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GENE EFFECT AND COMBINING ABILITIES FOR PLANT HEIGHT AND HEAD DIAMETER IN SUNFLOWER

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Plant height and head diameter are important parameters which effect on a yield in sunflower. Six restorer Rf lines, three tester A lines and their 18 F1 hybrids were studied, using line x tester method. Significant differences were found between restorer lines and testers and their F1 hybrids for plant height and head diameter. Regarding the inheritance of examined characteristic, super dominance and dominance of better parent occurred, and the intermediary too. Tester line HA-48A (188.25 cm) and F1 hybrid HA-48A x RHA-SELEUS (245.10 cm) had the highest mean value for plant height, and the lowest value had line RHA-BRE-1 (105.35 cm) and hybrid L-19A x RHA-BRE-1 (147.9 cm). For head diameter, the highest mean value had line L-19A (19.02 cm) and F1 hybrids HA-48A x RHA-TR-20 and L-19A x RHA-TR-20 (24.55 cm), and the lowest line RHA-BRE-1 (13.10 cm) and hybrid HA-26A x RHA-M-72 (20.25 cm). Based on the results, the following conclusion is that lines RHA-BRE-1 for plant height and RHA-SELEUS for head diameter have the best GCA, and the best SCA have hybrids L-19A x RHA-BRE-1 for plant height and HA-26A x RHA-SELEUS for head diameter. Analyzing components of genetic variance, the nonadditive component played the main role in the inheritance of plant height and the additive of head diameter. The largest average contribution in the expression of plant height had the tester A-

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lines (83.17%) and for head diameter Rf lines had the greatest influence (58.13%).

Key words: sunflower, combining abilities, GCA, SCA, plant height, head diameter

INTRODUCTION

The main objective of sunflower breeding is to develop productive F1 hybrid cultivars with stabile and high yield. Yield is a complex trait, which is the result of single and mass effects (MARINKOVIĆ, 1989). Plant height and head diameter are important parameters which indirectly influence on yield. Results of GIRIRAJ *et al*. (1979) indicate that there is high significant correlation between plant height and number of leaves on the plant, thousand seed mass, head diameter, hectoliter mass.

The average plant height in sunflower is between 160 and 180 cm (SHABANA, 1974; ŠKORIĆ, 1975). Reducing height and increasing stem thickness enhance sunflower stability. Shorter hybrids have a similar yield potential to standard- height hybrids (SCHNEITER, 1992; VELASCO *et al*., 2003a), with the additional advantage of being more resistant to lodging and stalk breaking (FICK *et al*., 1985). Furthermore, reduced-height genotypes may be better adapted to high yield environments (MILLER and HAMMOND, 1991). Reduced- height genotypes increase number of plants per hectare (SUZER and ATAKISI, 1993). Plant height in standard sunflower types is regarded as a quantitative trait with dominant gene effect (PUTT, 1966; MARINKOVIĆ, 1982). Reduced plant height is controlled by a single recessive gene (MILLER and FICK, 1997). VELASCO *et al*. (2003b) suggested that the trait is controlled by two major genes, among which is possible interaction.

Gene effect of head diameter is often minor compares to other agronomic traits (FICK, 1978), because it depends of environment condition and vegetation period (MARINKOVIĆ, 2003), as well as number of plants per hectare (ŠKORIĆ, 1989). Both nonadditive (SETTY *et al*., 1977; JOKSIMOVIĆ *et al*., 2000) and additive component (PUTT, 1977; MARINKOVIĆ, 1982) play important role in the inheritance of head diameter.

The objective of this study was to maintain the mode of inheritance and the effect of general combining abilities (GCA) of inbred lines and specific combining abilities of F1 hybrids, as well as gene effect, components of genetic variance and average contribution of Rf lines, testers and their interaction in the expression of plant height and head diameter.

MATERIALS AND METHODS

In this study were used 6 divergent Rf lines, 3 A tester lines and their 18 F1 hybrids. The restorer lines are RHA-M-72, RHA-BRE-1, RHA-SELEUS, RHA-RUS-RF-OL-168, RHA-TR-20, RHA-FT-284, and A tester lines are HA-48A, HA-26A and L-19A. Hybrid combinations were obtained by crossing Rf lines with A steril testers.

Comparative trial were carried out in four replication at the Experimental Field Rimski Šančevi of the Institute of Field and Vegetable Crops in Novi Sad. The lines and hybrids were sown manually, on 5th April 2004. The row-to-row spacing was 0.7 m and plant-to-plant spacing was 0.25 m. The basic sample for the analysis included 20 plants (5 of each replication). Measurements were made during the growing season, in physiological maturity.

Table 1. Mean values and mode of inheritance of plant height (cm) and head diameter (cm) in sunflower

	GENOTYPE	Plant height x±Sx	Head diameter x±Sx
1	RHA-M-72	163.25±1.40	13.65±0.09
2	RHA-BRE-1	105.35±3.54	13.10±0.21
3	RHA-SELEUS	172.70±4.08	16.10±0.27
4	RHA-RUS-RF-OL-168	165.00±2.05	16.45±0.39
5	RHA-TR-20	146.70±1.93	14.95±0.09
6	RHA-FT-284	135.55±3.05	14.87±0.31
7	HA-48A	188.25±3.63	19.02±0.26
8	HA-26A	157.70±2.98	17.10±0.48
9	L-19A	126.10±4.63	19.95±0.43
7x1	HA-48AxRHA-M-72	230.40±2.44 sd	21.70±0.57 d
8x1	HA-26AxRHA-M-72	211.95±3.18 sd	20.25±0.79 d
9x1	L-19AxRHA-M-72	182.80±3.37 sd	22.10±0.55 d
7x2	HA-48AxRHA-BRE-1	215.60±3.29 sd	22.35±0.37 sd
8x2	HA-26AxRHA-BRE-1	195.55±3.57 sd	20.75±0.84 d
9x2	L-19AxRHA-BRE-1	147.90±2.06 d	23.20±0.76 d
7x3	HA-48AxRHA-SELEUS	245.10±5.53 sd	22.35±0.62 sd
8x3	HA-26AxRHA-SELEUS	218.30±1.80 sd	22.50±1.31 d
9x3	L-19AxRHA-SELEUS	149.40±3.37 i	23.65±0.41 sd
7x4	HA-48AxRHA-RUS-RF-OL-168	237.40±4.76 sd	22.08±1.11 d
8x4	HA-26AxRHA-RUS-RF-OL-168	215.25±1.79 sd	20.90±0.38 sd
9x4	L-19AxRHA-RUS-RF-OL-168	175.05±1.76 d	22.85±0.51 d
7x5	HA-48AxRHA-TR-20	220.40±2.69 sd	24.55±0.32 sd
8x5	HA-26AxRHA-TR-20	198.45±4.06 sd	23.25±0.37 sd
9x5	L-19AxRHA-TR-20	172.05±2.13 sd	24.55±0.64 sd
7x6	HA-48AxRHA-FT-284	236.00±1.21 sd	22.05±0.33 sd
8x6	HA-26AxRHA-FT-284	218.70±0.77 sd	21.60±0.71 sd
9x6	L-19AxRHA-FT-284	186.30±1.16 sd	23.00±0.27 sd
	LSD (5%)	7.71	1.61
	LSD (1%)	10.25	2.14

sd- superdominace; d- dominace; i- intermediary

Mode of inheritance was evaluated by mean values of F1 hybrids comparing to mean value of better parent (BOROJEVIĆ, 1965) and test of significance (HADŽIVUKOVIĆ, 1973). Using line x tester method (SINGH and CHOUDHARY, 1976), the following informations were received; significant difference between

sources of variance, general combining abilities (GCA) inbred lines and specific combining abilities (SCA) F1 hybrids. Besides, components of variance and average contribution of lines, testers and their interaction in plant height and head diameter were measured.

RESULTS AND DISCUSSION

Mode of inheritance - The significant difference were maintained among inbred lines and their F1 hybrids regarding plant height and head diameter, indicating the existence of genetic difference between the genotypes. The smallest average for plant height had Rf line RHA-BRE-1 (105.35 cm), and the tallest had RHA-SELEUS (172.70 cm). As regards head diameter, the lowest mean value had RHA-BRE-1 (13.10 cm) and the highest had restorer line RHA-RUS-RF-OL-168 (16.45 cm). Of the A testers, L-19A (126.1 cm) was the smallest and HA-48A was the tallest (188.25 cm). The smallest haed had HA-26A tester (17.1 cm), and L-19A had the highest mean value for head diameter (19.95 cm). Among F1 hybrids, plant height ranged from 147.9 cm for L-19A x RHA-BRE-1 to 245.1 cm for HA-48A x RHA-SELEUS hybrid. F1 hybrid HA-26A x RHA-M-72 had the smallest head (20.25 cm) and the highest mean 24.55 cm had two combinations with RHA-TR-20 restorer (Tab. 1).

Table 2. GCA effect of plant height and head diameter for sunflower inbred lines

GENOTYPE		Plant height	Head diameter
RHA-M-72	1	3.75	-0.94
RHA-BRE-1	2	-18.28**	-0.35
RHA-SELEUS	3	8.56**	0.38
RHA-RUS-RF-OL-168	4	4.60*	-0.51
RHA-TR-20	5	-7.67**	1.66**
RHA-FT-284	6	9.03**	-0.24
HA-48A	7	26.783**	0.06
HA-26A	8	5.067**	-0.83*
L-19A	9	-31.25**	0.77*
S.E.(GCA for lines)		1.57	0.33
S.E.(Gi-Gj) for lines		2.23	0.47
S.E.(OKS for testers)		1.11	0.23
S.E. (Gi-Gj) for testers		1.57	0.33
LSD(1-6)	1%	4.45	0.93
	5%	5.92	1.24
LSD(7-9)	1%	3.15	0.66
	5%	4.18	0.88

Significant differences had been found among parent lines and F1 hybrids for plant height. Super dominance and dominance were approved in most hybrid combinations, except in L-19A x RHA-SELEUS, where intermediary was mani-

fested (Tab. 1). Super dominance for head diameter was manifested itself in 10 F1 hybrid, and dominance in 8.

Combining abilities - Analysis of general combining abilities (GCA) for plant height had shown that there are highly significant and significant differences among restorer lines and testers (Table 2). Highly significant and significant positive GCA effect was recorded in three Rf lines, which makes them bad general combiners. For the plant height, smaller genotypes are more desirable then taller. Restorers RHA-BRE-1 and RHA-TR-20 were noted as good general combiners for plant height, because of the highly significant negative value. Among testers, the most notable positive GCA effect had HA-48A line, and negative L-19A. An analysis of general combining abilities (GCA) for plant height showed that only one hybrid combination L-19A x RHA-BRE-1 had significant negative effect (Table 3). This combination was obtained by crossing two good general combiners for plant height.

Highly significant GCA effect for head diameter was manifested in one Rf line RHA-TR-20 (Table 2), while other restorers did not have significant GCA values. Tester A lines HA-26A and L-19A had significant GCA values. Analysis of SCA did not show significant effect of any F1 hybrid for head diameter.

Table 3. SCA effect of Plant height and head diameter for F1 sunflower hybrids

GENOTYP		Plant height	Head diameter
HA-48AxRHA-M-72	7x1	-4.17	0.13
HA-26AxRHA-M-72	8x1	-1.50	0.06
L-19AxRHA-M-72	9x1	5.67	-0.19
HA-48AxRHA-BRE-1	7x2	3.07	0.19
HA-26AxRHA-BRE-1	8x2	4.13	-0.52
L-19AxRHA-BRE-1	9x2	-7.90*	0.33
HA-48AxRHA-SELEUS	7x3	5.72	-0.54
HA-26AxRHA-SELEUS	8x3	0.03	0.50
L-19AxRHA-SELEUS	9x3	-5.75	0.05
HA-48AxRHA-RUS-RF-OL-168	7x4	1.98	0.07
HA-26AxRHA-RUS-RF-OL-168	8x4	0.95	-0.21
L-19AxRHA-RUS-RF-OL-168	9x4	-2.93	0.14
HA-48AxRHA-TR-20	7x5	-2.75	0.38
HA-26AxRHA-TR-20	8x5	-3.58	-0.04
L-19AxRHA-TR-20	9x5	6.33	-0.34
HA-48AxRHA-FT-284	7x6	-3.85	-0.23
HA-26AxRHA-FT-284	8x6	-0.03	0.21
L-19AxRHA-FT-284	9x6	3.88	0.01
S.E. (SCA)		2.73	0.57
S.E. (Sij-Ski)		3.85	0.81
LSD	5%	7.71	1.61
	1%	10.25	2.15

Components of genetic variance - The GCA/SCA ratio was lower then 1, meaning that nonadditive component of genetic variance in the expression of plant height played the main role in the inheritance of this trait (Table 4). These

results are in agreement with the findings of ŠKORIĆ *et al*. (2000). Contribution of additive component in the expression of head diameter was higher than nonadditive. MARINKOVIĆ (1982) also found that additive component had been more significant in the inheritance of head diameter, while SETTY *et al*. (1977), and JOKSIMOVIĆ *et al*. (2000) maintained the inportace of nonadditive component.

Table 4. Components of genetic variance for plant height and head diameter

TRAITS	KOMPONENTS	Vd	Va	Vd/Va	GCA	SCA	GCA/SCA
Plant height	F=1	70.15	123.46	0.57	61.73	70.15	0.88
	F=0	280.60	246.92	1.14			
Head diameter	F=1	0.18	0.41	0.44	0.21	0.18	1.17
	F=0	0.73	0.82	0.89			

The avarage contribution of A tester lines in the expression of plant height was 83.17%. oposite, for the head diameter contribution of Rf lines was the largest (58.13%) (Table 5).

Table 5. Average contribution (%) of Rf lines, testers and their interactions to expression of plant height and head diameter

TRAITS	Plant height	Head diameter
Rf LINE	14.37	58.13
TESTERS	83.17	35.31
L x T	2.46	6.56

CONCLUSIONS

Based on the study results, the following conclusions can be made. Significant differences were found among inbred lines and their hybrids in the mean values of plant height and head diameter. Regarding the inheritance of plant height and head diameter, superdominance, dominance of better parent and intermediarity were manifested. Nonadditive and additive components of genetic variance played the main role in the inheritance of plant height and head diameter. Rf line RHA-BRE-1 was noted as a good general combiner for plant height, and RHA-TR-20 for head diameter. Only one F1 hybrid had significant SCA effect for plant height, that is L-19A x RHA-BRE-1.

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EFEKAT GENA I KOMBINACIONE SPOSOBNOSTI ZA VISINU BILJKE I PREČNIK GLAVE KOD SUNCOKRETA

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Izvod

Visina biljke i prečnik glave su značajni parametri koji utiču na visinu prinosa kod suncokreta. Metodom linija x tester ispitano je šest restorer linija, tri tester A linije i njihovih 18 F1 hibrida. Utvrđene su značajne razlike između restorer linija i testera i njihovih F_1 hibrida za visinu biljke i prečnik glave. U nasleđivanju ispitivanih svojstava ispoljile su se superdominacija i dominacija boljeg roditelja, ali i intermedijarnost. Najveću srednju vrednost za visinu biljke su imali tester linija HA-48 A (188,25 cm) i F_1 hibrid HA-48A x RHA-SELEUS (245,1 cm), a najmanju linija RHA-BRE-1 (105,35 cm), odnosno hibrid L-19A x RHA-BRE-1 (147,9 cm). Kod prečnika glave najveću srednju vrednost su imali tester linija L-19A (19,95 cm) i F_1 hibridi HA-48A x RHA-TR-20 i L-19A x RHA-TR-20 (24,55 cm), a najmanju linija RHA-BRE-1 (13,10 cm) i hibrid HA-26A x RHA-M-72 (20,25 cm). Na osnovu dobijenih rezultata može se zaključiti da najbolje OKS imaju linije RHA-BRE-1 za visinu biljke i RHA-TR-20 za prečnik glave, a najbolje PKS, hibridi L-19A x RHA-BRE-1 za visinu biljke i HA-26A x RHA-SELEUS za prečnik glave. Analiziranjem komponenti genetske varijanse, neaditivna komponenta je imala najveći uticaj na nasleđivanje visine biljke, a aditivna na prečnika glave. Najveći prosečni doprinos u ekspresiji visine biljke dale su A-tester linije 83,17%, a za prečnik glave najveći uticaj su imale restorer linije 58,13%.

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