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EVALUATION OF THE GENETIC CONTROL, HERITABILITY AND CORRELATIONS OF SOME QUANTITATIVE CHARACTERS IN STRAWBERRY (*Fragaria* × *ananassa* Duch.)

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Abstract. The material for the study consisted of F_1 hybrid populations derived from crosses among strawberry genotypes such as: 'Calypso', 'Evita', 'Ostara', 'Selva' and 'Senga Sengana'. The crosses were conducted in a complete diallel design in accordance with Griffing's first method. In the analysed model, 8 quantitative characters such as: time of flowering and ripening, number of inflorescences, flowers per inflorescence, crowns and fruits as well as yield and average fruit weight were assessed. The obtained results showed that for the majority of analysed traits a considerable role is played by non-additive genetic effects except for ripening time, for which additive genetic effects were essential. Heritability coefficients of broad sense were very high in almost all cases, whereas ones of narrow sense were low for most characters. Yield was positively correlated with number of fruits, inflorescences and crowns.

Key words: diallel cross, correlation coefficient, heritability, quantitative characters

INTRODUCTION

A strawberry remains still very important fruit species and Poland is considered to be one of their major producers. However, it is worth mentioning that high production of these species is mainly the result of huge cultivation acreage and not of efficiency per area unit. First of all, plantations should be run in a modern way to change this situation. Moreover, conducting breeding studies, which aim at obtaining new cultivars, may be also helpful. Such cultivars should be fully adapted to natural conditions in Poland and at the same time they should constitute a guarantee of acquiring high quality fruits. Achieving the planned breeding purpose may be easier if one has an insight into genetic

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factors of individual plant characteristics. This knowledge is of importance in terms of breeding method choice and conducting selection works.

The aims of the following paper were to find the genetic actions determining some quantitative traits of a strawberry, to reveal relationships between them and to estimate coefficients of heritability.

MATERIAL AND METHODS

In the experiment hybrid populations F_1, which came from the complete diallel design conducted in accordance with Griffing's [1956] first method, were used. This model included the following strawberry cultivars: 'Calypso', 'Evita',' Ostara', 'Selva' and 'Senga Sengana'. Each of 25 hybrid combinations was planted three times, 25 plants each time and it was assessed in terms of such characteristics as: time of flowering and fruit ripening, number of inflorescences, flowers per inflorescence, crowns and fruits as well as yield and average fruit weight during two subsequent vegetation periods in years 2000–2001. Calculations were done on the basis of average values from both years of research and allow to estimate genetic, genotypic and environmental variations as well as the variation caused by additive and non-additive genetic effects. Two – year results were also the basis to determine coefficients of phenotypic correlation and coefficients of heritability in broad (h^2_l) and narrow sense (h^2_s).

RESULTS AND DISCUSSION

As a result of the conducted studies, it was found that non-additive action of genes influenced the analysed traits more than additive one (tab. 1). For the majority of traits, the level of variability caused by non – additive genetic effects in comparison with the whole genetic variability was very high and fluctuated between 0.68 for number of crowns and 0.97 for number of flowers per inflorescence. Only in case of fruit ripening time, the high level of additive genetic effects was revealed. Hortyński [1987], while examining the way of genetic control of some strawberry traits, acquired non – additive genetic effects on the level of 0.78 for yield in the first year of fruit bearing and even up to 1.00 in the second one. He acquired respectively 0.63 and 0.70 for weight of individual fruit and 0.70 and 0.90 for number of inflorescences. Whereas in terms of fruit ripening time, the above mentioned author obtained higher level of non – additive genetic effects than in the presented paper. By contrast, crosses between traditional cultivars with repeating fruit bearing and genotypes *Fragaria virginiana* Duch. conducted by Hancock et al. [2002] showed the high importance of the GCA effects in relation to number of fruits. Because of that, it should be assumed that this characteristic is mainly determined by additive genes. The use of breeding clones *F. virginiana* is to be perceived as the reason of different determinants of this trait compared to the results acquired in the following paper.

Table 1. Estimates of variance components for the analysed traits
Tabela 1. Oszacowania komponentów wariancyjnych dla badanych cech

Traits – Cecha	Variance components* – Komponenty wariancyjne*					
	σ^2_A	σ^2_{NA}	σ^2_G	σ^2_P	σ^2_E	σ^2_{NA}/σ^2_G
Time of flowering Termin kwitnienia	0.08	0.68	0.76	1.20	0.44	0.89
Time of ripening Termin dojrzewania	6.32	0.24	6.56	8.18	1.62	0.04
Number of inflorescences Liczba kwiatostanów	13.88	48.84	62.72	66.75	4.03	0.78
Number of flowers per inflorescence Liczba kwiatów w kwiatostanie	0.03	1.28	1.31	2.52	1.21	0.97
Number of crowns Liczba koron	8.96	19.12	28.08	34.44	6.36	0.68
Number of fruits Liczba owoców	65.00	353.7	418.7	435.3	16.5	0.84
Yield Plon owoców	2183.1	23897.6	26080.7	26934.7	854.0	0.91
Average fruit weight Średnia masa owoców	1.72	5.50	7.22	8.93	1.71	0.76

* – σ^2_A – additive variance – wariancja addytywna, σ^2_{NA} – non-additive variance – wariancja nieaddytywna,
σ^2_G – genetic variation – wariancja genetyczna, σ^2_P – phenotypic variation – wariancja fenotypowa,
σ^2_E – environmental variation – wariancja środowiskowa,
σ^2_{NA}/σ^2_G – ratio of non-additive variaton to genetic one – stosunek wariancji nieaddytywnej do genetycznej

Table 2. Heritability in broad (h^2_l) and narrow (h^2_s) sense in terms of analyzed characters
Tabela 2. Odziedziczalność w szerokim (h^2_l) i wąskim (h^2_s) zakresie analizowanych cech

Heritability Odziedziczalność	Traits* – Cecha*							
	1	2	3	4	5	6	7	8
h^2_l	0.63	0.80	0.94	0.52	0.81	0.96	0.97	0.81
h^2_s	0.07	0.77	0.21	0.01	0.26	0.15	0.08	0.20

* – analysed traits according table 1
* – analizowane cechy według tabeli 1

The very high values of coefficient of heritability (in broad sense) obtained for the majority of analysed characteristics prove high participation of genetic factors in their determination and low impact of environmental conditions on their expression (tab. 2). Only in relation to time of flowering and number of flowers per inflorescence, this coefficient was a bit lower. The values of coefficients of heritability in broad sense were substantially higher than of these coefficients in narrow sense. It indicates the significant role of non – additive genetic effects in inheriting the group of analysed traits besides time of ripening, which stays under the control of additive genes. The papers of such authors as Barrit et al. [1982], Hortyński [1989], Coman and Popescu [1997], Simpson [2002], Masny et al. [2005] indicate the changeable participation of additive and non – additive genetic effects in determining the individual strawberry traits. The divergence of estimation may result from the fact that the quoted researchers analysed diverse parental forms obtained from different crossing models.

Table 3. Phenotypic correlation coefficients of some quantitative strawberry traits
Tabela 3. Fenotypowe współczynniki korelacji dla niektórych cech ilościowych truskawki

Traits – Cecha	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Time of flowering X_1 Termin kwitnienia X_1	1.00							
Time of ripening X_2 Termin dojrzewania X_2	0.73*	1.00						
Number of inflorescences X_3 Liczba kwiatostanów X_3	0.07	0.07	1.00					
Number of flowers per inflorescence X_4 Liczba kwiatów w kwiatostanie X_4	-0.28*	-0.19*	-0.14	1.00				
Number of crowns X_5 Liczba koron X_5	0.09	0.11	0.62*	0.04	1.00			
Number of fruits X_6 Liczba owoców X_6	-0.18*	-0.15	0.48*	0.22*	0.38*	1.00		
Yield X_7 Plon owoców X_7	-0.06	-0.06	0.46*	0.12	0.33*	0.80*	1.00	
Average fruit weight X_8 Średnia masa owoców X_8	0.07	0.05	0.00	-0.05	-0.02	-0.08	0.28*	1.00

* Significant at the level $\alpha = 0.05$
* Istotne na poziomie istotności $\alpha = 0,05$

Relationships between the analysed traits (tab. 3) explicitly show that yield was correlated with number of fruits to the greatest extent. The moderate positive correlation between yield and number of inflorescences and crowns was also found. This relationship was emphasised by Shokaeva [2004] in her paper. On the one hand, it means that promoting the vegetative plant growth may influence their yield positively, which is confirmed by relationships between the mentioned characteristics observed by Hortyński [1987, 1989] as well as Nicoll and Galletta [1987]. On the other hand, strong vegetative growth expressed through many stolons may also weaken yield, which is also emphasized by the above mentioned authors. Correlations between average fruit weight and other traits appeared to be insignificant except for minor positive correlation between this trait and yield. The high positive correlation was acquired between time of flowering and fruit ripening time, whereas even its higher level was observed by Żurawicz [1990] in his research.

CONCLUSIONS

1. The inheritance of such traits as: number of flowers per inflorescence, yield, time of flowering, number of fruits and inflorescences is mainly influenced by non – additive genetic effects. Whereas, fruit ripening time remains under the control of additive genetic effects.

2. The acquired values of coefficient of heritability in broad sense indicate the high impact of genetic factors in determining phenotypic variability of the analysed traits. While the relatively low level of heritability in narrow sense for the group of evaluated traits except for fruit ripening time confirms the predominating impact of non – additive genetic effects on their expression.

3. The selection of high fertile strawberry cultivars may be indirectly based on number of fruits because of the high correlation coefficient between these traits. At the same time, lack of close relationship between the majority of other characteristics gives a chance to select new clones independently in direction of each of the traits.

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OCENA GENETYCZNEGO UWARUNKOWANIA NIEKTÓRYCH CECH ILOŚCIOWYCH, ODZIEDZICZALNOŚCI I KORELACJI U TRUSKAWKI (*Fragaria × ananassa* Duch.)

Streszczenie. Materiał badawczy stanowiły mieszańce pierwszego pokolenia (F_1) pochodzące z krzyżowań przeprowadzonych pomiędzy czterema odmianami truskawki: ‘Calypso’, Evita’, ‘Ostara’, ‘Selva’ i ‘Senga Sengana’. Krzyżowania przeprowadzono w kompletnym układzie dialleliczym według pierwszej metody Griffinga. Analizie poddano

8 cech ilościowych truskawki, takich jak: termin zakwitania roślin i dojrzewania owoców, liczbę kwiatostanów i kwiatów w kwiatostanie, liczbę koron, owoców, a także plon owoców i średnią masę pojedynczego owocu. Uzyskane wyniki wskazują na nieaddytywne oddziaływanie genów na większość analizowanych cech poza terminem dojrzewania, dla którego istotne były efekty addytywnego działania genów. W większości przypadków wartości współczynnika odziedziczalności sensu lato były wysokie, natomiast współczynnika sensu stricte niskie. Plon owoców był istotnie dodatnio skorelowany z liczbą owoców, kwiatostanów i koron.

Słowa kluczowe: krzyżowanie dialleliczne, współczynnik korelacji, odziedziczalność, cechy ilościowe

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