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INDUCED POLYPLOIDY IN *Phlox drummondii* HOOK.

I. Morphological Characteristics of Induced Tetraploid Plants

Susumu MAEKAWA

Introduction

In order to utilize more useful characters which occur through chromosome doubling, many workers have already induced polyploid ornamental plants and made observations on their morphological characteristics. SAITO (1951, 52, 61) and TANDON *et al.* (1957, 64), particularly, have made a series of works concerning induced polyploids and their utilization with many plants.

However, with respect to the effect of polyploidy on flower coloration, there have been published no detailed reports, as far author knows. To resolve these problems might provide further information for improvement of flower color.

From such a point of view, the present author has been working on the induced polyploidy in *Phlox drummondii*. In this paper an outline of morphological observations will be given on the induced tetraploid plants in comparison with their original diploid plants.

Before going further, the author wishes to thank Prof. N. NAKAMURA for his constant guidance throughout this work.

Materials and Methods

The materials used comprise the five strains of *Phlox drummondii* (2n=14), viz. strain numbers 28 (eosin pink), 35 (deep carmine), 37 (mouve), 38 (blue violet) and 39 (oriental red), and these plants have been maintained by means of artificial self pollinations. The induced tetraploid plants used were of C_1 or C_2 generation. Chromosome numbers of these plants were determined in root tips (Fig. 1).

Five to ten plants were used for each strain of the induced tetraploid plants and their original diploids. Sowing was made on October 1, 1966. The seedlings were transplanted into clay pots of 10cm diameter after they grew for 40 days, and kept in a plastic film house which was warmed with plastic covered electric resistance wires (80 watts per squar meter). when the first flower bloomed, each plant was placed in a growth chamber regulated at 20°C and 6000 Lux. (white fluorescent lamps and tangsten lamps).

Detailes of character measurements will be described in each item of the experimental results.

Results

1. *Size and shape of leaves*

Length and breadth of the 5th leaves were measured. The result are shown in Table 1. Leaves of the tetraploid plants showed considerable variation in the length ranging from 82.8 in strain 38 to 115.3 in strain 35, taking that of the original diploid as 100. In the average value, however, no difference was found between the diploid and tetraploid plants. On the other hand, in leaf breadth, all the tetraploid strains were remarkably broader than the diploids, showing a lower value in leaf-index (length/breadth).

2. *Size and number of stomata*

Observations were made in the 8th leaves. The tetraploids had larger stomata than those of the diploids, in the former, there being on an aver-

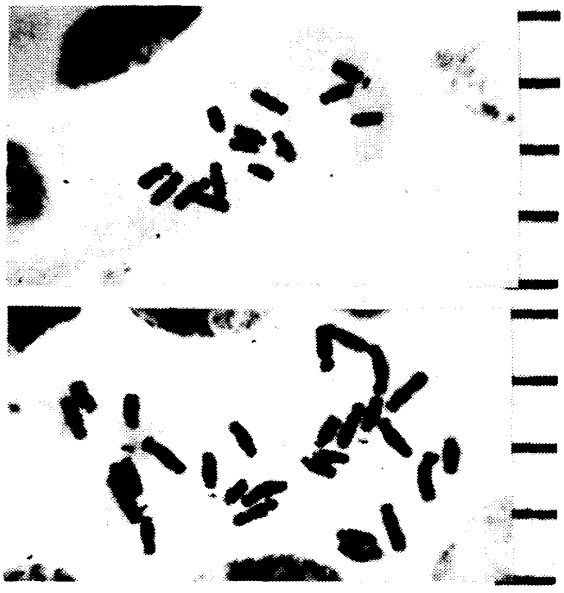

Fig. 1. Somatic chromosomes in root tip squashes of strain 39; Upper : diploid (2n=14) and lower : tetraploid (2n=28) (1 unit = 10 μ)

Table 1. Comparisons between diploid and tetraploid plants for leaf characters

Strain	Ploidy	5th leaf			Stomata		
		Length (cm)	Breadth (cm)	Index*	Length (μ)	Breadth (μ)	Number per unit area
28	2 x	5.02	1.41	356	41.87	30.42	47.8
	4 x	4.78	1.64	291	53.14	36.11	28.0
	Ratio**	95.2	116.3	—	126.9	118.7	58.6
35	2 x	5.08	1.53	329	52.23	32.80	35.8
	4 x	5.80	2.03	286	58.96	38.83	20.5
	Ratio	115.3	132.7	—	112.9	118.4	57.3
37	2 x	5.25	1.67	314	44.55	29.66	41.5
	4 x	5.70	2.03	281	56.24	36.36	25.8
	Ratio	108.6	121.6	—	126.2	122.6	62.2
38	2 x	5.94	2.02	294	39.77	28.96	44.2
	4 x	4.92	2.12	232	53.45	33.56	32.0
	Ratio	82.8	105.0	—	134.4	115.9	72.4
39	2 x	5.58	1.23	454	43.96	31.82	36.8
	4 x	5.76	1.52	379	49.65	35.69	24.7
	Ratio	103.2	123.6	—	112.9	112.2	67.1
Total	Ratio	101.0	119.8	—	122.7	117.6	63.5

* Length/breadth x 100 ** Tetraploid/diploid x 100

age an increase of about 23% in length and about 18% in breadth. The number of stomata per given leaf area in the tetraploids was about 36% lower than that of the diploids as given in Table 1.

3. *Chloroplast number in guard cells*

Chloroplasts, which were stained with 1% aqueous solution of silver-nitrate, were counted in the strain 35. There were found 50.1 particles per guard cell in the tetraploids as compared with only 31.7 in the diploids.

4. *Time of flowering*

In the tetraploids, as shown in Table 2, the strain 35 bloomed earliest and it was followed in order by the strains 28, 39, 37 and 38, whereas in the diploids, the strain 39 bloomed earliest and it was followed by the strains 35, 28, 38 and 37. The tetraploid plants bloomed, on the average, about 17 days later than the diploids.

5. *Number of flowers*

The number of flowers was counted during 35 days after the first flower came into bloom. The results obtained are noted in Table 2.

A wide variation was found among the five strains in both of the tetraploids and diploids. Comparing the tetraploids with the diploids taking 100 as standard, the two strains 38 and 35 of the former showed 31.8 and 32.8, and the strains 39 and 28 showed 80.3 and 95.6, respectively, showing a reduction of about 40% in the average number of the five strains.

6. *Size and shape of petals*

Measurements were made for length and breadth of the petals on the 3th day after blooming. As shown in Table 2, the petal size and shape (petal index) in the diploids exhibited a considerable variation among the five strains. The tetraploids were, on an average, about 15% larger than the diploids in length and breadth of the petals.

Of interest is that the edge of the petals of the tetraploids had a tendency to be ruffled, and it was not found in the diploids.

7. *Size of pollens*

Pollen size was represented by measuring the diameter of normal shaped grains which were stainable with aceto-carmine. The average size in the tetraploids was approximately 42 μ, it being 32% larger than that of the diploids averaging at 32 μ (Table 2).

Discussion

As seen from the results mentioned above, the induced-tetraploids of Phlox plants were characterized

Table 2. Comparisons between diploid and tetraploid plants for flower characters

Strain	Ploidy	Time of blooming of lst flower	No. of flowers	Petal			Pollen size (μ)
				Length (mm)	Breadth (mm)	Index *	
28	2 x	Feb. 20.7	59.0	10.7	9.2	116.2	31.82
	4 x	Mar. 9.6	56.4	11.8	9.9	119.2	42.67
	Ratio **	(16.9) ***	95.6	110.3	107.6	—	134.1
35	2 x	Feb. 20.0	121.0	12.9	10.0	129.0	32.03
	4 x	Mar. 6.6	39.7	14.4	11.2	128.6	44.07
	Ratio	(14.6)	32.8	111.6	112.0	—	137.6
37	2 x	Mar. 14.9	135.2	13.5	10.9	123.9	31.05
	4 x	Mar. 24.0	77.5	14.4	12.4	116.1	40.72
	Ratio	(9.1)	57.3	122.1	113.8	—	131.1
38	2 x	Mar, 5.1	103.2	12.7	10.8	117.6	31.82
	4 x	Mar. 22.1	32.8	15.4	12.5	123.2	41.17
	Ratio	(17.0)	31.8	121.3	115.7	—	129.4
39	2 x	Feb. 14.4	100.6	11.4	7.5	152.0	32.03
	4 x	Mar. 13.4	80.8	12.9	9.3	138.7	40.82
	Ratio	(27.0)	80.3	113.2	124.0	—	127.4
Total	Ratio	(16.9)	59.6	115.7	114.7	—	131.9

* Length/breadth x 100 ** Tetraploid/diploid x 100 *** Tetraploid - diploid

by larger sized flowers as compared with the original diploids, this being in good agreement with the observations by SAITO (1952) and SAXENA *et al.* (1960) in similar plants. However, when polyploids are induced artificially by colchicine treatment, a polyploid vigor does always appear in any case. SAITO (1951) has suggested that if plants have high chromosome numbers or numerous dominant genes by mutation and selection over long periods of time until today, a genic over-action may occur in such plants as a result of the competition of numerous genes located on duplicated chromosomes and, consequently, vigor will seldom appear in the plants.

From the above view, it may be considered that Phlox plants with such a low chromosome number as n=7 belong to the group in which chromosome doubling gives easily rised to vigorous growth.

TANDON *et al.* (1957) have made comprehensive investigations on colchicine induced polyploids of ornamental plants with small flowers and low chromosome numbers, such as *Linaria vulgaris*, *Iberis amara* and so forth, and pointed out that the tetraploids display an increase in the size of flowers, stomata and pollen grains as compared with their original diploids, although showing a reduction in the number of stomata per unit leaf area. These results agree closely with those obtained in the present study.

In the time of flowering, the tetraploids are later than the diploids, and show varying degrees of delay among the strains. These variations were seemed to result from the difference of inherent character in each strain. In addition, early flowering strains (for example, the strain 39) presented larger difference between the diploids and the tetraploids, because it might be resulted from exposing to relatively low temperature at the flowering stage and growing slowly as compared with late flowering strains.

On the other hand, in the diploids, the flowers differ in number and shape with different strains. This seems to be attributable to the difference in inherent characters in these strains. A reduction in the flower number of the tetraploids may also be due to such a difference. An increased number of chloroplasts per guard cell is invariably found in the tetraploids, and hence it may be used as a good aim for identifying polyploid forms from among colchicine-treated seedlings, as MOCHIZUKI *et al.* (1955) pointed out in the case of sugar beets.

Summary

Tetraploid plants (2n=28) were induced in the five strains (strain nos. 28, 35, 37, 38 and 39) of

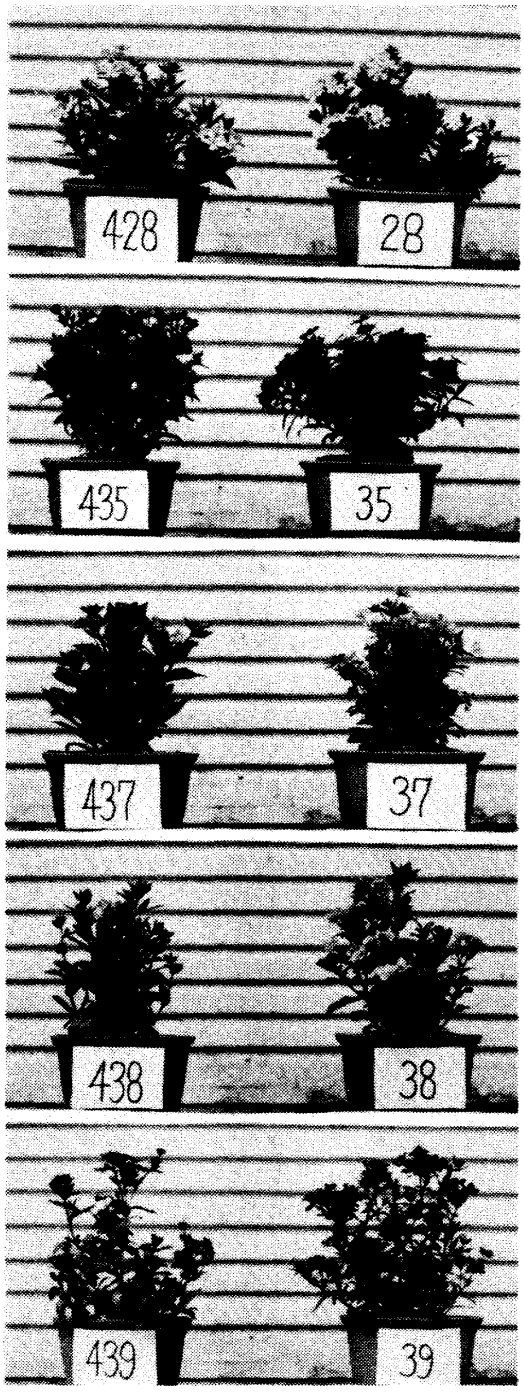

Fig. 2. Tetraploid (left) and diploid (right) plants at earlier stage of flowering; From top to bottom : strains 28, 35, 37, 38 and 39.

Phlox drummondii (2n=14) by treating seedlings with colchicine, and their morphological characters were studied in relation to the original diploids.

As compared with the diploids, the induced tetraploids were characterized by broader leaves, larger stomata, more chloroplasts per guard cell, later blooming, larger and fewer flowers and larger pollen grains.

(Laboratory of Vegetable and Ornamental Crops, Received Aug. 31, 1968)

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