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Combining Ability Effects in the Progeny of Male Sterile Strawberry – (*Fragaria x ananassa* Duch.)

Efekty zdolności kombinacyjnej w potomstwie męsko niepłodnej truskawki (*Fragaria x ananassa* Duch.)

Abstract. Combining ability effects in the progeny of three pollen sterile strawberry clones `*74 Ms*`, `*116 Ms*` and `*150 Ms*` were estimated. Maternal clones were crossed with eleven pollen fertile paternal components. In the obtained progenies the highest positive **GCA** effects concerning the yield per plant and the mean weight of single fruit was observed in the progenies of maternal clone `*150 Ms*`. The lowest negative **GCA** effects were estimated in the progenies of maternal clone `*74 Ms*`. Combining ability of the maternal clone `*116 Ms*` displayed a half lower value in comparison to the combining ability of clone `*150 Ms*`. Cv.`*Senga Sengana*` was the best paternal component for crossing with the clone `*150 Ms*` as for the inheritance of yielding. Cv.`*Dukat*` was the best paternal form for crossing with that maternal clone concerning the inheritance of the size of fruits.

Key words – słowa kluczowe: male sterile strawberry – męsko niepłodna truskawka, general combining ability **GCA** – ogólna zdolność kombinacyjna, specific combining ability **SCA** – specyficzna zdolność kombinacyjna, yield components – struktura plonu, crossing – krzyżowanie, progeny – potomstwo

INTRODUCTION

The phenomenon of pollen sterility in plants became of a great interest to breeders when the heterosis had been used in conventional breeding (Gajewski, 1972). Male sterility can be recognized as emasculation caused by genetic factors. Pollen sterility is determined by the cytoplasmic genes (cytoplasmic male sterility), nuclear genes (nuclear male sterility) or by nucleo-cytoplasmic gene

interaction (nucleo-cytoplasmic male sterility) (Hoffmann et al.,1985). This phenomenon creates the possibility for heterotic hybrid breeding of many crops with flowers very small or difficult for emasculation. Lines with nucleo-cytoplasmic male sterility were used in the heterotic hybrid breeding of onion (Kobabe, 1971), carrot and sugar beet. Male sterility is also observed in fruit crops, e.g. in the *Fragaria* genus. Inheritance of this phenomenon was examined in the *Fragaria vesca* (Irkajewa et al., 1993). The studies showed that the male sterility had been determined by two nuclear recessive alleles $m_s m_s$. Recessive male sterile forms crossed with heterozygous male fertile pollinators resulted in the progeny segregating in two phenotypic groups with the proportion of 50% of male sterile forms to 50% of male fertile forms. According to Bauer (1960), the crossing of different parental forms is the best method of creative breeding. The high genetic diversity in the obtained progeny is the best source for effective selection. Individual appropriate plant selection and their vegetative propagation defines the clonal selection, which is the main method of breeding in the strawberry (Darrow ,1966; Hoffmann et al.,1985; Hortyński, 1981,1987).

MATERIAL AND METHOD

The aim of the experiment was to assess the combining ability effects of three pollen sterile maternal strawberry clones which were crossed with eleven paternal forms. The combining ability effects were assessed on the basis of the breeding value of 33 obtained hybrid progenies. The crossing programme was carried out according to factorial design defined as North Carolina II (Ubysz-Borucka et al.,1985). The effects of general combining ability (**GCA**) and specific combining ability (**SCA**) of parental components were evaluated. Plants of hybrid progenies were planted in the field in the spacing 70x40 cm, 10 plants per plot in three replicates. Only hybrid progenies including minimum 10 plants were precisely assessed. The total number of analyzed individual plants was 477 and they belonged to 20 hybrid progenies. The GCA and SCA effects were evaluated for the yield components, i.e. the mean yield per plant (g) and mean weight of single fruit (g).

RESULTS AND DISCUSSION

The yielding of hybrid progenies was low. The obtained value was below 300 g per plant (tab.1). Nevertheless, this value differed between parental combinations. The highest yielding was observed in the progeny of clone *`150 Ms`*, slightly lower in the progeny of clone *`116 Ms`*, and the lowest in the progeny of clone *`74 Ms`*. The estimation of yielding among paternal groups revealed several forms where the yielding of the obtained progenies exceeded the value of 300 g per plant. There were clones *`B-302`*, *`Purpuratka $S_1$`*, *`Górny Śląsk $S_1$`*

Tab.1. Mean yield per plant (g) in the progeny of male sterile strawberry clones

Paternal components	Male sterile maternal clones 1)74 Ms	2) 116 Ms	3) 150 Ms	Total mean
1) Revada S_1	198.3	153.7	262.0	204.6
2) Redgauntlet	112.2	308.9	322.0	247.7
3) Purpuratka S_1	179.0			179.0
4) 3040	286.0		334.4	310.2
5) Senga Sengana		192.0	347.6	269.8
6) Górny Śląsk S_1		329.0		329.0
7) Purpuratka S_3		371.0	361.3	366.1
8) B-302	184.6	559.0		371.8
9) Dukat		206.4	245.6	226.0
10) Felina S_1		218.3		218.3
11) Solana S_1		300.7		300.7
Total mean	159.9	293.2	312.2	x.. = 273.6

x.. total mean of all progenies

Tab. 2. Mean weight of single fruit (g) in the progeny of male sterile strawberry clones

Paternal components	Male sterile maternal clones 1) 74 Ms	2) 116 Ms	3) 150 Ms	Total mean
		Progenies		
1) Revada S_1	7.4	4.7	5.7	6.0
2) Redgauntlet	4.9	8.7	7.7	6.9
3) Purpuratka S_1	6.5			6.5
4) 3040	8.8		5.5	7.1
5) Senga Sengana		8.6	7.3	7.9
6) Górny Śląsk S_1		8.0		8.0
7) Purpuratka S_3		7.7	7.9	7.8
8) B-302	6.9	6.7		6.8
9) Dukat		7.6	9.9	7.8
10) Felina S_1		5.9		5.9
11) Solana S_1		6.6		6.6
Total mean	6.9	7.2	7.3	x..= 7.1

x.. total mean of all progenies

Tab. 3. Estimation of general combining ability (**GCA**) of maternal (α_i) and paternal (β_j) components and specific combining ability (**SCA**)[1)] of parental combinations ($\alpha\beta_{ij}$) for the yield per plant

Maternal components (α_i)	Paternal components (β_j)											
	Revada S_1	Redgauntlet	Purpuratka S_1	3040	Senga Sengana	Górny Śląsk S_1	Purpuratka S_3	B-302	Dukat	Felina S_1	Solana S_1	**GCA (α_i)**
74 Ms	107.4[1)]	21.8	113.7	89.5	-	-	-	-73.5	-	-	-	-113.7
116 Ms	-70.6	41.6	-	-	-97.4	-19.6	-14.8	167.6	-39.2	-19.6	-19.6	19.6
150 Ms	18.7	35.7	-	-14.4	39.2	-	-43.5	-	-19.0	-	-	38.6
GCA (β_j)	-68.9	-25.9	-94.6	36.6	-3.8	55.4	92.6	98.2	-47.6	-55.3	27.1	XX

Tab. 4. Estimation of general combining ability (**GCA**) of maternal (α_i) and paternal (β_j) components and specific combining ability (**SCA**)[1)] of parental combinations ($\alpha\beta_{ij}$) for the mean weight of single fruit

Maternal components (α_i)	Paternal components (β_j)											
	Revada S_1	Redgauntlet	Purpuratka S_1	3040	Senga Sengana	Górny Śląsk S_1	Purpuratka S_3	B-302	Dukat	Felina S_1	Solana S_1	**GCA (α_i)**
74 Ms	1.6[1)]	-1.8	0.2	1.9	-	-	-	0.3	-	-	-	-0.2
116 Ms	-1.4	1.7	-	-	0.6	-0.1	-0.2	-0.2	-0.3	-0.1	-0.1	0.1
150 Ms	-0.5	0.6	-	-1.8	-0.8	-	-0.1	-	1.9	-	-	0.2
GCA (β_j)	-1.1	-0.2	-0.6	0.0	0.8	0.9	0.7	-0.3	0.6	-1.2	-0.5	XX

and *`3040.`* Only the yielding of hybrid progeny of parental combination *`116 Ms`* x *`B-302`* was higher than 500 g per plant . The lowest yield per plant below 150 g was observed in the progeny of *`74 Ms`* x *`Redgauntlet`*. The mean weight of single fruit reached the value of 7 g (tab.2). It was observed that this value did not depend on the maternal plant.The paternal plants influenced the mean weight in the progenies stronger in comparison to the maternal plants. The highest mean weight of single fruit exceeding the value of 8 g was observed in the progeny obtained after crossing of maternal clone *`150 Ms`* with cv.*`Dukat`*, clone *`116 Ms`* with *`Senga Sengana`* and *`74 Ms`* with clone *3040*. Plants of progeny after crossing between maternal male sterile clone of *`150 Ms`* with *`Dukat`* produced the largest fruits and the smallest ones were obtained in the progeny of *`116 Ms`* x *`Revada* $S_1$*`*.

Estimation of combining ability effects. Mean yield per plant (tab. 3). General combining ability (GCA) of maternal and paternal components differed among all analyzed parental forms. The highest GCA effect of maternal clones was observed in the clone *`150 Ms.`* The half lower GCA effect in comparison to the given previous value revealed the progeny of maternal clone *`116 Ms`*. The lowest value of GCA effect , significantly below zero was estimated in the progeny of male sterile clone *`74 Ms`*. The highest GCA effect of paternal components was observed in the clone *`Purpuratka* $S_3$*`* and *`B-302`*. The clone *`Górny Śląsk* $S_1$*`* used as a paternal component showed in its progeny a positive GCA effect (tab.4). Also in the progeny of paternal clones *`3040`* and *`Solana* $S_1$*`* the positive GCA effect was revealed. The highest and negative GCA effect was assessed in the progeny of paternal clones *`Purpuratka* $S_1$*`*, *`Revada* $S_1$*`*, *`Felina* $S_1$*`* *and* *`Dukat`*. Cv. *`Senga Sengana`* crossed with pollen sterile maternal components showed in its progenies the lowest negative GCA effect. The results displayed that the inheritance of yield per plant was the highest when the clone *`150 Ms`* was used as a maternal form and clones *`B-302`* *`Purpuratka* $S_3$*`* were used as paternal forms. Also, specific combining ability (SCA) effects of parental combinations differed among all analyzed progenies. The highest positive SCA effect was observed in the progeny of two parental combinations *`116 Ms`* x *`B-302`* and *`74 Ms`* x *`Purpuratka* $S_1$*`*. The progeny obtained after crossing between clone *`74 Ms`* and *`3040`* also showed the high positive SCA effect of yield per plant. The three parental combinations given above were the best components concerning the inheritance of yield per plant. The lowest inheritance of yielding was observed in the progeny after crossing between maternal clone *`116 Ms`* and *`Senga Sengana`*. Also the high negative

SCA effect displayed the progeny of clone *`116 Ms`* x cv.*`Revada $S_1$`* and clone *`74 Ms`* x *`B-302`* (tab. 3).

Mean weight of single fruit (tab.4). The analysis of GCA effects showed that the obtained values were mostly below zero and most of GCA effects of paternal components were significantly higher and positive in comparison to the maternal GCA effects. The highest positive GCA effects were observed in the progenies of crosses between all male sterile maternal clones with four paternal components such as *`Górny Śląsk $S_1$`*, *`Senga Sengana`*, *`Purpuratka $S_3$`* and *`Dukat`*. Clone *`Purpuratka $S_3$`* was the best paternal component concerning the inheritance of yield per plant as well as the weight of fruits. In its progeny the GCA effects of these traits were the highest and positive. Alternatively, clones *`Felina $S_1$`* and *`Revada $S_1$`* were the worst paternal components where the negative GCA effect was the highest. GCA effects of maternal clones *`116 Ms`* and *`150 Ms`* were positive and in the progeny of maternal clone *`74 Ms`* was negative. The highest inheritance of the weight of fruits was observed in the progeny of parental components *`74 Ms` x `3040`*, *`150 Ms` x `Dukat`*, *`116 Ms` x `Redgauntlet`*, *`74 Ms` x `Revada* $S_1$`, where the SCA effects were positive and the highest. The worst parental combination regarding the inheritance of weight of fruits were *`74 Ms`* x *`Redgauntlet`*,*`150 Ms`x `3040`*and *`116 Ms` x `Revada $S_1$`*.

In conclusion, it can be stated that combining ability effects obtained in the progeny of the analyzed pollen sterile maternal clones were different and depended on the maternal clone. Maternal pollen sterile clone *`150* Ms`* was the best component for crossing with different paternal forms because of the highest values of GCA effects estimated in the progeny. Alternatively, maternal clone *`74 Ms`* showed the lowest combining ability. Maternal clone *`116 Ms`* displayed a half lower combining ability effects when compared with the GCA effects in the progeny of maternal clone *`150 Ms`*.

REFERENCES

1.Bauer R.1960.Grundlanden und Methoden over Zuchtung der Garten (*F.ananassa* Duch.). Z.F.Pflanzenzuchtung 44: 403-430.

Darrow G.M.1966. The strwaberry, history, breeding and physiology. Holt Rinehart and Winston, N.York 447.

Gajewski W. 1972. Genetyka. PWRiL, Warszawa.

Hoffman W., Mudra A., Plarre W.1985. Ogólna hodowla roślin. PWRiL, Warszawa

Hortyński J.A. 1981. Niektóre problemy metodyki hodowli truskawek. Hodowla Roślin 3: 45-46.

Hortyński J.A. 1987. Dziedziczenie niektórych cech ilościowych truskawek (F. ananassa Duch.). Metody i problemy oszacowań. Rozpr. hab. Wyd. AR Lublin.

Irkajewa N.M., Liebiediewa L.W., Szaziatowa D. Sz. 1993. Genetica- Moskwa 29, 9, 1485-1491. Gosudarstwiennyj Universitiet, Sankt Petersburg.

Kobabe G. 1971. Genetische Untersuchunden an der Speisezwiebel. Fort schritte der Pflanzenzuchtungen 1. Verlag Paul Parey, Berlin und Hamburg.

Ubysz-Borucka L., Mądry W., Muszyński S. 1985. Podstawy statystyczne genetyki cech ilościowych w hodowli roślin. Wydawnictwo SGGW-AR, Warszawa.

STRESZCZENIE

Oceniano efekty zdolności kombinacyjnej w potomstwie trzech męskoniepłodnych klonów truskawki `*74 Ms*`, `*116 Ms*` i `*150 Ms*`. Klony mateczne były krzyżowane z 11 męskopłodnymi komponentami ojcowskimi. W uzyskanym potomstwie najwyższy pozytywny efekt ogólnej zdolności kombinacyjnej (GCA) dotyczący plonu z rośliny i średniej masy pojedynczego owocu obserwowano w potomstwie klonu matecznego `*150 Ms*`. Najniższy negatywny efekt **GCA** był oszacowany w potomstwie klonu matecznego `*74 Ms*`. Efekty zdolności kombinacyjnej klonu `*116 Ms*` osiągnęły wartości o połowę niższe w porównaniu ze zdolnością kombinacyjną klonu `*150 Ms*`. Odmiana `Senga Sengana` była najlepszym komponentem ojcowskim do krzyżowania z klonem `*150 Ms*` w odniesieniu do dziedziczenia plonu. Odmiana `Dukat` była najlepszą formą ojcowską do krzyżowania z klonem matecznym w odniesieniu do dziedziczenia wielkości owoców.