoichi
Horticultural Laboratory, Department of Agriculture, Kyushu University

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Studies on the alloplasmatic effect in tribe *Brassiceae*
III. On the effect on the manifestation of genome complements in some F_1 hybrids and in the strains having an extra-chromosome*

Shoichi IWASA

The *pekinensis* plants having *carinata*'s cytoplasm (denoted as *ca-pekinensis* plants in abbreviation) revealed chlorophyll deficiency and some conspicuous characters ascribable to the disharmony occurred between the allocytoplasm and the substituted-nucleus. The developmental aspect of these characters was described in some detail in the previous paper (Iwasa, 1963b).

The author could observe the different changes in the *carinata*-cytoplasmic effect produced in response to different nuclear contents (1) in F_1 hybrids, which have been raised from the crosses between *ca-pekinensis* plants and several species of *Brassica* and (2) in the strains having an extra-chromosome. The observations must be continued on a large scope if any decisive results are to be reached, but the results gained so far may well be reviewed for some consideration in this report.

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MATERIALS AND METHODS

The materials used in effecting the crosses (see Table 1): plants of 8 species (including 13 horticultural varieties) in genus *Brassica*, all of which were pedigree-cultured at the Horticultural Laboratory, Kyushu University; 3 kinds of other plants, chosen from the B_8F_{11}† of

* Contribution from the Horticultural Laboratory, Faculty of Agriculture, Kyushu University.

† B_8F_{11} denotes the eleventh generation hybrid strain derived through eight times of backcrossings.

the *ca-pekinensis* strain, and from the B_3F_4 and B_4F_5 strains of *ca*-$(10_{II}+1_I)$, respectively. The processes of nucleus-substitution were described elsewhere in the author's previous report I (Iwasa, 1963a).

The cytological observations of the pollen mother-cells were made by the smear method. The crossing was effected by the bud-pollination technique.

RESULTS

A. The *carinata*-cytoplasmic effect in F_1 hybrids

1. Results of crosses. Several species in the genus *Brassica*, as shown in Table 1, were crossed with *ca-pekinensis* plants in reciprocal combinations. The results are as follows: the reciprocal crosses between 10 chromosomes-species and *ca-pekinensis* plants resulted in the production of a large number of hybrid seeds; the reciprocal crosses between *B. juncea*, 18 chromosomes-species, and *ca-pekinensis* plants failed to produce any one hybrid seed (when *B. juncea* was used as mother plant in the cross, the seeds obtained were all matroclinous false-hybrid in nature); the reciprocal crosses between *B. napus*, 19 chromosomes-species, and *ca-pekinensis* plants resulted in the production of true hybrid seeds; the reciprocal crosses between *B. carinata*, only a 17 chromosomes-species, and *ca-pekinensis* plants did not produce

Table 1. Materials used in the experiment.

Species	Genome constitution	Horticultural varieties
Brassica pekinensis Rupr.	*aa*	Kashin-hakusai, Chifu-hakusai, Nozaki-hakusai, Hoshinkokyo-hakusai
B. chinensis L.	*aa*	Shigatsu-shirona, Hakusaishin
B. narinosa Baily	*aa*	Hisago-na, Kisaragi-na
B. rapa L.	*aa*	Hakatasuwari-kabu
B. japonica Sieb.	*aa*	Kyo-na
B. juncea Hemsl.	*aabb*	Katsuo-na, Miikeaka-takana
B. napus L.	*aacc*	Undai
B. carinata Braun	*bbcc*	Unkown

any one hybrid seed. When crossed with any species in the genus *Brassica*, the *ca-pekinensis* plants proved invariably as fertile as the control *pekinensis* plants, indicating in all probability that these two

kinds of *pekinensis* plants having different cytoplasm were somewhat identical in their crossability.

Table 2. Relationship between the cytoplasm and the plant height in F_1 hybrids raised reciprocally. (1961)

Cross combination	Plant height (cm)	Number of plants examined	Nature of cytoplasm
Ca-pekinensis × *narinosa* (H)[1]	86.2±11.8	19	*carinata*
Narinosa (H) × *ca-pekinensis*	138.6±16.0	20	*narinosa*
Ca-pekinensis × *napus*	161.0	1	*carinata*
〃	88.0	1[2]	〃
Napus × *ca-pekinensis*	168.8±17.5	12	*napus*
〃	89.0	1[2]	〃

N.B. 1) Hisago-na.
2) Plants were grown under the small pot-culture condition.

Table 3. Relationship between the cytoplasm and the petal sizes in F_1 hybrids raised reciprocally. (1961)

Cross combination	Petal length (cm)	Petal width (cm)	Total number of petals measured	Total number of plants used
A)				
Normal *pekinensis* selfed	12.4±0.378	8.7±0.452	80	2
Narinosa (H) × *ca-pekinensis*	12.1±0.297	8.4±0.325	80	2
Ca-pekinensis × normal *pekinensis*	11.0±0.447	7.0±0.366	62	2
Ca-pekinensis × *narinosa* (H)	10.9±0.467	6.7±0.384	120	4
Napus × *ca-pekinensis*	15.7±0.449	9.6±0.382	22	1
Ca-pekinensis × *napus*	16.0±0.485	9.6±0.443	22	1
B)				
Narinosa (K) × *ca-pekinensis*	13.1±0.761	8.2±0.335	40	4
Ca-pekinensis × *narinosa* (K)	10.1±0.421	5.4±0.348	40	4

N.B. A) Plants were grown in the experimental farm.
B) Plants were cultured in a nursery box, being densely crowded condition.
Abrrev.; (H) Hisago-na, (K) Kisaragi-na.

2. Growth of F_1 *hybrids.* The hybrid seeds were sown in pots during September and left grown continuously under the greenhouse condition until the end of December, when the plants were transplanted

in the experimental farm. Among the F_1 hybrids, produced by reciprocal crosses between 10 chromosomes-species and *ca-pekinensis* plants, *ca*-F_1 plants were inferior in the vigor of their growth to the F_1 plants produced by the reverse crosses. On the other hand, the F_1 plants produced by reciprocal crosses between *B. napus* and *ca-pekinensis* plant went on growing all at the same rate irrespective of the cytoplasmic differences. The comparative examinations of plant height and petal size were carried out with fully grown F_1 hybrids obtained reciprocally (Table 2 and 3). *Ca*-F_1 plants of *ca-pekinensis* plants (♀) × *B. narinosa* (♂) show not only lower plant height than *nar*-F_1 plants of the reverse cross, but also smaller flowers. And, moreover, when the plants were impeded in their growth under the adverse conditions, in *ca*-F_1 plants,

Table 4. Occurence of chlorophyll defect in F_1 hybrids raised between the *carinata*-cytoplasmic *pekinensis* and some *Brassica* species. (1960–1961)

Cross combination	Genome constitution of F_1	Chlorophyll defect in Sept. (1960)	Chlorophyll defect in March. (1961)	Chromosome pairings at MI
Ca-pekinensis × *pekinensis* Kashin-hakusai	*aa*	+	+	10_{II}
Chifu-hakusai	*aa*	+	+	—
Nozaki-hakusai	*aa*	+	+	10_{II}
Hoshinkokyo-hakusai	*aa*	+	+	—
〃 × *chinensis* Shigatsu-shirona	*aa*	+	+	10_{II}
Hakusaishin	*aa*	+	+	10_{II}
〃 × *narinosa* Hisago-na	*aa*	+	+	—
Kisaragi-na	*aa*	+	+	—
〃 × *rapa* Hakata-suwari-kabu	*aa*	+	+	10_{II}
〃 × *japonica* Kyo-na	*aa*	+	+	—
〃 × *napus* Undai	*aac*	−	−	$10_{II}+9_I$
pekinensis × *ca-pekinensis* Kashin-hakusai	*aa*	−	−	10_{II}
Narinosa × *ca-pekinensis* Hisago-na	*aa*	−	−	
Napus × *ca-pekinensis* Undai	*aac*	−	−	$10_{II}+9_I$

in contrast to *nar*-F_1 plants, the flowers became reduced severely in their size. These situations are just the same as the F_1 plants arising from reciprocally between *ca-pekinensis* plants and normal *pekinensis* plants. On the contrary, the F_1 plants produced by reciprocally be-

tween *ca-pekinensis* plants and *B. napus* did not appear different from each other in plant height and in flower size.

3. Chlorophyll deficiency in F_1 *hybrids.* Whether or not the *carinata* cytoplasmic F_1 plants became chlorophyll-deficient is a reliable fact which furnish a criterion to be used in considering the presence or absence of the *carinata*-cytoplasmic effect. In Table 4 a description of those F_1 plants is given in summarized form. It will be seen that chlorophyll deficiency developed in quite the same manner in *ca*-F_1 plants containing *aa* genomes and in *ca-pekinensis* plants (Figs. A and B), but not in any way in *ca*-F_1 plants containing *aac* genomes (Figs. C and D).

4. Fertility of F_1 *hybrids.* A few F_1 hydrids were kept under cytological observation and it was found as a result that, in F_1 plants produced by the crosses between *ca-pekinensis* plants and 10 chromosomes-species, 10_{II} was invariably observable at metaphase-I and, in consequence, subsequent meiotic divisions proceeded quite regularly, and that, in F_1 plants produced by the crosses between *ca-pekinensis* plants and *B. napus*, $10_{II}+9_I$ was exclusively obtained at metaphase-I and the resultant division processes behaved irregularly. Therefore, the pollen-fertility

Table 5. Differences in the pollen- and seed-fertilities in various F_1 hybrids, which have been derived through the reciprocal crosses. (1961)

Cross combination	Number of seeds per silique	Number of placentae per silique	Viable seeds per placentae developed (%)	Number of siliques examined	Fertile pollen-grains (%)	Number of plants examined
Normal *pekinensis* selfed	17.9	28.8	62.2	40	95.6	1
Ca-pekinensis × normal *pekinensis*	16.0	25.8	62.0	30	99.4	1
Narinosa (H) × *ca-pekinensis*	22.4	32.8	68.3	120	92.1	3
Ca-pekinensis × *narinosa* (H)	24.0	31.4	76.4	200	99.5	5
Napus × *ca-pekinensis*	7.9	31.6	24.7	80	67.6	2
„	5.7	26.1	21.8	30	—	1[1]
Ca-pekinensis × *napus*	8.6	29.9	28.8	40	73.0	1
„	5.8	26.6	21.8	30		1[1]

N.B. 1) Plants were obtained from the small pot-culrure.

was almost perfect with the former F_1 plants and ca. 70 per cent with the latter ones, while the seed-fertility of the former plants was as high as in the normal *pekinensis* plants and ca. 25 per cent with the latter. As shown in Table 5, there was no detectable cytoplasmic

difference between the two kinds of F_1 plants obtained reciprocally, though it was made clear through the further investigations, as shown in Table 6, that both the number of siliques set per plant and the total weight of seeds produced per plant were far smaller in amount with *ca*-F_1 plants than with *nar*-F_1 plants, and, moreover, with *ca*-F_1 and *nap*-F_1 plants having *aac* genomes, the above respect was not detected at all.

Table 6. Relationship between the cytoplasmic differences and the number of siliques set and amount of seeds produced in the F_1 hybrids derived from the reciprocal crosses. (1960)

Cross combination	Number of siliques per plant	Seeds produced per plant (g)	Number of plants examined	Nature of cytoplasm
Ca-pekinensis × *narinosa* (H)	240.5	13.6	5	*carinata*
Narinosa (H) × *ca-pekinensis*	1220.7	66.2	3	*narinosa*
Ca-pekinensis × *napus*	4171	71.9	1	*carinata*
,,	180	8.9	1[D]	〃
Napus × *ca-pekinensis*	1743.0	31.9	3	*napus*
,,	124	7.3	1[D]	〃

N.B. Materials were the same as in Table 4.

B. The *carinata*-cytoplasmic effect in the strains having an extra-chromosome

1. Morphological aspects. *Ca*-($10_{II}+1_I$) plants never became chlorophyll-deficient, with a normal quantity of chlorophylls regained and with carotenoid contained in an increasing quantity in them (Iwasa, 1963b). These plants were found, besides, to develop a few characters ascribable to the action of the added extra-chromosome, i.e., the leaves

Table 7. Frequency distribution of leaf-form index in ($10_{II}+1_I$) plants. (1954)

Materials	Leaf-form index (length/width)							Mean	Number of leaves used
	2.1	2.2	2.3	2.4	2.5	2.6	2.7		
(normal *pekinensis* × *ca-pekinensis*) selfed	—	—	2	3	2	—	1	2.4	10
(*ca-pekinensis* × normal *pekinensis*) selfed	2	6	1	1	—	—	—	2.2	10

N.B. Materials were grown under the greenhouse condition.

were a trifle slender in shape and deeper in color, the internode increased slightly in length even at the rosette stage of their growth,

the petioles colored with anthocyan pigment at their basal parts, and flowers larger in size than in 10_{II} plants.

Table 7 is compiled of the measurements (at the bolting stage) of the largest leaves of two lines of $(10_{II}+1_I)$ plants, differing cytoplasmically, showing the leaf-form index is much greater for $(10_{II}+1_I)$ plants than for 10_{II} plants. But the cytoplasmic difference observed in 10_{II} plants could be noticed in the reverse situation with $(10_{II}+1_I)$ plants, showing, presumably, that in the latter plants the leaves were altered in shape not so much by the *carinata*-cytoplasmic effect as by another stronger factors, as may be inferred from the fact that the extra-chromosome, when included into the *pe-pekinensis* genotype, promoted the growth of the plant and, when added to the *ca-pekinensis* plant, increased the *carinata*-cytoplasmic effect of inhibiting the growth of plant.

2. *Growth.* *Pe*-$(10_{II}+1_I)$ plants grew up more vigorously and became taller than the normal *pe*-10_{II} plants, and *ca*-$(10_{II}+1_I)$ plants, in turn, undergrew to *ca*-10_{II} plants, so that, among the whole $(10_{II}+1_I)$ plants, *pe*-$(10_{II}+1_I)$ plants were far taller and more densely foliated than *ca*-$(10_{II}+1_I)$ ones.

Table 8. Compraison of petal sizes between 10_{II} plants and $(10_{II}+1_I)$ plants. (1954)

Materials	Petal length (cm)	Petal width (cm)	Total number of petals used	Total number of plants used	Nature of cytoplams
(normal *pekinensis* × *ca-pekinensis*) selfed					
10_{II} plants	13.6±0.667	8.5±0.438	160	4	*pekinensis*
$10_{II}+1_I$ plants	15.6±0.597	9.5±0.575	166	4	„
(*ca-pekinensis* × normal *pekinensis*) selfed					
10_{II} plants	12.1±0.631	7.3±0.748	160	4	*carinata*
$10_{II}+1_I$ plants	14.6±0.465	8.5±0.343	112	3	„

N.B. Materials were grown under the greenhouse condition.

Table 8 shows that the flowers of $(10_{II}+1_I)$ plants became larger in size irrespective of their cytoplasm, but those of *ca*-$(10_{II}+1_I)$ plants, like those of *ca*-10_{II} plants, failed to increase their sizes at the same as that in *pe*-$(10_{II}+1_I)$ plants on account of the *carinata*-cytoplasmic effect realized in those plants.

3. *Fertility.* At the meiotic division of PMCs in $(10_{II}+1_I)$ plants, the univalent chromosome was usually distributed towards either one

of opposite poles at anaphase-I or in some rare cases was eliminated as the accessory micronucleus situated out of the daughter nuclei, so that the meiotic divisions became somewhat abnormal, though the frequency occurrence of the abnormal tetrads did not exceed 5—6 per cent. In pollen-fertility, a *pe*-($10_{II}+1_I$) plant was not lower than any of *pe*-10_{II} plants, while all the *ca*-($10_{II}+1_I$) plants were considerably lower than the *ca*-10_{II} plants (Table 9). The seed-fertility of the *ca*-($10_{II}+1_I$) plants was markedly affected by allocytoplasm than the pollen-fertility (Table 9). The presence of an extra-chromosome added did not appreciably affect the fertility of *pe*-($10_{II}+1_I$) plants, but did seriously in reducing that of *ca*-($10_{II}+1_I$) plant. Similar tendency was also recognizable in many progenies raised by selfing of *pe*-($10_{II}+1_I$) plant, though the latter form was examined in only one case, not furnishing data sufficient on evidence for Table 9.

Table 9. Pollen- and seed-fertilities in F_1 plants derived from the crosses between ($10_{II}+1_I$) plants having *carinata's* cytoplasm and the normal *pekinensis* plants. (1954)

Cross combination	F_1	Fertile pollen-grains (%)	Seed-fertilility (%)	Number of plants examined	Nature of cytoplasm
Ca-($10_{II}+1_I$) plant × normal *pekinensis*	10_{II} plants	99.4	53.2–68.7–87.5[1)]	4	*carinata*
	$10_{II}+1_I$ plants	86.7	22.2–23.7–25.1	2	„
Normal *pekinensis* × *ca*-($10_{II}+1_I$) plant	10_{II} plants	99.5	69.2–82.5–89.0	4	*pekinensis*
	$10_{II}+1_I$ plants	94.5	70.7	1	„

N.B. Materials were grown under the greenhouse condition.
1) minumum-average-maximum values.

4. *Progeny of the* ($10_{II}+1_I$) *plant.* Through either the crossing among or the selfing of the ($10_{II}+1_I$) plants, ($10_{II}+1_I$) and 10_{II} individuals could be obtained in the next generation, but not any one 11_{II} individual. And by the crossing between ($10_{II}+1_I$) and 10_{II} plant, ($10_{II}+1_I$) plants and 10_{II} plants were also raised in the next generation. With these progenies a majority of ($10_{II}+1_I$) forms have been derived from the crosses among ($10_{II}+1_I$) plants (Table 10). Crosses between 10_{II} plant (♀) and ($10_{II}+1_I$) plant (♂) could produce, however, only a few or no ($10_{II}+1_I$) plants, and this fact will suffice to show that the pollen-grains with 11 chromosomes are definitely lower in their fertilizing ability than those with 10 chromosomes as compared on the certation. Among the progeny seeds obtained by the crossing or the selfing of ($10_{II}+1_I$) plants there could be found a considerable amount of shriveled seeds which, if germinated, were likely to grow up into ($10_{II}+1_I$)

or 11_{II} plants. As shown in Table 10, with respect to the frequency occurrence of $(10_{II}+1_I)$ forms, the cytoplasmic difference was not detectable. The $(10_{II}+1_I)$ seeds were usually a trifle smaller, as pointed out elsewhere in the author's previous report (Iwasa, 1963a), as compared with 10_{II} seeds, so that the smaller seeds must be chosen to raise the $(10_{II}+1_I)$ individuals in large proportion. The actual chromosome numbers counted with each seed selected for this purpose from the progeny seeds obtained by the selfing of *pe*-$(10_{II}+1_I)$ plants are represented in Table 11.

Table 10. Chromosome survey of the offsprings raised by the crossings between $(10_{II}+1_I)$ and 10_{II} plants and those of selfing. (1953–1955)

Cross combination	Offspring		Number of plants examined	% of $10_{II}+1_I$ plants	Nature of cytoplasm
	$10_{II}+1_I$ plants	10_{II} plants			
$(10_{II}+1_I)$ selfed	10	46	56	17.9	*pekinensis*
$(10_{II}+1_I)\times 10_{II}$	17	154	171	9.9	„
$10_{II}\times(10_{II}+1_I)$	1	67	68	1.5	„
$(10_{II}+1_I)$ selfed	15	83	98	15.3	*carinata*
$(10_{II}+1_I)\times 10_{II}$	3	52	55	5.5	„
$10_{II}\times(10_{II}+1_I)$	0	46	46	0.0	„
$(10_{II}+1_I)\times(10_{II}+1_I)$	3	8	11	27.3	„

Table 11. Selecting out of $(10_{II}+1_I)$ plants in the progeny of $(10_{II}+1_I)$ plant by means of the seed size. (1955)

Seed size	Number of seeds sown	Number of seeds germinated	Segregation		Number of plants examined	Frequency of $10_{II}+1_I$ plants (%)
			$10_{II}+1_I$ plants	10_{II} plants		
Large	40	35	0	35	35	0
Small	30	22	10	11	21	47.6
Without discrimination	70	57	10	46	56	17.9

Discussion

In *Epilobium* F_1 hybrids, which obtained from the crosses between *hirtsutum* jena-strain (♀) and other different *hirsutum* strains (♂), various degrees of growth inhibition, from heterosis to lethality, could be observed. Furthermore, the degree of these inhibitions was different

with the strain which has been used as male parent (Michaelis, 1940a and b). In the F_1 hybrids obtained from the crosses between nucleus-substituted Emmer wheats ---*Triticum durum* having *Aegilops ovata*'s cytoplasm—, developing the male-sterility on account of alloplasmatic effect, and other kinds of normal Emmer wheat, all the *ovata*-cytoplasmic F_1 hybrids revealed the male-sterility, excepting one kind of *ovata*-cytoplasmic F_1 plant, which was derived from the cross between *ovata*-cytoplasmic *durum* plants (♀) and *T. dicocooides* var. *Koschyanum* (♂) and revealed only a trifle sign of male-sterility (Fukasawa, 1959). He inferred from this fact that the recovery of male-fertility in the F_1 hybrids having *ovata*'s cytoplasm might have resulted from the action of some dominant genes brought by the pollen parent. It may be expected from these accounts that in the F_1 plants having *carinata*'s cytoplasm obtained by the crosses between *ca-pekinensis* plants and several 10 chromosomes-species of the genus *Brassica*, the nucleus in each kind of F_1 plant, heterozygotic in its genotype, would inhibit or eliminate the effect of *carinata*'s cytoplasm incorporated in each individual. But the *ca*-F_1 plants were clearly observed to have all the characters of *ca-pekinensis* plants.

It may be safely asserted from the foregoing findings that the *carinata*'s cytoplasm does not harmonize as a rule with the nucleus consisted of genome *a*. The *ca*-F_1 plants composed of genomes *aac* were found to show no *carinata*-cytoplasmic effect. This fact will clearly due to the activity of the genome *c*. As described in the preceding page, reciprocal crosses between *ca-pekinensis* plants and *B. juncea* failed to produce the true hybrids (their genome constitution will be *aab*), so that the *carinata*-cytoplasmic effect that would exist in the *ca*-F_1 plants has been unexplorable. By the way, the pistils of *abc* trigenomous hexaploid plants (the original hybrid forms having *carinata*'s cytoplasm) could be easily fertilized by the pollens of artificial tetraploid plants of B. *juncea* in the open field and their progeny having *carinata*'s cytoplasm approached somewhat rapidly through generations to the parental *juncea* forms, quite resembling in the general appearance and the fertility. However, they did not revealed any sign of chlorophyll deficiency, indicating presumably that the action of *b* genome upon the *carinata*-cytoplasmic effect affecting chlorophyll deficiency may be the same as of *c* genome in *ca*-F_1 forms. If these are actually the case, the disharmony with the genome *a*, and the harmony with the genome *b* or *c*, of the *carinata*'s cytoplasm may be looked upon as an interesting fact, concerning with the processes of genomic differentiation from the urgenome to each *a*, *b* or *c* genome and of the formation of natural amphidiploid species in the genus *Brassica* (U, 1935; Haga, 1938; Sikka, 1940; Frandsen, 1943, '47; Fukushima, 1945;

Mizushima, 1952). Only the case of such cytoplasmic alterations—whether these are effected by degrees under the influence of differentiating genomes or cytoplasmic mutations—seems to remain as a problem of cytoplasmic inheritance to be solved through the further investigations.

It was made clear, besides, that the addition of an extra-chromosome derived from the genome *b* or *c* of *B. carinata* could inhibit chlorophyll defect, but brought a serious retardation in growth and a definite diminishing effect on the fertility of *ca*-($10_{II}+1_I$) plants, and, moreover, that the one chromosome added had exerted only a very limited action towards the *carinata*-cytoplasmic effect with those ($10_{II}+1_I$) plants. In other words, the usual *carinata*-cytoplasmic effect could be realized in *ca*-($10_{II}+1_I$) plants, but not in *ca*-10_{II} plants, probably because the allocytoplasm reacted rather severely with the unbalanced nuclear content (genotype) and its effect was so much intensified. This fact will be confirmed, in advance, by another fact that *pe*-($10_{II}+1_I$) plants were as fertile and as well grown up as, or still better grown up as compared with the *pe*-10_{II} plants. Thus, the examination of alloplasmatic effect in plants having one extra-chromosome may be expected to furnish a clue to make clear the mutual relation between cytoplasm and genes in the tribe *Brassiceae*.

SUMMARY

1. The aim of this investigation was to make clear the occurrence of an alloplasmatic effect in *carinata*-cytoplasmic F_1 hybrids derived from the crosses between *pekinensis* plants having *carinata*'s cytoplasm and some other species in *Brassica*. Plants of 8 species including 13 horticultural varieties were used.

2. In the production of F_1 hybrids, the *carinata*-cytoplasmic *pekinensis* plants behaved quite similarly as the normal *pekinensis* plants, revealing that these two kinds of plants were somewhat identical in their crossability irrespective of their cytoplasmic nature.

3. The *carinata*-cytoplasmic effect, i.e., chlorophyll deficiency, was observed exclusively in the *carinata*-cytoplasmic F_1 forms containing genomes *aa*, but not in the *carinata*-cytoplasmic F_1 plants containing genomes *aac*. Genome *c* added to genome *a* became to harmonize with the *carinata*-cytoplasm and could eliminate the *carinata*-cytoplasmic effect induced upon the genome *a*.

4. The *carinata*-cytoplasmic effect manifested itself conspicuously in ($10_{II}+1_I$) plants, i.e., in *pekinensis* plants containing one extra-chromosome derived from *B. carinata* (whose genome constitution is *bbcc*), and only slightly in 10_{II} plants. Compared with the vigor and

the fertility of the plants, excepting the chlorophyll character, the *carinata*-cytoplasmic ($10_{II}+1_I$) plants were definitely inferior to the *carinata*-cytoplasmic 10_{II} plants, and the *pekinensis*-cytoplasmic ($10_{II}+1_I$) plants were, in turn, quite equal to or a little exceed the normal control *pekinensis* plants. Those facts enumerated above may be taken to indicate that an alloplasmatic effect appeared always severely incorporated with a genotypically unbalanced nucleus.

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Explanation of Plates 8

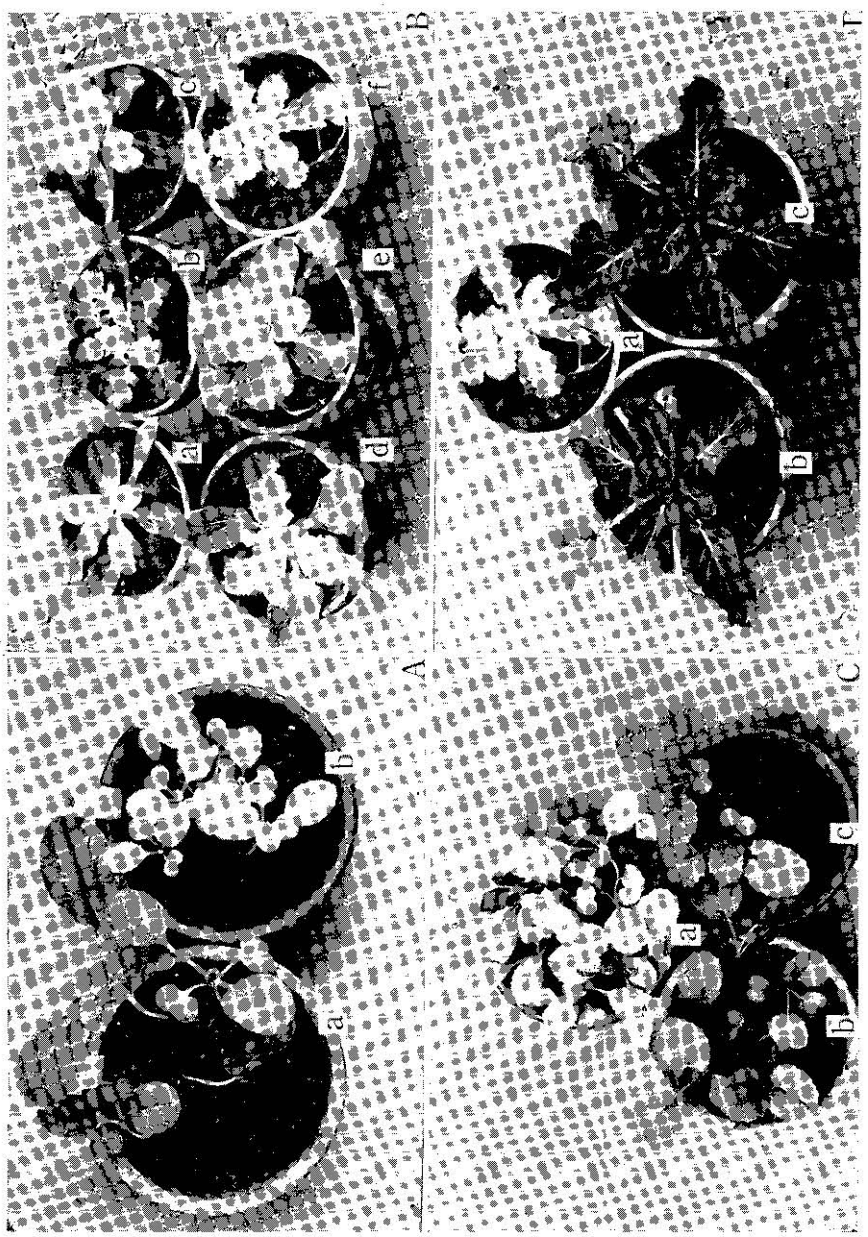
Appearance of chlorophyll deficiency in F_1 hybrids obtained by reciprocal crosses. (1960-1961)

Fig. A Very young *narinosa*-cytoplasmic (a) and *carinata*-cytoplasmic (b) F_1 plants.

Fig. B *Carinata*-cytoplasmic F_1 plants, derived from the crosses between *carinata*-cytoplasmic *pekinensis* (♀) and various ten chromosomes-species in *Brassica*, in later stages of growing under winter field condition.Ten chromosomes-species used as pollen provider respectively; (a) *B. pekinensis* (Chifu-hakusai), (b) *B. japonica* (Kyo-na), (c) *B. chinensis* (Shigatsu-shirona), (d) *B. narinosa* (Hisago-na), (e) *B. narinosa* (Kisaragi-na), and (f) *carinata*-cytoplasmic *pekinensis* as control.

Fig. C Very young *napus*-cytoplasmic (b) and *carinata*-cytoplasmic (c) F_1 hybrids and *carinata*-cytoplasmic *pekinensis* (a) as control.

Fig. D *Napus*-cytoplasmic (b) and *carinata*-tytoplasmic (c) F_1 hybrids and *carinata*-cytoplasmic *pekinensis* (a) in later stages of growing, under winter field condition.



Alloplasmatic effect in *Brassiceae*. III