プリムラ・オブコニカにおけるプリミン分泌の遺伝

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The Inheritance of Primin Secretion in *Primula obconica*

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Summary

The inheritance of primin secretion in *Primula obconica* was determined by studying the F_1, F_2 and BC_1 progenies of crosses between primin-secreting cultivars and primin-free ones.

All plants in a ten-cross combination of F_1 secreted primin; thus, the primin-secreting phenotype was dominant over the primin-free phenotype.

In four of ten cross combinations, the factor segregated in F_2 and BC_1 as Mendelian ratios of 3:1 and 1:1, respectively, indicating that primin secretion is controlled by a single gene. However, in another six cross combinations, the segregation ratios of F_2 were significantly different from 3:1, whereas those of BC_1 were 1:1. The results suggested that the distorted segregations observed in certain F_2 might have been caused by certation or gametic selection.

Given the above findings, the inheritance of primin secretion, which was characterized by distorted segregations in certain F_2 was found to be controlled by a major gene.

Key Words: certation, gametic selection, inheritance, primin, *Primula obconica*.

Introduction

Primula obconica Hance secrets primin which causes allergic-dermatitis; this character has prevented the expansion of the market for *Primula*. Recently, some primin-free cultivars were released; however, the earliness of blooming and a diversity of flower color are limiting. To improve and multiply primin-free cultivars, it is necessary to clarify the inheritance of primin secretion.

To do so, Heyting and Toxopeus (1989) crossed primin-free plants with primin-secreting ones, and investigated their segregation ratios in F_2 and BC_1 progenies. The results revealed that segregations in backcrosses followed a monogenic inheritance pattern, whereas those in certain F_2 indicated an existence of a second gene.

To seek the existence of this second gene, we repeated the experiments of Heyting and Toxopeus (1989) in detail.

Materials and Methods

Six cultivars of primin-secreting 'F_1 Crystal', three cultivars of the primin-free 'F_1 Prino' and four cultivars of the primin-free 'F_1 Libre' were investigated. In February 1997, crosses among the parental cultivars and between the 'F_1 Prino' (P.), 'F_1 Libre' (L.) and the 'F_1 Crystal' (C.) cultivars were carried out. *Primula obconica* is a distylic plant with heteromorphic-incompatibility, so that all pollinations were made between a long-styled plant and a short-styled one without emasculation. Flowers bloomed within a few days were used for the crosses. The seeds of the parents progenies and F_1 were sown in July 1997; the resulting plants were checked for primin secretion in September 1997.

F_2 and BC_1 were obtained by crossing F_1 sibling and backcrossing F_1 with primin-free parents, respectively in February 1998. Seeds, representing the F_2 and BC_1, were sown in September 1998, and checked for primin secretion in November 1998. Trichomes of the 4th leaf at the 5th-leaf expanding stage were observed under a microscope, and primin secretion was determined by the presence or absence of trichomes with a red secretion (Higuchi et al., 2000).

Furthermore, in three crosses of the F_2, the seedlings that were sown at the same time were potted and checked again at the flowering stage in March 1999. Trichomes of the calyx and peduncle were used for the primin-test at the flowering stage, based on our previous report (Higuchi et al., 1999).

The segregation ratios were compared with expected ratios of monogenic inheritance by χ^2-test.

Results

The primin analyses by progeny testing of 'F_1 Crystal' revealed that all seedlings secreted primin; whereas no progenies of primin-free 'F_1 Prino'and 'F_1 Libre'did (Table 1).

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Table 1. Segregation of primin-secreting plants and primin-free ones in sib-cross of parental cultivars.

Parental cultivars	Number of primin-secreting plants	Number of primin-free plants
Crystal Deep Blue	18	0
Red and White	18	0
Rose	18	0
Apricot	18	0
Carmine	18	0
Pink	18	0
Prino Light Blue	0	18
Rose	0	18
White	0	18
Libre Blue	0	18
Mazenta	0	18
Pink	0	18
Light Salmon	0	18

Table 2. Segregation of primin-secreting plants and primin-free ones in F_1 population.

Cross combination[z]	Number of observed plants	Number of primin-secreting plants
P. Light Blue × C. Deep Blue	36	32
P. Light Blue × C. Red and White	36	36
P. Rose × C. Rose	25	24
P. White × C. Red and White	36	36
P. White × C. Apricot	36	36
P. White × C. Pink	36	36
L. Blue × C. Deep Blue	36	36
L. Mazenta × C. Carmine	36	36
L. Pink × C. Rose	36	36
L. Light Salmon × C. Apricot	36	36

[z] Cultivars used. P., C. and L. means 'Prino', 'Crystal' and 'Libre', respectively.

Table 3. Segregation of primin-secreting plants and primin-free ones in F_1 population (1998 test).

Cross combination[z]	Number of observed plants	Number of primin-secreting plants
P. Light Blue × C. Deep Blue	100	100
P. Rose × C. Rose	100	100

[z] See Table 1.

Primin analyses of F_1 plants revealed that, except for 'P. Light Blue' × 'C. Deep Blue'and'P. Rose' × 'C. Rose', all secreted primin (Table 2). In 1998, two cross combinations of 'P. Light Blue' × 'C. Deep Blue'and 'P. Rose' × 'C. Rose'were retried. The pollinations were done just after emasculation to avoid self-pollination. The resulting seeds developed into F_1 progenies which all secreted primin (Table 3).

Segregation of primin-secreting plants and primin-free ones, determind at the 5th-leaf expanding stage, in the F_2, show that in four out of ten cross combinations, 'P. Light Blue' × 'C. Deep Blue', 'P. Rose' × 'C. Rose', 'P. White' × 'C. Pink', and 'L. Blue' × 'C. Deep Blue', their respective ratios were 3:1; whereas, those of the remaining six F_2 deviated significantly (Table 4). The F_2 population of three cross combinations also deviated significantly from the expected 3:1 ratio. Their segregation ratios (Table 5) are the same as those at the 5th-leaf expanding stage, unlike the expected ratios. Segregation ratios for all BC_1 were 1:1 (Table 6).

Table 4. Segregation of primin-secreting plants and primin-free ones in F_2 seedlings at the 5th-leaf expanding stage.

Cross combination[z]	Number of observed plants	Number of primin-secreting plants	Number of primin-free plants	χ^2 for 3:1
P. Light Blue × C. Deep Blue	338	251	87	0.063
P. Light Blue × C. Red and White	312	213	99	7.184*
P. Rose × C. Rose	272	191	81	3.064
P. White × C. Red and White	351	216	135	33.209*
P. White × C. Apricot	336	231	105	6.671*
P. White × C. Pink	332	244	88	0.325
L. Blue × C. Deep Blue	431	326	105	0.063
L. Mazenta × C. Carmine	373	253	120	9.853*
L. Pink × C. Rose	367	197	170	84.848*
L. Light Salmon × C. Apricot	214	142	72	8.075*

[z] See Table 1.

* Mean for 5% level.

Table 5. Segregation of primin-secreting and primin-free progenies in the F_2 population at the flowering stage.

Cross combination[z]	Number of observed plants	Number of primin-secreting plants	Number of primin-free plants	χ^2 for 3:1
P. White × C. Red and White	225	126	99	42.313*
L. Pink × C. Rose	199	116	83	28.745*
L. Light Salmon × C. Apricot	240	160	80	8.450*

[z] See Table 1.

* Mean for 5% level.

Table 6. Segregation of primin-secreting plants and primin-free ones in BC_1 population.

Cross combination[z]	Number of observed plants	Number of primin-secreting plants	Number of primin-free plants	χ^2 for 1:1
(P. Light Blue × C. Deep Blue) × P. Light Blue	389	191	198	0.093
(P. Light Blue × C. Red and White) × P. Light Blue	365	192	173	0.888
(P. Rose × C. Rose) × P. Rose	369	179	190	0.270
(P. White × C. Red and White) × P. White	385	180	205	1.496
(P. White × C. Apricot) × P. White	397	192	205	0.363
(P. White × C. Pink) × P. White	144	72	72	0.000
(L. Blue × C. Deep Blue) × L. Blue	386	192	194	0.003
(L. Mazenta × C. Carmine) × L. Mazenta	401	205	196	0.160
(L. Pink × C. Rose) × L. Pink	390	197	193	0.023
(L. Light Salmon × C. Apricot) × L. Light Salmon	424	211	213	0.002

[z] See Table 1.

Discussion

All progenies of 'F_1 Crystal' cultivars secreted primin, and all progenies of 'F_1 Prino' cultivars and 'F_1 Libre' cultivars did not secret primin, indicating that the primin secretion genotypes of parental cultivars were fixed.

All F_1 progenies, aside from 'P. Light Blue' × 'C. Deep Blue'and 'P. Rose' × 'C. Rose', are primin-secreting (Table 2). However, some primin-free plants segregated in two of the F_1 populations is attributed to contamination by self-pollination. *Primula obconica* is distylic plant with heteromorphic-incompatibility, so contamination of self-pollinated seeds scarcely occurred when flowers bloom within a few days were used for crosses. However, seeds occasionally form by self-pollination in old flowers. Thus, it seems that the

segregations of primin-free plants in these F_1 resulted from the use of old flowers.

In 1998, when hybridization between 'P. Light Blue' × 'C. Deep Blue' and 'P. Rose' × 'C. Rose' were repeated, all F_1 progenies secreted primin (Table 3); thus, the segregation of primin-free plants likely resulted from contamination by self-pollinated seeds. Therefore, the primin-secreting phenotype is completely dominant over the primin-free phenotype.

The segregation ratios of F_2 and BC_1 of 'P. Light Blue' × 'C. Deep Blue', 'P. Rose' × 'C. Rose', 'P. White' × 'C. Pink' and 'L. Blue' × 'C. Deep Blue' were 3:1 and 1:1, respectively. The results revealed that primin secretion was controlled by a major gene. However, in the remaining six cross combinations, the segregation ratios for all F_2 deviated significantly from 3:1, whereas all BC_1 ratios were 1:1. To examine the validity of primin-test stage, the three F_2 showing a large difference from the expected ratio were potted at random, and re -tested at the flowering stage. All three F_2 exhibited the same level of segregation as did those at the 5th-leaf expanding stage; thus, no problem was associated with the stage of the primin-test.

Heyting and Toxopeus (1989) also reported segregation distortion, and they considered the existence of a second gene. However, if the second gene is associated with primin secretion, the range of segregation ratios of F_2 should be 15:1 to 3:1. If the linkage exists between each gene, the frequency of primin-secreting plants should increase, but it did not. In our study, the segregation ratios of F_2 varied from 3:1 to 1.16:1. The presesce of a second gene would not explain the decrease of primin-secreting plants.

On the other hand, such segregation distortions have been reported in maize (Mangelsdorf・Jones, 1926; Emerson, 1934), *Olyza sativa* (Oka,1953; Mizushima and Kondo, 1959, 1961; Iwata et al., 1964; Nakagahra, 1972; Nakagahra et al., 1972) and barley (Konishi et al., 1990). Segregation distortions are observed when the genetic background of pollen is heterogeneous, and thus, distortions are caused by certation or gametic selection. Furthermore, the existence of gametophytic genes which influence fertility has been considered.

In our study, segregation distortion ocurred only in certain F_2, and not in BC_1. The seeds of F_2 were obtained by F_1 siblings indicate that the pollens are genetically heterogeneous so that the segregation distortion was caused by certation or gametic selection. It is necessary to prove in the future that certation or gametic selection occurs. Nevertheless, the present results confirm that the inheritance of primin secretion, even with a segregation distortion in a certain F_2 population, is controlled by a single dominant gene.

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プリムラ・オブコニカにおけるプリミン分泌の遺伝

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摘　要

プリムラ・オブコニカにおけるプリミン分泌の遺伝を明らかにする目的で，プリミン保有品種とフリー品種の間で交配を行い，F_1，F_2 および BC_1 における保有個体とフリー個体の分離比を調査した．

その結果，10組合せの F_1 はすべてプリミンを保有し，プリミン保有はフリーに対して優性であることがわかった．

また，10組合せのうち4組合せについては，F_2 および BC_1 における保有個体とフリー個体の分離比がそれぞれ3:1および1:1となったことから，プリミン分泌は単一遺伝子に支配されていることが明らかとなった．しかし，6組合せについては，F_2 において分離比が3:1とならなかったが，BC_1 では1:1となったので，F_2 において観察された分離比の乱れは競争受精または配偶子選択がその原因と推察された．

以上のことから，プリムラ・オブコニカのプリミン分泌は，F_2 において分離比の理論値からの乖離が発生する場合も含めて，単一遺伝子に支配されていると判断した．

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