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Morphological and cytological evaluation of progeny obtained from pollination of *Fragaria* x *ananassa* Duch. with *Potentilla* spp.

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Abstract

In the second year of growth, 131 (of 159) progeny from pollination of *F.* × *ananassa* with *Potentilla* spp. were examined for morphological characters such as leaf shape and lay-out, the ability to produce runners, flowering, the color of flower petals, sex, ability to develop torus and viability of seeds. On the basis of these characters, among which the ability of expansion of the fleshy receptacle (torus) serves to distinguish representatives of the genus *Fragaria* from *Potentilla* species, the progeny from this intergeneric pollination was considered matroclinous (85% produce fleshy fruits and the remaining plants also show *Fragaria* traits). Matroclinous plants preserve traits of the maternal species, but show a variability of these characters within the species, thus, they are not identical with the varieties from which they arose. Matroclinous plants differ widely in ploidy. Among the 153 examined individuals, tetraploids were most numerously represented (41%), next came penta- and hexaploids (36%), octoploids (8%), mixoploids and aneuploids (6.5%), triploids (5.5%) and others. From among 199 matroclinous plants, 77 produce relatively highly viable seeds in open pollination, 33 gave seeds of low viability and 8 produced completely sterile seeds. Preliminary examination of the progeny of matroclinous plants seems to indicate that it is possible to obtain a next fertile generation.

Key words: matroclinous progeny, ploidy level, tetrahaploids

INTRODUCTION

Obtaining viable and fertile intergeneric hybrids is a very rare phenomenon in the *Rosaidae* subfamily. In the 1960's (Ellis 1960/1961) and 1970's (Asker 1970, 1971, Barrientos and Bringhurst 1973, 1974, Hughes and Janick 1974) a few papers were published on obtaining hybrid *Fragaria* × *Potentilla* spp., as well as maternal type plants with a changed ploidy.

In the descriptions of the morphological features of plants, as traits deciding about their hybrid character, the pink or creme color of the petals or inability to form runners were mentioned (Ellis 1960/1961). Among the *Fragaria* species, forms with creme-colored petals are found, and in strawberry seedlings often, especially during the early spring, pinkish petals are observed. The ability to form runners is determined genetically and genotypes are known with this ability strongly limited. These are not, therefore, traits which can decide about the hybrid nature of a plant. On the other hand, all of the above mentioned authors admit that the leaves of plants obtained from *Fragaria-Potentilla* crosses were always of the *Fragaria* type, that is, with three leaflets. The question of expansion of the receptacle, an important trait differentiating the genera *Fragaria* and *Potentilla*, is rarely or never raised (Ellis 1960/ /1961), since most of the observations end with a description of seedlings incapable of further development or with a statement that the hybrids were sterile.

Starting from Ellis (1960/1961), the number of chromosomes was evaluated. Hybrids were determined on the basis of the chromosome number equal to the sum of the parental gametes, with the assumption that the process of meiosis took place normally. Individuals with a different number of chromosomes such as: tetrahaploids, aneuploids and those having the same number of chromosomes as the maternal form were described as matroclinous (Hughes and Janick 1974). A detailed analysis of a larger number of plants in full vegetative and generative development is lacking. Because a population of over 100 plants was obtained after pollinating female *Fragaria* × *ananassa* varieties with *Potentilla* species (Niemirowicz-Szczytt 1984a), an attempt was made to analyse the morphological and cytological characteristics of these plants in order to determine their nature and the species to which they belong.

MATERIAL AND METHODS

Plants obtained from cross pollination of *F.* × *ananassa* varieties (Freja, Sonja, Mieze Schindler, Dir. Wallbaum, Pozdnaya Slodkaya) with *Potentilla* species (*P. geoides, P. rupestris, P. fruticosa, P. purpureoides, P. fragiformis* and *P. glandulosa*) were used as the material in this study. The parental forms and offspring (in their second year of growth) were studied in respect to the following traits: a) leaf characteristics; b) ability to form runners; c) ability to bloom, color of petals and sex; d) ability to form fleshy fruit and seed development; e) ability of seeds to germinate, that is, the number of seedlings obtained up to 2 months after sowing; f) number of chromosomes; g) size, stainability and morphology of pollen grains.

The characteristics of the leaf were determined as follows: if the parental forms differed in respect to their number of leaflets and type of leaf, then for the offspring only the number of leaflets and type of compound leaf were evaluated. If the number o leaflets and type were the same in both parental forms, then by the Jentys-Szaferowa method (1959) the characteristics of the shape and size of the middle leaf were evaluated and compared with the parental forms. This method, adapted to the needs and possibilities of this study, depended on the choice of 13 characteristics of the size and shape of a leaf. The arithmetical average from the measurements of 20 leaves for the parental forms and 3 for each of the offspring were calculated. Picking more leaves from each offspring plant could have destroyed them.

The following characteristics of the middle leaf were chosen: 1) length of the petiole, 2) length of the leaf blade, 3) width of the leaf blade, 4) distance of the first tooth from the base of the petiole, 5) distance between the second and third vein, 6) position of the widest part of the leaf blade, 7) number of side vein pairs, 8) number of teeth between the second and third veins, 9) ratio of blade to petiole length, 10) ratio of blade length to its width, 11) ratio of the blade length to the distance of the first tooth, 12) angle of leaf base, 13) angle of second vein. Next, the sum of the squares of deviation for the studied plant from the arthmetical averages of each of the parental models was calculated. It should be accepted that the smaller the sum of the squares of deviation, the greater is the similarity to that parental model. The remaining morphological traits (b-e) were evaluated on the basis of field observations taken during the vegetation of the plants.

The number of chromosomes was determined in root meristem cells. Roots were taken from the plants during transplantation from pots to the ground or from runners beginning to root. Roots were fixed in Carnoy's solution (3 : 1, ethyl alcohol : acetic acid, v/v) and stored in 80% ethyl alcohol. They were stained with 2.5% acetocarmine at 4° C for a few days. In order to soften them, they were treated with 1 N HCl for 10 min at 60° C and crushed in 45% acetic acid.

Pollen was collected from two flower buds from each offspring plant with perfect flowers and from 2 buds from 5 parental plants. The buds, on the day before blooming, were taken from the II or III layer of inflorescence. The anthers, taken from each bud separately, were crushed in a drop of acetocarmine with glicerine (1 : 1 v/v), and after removing the anthers, the drop was covered with a cover slide. The pollen grains were measured using an ocular micrometer. The number of pollen grains counted in 10 fields of vision ranged from 200-2 500.

RESULTS

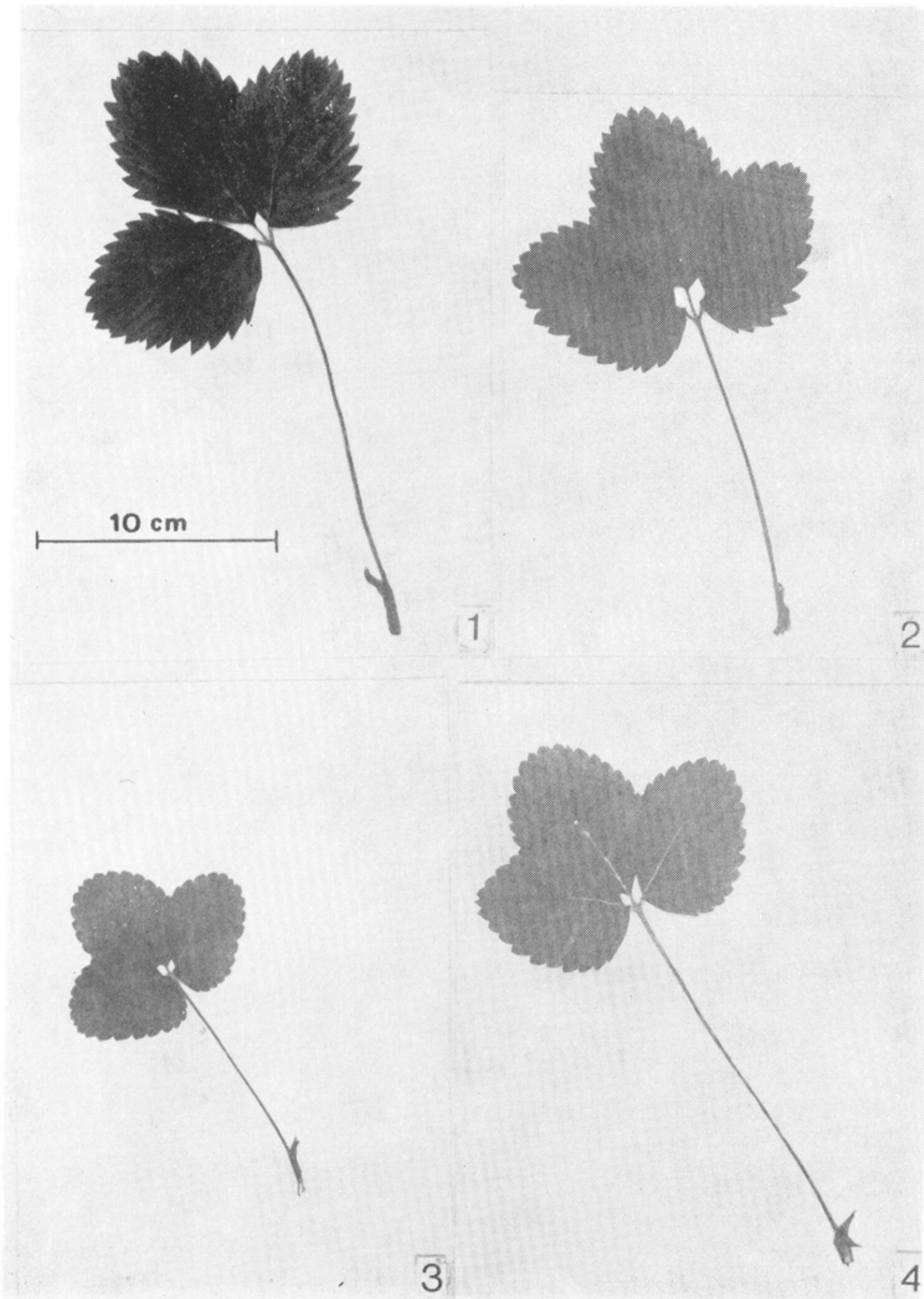
After pollinating female varieties of the strawberry with *Potentilla* species, 159 plants in their second year of growth (Niemirowicz-Szczytt 1984a) were obtained, from which part (131) were subjected to detailed cytomorphological studies. Comparison of the morphological traits is presented in Table 1 and cytological traits in Table 4 and 5.

Leaf characteristics. All of the maternal *F.* × *ananassa* forms have palmate leaves with three leaflets growing out from the base of a very shortened above-ground shoot (Figs. 1-4). Above-ground runners and inflorescences also develop from this short stem. Strawberry varieties differ in the size, shape, serration of and color intensity of their leaf blades, the arrangement of leaflets and the thickness and length of trichomes on the petioles. In some varieties, small stipules may grow below the leaves.

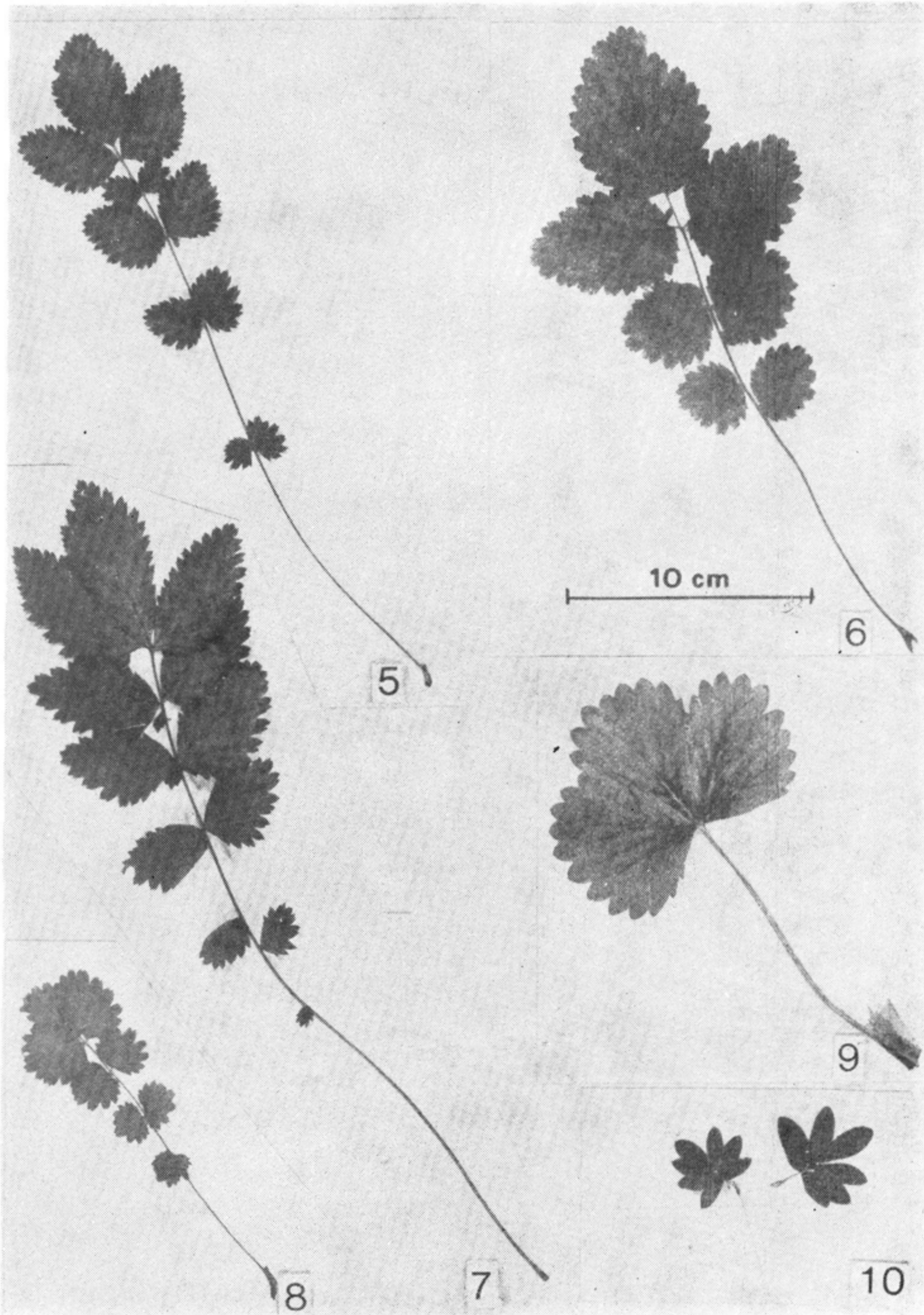
The paternal forms from the genus *Potentilla* are more differentiated in respect to their leaf structure. Plants from the species *P. geoides, P. rupestris, P. glandulosa* and *P. purpureoides* are characterized by pinnate leaves with 7-9 leaflets growing out of a shortened above-ground shoot (Figs. 5-8). Initially, these plants are rosette-shaped, then the flower stem grows out 30-60 cm above the rosette. The leaves which grow out from the flower stem are shaped a bit differently and have a variable number of leaflets. *P. fruticosa* is a herbaceous species with very small, 3-5 leaflet, palmately compound leaves (Fig. 10). The leaves are pointed and very piliferous. *P. fragiformis*, in accordance with its name, is the most similar to the strawberry in its rosette form and leaf shape (Fig. 9). The leaves have three leaflets, are palmately compund and grow out from a shortened above-ground stem. Compared with the strawberry, the leaf blades are wider and much thicker and the leaves along with the petioles are covered with many soft trichomes.

The offspring obtained from all of the combinations listed in Table 1 produced only leaves with three leaflets (Figs. 11-16). The range of shape and size variability of the leaves did not exceed that for the *F.* × *ananassa* species, but the variability was greater than in the maternal forms. This is also true for the progeny from the MR combination in which *P. fragiformis* with three leaflet leaves was the paternal from; by Jentys-Szaferowa's method (1959) a greater similarity of the progeny in the shape and size of its leaves to the maternal Sonja variety than to *P. fragiformis* (Table 2) was shown. Only in one case was the size of the plant's leaves from this combination closer to that of *P. fragiformis*, however, the shape of the leaves and its other traits were in agreement with those of the maternal form.

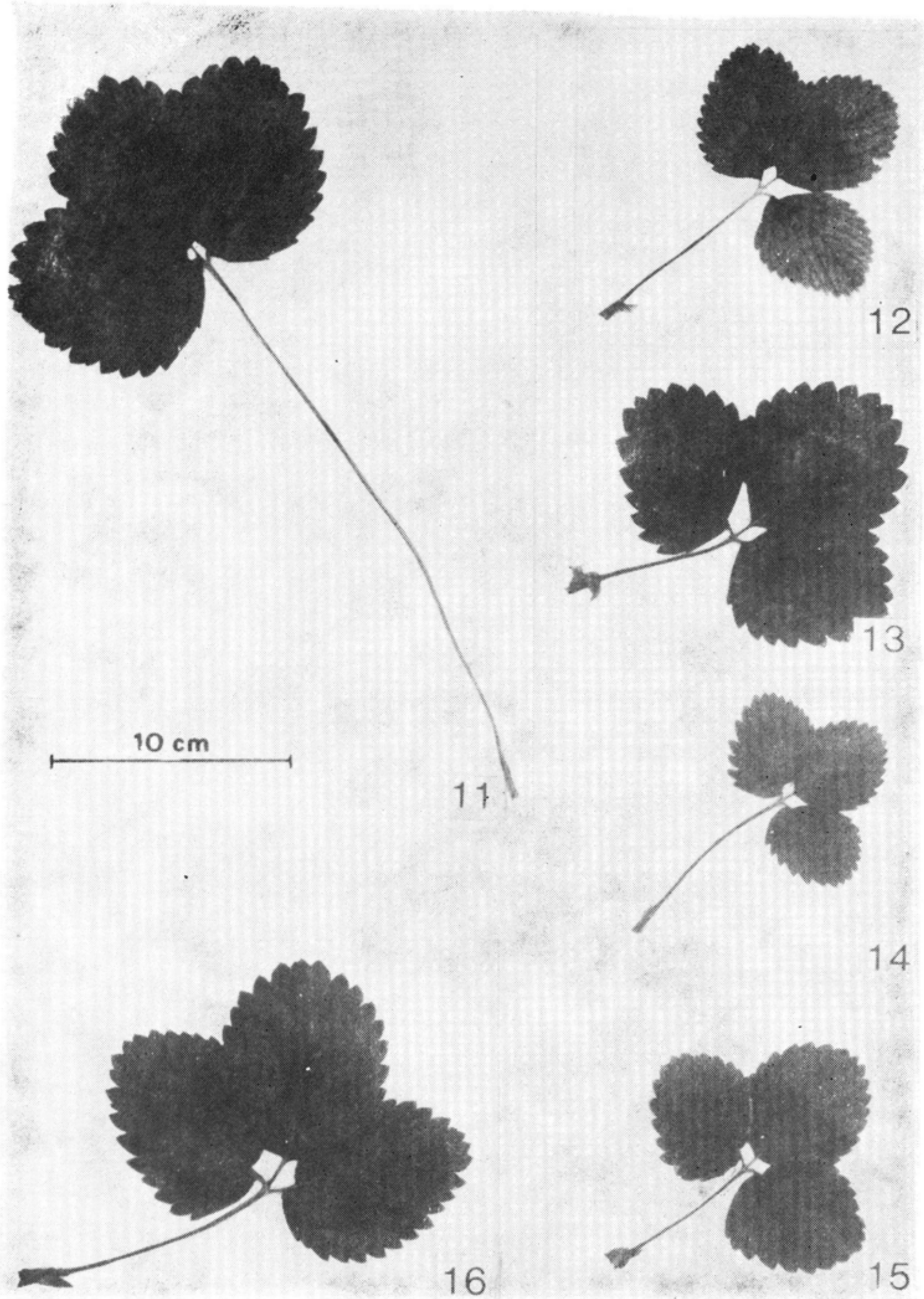
Ability to produce runners. The maternal forms produce above-ground runners and the parental forms reproduce vegetatively through



Figs. 1-4. Leaves from selected *F.* × *ananassa* varieties, in the same scale: 1 — Freja, 2 — Sonja, 3 — Mieze Schindler, 4 — Dir. Wallbaum

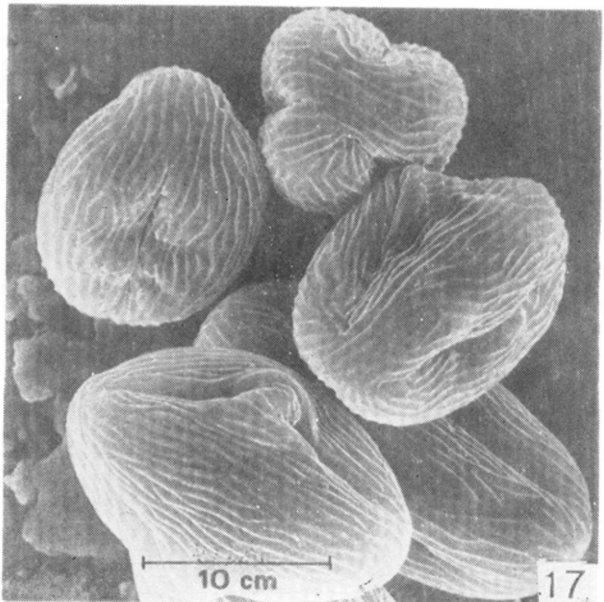


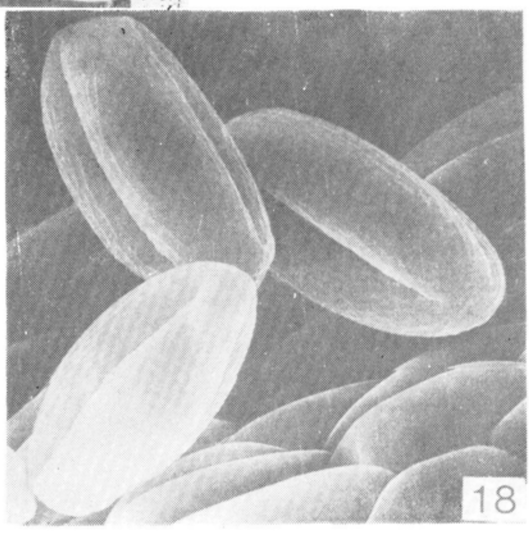
Figs. 5-10. Leaves from *Potentilla* species, in the same scale: 5 — *P. rupestris*, 6 — *P. geoides*, 7 — *P. glandulosa*, 8 — *P. purpureoides*, 9 — *P. fragiformis*, 10 — *P. fruticosa*

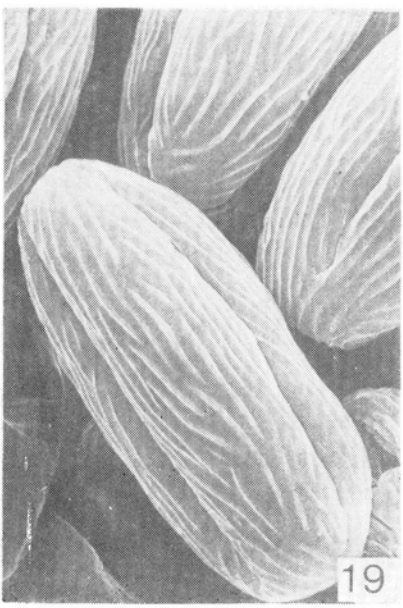


Figs. 11-16. Leaves of matroclinous offspring plants. in the same scale: 11-14 — tetraploid individuals, 15 — a hexaploid plant, 16 — an octoploid plant

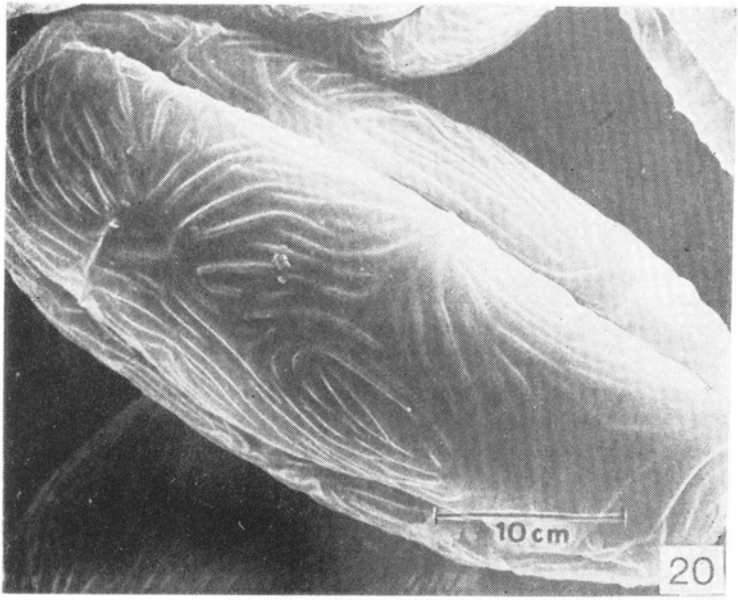
PLATE IV

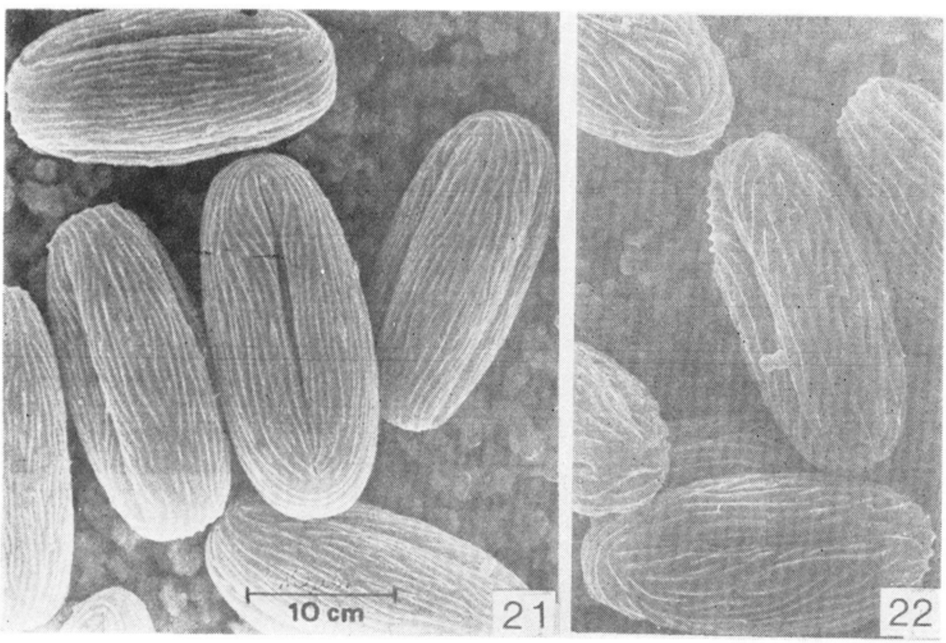






Figs. 17-20. *Potentilla* pollen grains: 17 — *P. geoides*, 18 — *P. fruticosa*, 19 — *P. rupestris*. 20 — *P. fragiformis*. Photographs from a scanning electron microscope, 2000 ×





Figs. 21-22, Pollen grains: 21 — *F.* × *ananassa*, 22 — a matroclinous plant. Photographs from a scanning electron microscope, 1500 ×

Table 1

Comparison of chosen morphological traits of parental forms and progeny from intergeneric crosses between *F.* x *ananassa* and *Potentilla* spp.

Parental forms	Number of plants	Number of leaflets and form*	Number of plants		Petal color**	Number of plants which bloomed						
			with runners	not blooming		total			blomed but bore no fruit	formed fruit	formed seeds	
											sterile	viable
Maternal forms — varietes of *F.* x *ananassa*	50	3d	50	—	b	50	50	—	—	50	—	50
Paternal forms:												
P. geoides	10	7-9p	—	—	y	10	—	10	—	—	—	10
P. rupestris	10	7-9p	—	—	b	10	—	10	—	—	—	10
P. fruticosa	8	3-5d	—	—	y, b	8	—	40	4	—	—	4
P. purpureoides	10	9p	—	—	y	10	—	10	—	—	—	10
P. fragiformis	10	3d	—	—	y	10	—	10	—	—	—	10
P. glandulosa	10	9p	—	—	y	10	—	10	—	—	—	10
Progeny — combinations:												
Freja x *P. geoides* (MR8)	7	3d	+	—	b	7	6	1	—	7	—	7
Mieze Sch. x *P. geoides* (MR6)	1	3d	+	—	b	1	—	1	—	1	—	1
Pozdn. Slod. x *P. geoides* (MR15)	1	3d	+	—	b	1	1	—	—	1	—	1
Dir. Wallb. x *P. geoides*	1	3d	+	—	b	1	—	1	—	1	—	1
Freja x *L. rupestris* (MR9)	40	3d	+	—	b	40	20	20	1	39	4	35
Sonja x *P. rupestris* (MR3)	34	3d	—1	2	b	32	15	17	1	31	1	29
Mieze Sch. x *P. rupestris* (MR7)	1	3d	+	—	b	1		1	—	1	—	1
Dir. Wallb. x *P. rupestris* (MR5)	1	3d	+	—	b	1	—	1	—	1	—	1
Sonja x *P. fruticosa* (MR14)	7	3d	+	—	b	7	5	2	—	7	—	7
Sonja x *P. purpureoides* (MR1)	22	3d	+	4	b	18	7	11	2	16	2	14
Dir. Wallb. x *P. purpureoides* (MR13)	6	3d	—1	—	b	6	1	5	—	6	—	6
Sonja x *P. fragiformis* (MR2)	8	3d	+	2	b	6	3	3	—	6	1	5
Sonja x *P. glandulosa* (MR10)	2	3d	+	—	b	2	2	—	—	2	—	2
Progeny, total	131	3d	—2	8	b	123	60	63	4	119	8	111

* leaves: d — palmately compound, p — pinnate; ** petal color: b — white, y — yellow.

Table 2

Sums of the squares of deviation of 13 leaf characteristics of an individual plant from the arithmetical averages of the maternal form. *F.* x *ananassa* var. Sonja and paternal form, *P. fragiformis*

Year	Plant symbol	Sums of the squares of deviation of values individual plant from	
		average maternal form	average paternal form
1978	MR 2/1	1.973	2.933
	MR 2/2	3.369	1.749
	MR 2/3	2.080	3.391
	MR 2/5	1.707	2.337
1980	MR 2/1	0.337	5.300
	MR 2/2	0.944	7.269
	MR 2/3	0.183	1.832

underground stems. Among the offspring, only two plants (MR 3/15 and MR 3/4) did not form above-ground runners, and were small and weak. The inability to form runners is not an exceptional characeristic in *Fragaria*. There are individuals in the species *F.* × *ananassa*, which do not possess this ability. In the strawberry, this trait is determined genetically and is connected with photoperiodical sensitivity and reaction to temperature.

The ability to bloom, petal color and flower sex. As indicated in Table 1, all of the maternal forms have only female flowers and are not able to develop seeds (nuts, achenes) or to form fruit without pollination. The paternal forms, excluding *P. fruticosa*, have perfect flowers. Some individual *P. fruticosa* plants form male flowers with rudimentary pistils, but individual plants are also found which have perfect flowers and develop seeds.

From among the 131 offspring plants, 8 did not bloom. Part of these plants were exceptionally small and part did not bloom in spite of their strong vegetative growth. These types of plants were found in only 3 combinations (MR 1, MR 2, MR 3), in which the maternal form was always Sonja. The offspring plants which bloomed had only white flower petals (Table 1) and shooting of inflorescence was not observed, as it is in some of the *Potentilla* species used as paternal forms. In each of the larger offspring populations, separation into plants with female and perfect flowers took place. In small populations numbering from a few to ten-odd plants, the ratio of the plants with female flowers to those with perfect flowers was variable (Table 1), whereas in larger populations, was close to 1 : 1. If all of the offspring plants are taken together, then it is found that there were 60 plants with female flowers to 63 with perfect flowers, which also is close to 1 : 1. Similar ratios are obtained when varieties with female flowers are crossed with plants with perfect flowers, which suggests that the female sex is heterogamic and that hermaphrodity is of a recessive, homogamic nature.

The ability to form fleshy fruits and develop seeds. Among the 123 plants which bloomed, 4 did not produce fruit or seeds (comp. Table 1). These plants could be considered sterile, but it cannot be excluded that during the next years of vegetation they could attain partial fertility, as was observed in plants obtained in 1978. Sterility of flowers is often found in the offspring of the strawberry, not only in intergeneric hybrids, but also in plants obtained through free pollination (unpublished results).

From the 119 plants whose seeds were obtained as the result of free pollination and were examined in respect to their fertility, 8 produced completely sterile seeds and so, the number of plants which were not able to produce offspring (did not bloom, had sterile flowers or seeds) equalled 20, which amounts to 15% of the progeny which was studied in respect to their morphological traits.

The viability of seeds was studied taking into account the manner of pollination through which they arose (Table 3). The viability classes of seeds take into account the natural periods of viability of the strawberry und the conditions of the experimental field in Wolica. The class

Table 3

Number of offspring plants obtained by crossing *F.* x *ananassa* with *Potentilla* spp. in seed viability classes (seed viability measured in % of germinating seeds during 2 months from sowing)

Offspring symbol	Mode of pollination														
	free					self					back-crosses to *Potentilla* spp.				
	number of plants in seed viability classes[a]														
	A	B	C	D	total	A	B	C	D	total	A	B	C	D	total
MR 8	—	3	3	1	7	—	—	1	—	1	4	—	—	—	4
MR 6	—	1	—	—	1	—	—	1	—	1	—	—	—	—	—
MR 11	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—
MR 15	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—
MR 9	4	8	25	2	39	1	5	6	—	12	11	4	—	—	15
MR 3	1	10	16	4	31	1	4	5	—	10	6	2	2	—	10
MR 7	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—
MR 5	—	—	1	—	1	—	1	—	—	1	—	—	—	—	—
MR 14	—	3	2	2	7	—	1	—	—	1	2	1	—	—	3
MR 1	2	4	7	3	16	—	3	2	2	7	2	2	—	—	4
MR 13	—	—	4	2	6	—	—	4	—	4	—	—	—	—	—
MR 2	1	3	2	—	6	—	2	—	1	3	1	—	1	—	2
MR 10	—	—	1	1	2	—	—	—	—	—	1	—	1	—	2
Total	8	33	63	15	119	2	16	19	3	40	27	9	4	0	40

[a] Division into seed viability classes: A — sterile seeds; B — 0.1-3.0%; C — 3.1-15%; D — over 15%.

0.1-3.0% of germinating seeds is the most common for the viability observed in intergeneric and interspecific crosses, the class 3.1-15% is the range typical for seeds obtained through free pollination or crossing of varieties, the class above 15% is considered high viability for seeds from free pollination (Niemirowicz-Szczytt 1981).

From among the 119 studied plants which produced seeds as the result of free pollination (Table 3), the seeds of 78 plants showed a relatively good viability (class C and D), which indicates that regular processes of generative reproduction can take place and that there is a possibility that future generations can be obtained.

From among the 63 plants with perfect flowers, 40 produced seeds as the result of self pollination. In this group of plants, about one-half produced seeds with the so-called "normal" viability (22 individual plants of the 40 studied), which is very valuable since it gives the chance to keep the offspring with different ploidy if of course, after self-pollination the initial ploidy is maintained.

From among the 60 plants with female flowers, after back crossing with pollen from the paternal *Potentilla* form, 40 formed fruit and seeds. A high degree of sterility of seeds was noted among them, since 27 plants had completely sterile seeds (67.5% of the studied plants) 9 had seeds of very low viability and only 4 had seeds of good viability. On the basis of these results it can be concluded that the progeny from the intergeneric crossing of *F.* x *ananassa* and *Potentilla* spp. does not cross better with *Potentilla,* although there were a few individuals which, when crossed with representatives of *Potentilla,* gave a rather high percentage of germinating seeds. Such individuals deserve special attention and the next generation should be subjected to precise cytomorphological examination.

Number of chromosomes. The maternal forms of *F.* x *ananassa* are octoploid (2n = 56). Disturbrances in mitotic divisions were not found in them. The paternal forms which, when used for pollination, gave viable offspring, are diploid species (*P. geoides, P. rupestris, P. fruticosa, P. glandulosa* and *P. purpureoides*) and only one is hexaploid (*P. fragiformis*). The ploidy of *Potentilla* species was determined on the basis of mitoses found in root meristems and on the basis of meiotic divisions.

In the progeny, the number of chromosomes was determined in mitotic divisions in root meristems (in 153 individuals), including part of the MR 3 progeny which was not included in the morphological description since it did not attain generative maturity. Progeny uniform in respect to ploidy was not obtained (Table 4). In each population there was a certain dispersion in the number of plants in each ploidy class, but a decided majority of them (63 in all, which is 41% of the offspring population) was tetraploid. In comparison with the maternal forms, these plants have half the number of chromosomes. The next most numerous classes were penta- and hexaploids. They constituted 36% of the studied offspring. The remaining ploidy classes contained only 23% of the studied plants. Among them were octoploids (13 plants) which is the ploidy of the maternal plants, triploids (9 plants) and one diploid and one heptaploid plant.

Table 4

Number of offspring plants in ploidy groups and number of chromosomes in parental forms

Parental forms	Symbol	Number of studied plants	Number of plants in ploidy classes							
			14	21	28	35	42	49	56	miksoploids and aneuploids
Maternal forms									×	
Paternal forms:										
P. geoides			×							
P. rupestris			×							
P. fruticosa			×							
P. glandulosa			×							
L. purpureoides			×							
P. fragiformis							×			
Offspring:										
Freja x *P. geoides*	MR 8	6	—	1	4	1	—	—	—	—
Mize Sch. x *P. geoides*	MR 6	1	—	—	—	—	1	—	—	—
Dir. Wallb. x *P. geoides*	MR 11	1	—	—	1	—	—	—	—	—
Pozd. Sl. x *P. geoides*	MR 15	3	—	—	—	1	1	—	1	—
Freja x *P. rupestris*	MR 9	39	—	1	10	12	9	1	5	1
Sonja x *P. rupestris*	MR 3	56	1	7	24	9	8	—	4	3
Mieze Sch. x *P. rupestris*	MR 7	1	—	—	—	—	1	—	—	—
Dir. Wallb. x *P. rupestris*	MR 5	—	—	—	—	—	—	—	—	—
Sonja x. *P fruticosa*	MR 14	7	—	—	3	2	1	—	—	1
Sonja x *P. purpureoides*	MR 1	22	—	—	13	1	2	—	1	5
Dir. Wallb. x *P. purpureoides*	MR 13	6	—	—	3	1	1	—	1	—
Sonja x *P. fragiformis*	MR 2	8	—	—	3	1	3	—	1	—
Sonja x *P. glandulosa*	MR 10	3	—	—	2	1	—	—	—	—
Total offspring		153	1	9	63	29	27	1	13	10

Mixoploid and aneuploid plants are presented in Table 4. Those plants in which different numbres of chromosomes were found in cells from one meristem or in different meristems from the same plant, were classified as mixoploids. Part of the mixoploids can be termed regular mixoploids since their ploidy was found to be a multiple of 7 — e.g. 28 and 56 (2 plants); 14, 28, 42 (1 plant); 14, 28, 35 (1 plant); 21, 28, 35 (1 plant); 28, 42 (1 plant). It is not excluded that, with the number of chronosomes counted with an accuracy of 2 or 3, part of the plants in the particular ploidy classes could actually have been aneuploid.

Size, staining and morphology of pollen grains. These studies could only be done on plants with perfect flowers. The parental forms and 56 offspring plants were examined. Since the female *Fragaria* varieties do not produce pollen, a few standard strawberry varieties with perfect flowers were studied for comparison (Table 5). One the basis of pollen grain diameter measurements, groups of plants with small pollen (17.5-20.0 μm) characteristic for diploid *Fragaria* species, large pollen (22.5-25.0 μm) characteristic for octoploid *Fragaria* and with pollen of different size (large and small) were set np. Each group of pollen size was divided into two subgroups depending on the percentage of pollen grains stained with acetocarmine, 0.1-50.0% and 50.1-100% (Table 5).

Table 5

Number of offspring plants from crossing *F.* x *ananassa* with *Potentilla* spp. in pollen size and viability groups

Forms	Number of plants in pollen size groups and subgroups of pollen viability[a]									
	small				mixed			large		
	0%	A	B	total	A	B	total	A	B	total
Maternal form *F.* x *ananassa*—variety:										
Redgauntlet					×					
Ostara										×
Senga Sengana									×	
Ananasowa								×		
Paternal forms:										
Potentilla geoides			×							
P. rupestris									×	
P. fruticosa			×							
P. purpureoides									×	
P. fragiformis									× and larger	
Offspring:										
MR 8						1	1			
MR 6			1	1						
MR 11						1	1			
MR 9	3	1	2	6	1	7	8	1	—	1
MR 3	—	—	—	—	4	8	12	2	2	4
MR 5	—	—	—	—	—	—	—	1	—	1
MR 14	—	1	—	1	—	1	1	—	—	—
MR 1	2	2	—	4	—	3	3	2	2	4
MR 13	—	—	1	1	—	1	1	1	2	3
MR 2	—	1	—	1	2	—	2	—	—	—
Total offspring	5	5	4	14	7	22	29	7	6	13

[a] Percentage of viable pollen grains: A — 0.1-50.0; B — 50.1-100.

The three studied strawberry varieties, 5 plants from each variety, had large pollen, characteristic for this species. The pollen from the variety Ananassowa z Grójca, had under 1980 conditions, pollen of a rather low viability. Pollen from the Redgauntlet variety had grains of different size, the low viability of this pollen indicates that there exists a possibility of disturbances in the processes of meiosis and production of male gametes of different ploidy.

Two diploid *Potentilla* species (*P. geoides* and *P. fruticosa*) produce small, uniform and viable pollen (Figs. 17 and 18), the three remaining (diploid *P. rupestris* (Fig. 19), and *P. purpureoides* and hexaploid *P. fragiformis* (Fig. 20)) produce large pollen. *P. fragiformis* also produces larger pollen, to 30 μm, which exceeds the natural range of variability in pollen size in plants from the genus *Fragaria*.

In the progeny, (MR 9 and MR 1) five individuals with completely sterile pollen, which can be found in large amounts in these plants, were found. Nine plants were found in the group with small but viable pollen, in the group with large pollen, 13 plants. It can then be seen that plants producing uniform pollen comprized 40% of the studied plants. Over 50% had pollen of different size, which probably arose as the result of disturbances in meiosis, but in the majority of cases, it did stain.

Observation of the pollen under the scanning microscope revealed that the sculpture of the surface of pollen grains of the strawberry varieties and offspring was identical (Figs. 21-22) and differed from that of *Potentilla* (Figs. 17-20).

In summary, it should be stated that in the studied populations the majority of plants produced pollen which was differentiated in respect to size and similarity. However, plants could be found with uniform, small pollen, characteristic for diploid *Fragaria* species, and with large pollen, characteristic for *Fragaria* species of higher ploidy.

DISCUSSION

As was already mentioned in the introduction, when describing offspring plants, it is difficult to cite literature since only Ellis (1960/1961) described fully developed plants, but did not give the number of studied plants. However, both Ellis (1960/1961) and other authors (Mangelsdorf and East 1927, Shangin-Berezovskiy 1962, 1963, Asker 1970, 1971, Barrientos and Bringhurst 1973, 1974, Hughes and Janick 1974) admitted that the offspring of *Fragaria* x *ananassa* x *Potentilla* are shaped like and have leaves of the same shape as the strawberry.

Evaluation of the morphological traits of 131 plants, and mainly the trait truely differing the genera *Fragaria* and *Potentilla*, which is the ability of *Fragaria* representatives to develop the receptacle into fleshy fruit shows, that the offspring obtained from pollinating *F.* x *ananassa* x *Potentilla* spp. are matroclinous. A noticeable effect of *Potentilla* on the offsprings' phenotype was not found. Since 85% of the progeny was capable of producing fleshy fruit, and the remaining 15% of plants, in spite of the lack of this ability, decidedly belonged to the maternal species in respect to their remaining traits, they can be called matroclinous. The offspring plants are not identical with the maternal form which they arose, but they retain their species' traits. This was also noted by Asker in his comprehensive paper from 1971.

The degree of ploidy of matroclinous plants is differentiated, which was observed in populations of a similar origin by Barrientos and Bringhurst (1974) and by Hughes and Janick (1974). The most numerously represented were tetraploids (41%), next penta- and hexaploids (36%), octoploids (8%), mixoploids and aneuploids (6.5%), triploids (5.5%) and others. An attempt to explain the forming of matroclinous plants with a differentiated number of chromosomes has been made in the next paper (Niemirowicz-Szczytt 1984b), where different forms of apomixis have been shown to exist in the strawberry maternal forms used in obtaining the offspring plants used in this study.

In each ploidy class there are individuals which produce large or small pollen, but most of the plants have pollen of different size. Also, in each ploidy class there are plants with viable seeds, and due to this it is possible to obtain a next generation. This creates the possibility of continuing cytogenetic and breeding studies in the classes with lower ploidy and gives a chance of obtaining homozygous starting material for breeding.

Observation of sex in matroclinous plants allows the supposition that sex interitance is independent of ploidy. The results obtained confirm the heterogamic nature of the female sex and the homogamic nature of hermaphrodity (Valleau 1923, Correns 1928, Staudt 1967, 1968).

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Morfologiczna i cytologiczna ocena potomstwa uzyskanego z zapylenia Fragaria x ananassa Duch. z Potentilla spp.

Streszczenie

Badano potomstwo powstałe w wyniku zapylenia *F.* x *ananassa* gatunkami *Potentilla* (131 roślin w drugim roku wzrostu) pod względem takich cech jak kształt i budowa liścia, zdolność do wytwarzania rozłogów, kwitnienie, barwa płatków kwiatu, płeć, zdolność do wytwarzania owocu pozornego i żywotność nasion. Na podstawie tych cech, wśród których zdolność do rozrastania zmięśniałego dna kwiatowego zasadniczo różni rodzaj *Fragaria* od *Potentilla*, uznano potomstwo powstałe z tego międzyrodzajowego zapylenia za matroklinalne (85% wydaje owoce pozorne, a pozostałe rośliny również miały cechy *Fragaria*). Rośliny matrokinal-

ne zachowały cechy gatunku matecznego, ale wykazywały zmienność cech w obrębie gatunku i nie były identyczne z odmianami z których powstały. Rośliny matroklinalne były zróżnicowane pod względem ploidalności. Wśród 153 badanych osobników najliczniej były reprezentowane tetraploidy (41%), następnie penta- i heksaploidy (36%), oktoploidy (8%), miksoploidy i aneuploidy (6,5%, triploidy (5,5%) i inne. Na 119 roślin matrokinalnych 78 wydało w wyniku wolnego zapylenia nasiona o stosunkowo dużej żywotności, 33 o małej żywotności, a 8 nasiona całkowicie sterylne. Wstępne badania wskazują, że z roślin matroklinalnych można otrzymać następne płodne pokolenie.