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ANALYSIS OF HETEROSIS AND COMBINING ABILITY IN SOME MORPHOLOGICAL CHARACTERS IN SESAME (*SESAMUM INDICUM* L.)

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Abstract

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This study covers two Bulgarian crosses between high-yield varieties sesame Milena and Sadovo 1 to shattering capsules and promising line non-shattering capsules Sadovo 3959. Used incomplete dialel crosses. Measured are 10 morphological traits, the mode of inheritance their heterosis effect inheritance in a broad sense, inheritance in the strict sense and the presence of additive-dominant model. Variety Sadovo 1 used as a maternal form transmitted high-dominant elements yield high heterosis effect in such cases and missing reciprocal action confirmed additive-dominant model. Milena variety also transmits these dominant elements. Signs responsible for suitable for mechanized harvesting of the plant architecture in Sadovo 3959 are inherited dominantly.

Key words: sesame, heterosis, inheritance, additive-dominant model
Abbreviations: BP - genuine heterosis; d / a - ratio of dominant to additive parameter); Gca - Inheritance in the broad sense; Sca - Inheritance in the strict sense

Introduction

At this stage the selection of sesame in Bulgaria is focused on creating highly, early and sesame varieties resistant to diseases and suited to mechanized harvesting. Studies of Georgiev at al. (2008), Stamatov, Deshev (2010) show that there are not always signs that determine the high yield were positively correlated with those of mechanized harvesting. Furthermore, there is conflicting information about the inheritance of the traits associated with high productivity of sesame. Probable reason lines I the fact that the authors use different varieties and combinations, and studies have been carried out in countries whit different climatic conditions.

The height of the stem is a sign, strongly influence the yield of seeds. For positive heterosis with respect to that mark in some crosses reported Dixit (1976), Mishra et al. (1994), Mishra and Sikarwar (2001).

Heterosis effect on the number of branches in the plant is reported in most of the crossings of Sankar and Kumar (2001).

Yadav and Mishra (1991) reported the receipt of positive heterosis inn some hybrid combinations by the number of capsules in the plant. Other researchers receive both positive and negative heterosis in relation to this indicator (Shrivas and Singh, 1981; Mishra et al., 1994; Mishra and

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Sikarwar, 2001).

Reciprocal action inheritance in the yield of seeds from a plant is established by Goyal and Kumar (1988), Mishra et al. (1994). Only one crossing of Padmavathi (1998) and Mishra and Sikarwar (2001) is valid dominant additive model in terms of this indicator.

Concerning the characteristics associated with mechanized harvesting: height of betting on the first node of the first capsule on the central stem and branches, so far we have not found research and publications.

The purpose of this article is to analyse the survey results on inheritance of some important morphological, combining ability and heterosys effect related to the productivity of sesame and its capabilities for mechanized harvesting.

Material and Method

The object of this study are 2 incomplete dialel crossbred varieties with sesame Milena and Sadovo 1, with shattering capsule (open type) and promising line with the selection number created in 3959 IRGR Sadovo closed type – non-shattering capsule are suitable for mechanized harvesting. Materials are planted in the bed width 2 m, in two rows. Steps have been 20 plants of parents and hybrid materials in F1 and F2. Measured are 10 morphological indicators. Indicators of seed yield plant height of the central stem, number of branches, average length of branches, number of capsules in the central stem, number of capsules on the branches and the total number of capsules in the plant are related to yield. The height of the first betting capsule on the central stem, branches and a height of betting at first branch are indicators that in addition to the production of seeds are related to the architecture of the plant, suitable for mechanized harvesting.

Statistical data processing was carried out using the computer program Statistica 09 and consistent with Genchev et al. (1975). Indicators d / a, heterosis and inheritance of the trait in the broad and narrow sense were made by formulas of Mather (1949). The presence or absence of reproach action is calculated by the average of six generations (P1, P2, F1, F2, BCP1, BCP2) and verified by the formulas:

$$A = 2 * \Delta VSR1 - \Delta P1 - \Delta F1$$
$$B = 2 * \Delta BCP2 - \Delta P2 - \Delta F1$$
$$C = 4 * \Delta F2 - 2 * \Delta F1 - \Delta P1 - \Delta P2$$

Results and Discussion

The data in Table 1 shows the variation analysis of quantitative traits, yield components and plant architecture in sesame. With the lowest variants in parents and offspring are the number of branches in the plant, but most signs vary - the number of capsules on the branches and the total number of capsules in the plant. With at least deviation from the mean, expressed through its error with respect to yield of seed plants are characterized by their parents. Relatively constant factor is the total number of boxes and the number of boxes in a branch № 3959 breeding line used as a parent.

Data from Table 2 illustrate the nature of inheritance in terms of yield of seed plants. In cross Milena x line № 3959 inheritance of this item is over domination with positive (positive) effect of heterosis. Missing reciprocal action, additive-dominant model is demonstrated in this interaction of genes of the parents. In the reciprocal cross inheritance of the trait with incomplete dominance of the parent with smaller seed yield. Null hypothesis in this case is not proven. The other two crosses with Sadovo 1 and № 3959 repeat gene effects of the two hybrid combinations.

At the height of the stem inheritance is incomplete with equal amounts of heterosis (Table 3). In crosses with maternal variety Milena form part dominates the higher parent in the lower back. Additive-dominant model is confirmed again in hybrids from crossing Milena x № 3959, and in the reverse cross-epistatic interaction. This rule also applies to hybrid combinations involving Sadovo

Table 1
Variation analysis of quantitative parameters of the components of yield in sesame

Parents / Hybrids	Indices	Signs associated with the seed's yield of plant							Sings associated whit the mechanized harvesting		
		Yield of plant seed	Height of plant	Number of branches	Length of branches	Number of capsules, total	Number of capsules, main stem	Number of capsules, branches	Height of first branch	Height of first capsule on main stem	Height of first capsule on branch
P_1 Milena	Mean	11.66±0.97	160.3±2.7	5.3±0.3	79.5±2.2	207.4±24.5	51.9±2.3	155.5±23.2	33.4±1.7	67.2±1.7	33.9±1.1
	Variance	18.9	142.9	2.1	96.9	11972.0	108.5	10789.3	57.7	54.5	25.1
P_2 № 3959	Mean	7.24±0.7	160.7±2.0	3.45±0.3	77.2±3.8	123.3±6.9	50±2.1	72.6±6.1	34.3±3.2	69.9±1.8	32.3±1.2
	Variance	11.8	80.0	2.3	291.9	973.1	94.3	743.8	208.2	67.2	28.0
P_3 Sadovo 1	Mean	9.5±0.6	153.7±3.5	5.1±0.2	79.9±1.3	163.6±10.3	38.5±3.6	125.1±9.8	38.8±2.6	71.8±1.7	34.8±1.9
	Variance	6.6	239.6	1/1	32.7	2102.1	261.5	1928.7	130.3	58.3	73.6
P_4 3959	Mean	6.9±0.8	139.3±2.4	3.0±0.4	74.1±3.6	121.9±5.1	48.1±2.2	71.3±6.9	31.8±3.6	71.2±1.9	30.5±1.3
	Variance	10.3	81.2	2/2	289.3	964.2	93.0	745.8	210.3	66.2	29.1
F_1 Milena x № 3959	Mean	21.5±5.9	128.3±3.3	4.3±0.5	78.9±4.3	163.9±33.5	40.7±3.8	123.4±31.1	21.8±2.0	44.3±2.6	30.7±1.2
	Variance	350.9	111.3	2.5	188.3	11197.4	145.6	9676.7	39.7	66.7	14.7
F_1 № 3959 x Milena	Mean	25.2±4.3	152.3±4.6	4.6±0.5	91.8±4.4	176.4±23.9	46.5±3.9	133.7±22.0	27.9±3.0	50.5±3.2	32.4±1.3
	Variance	239.6	269.4	3.1	257.4	7414.3	194.4	6271.9	120	137.8	22.2
F_1 Sadovo 1 x № 3959	Mean	26.4±4.4	144.1±4.3	4.1±0.4	93.2±4.3	183.8±23.0	52.1±4.2	131.7±19.4	18.3±1.4	41.4±3.1	30.4±1.4
	Variance	176.7	166.9	1.1	163.2	4775.4	160.9	3371.3	18.8	87.8	17.5
F_1 № 3959 x Sadovo 1	Mean	25.5±7.9	156.1±2.6	4.6±0.8	72.3±3.1	180.9±34.0	43.7±2.8	137.1±31.9	22.3±2.7	54.1±2.9	37.6±2.6
	Variance	438.1	47.5	4	68.2	8008.8	55.9	7126.5	52.2	57.8	48.6

Table 2
Seed yield of plant

№	Hybrids	Value	d/a	GD.= 0-1	BP	Gca	Sca	Additive dominant model
	Milena	9.1-13.1						
1	F_1 (Milena x №**3959)**	2.5-40.5	5.32	>	182.99	23.30	1.50	0
	№ 3959	7.2 - 7.3						
	№3959	7.2- 7.3						
2	F_1**(№**3959 x Milena)	9.2- 33.8	-0.04	<	50.82	75.22	75.14	-
	Milena	9.1- 13.1						
	Sadovo 1	7.8-11.2						
3	F_1 (Sadovo 1 x №3959)	12.5-40.3	1.84	>	136.56	57.29	21.27	0
	№ 3959	5.0- 9.5						
	№ 3959	5.0- 9.5						
4	F_1(3959 x Sadovo1)	1.0-50.0	-0.70	<	25.25	88.97	74.77	-
	Sadovo 1	7.8-11.2						

Table 3
Height of plant

№	Hybrids	Value	d/a	GD.= 0-1	BP	Gca	Sca	Additive dominant model
	Milena	152.6 - 168.0						
1	F_1 (Milena x №3959**)**	117.6 – 139.1	-0.30	<	83.67	63.30	60.50	**0**
	№ 3959	155.0 – 166.4						
	№3959	155.0 – 166.4						
2	F_1**(**№3959 x Milena)	138.2 – 166.4	0.31	<	88.03	74.18	70.77	-
	Milena	152.6 - 168.0						
	Sadovo 1	143.7 – 163.7						
3	F_1 (Sadovo 1 x №3959)	129.7 – 158.5	4.58	>	123.36	66.61	5.79	**0**
	№ 3959	132.4 – 146.2						
	№ 3959	132.4 – 146.2						
4	F_1(3959 x Sadovo 1)	146.5 – 165.7	0.61	<	97.58	32.69	54.27	-
	Sadovo 1	143.7 – 163.7						

Table 4
Number of branches

№	Hybrids	Value	d/a	GD.= 0-1	BP	Gca	Sca	Additive dominant model
1	Milena F_1 (Milena x №**3959)** №3959	4.40- 6.2 2.7 – 5.9 2.6 – 4.3	0.47	<	86.00	30.00	27.00	**-**
2	№3959 F_1**(№**3959 x Milena) Milena	2.6 – 4.3 3.1 – 6.1 4.40- 6.2	-0.42	<	76.28	17.77	16.31	-
3	Sadovo 1 F_1 (Sadovo 1 x №3959) № 3959	4.5 – 5.7 2.8 – 5.4 1.9 – 4.1	5.00	>	133.33	21.48	1.59	**0**
4	№ 3959 F_1**(**3959 x Sadovo 1) Sadovo 1	1.9 – 4.1 1.1 – 7.0 4.5 – 5.7	-0.61	<	65.30	35.01	3.09	-

Table 5
Length of branches

№	Hybrids	Value	d/a	GD.= 0-1	BP	Gca	Sca	Additive dominant model
1	Milena F_1 (Milena x №**3959)** №3959	73.2 – 85.7 64.9 – 92.9 66.3 – 88.1	15.64	>	118.34	18.30	0.10	**0**
2	№3959 F_1**(№**3959 x Milena) Milena	66.3 – 88.1 78.3 – 105.3 73.2 – 85.7	0.15	<	83.42	52.04	51.45	-
3	Sadovo 1 F_1 (Sadovo 1 x №3959) № 3959	75.9 – 83.9 80.0 – 106.4 66.3 – 88.1	13.95	>	153.95	65.38	0.66	**0**
4	№ 3959 F_1**(**3959 x Sadovo 1) Sadovo 1	66.3 – 88.1 62.2 – 82.4 75.9 – 83.9	-0.25	<	78.20	62.35	75.23	-

1. The interaction of genes to inheritance of plant height in crosses involving Sadovo 1 is dominant when the variety is maternal form. There is incomplete dominance in the inheritance of height when paternal form.

Dominance is incomplete and the number of branches (Table 4). For the two crosses in hybrid combinations involving Milena nature of inheritance is repeated in full, as well as indicators - height of the stem. Interaction is epistatic and

Table 6
Height of first branch

№	Hybrids	Value	d/a	GD.= 0-1	BP	Gca	Sca	Additive dominant model
	Milena	28.5 – 38.3						
1	F_1 (Milena x №**3959)**	12.7 – 30.9	**0.00**	=	94.78	0.40	0.00	**0**
	№3959	28.8 – 39.7						
	№3959	28.8 – 39.7						
2	F_1**(№**3959 x Milena)	18.7 – 37.1	1.14	>	103.56	21.40	12.90	**0**
	Milena	28.5 – 38.3						
	Sadovo 1	31.5 – 46.1						
3	F_1 (Sadovo 1 x №3959)	13.8 – 22.9	-0.29	<	62.06	24.4	23.04	**-**
	№ 3959	21.7 – 41.9						
	№ 3959	21.7 – 41.9						
4	F_1**(**3959 x Sadovo 1)	12.3 – 32.3	-0.54	<	74.28	9.91	51.52	**0**
	Sadovo 1	31.5 – 46.1						

Table 7
Height of first capsule on main stem, cm

№	Hybrids	Value	d/a	GD.= 0-1	BP	Gca	Sca	Additive dominant model
	Milena	62.4 – 72.0						
1	F_1 (Milena x №**3959)**	35.9 – 52.8	-0.88	<	73.83	43.50	31.30	**-**
	№3959	64.9 – 74.9						
	№3959	64.9 – 74.9						
2	F_1**(№**3959 x Milema)	46.4 – 72.0	**0.00**	=	93.44	3.49	0.00	**0**
	Milena	62.4 – 72.0						
	Sadovo 1	66.9 – 76.7						
3	F_1 (Sadovo 1 x №3959)	31.3 – 51.5	0.06	<	79.41	47.14	47.04	**-**
	№ 3959	65.8 – 76.6						
	№ 3959	65.8 – 76.6						
4	F_1**(**3959 x Sadovo 1)	43.3 – 64.9	0.61	<	94.98	35.41	40.80	**0**
	Sadovo 1	66.9 – 76.7						

additive-dominant model is missing.

Inheritance of this indicator is over dominant when Sadovo 1 is maternal form. In this hybrid combination null hypothesis is proven. There is over domination inheritance in the average length of branches in making crosses and incomplete dominance in reverse (Table 5). Again confirm additive-dominant model for crossing Milena x №

Table 8
Height of first capsule on branch, cm

№	Hybrids	Value	d/a	GD.= 0-1	BP	Gca	Sca	Additive dominant model
1	Milena F_1 (Milena x №**3959)** №3959	30.7 – 37.0 26.8 – 34.6 28.9 – 35.7	0.09	<	91.64	17.40	17.40	**-**
2	№3959 F_1**(№**3959 x Milena) Milena	28.9 – 35.7 26.4 – 34.4 30.7 – 37.0	-2.61	>	89.95	8.08	1.82	-
3	Sadovo 1 F_1 (Sadovo 1 x №3959) № 3959	33.0 – 43.8 25.9 – 35.0 26.3 – 33.7	1.23	>	103.94	33.38	18.91	**-**
4	№ 3959 F_1**(**3959 x Sadovo 1) Sadovo 1	26.3 – 33.7 28.0 – 47.2 33.0 – 43.8	**0.00**	=	117.41	13.41	0.00	**0**

Table 9
Number of capsules, total

№	Hybrids	Value	d/a	GD.= 0-1	BP	Gca	Sca	Additive dominant model
1	Milena F_1 (Milena x №**3959)** №3959	137.3 – 277.5 55.0 – 272.8 103.6 – 143.0	0.61	<	90.55	12.80	10.70	**-**
2	№3959 F_1**(№**3959 x Milena) Milena	103.6 – 143.0 103.3 – 249.5 137.3 – 277.5	0.30	<	91.39	4.25	4.06	-
3	Sadovo 1 F_1 (Sadovo 1 x №3959) № 3959	134.1 – 193.1 109.1 – 258.6 107.3 – 136.5	3.31	>	141.70	37.49	5.78	**0**
4	№ 3959 F_1(3959 x Sadovo 1) Sadovo 1	107.3 – 136.5 54.8 – 307 134.1 – 193.1	-0.59	<	47.09	71.88	84.12	-

3959 and in the presence of reciprocal action № 3959 x Milena, Sadovo 1 x № № 3959 and 3959 x Sadovo 1.

The total number of capsules in the plant, as derived from the number of boxes in the central stem and the number of boxes in branches dominated part in the three hybrid combinations. An exception is the hybrid combination in which 1

Table 10
Number of capsules, main stem

№	Hybrids	Value	d/a	GD.= 0-1	BP	Gca	Sca	Additive dominant model
	Milena	45.3 – 58.5						
1	F_1 (Milena x №**3959)**	28.5 – 53.2	0.04	<	81.40	29.10	29.00	**-**
	№3959	43.9 – 56.0						
	№3959	43.9 – 56.0						
2	F_1**(**№3959 x Milena)	34.6 – 58.4	0.38	<	83.10	49.39	45.90	-
	Milena	45.3 – 58.5						
	Sadovo 1	28.2 – 48.8						
3	F_1 (Sadovo 1 x №3959)	38.5 – 65.8	2.68	>	125.31	32.51	7.05	**0**
	№ 3959	41.8 – 54.4						
	№ 3959	41.8 – 54.4						
4	F_1**(**3959 x Sadovo 1)	33.3 – 54.1	-0.02	<	78.06	34.41	67.64	-
	Sadovo 1	41.8 – 54.4						

Table 11
Number of capsules, branches

№	Hybrids	Value	d/a	GD.= 0-1	BP	Gca	Sca	Additive dominant model
	Milena	89.1 – 221.9						
1	F_1 (Milena x №**3959)**	22.3 – 224.5	0.50	<	81.99	19.00	16.90	**-**
	№3959	55.2 – 90.0						
	№3959	55.2 – 90.0						
2	F_1**(**№3959 x Milena)	66.4 – 201.0	0.61	<	97.58	0.71	0.60	-
	Milena	89.1 – 221.9						
	Sadovo 1	97.1 – 153.1						
3	F_1 (Sadovo 1 x №3959)	68.7 – 194.8	3.53	>	149.54	31.57	4.34	**0**
	№ 3959	51.6 – 91.0						
	№ 3959	51.6 – 91.0						
4	F_1(3959 x Sadovo 1)	58.8 – 90.0	-0.65	<	41.81	71.13	81.41	-
	Sadovo 1	97.1 – 153.1						

is Sadovo maternal form in which inheritance is over dominant and null hypothesis is evidenced by the number of boxes in the central stem, branches and total. Heterosis is positive with respect to this indicator. Additive-dominant model is valid only for the number of boxes in the central stem in cross Milena x № 3959. Null hypothesis is confirmed by cross № 3959 x Milena (Tables 9, 10 and 11).

It is additive interaction of genes in determining the height of the appearance of the first node in crossing Milena x № 3959 over dominant in respect of this indicator is observed in the reverse cross and heterosis is positive. Additive-dominant model is valid for both crosses (Table 6). In hybrid combinations in which as a parental form part Sadovo 1 dominance is incomplete and hybrids accept the lower bid of the first node. Null hypothesis was proven when Sadovo 1 is a paternal form.

Confirm genes in other indicators, responsible for architecture of plant suitable for mechanized harvesting; the height of the first betting box on the central stem is incomplete in the right cross and additive in the opposite (Table 7). When parental form is Sadovo 1 dominance is incomplete and null hypothesis has been demonstrated in the reverse cross.

Hybrid offspring from crossing № 3959 x Milena bet lower boxes on the branches to their parents (over dominance). In cross rights in respect of this indicator is observed incomplete dominance. Null hypothesis is not proven in either case, table. 8. Ultra dominance of this indicator is observed when 1 is Sadovo maternal form. The action of genes is additive in the reciprocal combination, in this case is proved and the null hypothesis.

Conclusions

Increased production of plant seeds in hybrid materials of F_1 is due to heterosis effect derived from the crossing of a promising line up non-shattering capsules Sadovo 3959 varieties whit shattering capsules cans Sadovo 1 and Milena. In making crosses of both parents was observed over the dominance of this character and the lack of reciprocal action in his inheritance.

Variety Sadovo 1 used as a parent transmits all elements connected productivity with super dominant, with large heterosis effect in hybrid. In all cases of over dominant inheritance of these indicators confirms the null hypothesis, i.e. in hybrids will interaction epistatic alleles of genes outside the inheritance of these indicators. High heterosis effect in hybrids in terms of indicators related to the productivity of plants occurs when a parent has used variety Vol.

Indicators responsible for the proper architecture of the plant to its mechanized harvest are associated with higher betting productive elements (boxes and pads) on the central stem. Selection line № 3959, which is suitable for mechanized harvesting, where as a parent involved in these crossings transmit dominant performance in hybrids.

The study will assist breeders in choosing parental forms that combine to produce high yields in plants suitable for mechanized harvesting.

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