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VARIANCE COMPONENTS AND GENE EFFECTS OF MORPHOLOGICAL TRAITS IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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In order to enable progress in sunflower breeding, an increasing amount of attention has to be paid to the morpho–physiological traits (petiole angle and length) of this crop that have a significant effect on its seed yield and oil concentration. In the inheritance of petiole angle and petiole length the additive component of genetic variance had the predominant role in the F_1 and F_2 generation. The mean degree of dominance $(H_1/D)^{1/2}$ and the intersection of the expected regression line with the Wr axis indicated partial dominance in the inheritance of petiole angle and petiole length. Broad sense heritability for petiole angle was 88% and for petiole length 85%.

Key words: sunflower, morpho-physiological, inheritance, gene effect, heritability

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INTRODUCTION

In order to alter sunflower plant architecture, the creation of new lines and hybrids is aimed at the development of plants with small height, erectophile leaves, short petioles, a favorable head movement angle, and no leaves just below the head (ŠKALOUD and KOVAČIK, 1992).

The reduction of the petiole and incorporation of genes for erect leaf position can increase the plant population by 20-30% without having to augment the head and absolute mass. The development of sunflower hybrids with an erectoid leaf and shortened petiole represents one of the more recent trends in sunflower breeding-a trend that should speed up the flow of assimilates and increase plant number per hectare and, hence, oil yield and oil content. In order to be able to select from the existing genetic materials, i.e. genotypes that will be used for hybridization, it is essential that the parents used in the crosses possess the desired traits, and this, in turn, requires that we determine the mode of inheritance, gene effects, the distribution of dominant and recessive genes in the parental lines, and the heritability of petiole angle and length in the F_1 and F_2 generations.

The objective of this study was to determine the mode of inheritance and assess gene effects and heritability for petiole angle and length in the F_1 and F_2 generations developed by crossing six genetically divergent sunflower inbred lines.

MATERIAL AND METHODS

Half diallel crosses were made with six genetically divergent inbred lines ($OCMS_1$, NS-204B, NS-BD, NS-22B, NS-NDF, and NS-K) developed at the Institute of Field and Vegetable Crops in Novi Sad. The trial was set up at the experimental field at Rimski Šančevi according to a randomized block design with three replications. It involved six inbred lines, 15 F_1 hybrids, and 15 F_2 generations. In order to obtain full information about the components of genetic variance and gene effects for the studied traits, we performed an analysis of diallel crosses for combining ability according to GRIFFING (1956), Method 2, Model I. The MATHER and JINKS (1982) method was used to assess the components of genetic variance and perform regression data analysis. Narrow sense heritability was calculated according to MATHER and JINKS (1971).

RESULTS AND DISCUSION

The six inbreds and F_1 and F_2 hybrids differed significantly with respect to the traits under study (petiole angle and length). The mean values of the parental lines for petiole angle ranged from 24.2° in the NS-BD inbred line to 56.1° in in the NS-22B inbred. In the F_1 and F_2 generations, the lowest mean was found in the hybrid combination $OCMS_1$ x NS-BD (33°, 32.4°) and the highest in NS-BD x NS-NDF (53°, 50.5°) (Table 1). Among the inbred lines, the lowest mean value for petiole length was recorded in NS-NDF (5.2 cm) and the highest in $OCMS_1$ (24.2 cm). Among the F_1s and F_2s, the lowest mean was that of the combination NS-22B

x NS-NDF (15.6 cm, 14.8 cm) and the highest that of $OCMS_1$ x NS-K (23.4 cm, 22.3 cm) (Table 2).

Table 1. Mean values of petiole angle (°) in sunflower

Parents	OCMS	NS-204B	NS-22B	NS-BD	NS-NDF	NS-K
OCMS	**43.0**	45.1	50.0	33.0	44.0	42.0
NS-204B	44.3	**46.0**	48.0	40.0	47.0	45.0
NS-22B	49.2	46.5	**56.1**	43.0	53.0	46.0
NS-BD	32.4	38.7	42.4	**24.2**	43.0	36.0
NS-NDF	43.1	46.7	50.5	42.0	**48.1**	46.0
NS-K	41.0	44.9	45.2	35.6	45.7	**34.0**

*F_1 means are above the diagonal and F_2 means below the diagonal

In the F_1 and F_2 generations, values of the additive component (D) were significantly higher than those of the dominant one (H_1 and H_2), meaning that, overall, the additive component accounted for the main portion of genetic variance in the inheritance of petiole angle and length. These results are in agreement with those of a study of leaf angle above the maize ear by KOJIĆ (1982) and a study of sunflower petiole length by MARINKOVIĆ *et al.* (1994).

Table 2. Mean values and inheritance of petiole length in sunflower

Parents	OCMS	NS-204B	NS-22B	NS-BD	NS-NDF	NS-K
OCMS	**24.2**	23.3	21.2	21.2	17.1	23.4
NS-204B	22.2	**19.3**	18.2	20.3	17.3	22.3
NS-22B	20.1	17.8	**15.9**	17.3	15.6	19.4
NS-BD	20.9	19.5	16.9	**18.2**	18.1	22.4
NS-NDF	16.7	16.5	14.8	17.2	**5.2**	18.4
NS-K	22.32	21.0	18.7	21.4	17.1	**19.4**

*F_1 means are above the diagonal and F_2 means below the diagonal

As the F value (additive x dominant interaction) was positive, it was concluded that dominant genes predominated over recessive ones in the expression of petiole angle and length. The frequency of dominant genes (u) was greater than that of recessive ones (v), which is in agreement with the calculated F value. Dominant and recessive genes were not evenly distributed in the parental lines, as shown by fact that the $H_2/4H_1$ ratio was not 0.25. The average degree of dominance $(H_1/D)^{1/2}$ was less than 1, which indicates that this was a case of partial dominance in the inheritance of petiole angle and length looking at all the combinations in both generations. The fact that the ratio of the total number of dominant to total number of recessive alleles in all the parents (Kd/Kr) was higher than 1 showed that dominant alleles predominated over recessive ones. Narrow sense heritabilities

of petiole angle and petiole length were 88 and 85%, respectively (Table 3).

Table 3. Variance components of petiole angle and petiole length in sunflower

Components	Petiole angle Values		Petiole length Values	
	F_1	F_2	F_1	F_2
D	172.63	126.53	41.45	41.21
H_1	30.82	31.34	16.10	12.05
H_2	22.04	21.47	11.52	7.84
F	57.55	60.94	23.53	23.88
E	0.03	0.04	0.01	0.04
$H_2/4H_1$	0.18	0.17	0.18	0.16
u	0.77	0.78	0.77	0.80
v	0.23	0.22	0.23	0.20
$(H_1/D)^{1/2}$	0.49	0.50	0.62	0.54
Kd/Kr	2.70	2.88	2.69	3.31
h^2_n	88%		85%	

Regression analysis of these two traits in the F_1 and F_2 confirmed that additive gene action had more influence in the inheritance of petiole angle and petiole length that non-additive, since the expected line of regression intersected the Wr

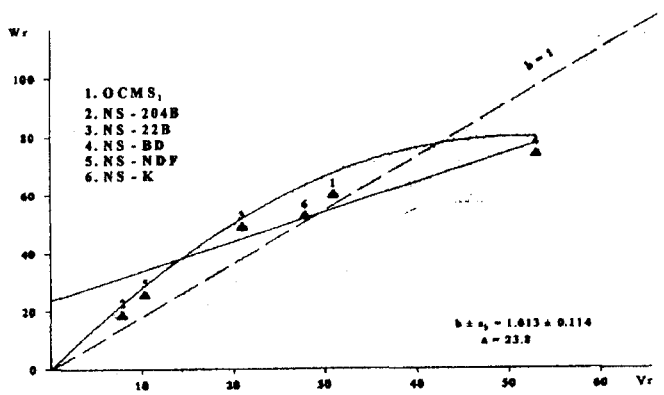

Figure1.a. Regression analysis of VrWr petiole angle in sunflower (F_1)

axis above the beginning of the coordinate system and was quite close to the limiting parabola. The distribution of points in the dispersion diagram was indicative of the parents' genetic divergence. Lines NS-204B and NS-NDF had more dominant and less recessive genes for petiole angle, since their points were the closest to the start of the coordinate system. Three lines whose points were

removed from the start of the system (NS-22B, NS-K, and $OCMS_1$) had an equal number of dominant and recessive genes for petiole angle, while line NS-BD was farthest from the beginning of the system in both generations and, hence, had the largest number of recessive genes. NS-BD was the closest to the start of the system and had the largest number of dominant genes controlling petiole length, whereas line NS-NDF had the largest number of recessive genes for this trait, since it was farthest away from the start of the system. In the present study, lines NS-BD, NS-K, NS-22B, NS-204B, and $OCMS_1$ had more dominant than recessive genes in the F_1 and F_2 generations, whereas line NS-NDF had more recessive genes than dominant ones (Fig. 1 and 2).

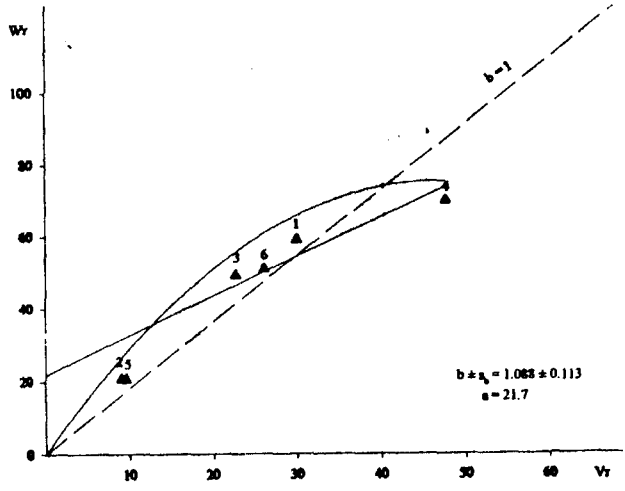

Figure1.b. Regression analysis of VrWr petiole angle in sunflower(F_2)

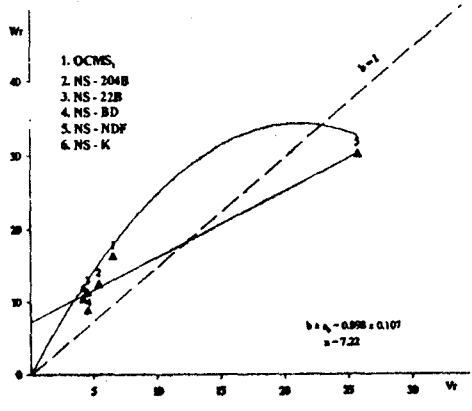

Figure 2.a. Regression analysis of VrWr petiole length in sunflower (F_1)

The results of this research will be used to develop new genotypes with an altered plant architecture, i.e. an altered leaf architecture (reduced leaf angle and petiole length), which will lead to greater exposure of leaf area to sunlight and increase the efficiency of photosynthesis in thicker stands, all of which will, in turn, increase sunflower yields.

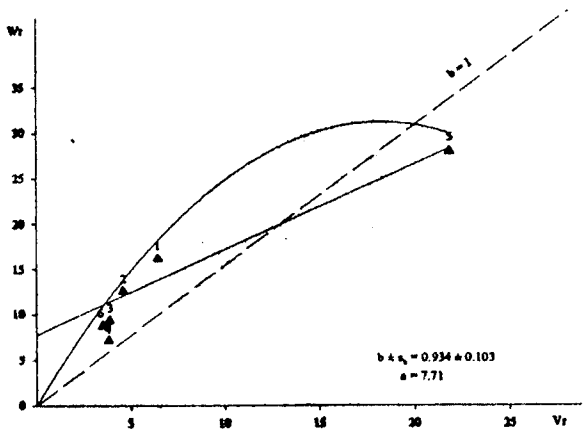

Figure 2.b. Regression analysis of VrWr petiole length in sunflower (F_2)

CONCLUSION

After 6 x 6 half diallel crosses were made, the six inbreds differed significantly concerning their means for petiole angle and petiole length. Our analysis of components of genetic variance and regression analysis of petiole angle and length confirmed the prevailing influence of additive gene action and partial dominance as the mode of inheritance of these two characters in both generations. Line NS-BD had the smallest petiole angle and the largest number of recessive genes for that trait and can therefore be used in breeding programs for petiole reduction. Line NS-BD had the shortest petiole and the biggest number of recessive genes for the trait, so it too can be used in breeding programs for petiole reduction purposes.

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KOMPONENTE VARIJANSE I EFEKAT GENA MORFOLOŠKIH SVOJSTAVA SUNCOKRETA (*HELIANTHUS ANNUUS* L.)

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Izvod

Da bi se obezbedio napredak u selekciji suncokreta potrebno je obratiti veću pažnju na morfo-fiziološke osobine (ugao lisne drške i dužinu lisne drške) koje značajno utiču na prinos semena i sadržaj ulja. Radi proučavanja nasleđivanja, efekta gena, komponenti genetske varijanse i heritabilnosti ugla i dužine lisne drške šest genetski divergentnih inbred linija suncokreta u F_1 i F_2 generaciji primenjena analiza dialelenih ukrštanja za kombinacione sposobnosti, GRIFFING, 1956 metod 2, model I. Za ocenu komponenti genetske varijanse i regresionu analizu korišćen je metod MATHER and JINKS (1982). Ocena heritabilnosti u užem smislu je rađena po formuli MATHER and JINKS (1971). U nasleđivanju ugla i dužine lisne drške aditivna komponenta genetske varijanse je bila predominantna u F_1 i F_2 generaciji. Prosečan stepen dominacije $(H_1/D)^{1/2}$ i presek očekivane linije regresije sa Wr osom ukazuje na parcijalnu dominaciju u nasleđivanju ugla i dižine lisne drške. Heritabilnost u užem smislu za ugao lisne drške iznosi 88%, a za dužinu lisne drške 85%.

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