The Inheritance of Plural-pistillate Flowering in Cucumber

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Summary
While standard-type cucumbers usually bear a single pistillate flower (SP) on each pistillate node, there are variants that bear double pistillate flowers (DP) and multiple pistillate flowers (MP) per node. Genetical analysis of SP, DP and MP was carried out by examining the sex expression of F1, F2 and of the BC lines obtained from crossing these plants.

Our results showed that this flowering character was controlled by multiple alleles and that less pistillate flowering was dominant or incompletely dominant over more pistillate flowering. The locus controlling this character was named pf*, and the genes for SP, DP and MP were named pf0, pfD and pfM, respectively.

Introduction
Cucumbers are generally monoecious, bearing separate staminate and pistillate flowers on a single plant. Each leaf axil of the plant bears either a cluster of staminate flowers or one pistillate flower. There are variants, however, that bear 2, 3 or more pistillate flowers per node. In Japan, cultivars with 2 pistillate flowers per node are now preferred to the standard-type cultivars that bear one pistillate flower per node. This is because double-pistillate cultivars save us some of the work in training and pruning, and give us an advantage of harvesting a large amount of immature fruit. In the United States, cucumber lines which produce multiple pistillate flowers per node were reported to have given increased yield in the once-over harvest system of pickling cucumbers(4).

Plural-pistillate flowering of cucumbers is hence considered as an important character in breeding. In the present study, gene analysis was carried out on double-pistillate and multiple-pistillate flowering.

Materials and Methods
A standard, single-pistillate cultivar 'Aofushinari' (SP, Fig. 1-A), a double-pistillate 'Shindome-Q' (DP, Fig. 1-B) and a multiple-pistillate 'Kurume-ochiai No.1' (MP, Fig. 1-C) were used. Inbred lines, F1 and F2 between the three cultivars, and backcross lines were established in 1977.

DP vs. MP series was sown directly in a vinyl house on March 23, 1978 and the sex expression of flowers up to the 25th node of the main stem was examined on May 26. Sp vs. DP series was sown on March 1, 1979, the sex expression was examined on May 21, and SP vs. MP series was sown on March 27, 1980, followed by an examination on May 28.

Results
Single-pistillate vs. double-pistillate flowering
Sex expression of the parents and the F1 plants is shown in Figure 2. In most cases, pistillate nodes on SP plants bore single pistillate flowers, while double pistillate flowers were observed in rare cases. DP plants bore single pistillate flowers on the lower nodes of the stem and showed gradual increase in double pistillate flowers on the upper nodes. The F1 plants bore single pistillate flowers on most nodes and differed clearly from the DP plants. However, the
number of the nodes bearing double pistillate flowers was somewhat greater in the F₁ plants than in the SP plants. This result appeared to show the incomplete dominance of SP over DP.

Frequency of the SP (heterozygous plants included) and DP plants for each line of SP vs. DP series is listed in Table 1. From the segregation ratios of the F₂ and BC₁...
(F,DP × SP) × DP, we could assume that SP and DP were allelomorphs. However, two DP plants occurred among the 97 plants of the BC, (F,DP × SP) × SP. Since no genetical explanation could be found for them, they were regarded to have occurred as consequence of contamination that had taken place during pollination or of errors made during the harvest of seeds. Hence the hypothesis that SP and DP were allelomorphs in which

<table>
<thead>
<tr>
<th>Population</th>
<th>Phenotype</th>
<th>Total</th>
<th>Expected ratio</th>
<th>$\chi^2$ value</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>F,DP × DP</td>
<td>Double*</td>
<td>73</td>
<td>3 : 1</td>
<td>.00</td>
<td>1.00~1.90</td>
</tr>
<tr>
<td>BC(F,DP × DP) × DP</td>
<td>Multiple</td>
<td>24</td>
<td>1 : 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC(F,DP × DP) × MP</td>
<td></td>
<td>97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Double*</td>
<td>52</td>
<td>1 : 1</td>
<td>.16</td>
<td>.70~.50</td>
</tr>
</tbody>
</table>

* Heterozygous plants included.
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SP had an incomplete dominance over DP was adopted here.

**Double-pistillate vs. multiple-pistillate flowering**

Sex expression of the parents and F1 plants is shown in Figure 3. The MP plants exhibited multiple-pistillate flowering, that is, many of its nodes bore 3 or more pistillate flowers. However, there were some nodes on the lower part of the stem that bore single or double pistillate flowers. Most nodes of the F1 plants, like the DP plants, bore double pistillate flowers, showing dominance of DP over MP.

Frequency for the DP and MP plants of each line of DP vs. MP series is shown in Table 2. Chi-square test of the segregation ratios of the F2 and BC had shown that DP and MP were allelomorphs.

**Single-pistillate vs. multiple-pistillate flowering**

Figure 4 shows the sex expression of the parents and the F1 plants. In the SP plants, most of the pistillate nodes bore single pistillate flowers. Nodes on the lower part of the stem of the MP plants bore single or double pistillate flowers, whereas those on the upper part of the stem bore 3 or more pistillate flowers. Mixed occurrences of single and double pistillate flowers on the nodes of the F1 plants showed an incomplete dominance of SP over MP.

Table 3 shows the frequency of the SP (heterozygous plants included) and the MP plants for each line of the SP vs. MP series. Chi-square test of the segregation ratios proved the validity of the hypothesis that SP was monogenically dominant over MP.

**Discussion**

Multiple flower buds initiate on each node of cucumbers. This fact holds even for standard-type cucumbers that bear only one pistillate flower per node. In this case, the flower buds except the first one stop their growth and degenerate at or before sepal formation stage when the first flower bud is destined for the pistillate flower(1, 2, 3). The DP plants used in this study developed normal pistillate flowers from the first and second flower buds, and the MP plants from the first 3 to 5 flower buds. The rest of the flower buds degenerated.

The ability of these DP and MP plants to develop plural pistillate flowers was low in the young stages. The DP plants were liable to bear single pistillate flowers and the MP plants to bear single or double pistillate flowers on their lower nodes. Furthermore, environmental factors had an effect upon the occurrence of the nodes that bore less number of pistillate flowers than that expected genetically. It is known empirically that high temperature and long-day conditions increase the occurrence of such nodes.

The fact that less pistillate flowering was dominant was observed in the F1 hybrids between the 3 cultivars used. Dominance of SP over DP and MP was somewhat incomplete, however, and for instance, not a few nodes bore double pistillate flowers in the F1 plants of SP × MP. Further, the analysis of the segregation ratios of the F2 and the BC lines showed that SP and DP, DP and MP, and SP and MP were allelomorphs.

This flowering character is probably controlled by the multiple alleles of a single locus, so if we name this locus pf, the gene of SP can be expressed as pf^1, that of DP as pf^2, and that of MP as pf^3.

Since variants that bear more pistillate flowers per node than the MP plants or that
exhibit an intermediate character between DP and MP are found in cucumbers, there must exist more alleles for locus $pf$ than those discussed here.

**Literatures Cited**