UDC 575.12
Original scientific paper

GENETIC VARIANCE OF SUNFLOWER YIELD COMPONENTS (*HELIANTUS ANNUUS* L.)

Nada HLADNI[1], Dragan ŠKORIĆ[1], and Marija KRALJEVIĆ-BALALIĆ[2]

[1]Institute of Field and Vegetable Crops, Maksima Gorkog 30, 21000 Novi Sad,
[2]Institute of Field and Vegetable Crops, Faculty of Agriculture, 21000 Novi Sad,
Serbia and Montenegro

Hladni N., D. Škorić, and M. Kraljević-Balalić (2003): *Genetic variance of sunflower yield components (Heliantus annuus L.)* – Genetika, Vol. 35, No. 1, 1-9.

The main goals of sunflower breeding in Yugoslavia and abroad are increased seed yield and oil content per unit area and increased resistance to diseases, insects and stress conditions via an optimization of plant architecture. In order to determine the mode of inheritance, gene effects and correlations of total leaf number per plant, total leaf area and plant height, six genetically divergent inbred lines of sunflower were subjected to half diallel crosses. Significant differences in mean values of all the traits were found in the F_1 and F_2 generations. Additive gene effects were more important in the inheritance of total leaf number per plant and plant height, while in the case of total leaf area per plant the nonadditive ones were more important looking at all the combinations in the F_1 and F_2 generations. The average degree of dominance $(H_1/D)^{1/2}$ was lower than one for total leaf number per plant and plant height, so the mode of inheritance was partial dominace, while with total leaf area the value was higher than one, indicating superdominance as the mode of inheritance. Significant positive correlation was found between total leaf area per plant and total leaf number per plant (0.285*) and plant height (0.278*). The results of the study are of importance for further sunflower breeding work.

Corresponding author: Nada Hladni, Scientific Institute of Field and Vegetable Crops, M.Gorkog 30, 21000 Novi Sad, Serbia and Montenegro

Key words: sunflower, inbred lines, mode of inheritance, gene effects, simple correlation coefficient

INTRODUCTION

The sunflower is the main crop for the production of edible oil in many countries of the world, including Yugoslavia. The main goals of sunflower breeding are increased seed yield and oil content per unit area, sink capacity, harvest index, and resistance to dominant diseases and insects as well as optimized plant architecture, earlier maturity (*via* shortened vegetative phase) and improved adaptability (ŠKORIĆ, 2002). The development of sunflower lines and hybrids is aimed at developing hybrids with changed appearance, or plant architecture, that should produce increased plant number per unit area and hence increased yields in intensive agronomic practice conditions.

Selection of genotypes to be used for hybridization from the existing genetic material requires parents that have the desired traits, which, in turn, makes it necessary to study the mode of inheritance, gene effects and interdependence of total leaf number per plant, total leaf area and plant height.

Leaf number and size determine total leaf, or assimilatory, area. Additive gene action for total leaf area per plant was found by KOVAČIK (1960), NEDELJKOVIĆ *et al.* (1992), and KUMNAR *et al.* (1998) and dominant one by MOROZOV (1947), SINDAGI *et al.* (1980), MARINKOVIĆ (1982), CHAUDHARY and ANAND (1985)

According to SAKAČ *et al*. (1997), moderate leaf area size and greater leaf area longevity are significant factors in obtaining high seed and oil yields per sunflower plant as well as sunflower crop. ŠKORIĆ (1989**)** reports finding that the maximum leaf area in F_1 hybrids should be 6,000 to 7,000 cm^2 per plant.

Partial dominance as the mode of inheritance and additive gene action for leaf area size are reported by KRALJEVIĆ-BALALIĆ (1975**)** in wheat and CECOONI and BALDINI (1991) in sunflower. According to MOROZOV (1974), MARINKOVIĆ (1980), ŠKORIĆ (1985), CHAUDHARY and ANAND (1985), KOVAČIK and ŠKALOUD (1990) and JOKSIMOVIĆ *et al*. (1997), the nonadditive component of genetic variance had more importance in the inheritance of this trait and the modes of inheritance were dominance and superdominance.

The optimum average plant height for sunflower hybrids is 160-180 cm (SHABBANA, 1974; ŠKORIĆ, 1975). The development of sunflower hybrids with a plant height changed to 120-150 cm would bring about higher resistance to lodging and easier cultivation and harvesting (SCHENEITER, 1988). One of the more recent goals of sunflower breeding is breeding for increased harvest index and improved resistance to lodging via reduced plant height (MARINKOVIĆ and DOZET, 1997).

PUTT (1965), VELKOV (1977), MARINKOVIĆ (1981), DUA and YADAVA (1985) report a larger contribution of nonadditive genetic variance. TYAGI (1988), KOVAČIK and ŠKALOUD (1990), and GANGAPPA *et al*. (1997) found that plant height is determined by additive and nonadditive gene action, while RAO and

SINGH (1977) argue that the additive component of genetic variance is of greater importance that nonadditive one in the inheritance of plant height in sunflower.

Selection of genotypes to be used for hybridization from the existing genetic material requires parents that have the desired traits, which, in turn, makes it necessary to study the mode of inheritance, gene effects and interdependence of total leaf number per plant, total leaf area and plant height.

MATERIALS AND METHODS

In order to determine gene effects and heritability of sunflower yield components in the F_1 and F_2 generations, six genetically divergent inbred lines ($OCMS_1$, NS-204B, NS-22B, NS-BD, NS-NDF, and NS-K) developed at the Institute of Field and Vegetable Crops in Novi Sad were subjected to half diallel crosses (the main characteristics of the inbreds are discussed in HLADNI (1999)). A randomized block design with three replicates was used in a trial established at the Rimski Šančevi site. The trial included six inbred lines, 15 F_1 hybrids and 15 F_2 hybrids. Sample plants to be used for analysis were taken from central rows (excluding the outermost plants) as follows: five plants per replicate from parental lines and F_1s and 30 plants per replicate from the F_2 generation. Relevant traits were analyzed in the field and laboratory. At flowering, total number of leaves per plant was determined in the laboratory by counting the total number of dry and green leaves and total leaf area per plant in cm^2 was measured on a leaf area measurement apparatus (LI-300, Licor). At maturity, plant height (distance from the ground to the middle of the head) was measured in the field and expressed in cm.

The mean values and coefficients of correlation (r) as indicators of interdependence of two variables were determined according to HADŽIVUKOVIĆ (1991).

The components of genetic variance were assessed by the MATHER and JINKS (1982) method.

RESULTS AND DISCUSSION

Significant differences were found between the inbreds' means and the mean values of their F_1 and F_2 hybrids in total leaf number per plant, total leaf area per plant and plant height.

Among the parent lines, line NS-22B had the smallest (18.2) and line NS-BD the largest (43.4) average number of leaves. The smallest average leaf number in the two generations was found in NS-22B x NS-NDF (21.2, 20.7) and the largest in NS-22B x NS-BD (32.3, 31.8) (Table 1).

Among the six inbreds, the smallest average leaf area per plant was that of NS-204B ($0.20m^2$) and the largest that of NS-BD ($0.41m^2$). In the F_1 generation, NS-22B x NS-NDF had the smallest and $OCMS_1$xNS-BD the largest mean value of this parameter (0.42 and 0.57 m^2, respectively). With the F_2s, the lowest and highest values were those of NS-22BxNS-NDF and $OCMS_1$xNS-K, respectively (Table 1).

Table 1. Mean values of sunflower yield components

	PARENTS and hybrids	Ubl	ulp (m^2)	vb (cm)
P_1	$OCMS_1$	24.0	0.38	87.6
F_1	$OCMS_1$xNS204B	25.3	0.50	141.6
F_2		24.3	0.42	137.7
F_1	$OCMS_1$xNS22B	23.2.	0.48	133.8
F_2		21.9	0.36	114.6
F_1	$OCMS_1$xNSBD	26.3	0.57	110.2
F_2		24.7	0.35	107.1
F_1	$OCMS_1$xNSNDF	24.4	0.53	101.6
F_2		23.2	0.38	96.6
F_1	$OCMS_1$xNSK	25.2	0.51	131.4
F_2		24.7	0.47	120.6
P_2	NS204B	20.2	0.20	114.0
F_1	NS204BxNS22B	25.4	0.43	131.8
F_2		24.8	0.34	120.4
F_1	NS204BxNSBD	24.4	0.48	129.4
F_2		24.0	0.41	111.2
F_1	NS204BxNSNDF	25.2	0.46	112.8
F_2		24.3	0.35	91.5
F_1	NS204BxNSK	24.2	0.43	138.8
F_2		24.0	0.36	133.3
P_3	NS22B	18.2	0.36	99.8
F_1	NS22BxNSBD	32.3	0.55	115.2
F_2		31.8	0.40	94.6
F_1	NS22BxNSNDF	21.2	0.42	102.4
F_2		20.7	0.30	79.6
F_1	NS22BxNSK	26.8	0.51	135.8
F_2		26.4	0.40	126.6
P_4	NSBD	43.4	0.41	84.4
F_1	NSBDxNSNDF	27.2	0.55	88.4
F_2		26.1	0.41	88.1
F_1	NSBDxNSK	26.2	0.75	129.4
F_2		25.6	0.37	127.9
P_5	NSNDF	22.2	0.33	54.0
F_1	NSNDFxNSK	23.6	0.47	120.0
F_2		22.3	0.45	110.9
P_6	NSK	24.2	0.26	127.4

The lowest mean for plant height was recorded in the inbred line NS-NDF (54.0cm) and the highest in NS-K (127.4 cm). The smallest average plant height in the F_1 generation was obtained with NS-BD x NS-NDF (88.4 cm) and the highest $OCMS_1$ x NS-204B (141.6 cm). In the F_2 generation, the plant height means dropped relative to the F_1s — the lowest were found in NS-22B x NS-NDF (79.6 cm) and the highest in $OCMS_1$ x NS-204B (137.7 cm) (Table 1).

The additive component of genetic variance (D) was larger than the dominant one (H_1 and H_2), so additive gene effects apparently are of greater importance in the inheritance of leaf number in sunflower.

That additive gene action has more influence on inheritance the of leaf number in this crop is supported by the findings of KOVAČIK (1960), NEDELJKOVIĆ (1992**)** and KUMNAR *et al*. (1998) but contradicts results obtained by MARINKOVIĆ (1982), who argues that it is the dominant gene effects that have a larger influence in the inheritance of leaf number in sunflowers.

The F value was positive, meaning that dominant genes prevailed over recessive ones, as confirmed by the calculated frequency of dominant (u) and recessive (v) genes in the two generations. When these two types of genes are distributed symetrically in the parents, the value of the expression $H_2/4H_1$ is 0.25.

In the case of leaf number, as shown by our data, dominant and recessive genes were not evenly distributed in the parent lines, as the $H_2/4H_1$ value was different from 0.25 in both generations. The calculated degree of dominance value $(H_1/D)^{1/2}$ was lower than one, indicating that in the inheritance of leaf number we had a case of partial dominance looking at all the combinations as a whole. The ratio of the total number of dominant genes to total number of recessive ones (Kd/Kr) was higher than one in all the parents, which suggests that the dominant genes prevailed over recessive ones (Table 2).

Table 2. Variance components of total leaf number per plant, total leaf area and plant height

Variance components	Total leaf number		Total leaf area		Plant height	
	F_1	F_2	F_1	F_2	F_1	F_2
D	83.60	83.25	0.006	0.006	655.67	635.36
H_1	59.43	62.05	0.026	0.016	619.51	443.54
H_2	36.43	38.00	0.024	0.012	592.59	376.62
F	85.62	86.36	0.002	0.004	53.16	26.37
E	0.03	0.03	0.001	0.001	0.01	0.01
$H_2/4H_1$	0.15	0.14	0.023	0.021	0.24	0.21
u	0.81	0.82	0.664	0.632	0.61	0.69
v	0.19	0.18	0.336	0.368	0.40	0.31
$(H_1/D)^{1/2}$	0.84	0.86	2.115	2.162	0.97	0.84
Kd/Kr	4.09	4.01	1.204	1.182	1.09	1.05

Analysis of genetic variability components in both generations (F_1 and F_2) showed that the value of the dominant component (H_1 and H_2) was higher than that of the additive one (D). This means that dominant effects were of greater importance in the inheritance of leaf area per plant. In the present paper, dominant gene effects were more important than additive ones in the inheritance of leaf area per plant, which is in agreement with the findings of Morozov (1974), Marinković (1980), Škorić (1980), Chaudhary and Anand (1985), Kovačik and Škaloud (1990) and Joksimović *et al*. (1997) but not in agreement with Cecooni and Baldini (1991), who found additive gene effects in the inheritance of total leaf area per plant. The F value was positive, indicating that dominant genes prevailed over recessive ones, which agrees with the calculated frequencies of dominant (u) and recessive (v) genes. Dominant and recessive genes were not evenly distributed in the parental lines, since the $H_2/4H_1$ value was not 0.25 in either generation. The ratio of the total number of dominant genes to total number of recessive ones (Kd/Kr) in all the parents was higher than one, suggesting that the dominant genes prevailed over recessive ones (Table 2). The average degree of dominance $(H_1/D)^{1/2}$ was higher than one, indicating that in the inheritance of leaf area superdominance was present in both generations (Table 2).

The additive component of genetic variance (D) for plant height was greater than the dominant one (H_1 and H_2) in the F_1 and F_2 generations. The results of the present study show that the inheritance of this trait in sunflower is controlled by additive gene action, which is supported by the results of Rao and Sing (1977) but does not agree with those of Putt (1965), Velkov (1977), and Marinković (1981). Kovačik and Škaloud (1990) and Gangappa *et al*. (1997) argue that this traits is affected by additive as well as nonadditive genes. The F value was positive, meaning that dominant genes prevailed over recessive ones. This was confirmed by the frequency of dominant (u) and recessive (v) genes. Dominant and recessive genes were not distributed evenly in the parent lines, as the $H_2/4H_1$ value differed from 0.25. The ratio of dominant to recessive genes (Kd/Kr) was above the value of one, suggesting that the dominant genes prevailed over recessive ones (Table 2). The fact that the $(H_1/D)^{1/2}$ ratio was smaller than one in both generations shows that the mode of inheritance of plant height was partial dominance.

Table 3. Correlation coefficients for total leaf number per plant and leaf area, total leaf number per plant and plant height, and total leaf area and plant height

Trait	Total leaf number	Total leaf area	Plant height
Interdependence R	0.285*		
		-0.078	
			0.278*

*,** Significant at 5% and 1%, respectively

The determination of interdependence among total leaf number, total leaf area per plant and plant height (Table 3), has revealed significant positive interdependence between total leaf area per plant and total leaf number per plant (0.285*) and plant height (0,278*).

The study has shown that in developing lines and hybrids with altered appearance, i.e. plant architecture, it is essential to know the mechanism of gene action and gene interaction with other genes and the environment when it comes to the expression of a particular trait.

CONCLUSION

Significant differences in mean values of all the traits were found among the genotypes in the F_1 and F_2 generations.

Additive gene effects were of greater importance in the inheritance of total leaf number per plant and plant height, while in the case of total leaf area per plant the nonadditive ones were more important looking at all the combinations in the F_1 and F_2 generations.

The average degree of dominance $(H_1/D)^{1/2}$ was lower than one for total leaf number per plant and plant height, so the mode of inheritance was partial domination. With total leaf area, on the other hand, the value was higher than one, indicating superdominance was the mode of inheritance.

Significant positive correlation was found between total leaf area per plant and total leaf number per plant (0.285*) and plant height (0,278*).

Received January 3rd, 2003
Accepted April 28th, 2003

REFERENCES

CECCONI F. and M. BALDINI (1991): Genetic analysis of some physiological charactars in relation to plant development of a sunflower (*Helianthus annuus* L.) diallel cross. Helia, *14*, 93-100.

CHAUDHARY S.K. and I.J. ANAND (1985): Heterosis for seeds yield traits in sunflower (*Helianthus annuus* L.). Genetika, *17*, 35-42.

DUA P.R. and T.P. JADOVA (1985): Genetics of seed yield and its components in sunflower (*Helianthus annuus* L.). Proc. of 11th Inter. Sunf. Conf., 627-632, Mar del Plata, Argentina.

GANGAPPA E., K.N. CHANNAKRISHNAIAH, M.S. HARINI, and S. RAMESH (1997): Studies of combining ability in sunflower (*Helianthus annuus* L.). Helia, *20*, 73-84.

HADŽIVUKOVIĆ S. (1991): Statistički metodi. Drugo prošireno izdanje. Poljoprivredni fakultet, Novi Sad.

HLADNI N. (1999): Nasleđivanje arhitekture biljke suncokreta (*Heliantus annuus* L.) u F_1 i F_2 generaciji suncokreta. Magistarska teza, Univerzitet u Novom Sadu, Poljoprivredni fakultet.

JOKSIMOVIĆ J., R. MARINKOVIĆ i M. MIHALJČEVIĆ (1997): Uticaj lisne površine na prinos semena i ulja kod F_1 hibrida suncokreta (*Helianthus annuus* L.). Proizvodnja i prerada uljarica, *38*, 509-516.

KOVAČIK A. (1960): The effect of intervarietal hybridization on methodological propertiers of F_1 and F_2 generation sunflower. Zbornik československe akademie zemedelskych ved, Praha, *4*, 447-466.

KOVAČIK A. and V. ŠKALOUD (1990): Results of inheritance evaluation of agronomically important traits in sunflower. Helia, *13*, 41-46.

KRALJEVIĆ-BALALIĆ M. (1975): Nasleđivanje lisne površine kod nekih genotipova vulgare pšenice. Savremena polj., *23*, 19-31.

KUMAR A.A., M. GANESH, and P. JANILA (1998): Combining ability analysis for yield and yield contributing characters in sunflower (*Helianthus annuus* L.). Annalis of Agr. Research, *19*, 437-440.

MARINKOVIĆ R. (1980): Nasleđivanje veličine lisne površine suncokreta u F_1 generaciji i komponente varijabilnosti. Arhiv za polj. nauke, *41*, 385-392.

MARINKOVIĆ R. (1981): Nasleđivanje veličine lisne površine, broja listova i visine biljaka u dialelnim ukrštanjima inbred linija suncokreta. Univerzitet u Novom Sadu, Magistarska teza, Poljoprivredni fakultet.

MARINKOVIĆ R. (1982): Inheritance of plant height and leaf number in diallel crossing of sunflower inbreds. Proc. of X Inter. Sunfl. Conf. Australia, 232-233.

MARINKOVIĆ R. and B. DOZET (1997): Genetička istraživanja u svetu u funkciji oplemenjivanja. Zbornik radova Naučnog instituta za ratarstvo i povrtarstvo, Novi Sad, *29*, 569-592.

MATHER K. and J.L. JINKS (1982): Biometrical genetics. Third Edton, Chapman and Hall, London, England, 65-83.

MOROZOV V.K. (1947): Selekcija podsolnečnika v SSSR. (knjiga) Moskva

NEDELJKOVIĆ S., D. STANOJEVIĆ i D. JOVANOVIĆ (1992): Nasleđivanje broja listova i dinamike gubitka fiziološke aktivnosti kod inbred linija i F_1 hibrida suncokreta. Proizvodnja i prerada uljarica, *33*, 57-62.

PUTT E.D. (1965): Heterosis, combining ability and predicted synthetics from a diallel cross in sunflower (*Helianthus annuus* L.). Can. J. Pl. Sci., *46*, 59-67.

RAO N.M. and B. SINGH (1977): Inheritance of some quantitative charters in sunflower (*Helianthus annuus* L.). Pak. J. of Rfs. *2*, 144-146.

SAKAČ Z., T. ĆUPINA, M. PLESNIČAR i D. PANKOVIĆ (1997): Adaptacija listova u usevu suncokreta. Proizvodnja i prerada uljarica, *38*, 490-505.

SCHENEITER A., B. CURADAR, G. ZAFFDRONI, and H. MAID (1988): Agronomic evaluation of semidvarf sunflower. Proc. of 12th Inter. Sunfl. Conf.1, 406-408, Novi Sad, Yugoslavia.

SHABANA M.R. (1974): Genetic variability of the yield components of oil in different sunflower variaties and inbred lines. PhD. thesis, University of Novi Sad, Faculty of Agriculture.

SINDAGI S.S., A.R.K. RAO, and A. SEETHARAM (1980): Analysis in sunflower component of genetic variation. Proc. of IX Inter. Sunfl. Conf., Torremolinos, 432-437.

ŠKORIĆ D. (1985): Mode of inheritance of LAI in F_1 generation of different sunflower inbreds. Proc. of XI Inter. Sunfl. Conf., Argentina, 683-689.

ŠKORIĆ D. (1975): Mogućnost korišćenja heterozisa na bazi muške sterilnosti kod suncokreta. Doktorska disertacija, Univerzitet u Novom Sadu, Poljoprivredni fakultet.

ŠKORIĆ D. (1980): Desired model of hybrid and the newly developed NS-hybrids. Helia, *3*, 19-24.

ŠKORIĆ D., T. VREBALOV, T. ĆUPINA, R. MARINKOVIĆ, S. MAŠIREVIĆ, J. ATLAGIĆ, L. TADIĆ, R. SEKULIĆ, D. STANOJEVIĆ, M. KOVAČEVIĆ, V. JANČIĆ i Z. SAKAČ (1989): Suncokret (monografija), Nolit, 613str.

TYAGI A.P. (1988): Combining ability analysis for yield components and maturyti traits in sunflower (*H. annuus* L.). Proc. of 12th Inter. Sunf. Conf., Novi Sad, Yugoslavia,

VELKOV N.V. (1970): Nasledovane na visočinata na stblato pri slnčogleda. Genetika i selekcija. Sofia. *3*, 393-401.

GENETSKA VARIJANSA KOMPONENTI PRINOSA SUNCOKRETA (*HELIANTUS ANNUUS* L)

Nada HLADNI[1], Dragan ŠKORIĆ[1] i Marija KRALJEVIĆ-BALALIĆ[2]

[1]Naučni institut za ratarstvo i povrtarstvo, Maksima Gorkog 30, 21000 Novi Sad
[2]Naučni institut za ratarstvo i povrtarstvo, Poljoprivredni fakultet, 21000 Novi Sad, Srbija i Crna Gora

Izvod

Oplemenjivanje suncokreta u svetu i kod nas usmereno je na povećanje prinosa semena i sadržaja ulja po jedinici površine, otpornosti prema bolestima, insektima i stresnim uslovima optimalizacijom arhitekture biljke. U cilju utvrđivanja načina nasleđivanja, efekta gena i međuzavisnosti ukupnog broja listova po biljci, ukupne lisne površine po biljci i visine biljke, izvršena su dialelna ukrštanja isključujući recipročna sa šest genetski divergentnih inbred linija suncokreta. Dobijene su signifikantne razlike u srednjim vrednostima za sva ispitivana svojstva F_1 i F_2 generaciji. Aditivni efekat gena je bio od većeg značaja u nasleđivanju ukupanog broja listova po biljci i visini biljke dok je neaditivni efekat gena bio značajniji kod ukupne lisne površine po biljci uzevši u obzir sve kombinacije ukrštanja u F_1 i F_2 generaciji. Prosečan stepen dominacije $(H_1/D)^{1/2}$ je kod ukupnog broja listova po biljci i visine biljke manji od jedinice iz toga se može zaključiti da je način nasleđivanja parcijalna dominacija, a kod ukupne lisne površine je veći od jedinice što ukazuje na superdominaciju. Značajna pozitivna međuzavisnost ustanovljena je između ukupne lisne površine po biljci i ukupnog broja listova po biljci (0.285*), visine biljke (0.278*). Rezultati ovih istraživanja imaće značaja u daljem radu na oplemenjivanju suncokreta.

Primljeno 3. I 2003.
Odobreno 28. IV 2003.