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Inheritance of Multi-pistillate Flowering Habit in Gynoecious Pickling Cucumber[1]

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Abstract. **From progenies of crosses between 2 multi-pistillate (MP) and 2 single-pistillate (SP) gynoecious pickling cucumber (*Cucumis sativus* L.) cultivars, it was determined that MP is recessive to SP expression. Genetic analyses suggested that one major gene with several modifying factors affect this character. The gene symbol proposed for multi-pistillate expression is *mp*.**

The development of pickling cucumber cultivars for once-over mechanical harvest has received considerable effort from plant breeders. Most of the cucumber acreage in Michigan is mechanically harvested; however, greater yields are desirable for once-over harvest. The combination of highly female expression with concentrated fruit-set is a requirement for high yields in once-over harvest systems. Currently, hybrid cultivars of pickling cucumber produce from 1 to 2 fruits per plant for once-over harvest (1, 7, 8, 12). This low fruit-set is due partially to "first-set fruit" inhibition (2, 3, 9, 10, 15). This yield inhibition might be overcome by breeding cultivars which simultaneously develop several fruits at the same node. This approach was first suggested by Tiedjens (14) and again in recent reports (2, 15). The latter (15) reported a significantly greater number of fruits per plant with multi-pistillate (MP) flowers per node as against single-pistillate (SP) flowers/per node. The greater number of flowers available for pollination possibly increased the number of fruits per plant by circumventing first fruit inhibition. The development of pickling cucumber hybrids with MP expression might be superior for once-over harvest to presently used hybrid cultivars with the SP habit.

Multiple bisexual flowers per node are observed by cucumber breeders in hermaphroditic lines, but single-pistillate is common to monoecious and gynoecious lines. Crosses between gynoecious and hermaphroditic lines were used to produce gynoecious F_2 recombinants with MP flowering habit (15).

The purpose of our study was to determine the genetics of SP and MP flowering in gynoecious cucumber.

Materials and Methods

Parental material. Two MP gynoecious lines, 604G and 598G described earlier by our program (15) were crossed with the two SP gynoecious lines, GY14 and 551F, developed by Dr. C. Barnes, Clemson University and Dr. H. Munger, Cornell University, respectively, to produce the reciprocal F_1, F_2 and BC_1 populations. All crosses were produced in the greenhouse by controlled pollination using standard methods.

Genetic analysis. In the spring of 1980, plants of P_1, P_2, F_1, F_2, and BC_1 populations from the 4 crosses were grown in the greenhouse using standard cultural practices in a randomized complete block design with 3 replications. Each replicate consisted of 5 plants for the P_1, P_2, F_1, and BC_1P_2 generations, 20 plants for the F_2 generation and 10 plants for the BC_1P_1 generation. The plants were spaced 30 by 48 cm on the bench. The temperature was maintained at 27° ± 2°C (day) and 21° ± 2° (night). The numbers of pistillate flowers per node were recorded for nodes 6 through 15 on the main stem as reported previously (15).

The populations were analyzed using 1-gene and 2-gene models. For the 1-gene model, the MP class of 2.7–3.2 pistillate flowers per node was selected to divide SP from the MP classes. This class approximated the arithmetic mean of the 4 parents used in this study. This separation of SP and MP classes was also suggested by the lower number of individuals of BC_1P_1 (MP recessive parent) populations in all 4 crosses falling into this class. Classification into 2 phenotypes, SP and MP, was followed by appropriate testing. Chi-square tests were used to determine the goodness of the fit of the observed data to the proposed genetic model.

Evaluation of F_3 generation. Shoot cuttings were made of random F_2 plants from all 4 crosses and rooted in a mist chamber. All rooted cuttings were self-pollinated to produce F_3 seed. In August and September of 1980, seven F_3 populations from each of the 4 crosses and the parental populations were grown as described above. The number of pistillate flowers per node on the main stem were recorded as mentioned above.

Statistical analysis. For all experiments, means and standard deviations were calculated from individual plant data. The reciprocal F_1 populations were not significantly different ($P = .05$), hence F_1 data were pooled. Based on monogenic inheritance, the theoretical F_2 means were estimated by the equation (11):

$$\bar{P}_1 (0.75) + \bar{P}_2 (0.25) = \bar{F}_2$$

Where $\bar{P}_1$ is the mean of dominant parent;
$\bar{P}_2$ is the mean of recessive parent; and
$\bar{F}_2$ is the theoretical mean of F_2 population.

Results and Discussion

Parental material. The numbers of pistillate flowers per node were significantly higher for MP than SP lines (Table 1). Within experiments, the actual numbers of pistillate flowers per node varied more (2.6–6.3) for the MP lines, 604G and 598G, than for the SP lines, GY 14 and 551F (0.9–1.1). Environmental conditions influence flowering of cucumber (4, 13), and appear to play a more significant role in MP for the number of pistillate flowers per node than for SP expression.

Genetic analysis. By observation of MP and SP expression from the 4 crosses in this study, 1 major gene is hypothesized to control this character; SP being dominant to MP expression

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Table 1. Characterization of parents for number of pistillate flowers per node (1979–1980)[z]

Parental line no.	Pistillate flowers/node		
	Winter 79	Spring 80	Summer 80
604G (MP)	5.2 a	4.7 a	2.6 a
598G (MP)	6.3 a	5.7 a	4.3 a
GY14 (SP)	1.1 b	1.1 b	1.0 b
551F (SP)	1.1 b	1.1 b	0.9 b

[z]Mean separation within columns by Duncan's multiple range test at 5% level.

Table 3. Calculated theoretical means and observed means for pistillate flowering habit in F_2 populations of pickling cucumbers derived from gynoecious crosses of MP x SP lines based on one-factor-pair difference.

F_2 population	Mean flower no./node		P value
	Theoretical	Observed	
604G x GY14	2.0	2.6	.75-.90
598G x GY14	2.3	2.3	>.99
604G x 551F	2.0	2.1	.95-.99
598G x 551F	2.3	2.6	.75-.90

Table 2. Mean number of pistillate flowers per node in 2 MP x 2 SP crosses of gynoecious pickling cucumbers.

Generation	Total plants/cross	Mean ± SD			
		604G x GY14	598G x GY14	604G x 551F	598G x 551F
P_1 (MP)	15	4.7 ± 0.7	5.7 ± 0.7	4.7 ± 0.7	5.7 ± 0.7
P_2 (SP)	15	1.1 ± 0.2	1.1 ± 0.2	1.1 ± 0.2	1.1 ± 0.2
F_1	30	1.7 ± 0.3	1.9 ± 0.4	1.9 ± 0.2	1.9 ± 0.3
F_2	60	2.6 ± 1.2	2.3 ± 1.0	2.1 ± 0.7	2.6 ± 0.8
BC_1P_1	30	2.8 ± 1.1	3.4 ± 1.2	2.9 ± 1.2	3.7 ± 1.4
BC_1P_2	15	1.3 ± 0.3	1.6 ± 0.4	1.8 ± 1.2	1.5 ± 0.4

Table 4. Segregation for single (SP) and multi-pistillate (MP) flower expression in 4 crosses of gynoecious pickling cucumbers.

Population	Total plants (No.)	Class frequencies		Expected ratio (SP:MP)	P value
		SP	MP		
Cross I					
604G (MP)	15	0	15	All MP	–
GY14 (SP)	15	15	0	All SP	–
F_1	30	30	0	1:0	–
F_2	60	44	16	3:1	0.9>P>0.75
BC_1P_1	30	17	13	1:1	0.5>P>0.25
Cross II					
598G (MP)	15	0	15	All MP	–
GY14	15	15	0	All SP	–
F_1	30	30	0	1:0	–
F_2	60	48	12	3:1	0.5>P>0.25
BC_1P_1	30	17	13	1:1	0.5>P>0.25
BC_1P_2	15	15	0	1:0	–
Cross III					
604G (MP)	15	0	15	All MP	–
551F (SP)	15	15	0	All SP	–
F_1[z]	15	15	0	1:0	–
F_2	60	52	8	3:1	0.05>P>0.025
BC_1P_1	30	12	18	1:1	0.5>P>0.25
BC_1P_2	15	13	2	1:0	–
Cross IV					
598G (MP)	15	0	15	All MP	–
551F (SP)	15	15	0	All SP	–
F_1	30	30	0	1:0	–
F_2	60	45	15	3:0	P>0.99
BC_1P_1	30	13	17	1:1	0.5>P>0.25
BC_1P_2	15	15	0	1:0	–

[z]Seed from reciprocal F_1 (551F x 604G) was obtained too late for inclusion, but later observation showed no difference in reciprocals.

Table 5. Genetic analysis of 29 F_2 lines resulting from four crosses of gynoecious cucumber for flowering habit in the F_3 generation.

Cross	Population	No. lines	Class frequencies/cross		Classes for SP/MP		P values
			SP and SP/MP	MP	SP	MP	
I	604G x GY14	7	6	1	40	8	.10-.20
II	598G x GY14	7	7	0	42	22	.05-.10
III	604G x 551F	7	6	1	67	13	.05-.10
IV	598G x 551F	8	4	4	32	15	.20-.30
	Totals	29	23	6	181	58	

(Table 2). More than 1 pistillate flower per node in F_1 and BC_1P_2 populations as compared to the dominant parent probably is due to either hybrid vigor (5) or modifying factors. Vigorous hybrid plants probably respond better to divergent environmental conditions than parental inbred lines (15). The theoretical F_2 means were calculated for a 1-factor-pair difference using the formula suggested by Powers and Locke (11). The calculated theoretical and observed means for the F_2 populations were not significantly different (Table 3).

Goodness of fit based on a single gene model with SP dominant to MP expression was determined for the segregating populations (Table 4). The expected F_2 ratio was 3SP:1MP. The P values obtained from the segregating populations ranged from 0.05 to 0.95, suggesting a good fit to the proposed model.

The exception from the one-gene model was noted for the cross 604G x 551F. The F_2 population did not give a good fit to a 3:1 ratio ($p>0.025$) and the BC_1P_2 segregated 2 MP plants when none were expected. These 2 exceptions suggested that there may be modifying factors affecting expression of this character.

Evaluation of F_3 generation. A total of 29 F_3 families from the 4 crosses were classified as either SP, segregating SP/MP or MP for flowering habit (Table 5). These F_3 findings supported the F_2 data which showed that MP was recessive to SP flowering habit. Progenies of MP F_2 plants produced MP expression, while progenies from SP F_2 plants either segregated or produced SP plants. The segregating F_2 progenies (F_3 plants) were classified for SP/MP expression. Crosses I and IV gave good fits; whereas the other two crosses gave an excess of MP plants in one cross and SP in the other cross for a 3:1 ratio. The segregation observed in the F_3 generation supported our contention that one major gene with possible modifiers affected pistillate flowering habit in gynoecious cucumber. We propose this gene be designated pistillate flowering habit and symbolized *mp*. Our genetic information on MP expression should be helpful to cucumber breeding programs. Through backcrossing, the MP character can be transferred to established parental lines of gynoecious and monoecious pickling cucumbers in order to determine whether cultivars with MP expression will increase yields for once-over harvest.

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