

COMBINING ABILITIES OF NEW INBRED LINES OF SUNFLOWER
(Helianthus annuus L.)

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Combining abilities for plant height and head diameter of ten sterile A-lines, three restorers - RF lines and their (10x3) F1-hybrids were examined by line x tester method. Significant differences were found between A-lines, RF-lines (testers) and their hybrids. The highest mean for plant height had line MI-A-57 (198.17 cm) and hybrid combination MG-MI-1 x MI-A-57 (239 cm), and the lowest mean had line PL-DI-13 (79.67 cm) and hybrid MG-MI-4 x PL-DI-13 (152.67 cm). Line PL-DI-52 (24.47 cm) and hybrid MG-MI-4 x MI-A-57 (25.37 cm) had the highest mean for head diameter, and the lowest mean was determined in line PL-DI-44 (13.60 cm) and hybrid MG-MI-2 x PL-DI-15 (17.90 cm). Lines with the best general combining abilities were PL-DI-13 for plant height and MI-A-57 for head diameter. Hybrids with the best specific combining abilities were MG-MI-2 x PL-DI-15 for plant height and MG-MI-1 x PL-DI-15 for head diameter.

Key words: sunflower, combining abilities, General Combining Ability, Specific Combining Ability, plant height, head diameter

INTRODUCTION

Primary objective of plant breeding is creating new hybrids and varieties for fulfilling the needs of humans and farm animals (JOCIĆ *et al.*, 2011). Creating hybrids with many good traits is the main goal of plant breeding in sunflower. In commercial sunflower breeding there are two main types: oil and non-oil sunflower type (HLADNI *et al.*, 2011b) This refers mainly to higher oil yield, but to achieve that task it is necessary to aim research in direction of other traits which are directly or indirectly connected to yield. In the group of important traits are plant height and head diameter. JOKSIMOVIĆ *et al.* (2000) emphasize that plant height, size, form

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and position of head on stem have an important role in defining optimal architecture of sunflower hybrid.

Modern varieties of sunflower show great variability in height, but for achieving higher yields lower plants are preferred. For increasing resistance to lodging it is necessary to create hybrids with average height between 120 and 150 cm. Lower plants are also more convenient for mechanical harvesting. Semidwarf hybrids are more tolerant to higher number of plants per hectare and have the similar yield potential as standard hybrids (HLADNI *et al.*, 2008).

In sunflower plant breeding attention is on to morphological traits of head (MIJIĆ *et al.*, 2003). Head diameter is a trait less influenced by genetic factors and more by environment conditions and vegetation period (MARINKOVIĆ *et al.*, 2003). Sunflower head should be middle size, with diameter 20 – 25 cm, thin and with firm epidermis.

Successful hybridization program is determined by selection of convenient genotypes which could be used as parental lines (KHAN *et al.*, 2009). Line x tester analysis was often used to examine combining abilities of important agronomic traits of sunflower by many authors (MARINKOVIĆ, 2005; HLADNI *et al.*, 2008, 2011; JOČIĆ *et al.*, 2012). The objective of this study was to obtain the effect of general combining abilities (GCA) of inbred lines and specific combining abilities (SCA) of F1 hybrids, components of genetic variance and average contribution of A-sterile lines, RF testers and their interaction in the expression of plant height and head diameter.

MATERIALS AND METHODS

In this study ten sterile - A lines, three restorers - RF tester lines and their (10x3) F1 hybrids were used. The A-lines were PL-DI-4, PL-DI-12, PL-DI-13, PL-DI-15, PL-DI-25, PL-DI-33, PL-DI-44, PL-DI-52, MI-A-56 and MI-A-57. The tester, RF lines, MG-MI-1, MG-MI-2 and MG-MI-4 are male restorer lines with good combining abilities. Hybrid combinations were created by crossing A-sterile lines with RF-restorer testers during year 2009. During the year 2010 the trial was placed on Experimental field Rimski Šančevi of Institute of Field and Vegetable crops in Novi Sad with 3 replications. The seed of lines and hybrids were sown by seeding machines in a well-prepared soil. The row-to-row spacing was 70 cm and plant-to-plant spacing was 25 cm. The sample for analysis had 10 plants (5 for each row). Data were recorded during vegetation season in physiological maturity. Line x tester method (SINGH and CHAUDHARY, 2010) was used to collect information for the following parameters: significant difference between sources of variance, general combining abilities (GCA) inbred lines and specific combining abilities (SCA) F1 hybrids. Also, components of variance and average contribution of lines, testers and their interaction in plant height and head diameter were investigated. Statistical analysis of data was carried out by program Statistica.

Table 1.

RESULTS AND DISCUSSION

The significant difference were found among inbred lines and their F1 hybrids regarding plant height and head diameter which indicates the existence of genetic difference between the genotypes. The lowest mean of plant height in A - lines had PL-DI-13 (79.67 cm) and the highest MI-A-57 (198.17 cm). Results for head diameter show that the smallest mean was recorded at line PL-DI-44 (13.60 cm) and the highest at line PL-DI-52 (24.47 cm).

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

No.	Inbred Line and Hybrids	Plant height (cm)	Head diameter (cm)
1.	PL-DI-4	147.83	19.40
2.	PL-DI-12	115.00	14.60
3.	PL-DI-13	79.67	13.67
4.	PL-DI-15	92.50	16.47
5.	PL-DI-25	131.17	17.23
6.	PL-DI-33	127.17	18.83
7.	PL-DI-44	88.33	13.60
8.	PL-DI-52	108.50	24.47
9.	MI-A-56	158.67	19.27
10.	MI-A-57	198.17	23.17
11.	MG-MI-1	128.00	14.60
12.	MG-MI-2	160.83	13.90
13.	MG-MI-4	166.17	18.33
14.	MG-MI-1 x PL-DI-4	214.50	22.87
15.	MG-MI-2 x PL-DI-4	195.67	20.23
16.	MG-MI-4 x PL-DI-4	170.17	21.13
17.	MG-MI-1 x PL-DI-12	178.50	20.83
18.	MG-MI-2 x PL-DI-12	185.17	19.40
19.	MG-MI-4 x PL-DI-12	195.17	22.20
20.	MG-MI-1 x PL-DI-13	182.33	21.37
21.	MG-MI-2 x PL-DI-13	187.00	21.03
22.	MG-MI-4 x PL-DI-13	152.67	18.87
23.	MG-MI-1 x PL-DI-15	201.83	22.70
24.	MG-MI-2 x PL-DI-15	156.00	17.90
25.	MG-MI-4 x PL-DI-15	164.83	19.77
26.	MG-MI-1 x PL-DI-25	193.67	21.13
27.	MG-MI-2 x PL-DI-25	196.67	21.77
28.	MG-MI-4 x PL-DI-25	191.33	21.67
29.	MG-MI-1 x PL-DI-33	187.17	20.00
30.	MG-MI-2 x PL-DI-33	202.50	18.70
31.	MG-MI-4 x PL-DI-33	190.83	19.67
32.	MG-MI-1 x PL-DI-44	195.00	21.30
33.	MG-MI-2 x PL-DI-44	219.33	21.50
34.	MG-MI-4 x PL-DI-44	192.67	22.70
35.	MG-MI-1 x PL-DI-52	200.00	22.63
36.	MG-MI-2 x PL-DI-52	196.33	23.03
37.	MG-MI-4 x PL-DI-52	187.33	24.90
38.	MG-MI-1 x MI-A-56	203.83	21.93
39.	MG-MI-2 x MI-A-56	208.33	23.80
40.	MG-MI-4 x MI-A-56	210.33	24.40
41.	MG-MI-1 x MI-A-57	239.00	24.97
42.	MG-MI-2 x MI-A-57	221.50	24.37
43.	MG-MI-4 x MI-A-57	225.83	25.37

Among RF-testers plant height ranged from 128 cm (MG-MI-1) to 166.17 cm (MG-MI-4) and head diameter from 13.90 cm (MG-MI-2) to 18.33 cm (MG-MI-4). Amongst the F1 hybrids, the lowest mean for plant height had combination MG-MI-4 x PL-DI-13 (152.67 cm) and the highest mean for this trait as recorded at combination MG-MI-1 x MI-A-57 (239 cm). F1 hybrids with the smallest head was MG-MI-2 x PL-DI-15 (17.90 cm) and the highest mean of 25.37 cm had combination MG-MI-4 x MI-A-57 (Tab. 1).

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

No.	Inbred Lines	Plant height	Head diameter
1.	PL-DI-4	-1.41	-0.33
2.	PL-DI-12	-8.57*	-0.93
3.	PL-DI-13	-20.85**	-1.32*
4.	PL-DI-15	-20.63**	-1.62*
5.	PL-DI-25	-0.96	-0.22
6.	PL-DI-33	-1.35	-2.28**
7.	PL-DI-44	7.48	0.10
8.	PL-DI-52	-0.29	1.78**
9.	MI-A-56	12.65**	1.64*
10.	MI-A-57	33.93**	3.16**
11.	MG-MI-1	4.73*	0.24
12.	MG-MI-2	2.00	-0.56
13.	MG-MI-4	-6.73**	0.33
S.E.(GCA for lines)		3.44	0.53
S.E.(Gi-Gj) for lines		4.87	0.75
S.E.(GCA for testers)		1.88	0.29
S.E.(Gi-Gj) for testers		2.67	0.41
LSD for lines (5%)		8.10	1.24
LSD for lines (1%)		11.55	1.77
LSD for testers (5%)		4.44	0.68
LSD for testers (1%)		6.33	0.97

Analysis of GCA for plant height had shown that there are highly significant and significant differences between A-lines and RF-testers (Tab 2.). Two A-lines, MI-A-56 and MI-A-57, had highly significant positive GCA effect which makes them a bad general combiners because lower genotypes are more appropriate for this trait. Highly significant and significant negative values had three A-lines, PL-DI-12, PL-DI-13 and PL-DI-15, therefore they are marked as good combiners of this trait. Results of testers show that MG-MI-1 had significant positive value and MG-MI-4 had highly significant negative value. Amongst F1 hybrids three of them stand out for its significant and highly negative effect. These combinations are MG-MI-4 x PL-DI-4, MG-MI-4 x PL-DI-13 and MG-MI-2 x PL-DI-15 which have good SCA for plant height (Table 3.). For head diameter genotypes with significant positive values of GCA effect such as PL-DI-52 and MI-A-57 are desirable. In the case of this trait testers were without significant

GCA effects while among F1 hybrids only one combination, MG-MI-1 x PL-DI-15, stood out for its significant positive SCA value.

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

Hybrids	Plant height	Head diameter
MG-MI-1 x PL-DI-4	16.32*	1.22
MG-MI-2 x PL-DI-4	0.22	-0.61
MG-MI-4 x PL-DI-4	-16.54*	-0.61
MG-MI-1 x PL-DI-12	-12.51	-0.21
MG-MI-2 x PL-DI-12	-3.11	-0.85
MG-MI-4 x PL-DI-12	15.62*	1.06
MG-MI-1 x PL-DI-13	3.60	0.71
MG-MI-2 x PL-DI-13	11.00	1.18
MG-MI-4 x PL-DI-13	-14.60*	-1.88
MG-MI-1 x PL-DI-15	22.88**	2.34*
MG-MI-2 x PL-DI-15	-20.22**	-1.66
MG-MI-4 x PL-DI-15	-2.66	-0.68
MG-MI-1 x PL-DI-25	-4.96	-0.62
MG-MI-2 x PL-DI-25	0.78	0.81
MG-MI-4 x PL-DI-25	4.18	-0.18
MG-MI-1 x PL-DI-33	-11.07	0.31
MG-MI-2 x PL-DI-33	7.00	-0.19
MG-MI-4 x PL-DI-33	4.07	-0.12
MG-MI-1 x PL-DI-44	-12.07	-0.77
MG-MI-2 x PL-DI-44	15.00*	0.23
MG-MI-4 x PL-DI-44	-2.93	0.54
MG-MI-1 x PL-DI-52	0.71	-1.12
MG-MI-2 x PL-DI-52	3.44	-0.32
MG-MI-4 x PL-DI-52	-0.49	1.05
MG-MI-1 x MI-A-56	-8.40	-1.68
MG-MI-2 x MI-A-56	-1.17	0.99
MG-MI-4 x MI-A-56	9.57	0.69
MG-MI-1 x MI-A-57	5.49	-0.17
MG-MI-2 x MI-A-57	-9.28	0.03
MG-MI-4 x MI-A-57	3.79	0.14
S.E. (SCA)	5.96	0.91
S.E. (Sij-Ski)	8.43	1.29
LSD (5%)	14.03	2.15
LSD (1%)	20.01	3.07

The GCA/SCA ratio was less than 1, which indicates that non additive component of genetic variance in the expression of plant height and head diameter had the main role in the inheritance of this trait (Table 4). JOKSIMOVIĆ *et al.* (2000) and GVOZDENOVIĆ *et al.* (2005) had similar results with contribution of non additive component in plant height.

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

Traits	Components	Vd	Va	Vd/Va	GCA	SCA	GCA/SCA
Plant height	F=1	139.01	22.11	6.29	11.05	139.01	0.08
	F=0	417.02	44.21	9.43			
Head diameter	F=1	0.67	0.26	2.57	0.13	0.67	0.19
	F=0	2.01	0.52	3.85			

In the expression of this two traits contribution of A lines was the highest. Amount of A lines contribution for plant height was 64.19% and for head diameter 71.30% (Tab 5.). These findings correspond with the results of JOKSIMOVIĆ *et al.* (2000) and disagree with MARINKOVIĆ (2005) and GVOZDENOVIĆ *et al.* (2005).

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

Traits	Plant height	Head diameter
A- lines	64.19	71.30
Testers	6.66	4.33
L x T	29.15	24.37

CONCLUSION

The results of this study show the following conclusions. Significant differences were found among inbred lines and their hybrids in the mean values of plant height and head diameter. Non additive components of genetic variance played the main role in the inheritance of plant height and head diameter. Sterile A-lines PL-DI-12, PL-DI-13 and PL-DI-15 are marked as good combiners for plant height, while analysis also showed that good combiners for head diameter are A-lines PL-DI-52 and MI-A-57.

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KOMBINACIONE SPOSOBNOSTI NOVIH INBRED LINIJA SUNCOKRETA
(Helianthus annuus L.)

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Izvod

Kombinacione sposobnosti za visinu biljke i prečnik glave 10 sterilnih A- linija, 3 restorera, RF linije i njihovih (10x3) F1 hibrida je ispitivano metodom linija x tester. Značajne razlike su utvrđene između A linija, RF-linija (testeri) i njihovih hibrida. Najveću prosečnu visinu biljke je imala linija MI-A-57 (198,17 cm) i hibrid MG-MI-1 x MI-A-57 (239 cm), a najmanju linija PL-DI-13 (79,67 cm) i hibrid MG-MI-4 x PL-DI-13 (152,67 cm). Linija PL-DI-52 (24,47 cm) i hibrid MG-MI-4 x MI-A-57 (25,37 cm) imali su najveći prosečni prečnik glave, dok je najmanji prosečan prečnik zabeležen kod linije PL-DI-44 (13,60 cm) i hibrida MG-MI-2 x PL-DI-15 (17,90 cm). Linije sa najboljim opštim kombinacionim sposobnostima su PL-DI-13 za visinu biljke i MI-A-57 za prečnik glave. Hibridi sa najboljim posebnim kombinacionim sposobnostima su MG-MI-2 x PL-DI-15 za visinu biljke i MG-MI-1 x PL-DI-15 za prečnik glave.

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