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CARNATION MUTATION FREQUENCY RELATED TO SIZE AND POSITION OF SHOOT TIP

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When the shoot tip technique was incorporated in the clean stock program at CSU an increase in mutations was immediately observed. Whereas 50 to 75 percent of lines grown from indexed cuttings had been retained as acceptable, this percent dropped to 10 to 25 with progenies from shoot tips. The criteria used for increasing or discarding individual shoot tipv selections have been their production of malformed and other off-type flowers that reduce their grade. Many other judgements, especially on growth habit and yield, are made on the off-spring from each selection before it is approved for increase.

Heat treatment prior to shoot tipping has been added to the technique in the past five or six years, and is now standard procedure. Whether or not heat treatment increases mutation frequency is not known. No significant increase in mutations has been observed since heat treatment was added to the program.

To gain more knowledge of factors affecting the mutation frequency of carnation, mutation rates of three sizes of shoot tips taken from several positions on four stock plants were compared. The technique and media described by Phillips (2) were used. The individual shoot tips were grown to stock plant size, cuttings were removed, and these were rooted to plant one row of five to seven plants across a bed in the Bay Farm greenhouse. There were 125 shoot tips that survived to produce progeny rows. As these plants began producing flowers a coded tag was placed above each plant each time an off-type flower was cut. Five of the shoot tips produced progenies that were completely mutant, either for growth habit or color. The remaining 120 offspring produced from none to 16 off-type and malformed flowers over a period of about 15 months of flowering. During this time each row produced around 150 flowers.

Results and Discussion

Table 1 summarizes the major information obtained from size of shoot tip and individual stock plants. The four stock plants from which tips were derived were Gayety, CSU Pink, and Pikes Peak Frosted I and II. Nearly equal numbers of tips less than 1, 1-5, and 5-10 millimeters in length survived. While there was a slight increase in mutations from the 5-10 mm shoot tip size, it is doubtful that this difference is real. There was a significant difference in the mutation rate from the different stock plants. This confirms our observation that stock plants can be selected that are much more stable genetically. We often retain most of the shoot tips from one stock plant and discard all from another because of this variation.

Individual shoot tip records from Pikes Peak Frosted I (Table 2) show the tremendous variation between progenies derived from a single plant. Tips were obtained from four sections of the stock plant. *A* was a lower original branch with all its side branches, *B* and *C* were in the upper center of the plant being the two top original branches, and *D* was the third original branch from the top. No tips were taken from *E*,

Table 1. Mean number of mutations per progeny from shoot tips of three sizes taken from four stock plants.

Stock plant	Size of shoot tip in millimeters			Mutations per progeny per stock plant
	1	1-5	5-10	
Gayety[a]	4.8	2.0	7.0	4.2
CSU Pink	7.8	4.5	10.0	6.9
PPF I[b]	3.0	4.9	6.2	4.8
PPF II[c]	4.0	1.5	2.7	3.5
Number progenies in each shoot tip size	42	42	36	
Ave. mutations per progeny	4.3	4.0	5.6	

[a] *One complete mutant progeny not included.*
[b] *Two complete mutants for plant habit not included.*
[c] *One complete habit mutant not included.*

Table 2. The number of mutations on progenies from shoot tips derived from four sections of a carnation stock plant — cv Pikes Peak Frosted I. Approximately 150 flowers were cut from each progeny of one row.

	Section of stock plant			
	A	B	C	D
	5	15	5	5
	5	Complete[a]	5	11
	6	12	1	2
		8	3	7
		1	2	7
		5	4	2
		3	3	8
		7	7	1
		3	4	3
		9	4	4
		Complete	0	Complete
		3	4	2
		8	8	8
		5	2	4
		6	3	16
			3	6
			5	6
			3	10
			1	1
Total mutants	16	85	67	103
No. progenies	3	13	19	18
Ave. number mutants per progeny	5.3	6.5	3.5	5.7

[a] *Complete mutant progenies not used in totals.*

Table 3. Number of mutations observed on progenies from terminal and lateral shoot tips taken from one plant of carnation cv Gayety.

Position of meristem			
Terminal		Lateral	
Number of progeny	Number of mutants	Number of progeny	Number of mutants
1	9	1	0
2	9	2	5
3	6	3	4
4	1	4	0
5	2	5	4
6	1	6	11
7	11	7	5
8	7	8	complete
9	3	9	3
		10	0
Number of progenies	9	Number of progenies	9
Total mutations	49	Total mutations	32
Ave. mutations per progeny	5.4	Ave. mutations per progeny	3.6

the bottom original break on the plant. All of these tips were terminals from short lateral breaks. A much lower mutation rate was shown by tips derived from branch *C*. In addition to a higher average mutation rate, two tips from branch *B* and one from *D* were complete mutations for a different plant habit. These two branches probably had common tissue at their origin that was not present or did not come to the surface in branch *C*.

Terminal vs. Lateral Meristems

As the experiment was designed equal numbers of terminal and lateral meristems were planned. Gayety and CSU Pink were handled in this manner but all tips from Pikes Peak Frosted I and II were terminals. Table 3 gives the results from nine terminal and 10 lateral shoot tips from Gayety. There were fewer malformed and mutant flowers produced by the progenies of side shoot tips; however, one of these was a complete mutant for color (white). Many of the mutants on other progenies were for color (red). Gayety is considered one of the most unstable cultivars, especially because of its production of red flowers.

An interesting study was made on one shoot of Gayety taken from the top central area of the stock plant. This shoot diagrammed in Figure 1, had six visible leaf pairs and corresponded to the shoot illustrated in Phillips' anatomical study (1) as a 36-day or 14-node shoot. The terminal and four lateral shoot tips were produced from buds of this shoot. Lateral buds were taken from nodes 4, 9, 10, and 12, with node 1 being the topmost from

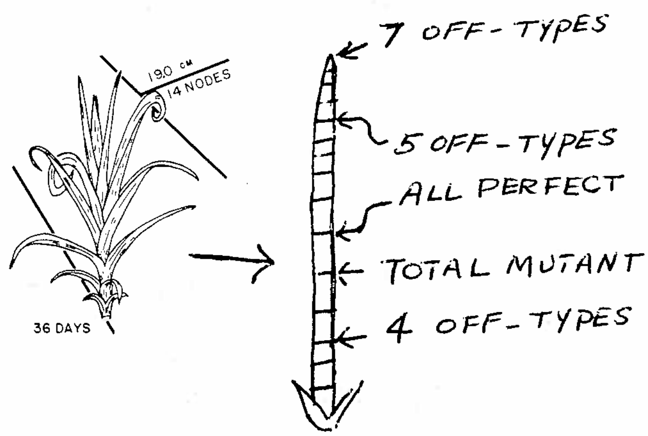

Figure 1. Diagram of the size and development of a carnation shoot showing points from which five shoot tips were taken. The number of mutants and off-type flowers is indicated for each shoot tip progeny.

the base of the shoot. Part of the drawing in Figure 1 is adapted from Phillips' drawing. The number of mutants from progenies of each shoot tip is indicated. The progeny from the terminal shoot tip produced six slabsided flowers and one light-colored sport. The first bud taken at the 4th node produced five off-type flowers. The next taken at the 9th node produced all perfect flowers, the 10th node shoot tip was a complete mutant for white flowers, and the bud from the 12th node was approximately the same as the 4th. Quality of all flowers except the malformed was very high as these shoot tips came from an outstanding selection of Gayety.

Conclusions

It was hoped that larger shoot tips from relatively stable plants would show a very low mutation rate. Phillips has devised methods of storing rooted shoot tips up to nine months (1). Hundreds of shoot tips from outstanding plants could be kept in storage until needed, then planted for increase without progeny testing. This experiment indicates the need for progeny testing of every carnation shoot tip. Plants derived from untested shoot tips are certain to give mixed progenies that could greatly reduce the quality and grade of flowers eventually produced. Should we ever have cultivars more genetically stable than those from William Sim, mass banking of shoot tips would be practical.

The study further indicates that shoot tips from some plants are much more stable than those from others. But, the only way to reveal stability is by flowering the first progeny from a shoot tip.

Literature Cited

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