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INBREEDING DEPRESSION FOR YIELD AND YIELD COMPONENTS IN *Fragaria* × *ananassa* Duch.

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Abstract. In case of plants, inbreeding depression can be measured through comparison of the fitness of selfed individuals with outcrossed individuals. In this paper the effect of repeated inbreeding on fruit yield and yield component of strawberries (*Fragaria* × *ananassa* Duch.) was examined. Five strawberry cultivars (from 10 initial ones) including 'Kent', 'Teresa', 'Senga Sengana', 'Chandler' and the breeding clone 1387 were examined and self-pollinated in order to obtain first (S_1), second (S_2) and third (S_3) inbreeding generations. 5 cultivars differing in pedigree which were assumed to have the inbreeding coefficient of zero (F = 0) were compared with self-pollinated populations with expected inbreeding coefficients F = 0.5 (S_1), F = 0.75 (S_2) and F = 0.87 (S_3). The effects of different inbreeding levels were estimated for the following traits: number of inflorescences, number of flowers per inflorescence, fruit yield per plant, fruit number per plant, average fruit weight, weight of leaves per plant and pollen viability. Both positive and negative inbreeding depressions were found in many progenies in terms of the analysed characters. Weight of leaves per plant in S_1, S_2 and S_3 was affected the most (inbreeding depression ID = 62.5, ID = 66.2 and ID = 67.2, respectively). In the second generation (S_2), average fruit number per plant increased in comparison to S_0 (ID was -6.1). Inbreeding depression for average fruit weight per plant decreased in the successive inbreeding generations.

Key words: ID, strawberry, fruit yield characters, repeated inbreeding

INTRODUCTION

Inbreeding appears universally to reduce fitness, but its magnitude and specific effects are highly variable because they depend on the genetic constitution of the species or populations and the fact how these genotypes interact with the environment [Alam at al. 2004].

Inbreeding depression (ID) and heterosis are related phenomena of fundamental importance for evolutionary biology and applied genetics. Inbreeding depression refers to

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lowered vigour of progenies compared with their non-inbred counterparts. Whereas, heterosis or hybrid vigour is defined as the superiority of a F_1 hybrid over its parent [Hedrick and Kalinowski 2000, Stuber 1994].

Inbreeding depression varies from year to year within the same population and also some life history stages are more susceptible to inbreeding depression within a population and across taxa [Charlesworth and Charlesworth 1987]. Moreover, a significant correlation exists between inbreeding depression and selfing/outcrossing species, namely repeated selfing reduces the magnitude of inbreeding depression [Husband and Schemske 1996, Pico et al. 2007]. Selfing increases homozygosity and more homozygous genotypes may be susceptible to environmental harshness. In contrast, outcrossing usually increases or maintains heterozygosity that tends to produce genotypes better able to buffer themselves against environmental variability [Falconer 1981, Thiemann et al. 2009].

In case of plants, inbreeding depression is generally estimated based on populations or progenies with known inbreeding levels generated under experimental systems. In most cases randomly mating populations are assumed to have an inbreeding coefficient of zero (F = 0) and are compared with self-pollinated progenies obtained at random from the reference population [Chaves et al. 2010].

Inbreeding in strawberries is difficult to apply because of the strong inbreeding depression in selfed progenies. Seedlings possess no vigour, are not resistant to diseases and produce very small fruits [Hulewicz and Hortyński 1979]. Lots of seedlings are not winter-hardy enough and die during winter season.

Experiments were conducted to estimate the effect of multigenerational inbreeding on different yield contributing characters in the strawberry.

MATERIAL AND METHODS

The experiments testing the strawberry germplasm were conducted between 2004 and 2010 at the Felin Research Plantation of the University of Life Sciences in Lublin. Ten strawberry cultivars including ‘Kent’, ‘Selva’, ‘Elkat’, ‘Elsanta’, ’Paula’, ‘Ostara’, ‘Teresa’, ‘Senga Sengana’, ‘Chandler’ and the breeding clone 1387 were examined and self-pollinated but only 5 of them developed second and third inbreeding generations.

The first self-pollination was performed in May 2004. Before flowering time inflorescences were covered with small bags made of cloth and left undisturbed for spontaneous selfing. 150 seedlings (S_1) derived from each of the cultivars (non-inbred progenies) were used in field trials on September 10, 2005.

In May 2006, the second self-pollination was performed. Twenty seedlings randomly chosen from the first-generation self were self-pollinated to generate the second-generation self (S_2). In 2008 some seedlings were retained from this populations and used as parents to obtain the third-generation self. Progeny S_3 marked with corresponding numbers was derived from the same S_2 parental plants.

In the years 2006, 2008 and 2010 the following indices were recorded: number of inflorescences, number of flowers per inflorescences, fruit yield per plant, fruit number per plant, average fruit weight, weight of leaves per plant and vitality of pollen. Data for growth and productivity traits were collected for individual plants (non-inbred control and inbreeding populations) throughout the season following the plantation establishment. Weight of leaves per plant was obtained on July 20, after harvest. Yields and fruit numbers were recorded for each plant for 4 consecutive weeks starting from the first week of June. Weight of the single fruit was calculated by dividing weekly yields by corresponding fruit numbers.

Pollen viability of 5 strawberry cultivars and their progenies was measured based on the grain colour. One day prior to flowering of each clone, 20 flowers were randomly collected and then microscopic preparations were made. Slides were coloured with 2% solution of acetocarmin and glicerin (1:1) and examined by use of the Olympus BX41 microscope under magnification 400 x. In any combination (the microscopic slide) were analyzed to 100 grains in 10 fields of vision. Pollen grains with 75–100% content of cytoplasm were taken as vital. The percentage data of pollen viability were transformed before analysis using the Bliss function Y = arcsine √p.

Inbreeding depression (ID) was assesses using means according to the following formula:

$$\text{ID for } S_1 = \frac{\overline{S}_0 - \overline{S}_1}{\overline{S}_0} \cdot 100$$

$$\text{ID for } S_2 = \frac{\overline{S}_0 - \overline{S}_2}{\overline{S}_0} \cdot 100$$

$$\text{ID for } S_3 = \frac{\overline{S}_0 - \overline{S}_3}{\overline{S}_0} \cdot 100$$

where: $\overline{S}_0$ – mean of S_0,
$\overline{S}_1$ – mean of S_1,
$\overline{S}_2$ – mean of S_2,
$\overline{S}_3$ – mean of S_3.

Data obtained were statistically evaluated with ANOVA (SAS System 9.1.3 software). Results were analysed statistically by means of two-way analysis of variance with use of the Duncan test at the significance level $\alpha = 0.05$. The Pearson's coefficient (CV%) was evaluated for the following traits: number of inflorescences, number of flowers per inflorescences, fruit yield per plant, fruit number per plant and weight of leaves per plant. Data presented in the tables are means for three seasons of the study.

RESULTS AND DISCUSSION

Seeds of 10 cultivars were obtained after the first self-pollination. However, the percentage of germinating seeds was very low – 6.8% on average, fluctuating from 0.9% to 18%. The percentage of mature plants obtained from the seedlings was also very low. Three cultivars including: 'Paula', 'Selva' and 'Ostara' gave no S_1 progeny.

The second self-pollination of ‘Elkat’ and ‘Elsanta’ cultivars resulted in the very small number of viable mature plants (9 and 13 individuals), so the number of initial genotypes was strongly reduced.

In this research inbreeding depression (ID) was found to occur in S_1 populations for the studied characters (tab. 1, 2, 3). Among other characters, three characters, namely vitality of pollen (ID = 40.7), yield per plant (ID = 52.5) and weight of leaves per plant (ID = 62.5) were affected the most.

In domestic strawberries fruit yield is among the traits the most affected through inbreeding and can be reduced by as much as 80% after two generations of self-fertilization [Spangelo et al. 1971, Shaw 1995, 1997].

In this experiment ID for fruit weight per plant decreased in successive inbreeding generations and amounted to 52.5 for S_1, 36.6 for S_2 and 22.0 for S_3 (tab. 2, 5, 8). Bellusci at al. [2009] indicates that the magnitude of trait mean depression depends on the rate at which homozygosity accumulates and the strength of selection pressure counteracting this depression. Additionally, it is supposed that reciprocal recurrent selection would give more viable and homogeneous inbred lines.

The magnitude of mean depression observed for the first-generation self in this study is consistent with results obtained from Żurawicz [1990], where strong inbreeding cultivar ‘Dukat’ caused a very strong reduction in yield compared to the families obtained through sibcrossing and mating non related parents.

As fruit yield per plant is concerned, it is worth mentioning that there was a considerable variability of this trait (a wide range observable for each cultivar). Most plants produced very small distorted fruits, the plants themselves were also more compact and smaller than the initial cultivars.

The experiments with strawberries have demonstrated significant and occasionally severe trait mean depression for populations of inbred offspring constructed from matings among current generation relatives; fruit yields decreased significantly even when rather modest rates of inbreeding were applied [Shaw 1995].

During three years of research (2006, 2008, 2010) inbred progenies showed higher variability in relation to the non-inbred control populations in terms of five studied traits, which shows the calculated coefficient of variation (CV %). However, the greatest differences in average fruit yield per plant were observed among individuals (CV about 60%) as shown in table 2, 5 and 8. This is consistent with the results obtained by Żurawicz [1990], where the calculated CV for ‘Dukat’ S_1 amounted to 59.4%.

A low depression was found for number of inflorescences and number of flowers per inflorescences (12.7% and 27.8% reduction for the third-generation selfs) (tab.7), and a larger depression was observed for pollen viability and fruit number per plant (35.0% and 44.5% reduction for the third-generation selfs) (tab. 7, 8).

ID for average weight of single fruit appeared at a similar level and equalled 29.6, 27.9 and 29.0 in S_1, S_2 and S_3, respectively.

Depression for weight of leaves per plant increased with rising F in S_1, S_2 and S_3, where inbreeding depression was ID = 62.5, ID = 66.2 and ID = 67.2 (tab. 3, 6, 9), respectively. The trends were similar to those reported earlier for the first-generation [Shaw 1995] and the second-generation inbred ones in the strawberry [Shaw 1997].

Table 1. Comparison of yield components of S_0 and S_1 progeny and inbreeding depression in S_1 generation
Tabela 1. Porównanie cech plonotwórczych potomstwa S_0 i S_1 oraz depresja wsobna w pokoleniu S_1

Cultivar /S_1 Odmiana/S_1	Number of inflorescences Liczba kwiatostanów					Number of flowers per inflorescences Liczba kwiatów w kwiatostanie					Pollen viability% Żywotność pyłku %		
	mean S_0 średnia S_0	CV** %	mean S_1 średnia S_1	CV%	depression (ID) depresja	mean S_0 średnia S_0	CV%	mean S_1 średnia S_1	CV%	depression (ID) depresja	viable pollen S_0 pyłek żywotny S_0	viable pollen S_1 pyłek żywotny S_1	depression (ID) depresja
S. Sengana	8.55ab*	41.3	6.07a	67.1	29.0	8.46a	37.0	6.73a	35.6	20.5	40.09cd	17.75c	55.7
Teresa	8.30abc	31.0	6.24a	44.6	24.8	7.60a	14.4	6.90a	27.1	9.2	33.83d	19.18c	43.3
Kent	6.23bc	41.0	6.80a	46.7	-9.1	7.05a	21.9	6.83a	23.8	3.1	45.72bc	19.56c	57.2
Chandler	6.11c	32.2	7.56a	49.7	-23.7	7.51a	19.5	7.54a	67.9	-0.4	51.98ab	43.70a	15.9
Klon 1387	8.94a	27.9	8.51a	63.4	4.8	8.03a	19.8	7.20a	20.2	10.3	56.74a	38.81a	31.6
Mean – Średnio	7.63ABC	34.7	7.04A	54.3	5.16	7.73A	22.5	7.04A	34.9	8.5	45.67BC	27.80B	40.7
LSD – $NIR_{p<0.05}$	2.41		3.11			2.38		2.78			7.58	7.51	

*The means followed by the same letters do not differ at $\alpha = 0.05$ – Średnie oznaczone tymi samymi literami nie różnią się istotnie przy $\alpha = 0,05$
**Coefficient of variation (CV) – Współczynnik zmienności

Table 2. Means, coefficient of variation (CV%) for cultivars and S_1 progeny and inbreeding depression in S_1 generation
Tabela 2. Średnie wartości cech, współczynnik zmienności (CV%) dla odmian i potomstwa S_1 oraz depresja wsobna w pokoleniu S_1

Cultivar /S_1 Odmiana/S_1	Fruit yield per plant (g) Plon owoców z rośliny (g)					Number of fruit per plant Liczba owoców z rośliny				
	mean S_0 średnia S_0	CV** %	mean S_1 średnia S_1	CV%	depression (ID) depresja	mean S_0 średnia S_0	CV%	mean S_1 średnia S_1	CV%	depression (ID) depresja
Senga Sengana	290.31c*	50.7	140.65bc	68.4	51.5	46.43b	35.1	26.91a	51.4	42.0
Teresa	470.45a	39.8	165.90ab	59.0	64.7	45.90b	40.5	34.38a	48.0	25.1
Kent	250.04c	52.3	120.33c	60.1	51.9	50.35b	33.4	25.26a	44.6	49.8
Chandler	190.50d	45.7	130.52c	62.6	31.5	30.37c	42.8	35.50a	39.7	-16.9
Klon 1387	510.68a	49.0	189.07a	56.8	63.0	63.79a	28.0	35.97a	67.2	43.6
Mean – Średnio	342.40B	47.5	149.29BC	61.4	52.5	47.37B	36.0	31.60A	50.2	28.7
LSD – $NIR_{p<0.05}$	53.32		35.95			10.29		13.71		

*The means followed by the same letters do not differ at $\alpha = 0.05$ – Średnie oznaczone tymi samymi literami nie różnią się istotnie przy $\alpha = 0,05$
** Coefficient of variation (CV) – Współczynnik zmienności

Table 3. The means and inbreeding depression in S_1 progeny in terms of weight of leaves per plant and weight of the single fruit
Tabela 3. Średnie wartości cech oraz depresja wsobna w potomstwie S_1 pod względem masy liści i masy pojedynczego owocu

Cultivar /S_1 Odmiana/S_1	Weight of leaves per plant (g) Masa liści z rośliny (g)					Weight of fruit (g) Masa pojedynczego owocu (g)		
	mean S_0 średnia S_0	CV** %	mean S_1 średnia S_1	CV** %	depression (ID) depresja	mean S_0 średnia S_0	mean S_1 średnia S_1	depression (ID) depresja
Senga Sengana	125.04ab*	30.6	56.80ab	48.5	54.6	6.27b	5.16a	17.7
Teresa	144.57a	38.6	46.44abc	44.5	67.9	10.08a	6.45a	36.0
Kent	90.60c	41.7	27.93c	55.0	69.2	6.90b	4.60a	33.3
Chandler	105.33bc	32.4	35.91bc	46.4	65.9	6.14b	3.61a	41.2
Klon 1387	134.25ab	40.0	60.62a	54.2	54.8	7.01b	5.62a	19.8
Mean – Średnio	119.96AB	36.6	45.54ABC	49.7	62.5	7.28B	5.09A	29.6
LSD – $NIR_{p<0.05}$	31.13		21.66			2.80	3.85	

*The means followed by the same letters do not differ at α = 0.05 – Średnie oznaczone tymi samymi literami nie różnią się istotnie przy α = 0,05
** Coefficient of variation (CV) – Współczynnik zmienności

Table 4. Comparison of yield components of S_0 and S_2 progeny and inbreeding depression in S_2 generation
Tabela 4. Porównanie cech plonotwórczych potomstwa S_0 i S_2 oraz depresja wsobna w pokoleniu S_2

Cultivar /S_2 Odmiana/S_2	Number of inflorescences Liczba kwiatostanów					Number of flowers per inflorescences Liczba kwiatów w kwiatostanie					Pollen viability % Żywotność pyłku %		
	mean S_0 średnia S_0	CV** %	mean S_2 średnia S_2	CV%	depression (ID) depresja	mean S_0 średnia S_0	CV%	mean S_2 średnia S_2	CV%	depression (ID) depresja	viable pollen S_0 pyłek żywotny S_0	viable pollen S_2 pyłek żywotny S_2	depression (ID) depresja
S. Sengana	11.30a*	34.2	8.48ab	54.2	24.9	6.67ab	21.8	3.30b	25.6	50.5	52.34ab	20.71b	60.4
Teresa	14.75a	35.6	9.29a	42.1	37.0	8.57a	27.5	6.08a	32.7	29.0	51.60ab	29.75ab	42.3
Kent	12.35a	26.1	6.97ab	63.4	43.6	4.95b	26.0	3.68b	27.7	25.6	40.55b	32.30ab	20.3
Chandler	13.62a	25.9	9.40a	38.0	31.0	5.50ab	28.3	5.06ab	28.1	8.0	56.02a	45.82a	18.2
Klon 1387	11.05a	37.2	6.54b	55.3	40.8	6.03ab	18.7	4.10ab	29.2	32.0	60.79a	44.67a	26.5
Mean – Średnio	12.61A	31.8	8.14AB	50.6	35.5	6.34AB	24.5	4.44AB	28.7	29.0	52.26AB	34.65AB	33.5
LSD – $NIR_{p<0.05}$	4.25		2.78			3.59		2.41			12.84	14.42	

*The means followed by the same letters do not differ at α = 0.05 – Średnie oznaczone tymi samymi literami nie różnią się istotnie przy α = 0,05
** Coefficient of variation (CV) – Współczynnik zmienności

Table 5. Means, coefficient of variation (CV%) for cultivars and S_2 progeny and inbreeding depression in S_2 generation
Tabela 5. Średnie wartości cech, współczynnik zmienności (CV%) dla odmian i potomstwa S_2 oraz depresja wsobna w pokoleniu S_2

Cultivar /S_2 Odmiana/S_2	Fruit yield per plant (g) Plon owoców z rośliny (g)					Number of fruit per plant Liczba owoców z rośliny				
	mean S_0 średnia S_0	CV** %	mean S_2 średnia S_2	CV%	depression (ID) depresja	mean S_0 średnia S_0	CV%	mean S_2 średnia S_2	CV%	depression (ID) depresja
S. Sengana	242.25b*	56.4	101.48bc	65.0	58.1	56.25ab	29.6	64.31a	52.1	-14.3
Teresa	301.00a	40.7	184.35a	55.3	38.5	65.45a	37.8	59.80ab	49.7	8.6
Kent	129.07c	45.0	86.29c	60.1	33.1	40.70b	24.0	40.02c	56.2	1.67
Chandler	124.68c	38.9	107.08bc	59.6	14.1	39.12b	39.7	51.13b	50.6	-30.7
Klon 1387	192.50b	42.9	116.78b	61.4	39.3	56.30ab	34.3	54.02b	55.0	4.05
Mean – Średnio	210.29B	44.8	119.19B	60.3	36.6	51.56AB	33.1	53.86B	52.7	-6.1
LSD – $NIR_{p<0.05}$	57.40		27.84			21.66		9.94		

*The means followed by the same letters do not differ at α = 0.05 – Średnie oznaczone tymi samymi literami nie różnią się istotnie przy α = 0,05
** Coefficient of variation (CV) – Współczynnik zmienności

Table 6. The means and inbreeding depression in S_2 progeny in terms of weight of leaves per plant and weight of the single fruit
Tabela 6. Średnie wartości cech oraz depresja wsobna w potomstwie S_2 pod względem masy liści i masy pojedynczego owocu

Cultivar /S_2 Odmiana/S_2	Weight of leaves per plant (g) Masa liści z rośliny (g)					Weight of fruit (g) Masa pojedynczego owocu (g)		
	mean S_0 średnia S_0	CV** %	mean S_2 średnia S_2	CV%	depression (ID) depresja	mean S_0 średnia S_0	mean S_2 średnia S_2	depression (ID) depresja
S. Sengana	125.65b*	39.8	54.90a	60.2	56.3	5.42a	3.58a	33.9
Teresa	207.33a	40.5	46.88ab	35.8	77.4	6.58a	5.08a	22.8
Kent	98.07b	33.1	43.07ab	59.7	56.1	5.16a	4.16a	19.4
Chandler	105.87b	41.0	35.50b	53.0	66.5	5.76a	4.04a	29.9
Klon 1387	120.60b	49.9	30.67b	64.3	74.6	6.30a	4.18a	33.6
Mean – Średnio	131.50B	32.9	42.20AB	54.6	66,2	5.84A	4.21A	27.9
LSD – $NIR_{p<0.05}$	37.74		17.99			2.42	1.52	

*The means followed by the same letters do not differ at α = 0.05 – Średnie oznaczone tymi samymi literami nie różnią się istotnie przy α = 0,05
** Coefficient of variation (CV) – Współczynnik zmienności

Table 7. Comparison of yield components of S_0 and S_3 progeny and inbreeding depression in S_3 generation
Tabela 7. Porównanie cech plonotwórczych potomstwa S_0 i S_3 oraz depresja wsobna w pokoleniu S_3

Cultivar /S_3 Odmiana/S_3	Number of inflorescences Liczba kwiatostanów					Number of flowers per inflorescences Liczba kwiatów w kwiatostanie					Pollen viability % Żywotność pyłku %		
	mean S_0 średnia S_0	CV** %	mean S_3 średnia S_3	CV%	depression (ID) depresja	mean S_0 średnia S_0	CV%	mean S_3 średnia S_3	CV%	depression (ID) depresja	viable pollen S_0 pyłek żywotny S_0	viable pollen S_3 pyłek żywotny S_3	derpession (ID) depresja
S. Sengana/(17)	10.70ab*	45.1	8.36bc	43.4	21.9	6.89b	27.7	3.10b	29.6	55.0	51.35ab	35.91a	30.1
Teresa/(18)			7.93bc	45.2	10.5			4.85ab	25.1	48.0			
Teresa/(21)	8.86ab	32.7	4.24d	31.3	52.1	9.33a	24.5	5.43a	42.7	41.8	54.30ab	32.30ab	40.5
Teresa/(25)			9.30abc	42.6	-5.0			6.51a	36.1	30.2			
Kent/(7)	6.66b	43.7	6.51cd	58.8	2.2	5.80b	25.0	4.80ab	29.0	17.2	37.28b	36.25a	2.8
Chandler/(122)	9.55ab	29.2	11.61a	37.8	-21.6	5.37b	20.3	5.11a	18.4	4.5	50.39ab	22.64c	55.1
Chandler/(123)			8.30bc	52.2	13.1			5.60a	31.7	-4.3			
Klon 1387/(35)	14.00a	32.8	10.05ab	47.1	28.2	6.98b	18.0	4.86ab	25.5	30.4	58.22a	29.04b	46.3
Mean – Średnio	9.95AB	36.7	8.29BC	44.8	12.7	6.87B	23.1	5.03A	24.9	27.8	50.31AB	31.23B	35.0
LSD – $NIR_{p<0.05}$	5.62		3.08			2.10		1.96			17.72	4.47	

*The means followed by the same letters do not differ at $\alpha = 0.05$ – Średnie oznaczone tymi samymi literami nie różnią się istotnie przy $\alpha = 0,05$
** Coefficient of variation (CV) – Współczynnik zmienności

Table 8. Means, coefficient of variation (CV%) for cultivars and S_3 progeny and inbreeding depression in S_3 generation

Tabela 8. Średnie wartości cech, współczynnik zmienności (CV%) dla odmian i potomstwa S_3 oraz depresja wsobna w pokoleniu S_3

Cultivar /S_3 Odmiana/S_3	Fruit yield per plant (g) – Plon owoców z rośliny (g)					Number of fruit per plant – Liczba owoców z rośliny				
	mean S_0 średnia S_0	CV** %	mean S_3 średnia S_3	CV%	depression (ID) depresja	mean S_0 średnia S_0	CV%	mean S_3 średnia S_3	CV%	depression (ID) depresja
S. Sengana/(17)	139.87bc*	60.9	72.32f	60.5	48.3	42.66b	33.7	14.23de	49.0	66.6
Teresa/(18)			90.40e	46.5	54.2			17.70cde	46.4	65.5
Teresa/(21)	197.20a	47.0	68.32f	64.1	65.4	51.30a	38.1	11.34e	59.9	77.9
Teresa/(25)			153.27a	47.7	22.3			26.20b	42.3	48.9
Kent/(7)	128.17b	44.7	118.44cd	63.3	7.6	46.53ab	10.4	24.53bc	48.9	47.3
Chandler/(122)	117.00c	39.8	144.70ab	66.6	- 23.7	33.50c	47.7	40.61a	55.5	- 21.2
Chandler/(123)			134.22bc	56.1	- 14.7			28.07b	53.2	16.2
Klon 1387/(35)	152.69b	51.4	127.80cd	60.7	16.3	44.12ab	24.7	20.11bcd	51.1	54.4
Mean – Średnio	146.99BC	48.8	113.68D	58.2	22.0	43.62B	30.9	22.85BC	50.8	44.5
LSD – $NIR_{p<0.05}$	35.76		18.29			7.75		8.69		

*The means followed by the same letters do not differ at α = 0.05 – Średnie oznaczone tymi samymi literami nie różnią się istotnie przy α = 0,05

** Coefficient of variation (CV) –Współczynnik zmienności

Table 9. The means and inbreeding depression in S_3 progeny in terms of weight of leaves per plant and weight of the single fruit

Tabela 9. Średnie wartości cech oraz depresja wsobna w potomstwie S_3 pod względem masy liści i masy pojedynczego owocu

Cultivar /S_3 Odmiana/S_3	Weight of leaves per plant (g) – Masa liści z rośliny (g)					Weight of fruit (g) – Masa pojedynczego owocu (g)		
	mean S_0 średnia S_0	CV** %	mean S_3 średnia S_3	CV%	depression (ID) depresja	mean S_0 średnia S_0	mean S_3 średnia S_3	depression (ID) depresja
S.Sengana/(17)	106.87bc	42.5	34.01bc	53.8	68.2	6.17bc	5.07ab	17.8
Teresa/(18)			47.73a	29.6	72.3		5.45ab	39.6
Teresa/(21)	172.50a	34.4	30.35cd	42.4	82.4	9.02a	6,29a	30.3
Teresa/(25)			47.06a	33.4	72.7		5.90ab	34.6
Kent/(7)	75.00c	24.0	38.24b	66.2	49.0	8.07a	4.71ab	41.6
Chandler/(122)	88.33bc	43.1	27.90d	96.1	68.4	5.12c	3.47b	32.2
Chandler/(123)			44.13a	34.4	50.0		5.60ab	- 9.4
Klon 1387/(35)	133.33ab	50.8	33.56bc	68.3	74.8	8.89a	4.87ab	45.2
Mean – Średnio	115.21BC	38.9	37.87B	53.0	67.2	7.45AB	5.17AB	29.0
LSD – $NIR_{p<0.05}$	55.98		5.64			2.33	2.53	

*The means followed by the same letters do not differ at α = 0.05 – Średnie oznaczone tymi samymi literami nie różnią się istotnie przy α = 0,05

** Coefficient of variation (CV) – Współczynnik zmienności

Among the studied genotypes, inbred progenies of ‘Chandler’ were distinguished through another reaction to the selfing – there was an increase in number of inflorescences per plant (in S_1, S_3), number of flowers per inflorescences (in S_1, S_3), yield of fruits (in S_3), number of fruits per plant (in S_1, S_2 and S_3).

Hulewicz and Hortyński [1972] claim that fruit development in strawberries is strictly dependent on the number of fertilized ovules, which stimulate the receptacle to develop around the growing seed by way of secreting substances. The degree of self-compatibility in different cultivars of the strawberry is largely variable and so is their pollen fertility. Good pollen viability is of great importance in culturing strawberries under glasshouse conditions, in which number of pollinating insects is very limited. In current evaluations average pollen vitality values in parental plants ranging from 45.7% to 52.3% and inbreeding depression for this trait ranged from 33.5 in S_2, to 40.7 in S_1 as shown in table 1, 4 and 7.

Fragaria × *ananassa* (2n = 2x = 56) is a complex polyploidy with multiple independent genomes, because it is a hybrid produced from a cross between the two New World octoploid strawberry species, *F. chiloensis* and *F. virginiana.* From allo-autopolyploidy nature may be due high sensitivity of this species for inbreeding.

Different cross combinations were tested for developing high yielding hybrid strawberry cultivars and some of them were found to be promising. The strawberry, traditionally, is vegetatively multiplied species and therefore, the obtained F_1 hybrids may become the initial forms for new cultivars.

To sum up, it is concluded that the response of the strawberry to repeated inbreeding does not differ from that of other plant species because the mechanisms (*i. e.* the partial dominance and/or overdominance hypotheses) that contribute to inbreeding depression are universal.

CONCLUSIONS

1. After the first and the second self-pollination, plant viability decreased considerably, which made developing progeny practically impossible in case of many genotypes.

2. Some of the tested cultivars, namely: ‘Paula’, ‘Selva’ and ‘Ostara’ produced no viable S_1 plants. Others such as ‘Elkat’ and ‘Elsanta’ gave no S_2 progeny.

3. Average fruit yield per plant in inbred lines of strawberry appeared to be much lower than that of the standard cultivars (inbreeding depression for this trait decreased in successive inbreeding generations and amounted to 52.5 for S_1, 36.6 for S_2 and 22.0 for S_3).

4. As a result of strong inbreeding, weight of leaves per plant in S_1, S_2 and S_3 was affected the most (inbreeding depression ID = 62.5, ID = 66.2 and ID = 67.2, respectively).

5. The greatest variability among the tested traits in the inbred generations was observed in terms of fruit yield per plant.

6. The percentage of viable pollen in subsequent inbred generations (S_1, S_2 and S_3) was lower as compared with the parental forms.

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DEPRESJA WSOBNA POD WZGLĘDEM PLONU I CECH PLONOTWÓRCZYCH U *Fragaria* × *ananassa* Duch.

Streszczenie. U roślin depresję inbredową szacuje się, porównując żywotność pojedynków uzyskanych poprzez samozapylenie z pojedynkami krzyżującymi się swobodnie. W pracy badano wpływ chowu wsobnego na plon owoców i cechy plonotwórcze u truskawki (*Fragaria* × *ananassa* Duch.). Doświadczenia zostały przeprowadzone w latach 2004–2010 w Gospodarstwie Doświadczalnym UP w Felinie. Badano 10 odmian truskawki: ‘Kent’, ‘Selva’, ‘Elkat’, ‘Elsanta’, ’Paula’, ‘Ostara’, ‘Teresa’, ‘Senga Sengana’, ‘Chandler’ i klon hodowlany 1387, które samozapylano w celu uzyskania kolejnych potomstw wsobnych: S_1, S_2 i S_3. Po dwóch kolejnych cyklach samozapylenia znaczna część siewek S_1 i S_2, wywodzących się od 5 odmian, zamarła na skutek silnego spadku wigoru. Pięć pozostałych odmian zróżnicowanych pod względem pochodzenia, o współczynniku wsobności (F) przyjętym jako zero (F = 0), porównywano z trzema pokoleniami wsobnymi o spodziewanym współczynniku wsobności F = 0,5 (S_1), F = 0,75 (S_2) i F = 0,87 (S_3). Efekty różnego poziomu wsobności oszacowano dla następujących cech: liczby kwiatostanów, liczby kwiatów w kwiatostanie, plonu owoców z rośliny, liczby owoców z rośliny, średniej masy owocu, masy liści z rośliny i żywotności pyłku. U potomstwa stwierdzono zarówno dodatnią, jak i ujemną depresję wsobną pod względem badanych cech. Depresja inbredowa w pokoleniach S_1, S_2 oraz S_3 najsilniej przejawiła się pod względem masy liści z rośliny (wynosiła ona odpowiednio: ID = 62,5; ID = 66,2 i ID = 67,2). W pokoleniu S_2 średnia liczba owoców z rośliny zwiększyła się w stosunku do S_0 o 6,1%. W kolejnych pokoleniach wsobnych zmniejszył się poziom depresji pod względem średniej masy owoców z rośliny i wynosił odpowiednio: 52,5 w S_1; 36,6 w S_2 oraz 22,0 w $S_{3.}$

Słowa kluczowe: ID, truskawka, plon owoców, chów wsobny

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