CORRELATION OF YIELD COMPONENTS AND SEED YIELD PER PLANT IN SUNFLOWER (*HELIANTHUS ANNUUS*)

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Abstract

Studied in this paper was the interdependence of six morphophysiological sunflower traits (petiole angle, petiole length, total leaf number per plant, total leaf area per plant, plant height and head diameter) and their correlations with seed yield per plant. Path coefficient analysis was used to gain information on direct and indirect effects of the above characters on seed yield per plant. For most of the traits significant and highly significant correlations were found in the F1 and F2 generations. Plant height and total leaf area per plant had a high positive direct effect on seed yield per plant, while petiole angle and total leaf number per plant had a negative direct effect on the same trait in both generations. Petiole length had a positive and head diameter a negative direct effect on seed yield per plant in the F1 generation, whereas in the F2 generation the two traits behaved the opposite. Path coefficient analysis indicated that plant height, total leaf area, and petiole length were the most important traits for seed yield per plant. Based on the coefficient of determination for the F1 and F2 generations (R2=0.73), it can be concluded that the influence of traits from the study on total variability of seed yield per plant was 73%, while the remaining 27% can be attributed to factors not included in the study.

Introduction

The sunflower is the most important oil crop in Serbia and Montenegro. The prime task of sunflower breeding is to develop new hybrids with a high genetic potential for seed yield. Seed yield is a complex character affected by different factors, which may act individually or collectively. More information is needed to clarify the relations between seed yield per plant and yield components. Correlations between different characters are an aspect that should be kept in mind for better planning of breeding programs in sunflower.

Correlation coefficients have been used by many researchers (Škorić, 1974; Joksimović et al., 1997; Razi, 1998) to determine seed yield and other characters in sunflower. Since we could not establish the effect of relationships between the examined yield components and seed yield per plant on the basis of correlation coefficients, we processed the data by path-coefficient analysis, which enabled the partitioning of the direct and indirect effects of individual yield components and indentification of yield components applicable as selection criteria in sunflower breeding (Marinković, 1992). This statistical model has been used extensively by sunflower researchers (Marinković, 1988, 1992; Punia and Gill, 1994; Joksimović et al., 1999).

In this paper we studied mutual relationships between several yield components on the one hand and seed yield on the other as well as the direct and indirect effects of these components on seed yield in sunflower.

Materials and Methods

In order to determine the interdependence between seed yield and sunflower yield components in the F1 and F2 generations, half-diallel crosses were made with six genetically divergent inbred lines (OCMS1, NS-204B, NS-22B, NS-BD, NS-NDF, NS-K) developed at the Institute of Field and Vegetable Crops in Novi Sad. A trial was set up at the Rimski Šančevi site using a randomized block design with three replicates. Included in the trial were six inbreds, 15 F1 hybrids and 15 F2 hybrids. Plants to be used for analysis were taken from the rows in the middle and no plants on the edges of the rows were included. Five plants per replicate were taken from the parental lines and F1s and 30 per replicate from the F2s. The following characteristics were analyzed: petiole angle (PA), petiole length (PL), total leaf number per plant (TLN), total leaf area per plant (TLA), plant height (PH), head diameter (HD) and seed yield per plant (SY). The traits were analyzed in the field and in the laboratory. Petiole angle (PA) and PL were measured in the field at budding (12th leaf), while TLN and TLA (expressed as cm sq.) were determined in the laboratory at flowering by counting the total number of leaves (dry and green) and using a device for measuring leaf area (LI-300, Licor), respectively. Plant height (PH-distance from the ground to the center of the head) and HD (cm) were measured in the field at maturity. Seed yield (SY) was measured in the laboratory after harvesting had been done, all impurities removed, and moisture adjusted to 11%. The mean values and correlation coefficient (r) as indicators of interdependence between two variables were determined according to Hadživuković (1991). Mutual relationships among the characteristics and direct and indirect effects on seed yield were analyzed by path coefficient analysis using the method developed by Wright (1921) and applied by Dewey and Lu (1952). The significance of direct effects was tested by the method of Ivanović (1984).

Results and Discussion

The genotypes differed significantly in the means of all the traits in both the F1 and F2 generations, as reported previously by Hladni (1999).

The simple correlation coefficients show that there was a significant positive correlation between PL (0.429*), TLA (0.367*), and PL (0.444*) on the one hand and SY on the other in the F1 generation (Table 1). In the F2 generation, these coefficients indicate a highly significant correlation between SY and PL (0.716**), TLA (0.558**), PH (0.677**) and HD (0.642**) (Table 2). Between SY and PA, there was a significant negative correlation (-0.377*) in F1 and a highly significant negative correlation (-0.489**) in F2. Significant and highly significant correlations were found between most of the traits, except for SY and HD in F1 and SY and TLN in F1 and F2. Many authors have found positive and significant correlations between SY and PH (Dagustu, 2002; Joksimović et al., 1997) and HD (Singh et al., 1998; Dagustu, 2002).

Table 1. Correlation coefficients of six components of seed yield per sunflower plant (F1).

Characteristic		PL	TLN	TLA	PH	HD	SY
F1		X2	X3	X4	X5	X6	Y
PA	X1	-0.461*	-0.429*	-0.727**	0.028**	-0.593**	-0.377*
PL	X2		-0.021	0.021	0.693**	-0.654**	0.429*
TLN	X3			0.443*	-0.078	0.159	-0.056
TLA	X4				-0.087	0.411*	0.367*
PH	X5					0.223	0.444*
HD	X6						0.054

Table 2. Correlation coefficients of six components of seed yield per sunflower plant (F2).

Characteristic		PL	TLN	TLA	PH	HD	SY
F2		X2	X3	X4	X5	X6	Y
PA	X1	-0.497**	-0.334*	-0.233	-0.179	-0.629**	-0.489**
PL	X2		0.006	0.362*	0.815**	0.717**	0.716**
TLN	X3			0.216	-0.031	0.060	0.130
TLA	X4				0.312*	0.268	0.558**
PH	X5					0.422*	0.677**
HD	X6						0.642**

X1=petiole angle; X2=petiole length; X3= total leafnumber; X4=total leaf area per plant; X5=plant height; X6=head diameter; and Y=seed yield per plant.

The correlation values were higher in F2 than in F1, except in the case of HD and SY as well as TLN and SY, where the values were negative in F1 but positive in F2. In the segregating F2 generation, because of the change in the mean values of the traits, the values in the correlative relations changed as well.

At the same time, the direct effects of the traits on SY were greater in F1 than in F1 (which can be attributed to the segregation in the F2 generation) in all cases except those of PL and HD, where the values had the opposite sign. The largest difference in the direct effect between the two generations was found for HD and SY (-0.7214 in F1 compared with 0.3319 in F2). This supports the findings of Hladni et al. (2003), where nonadditive genetic variance made the higher contribution to the inheritance of HD. A negative direct effect of HD on SY has been reported by Marinković (1992), while Ashok (2000), Nirmala (2000) and Tahir (2002) have found a positive one. For the other traits, a higher contribution of additive genetic variance was found, as reported by Hladni (1999) for TLA, Hladni et al. (2000) for PA, Hladni et al. (2001) for PH, and Hladni et al. (2002) for PL and TLN.

The correlation between PL and SY was medium high and significant in F1 (0.4288*) and highly significant in F2 (0.7164**). Direct influence of PL on SY was negligible, meaning that PL had large indirect effects. Those produced via PA and PH were positive in both generations, while those exerted via HD were negative in F_1 and positive in F2 (Table 3).

Table 3. Analysis of direct and indirect effects of six components on seed yield per plant in sunflower.

Component	F_1			F_2		
	DE (P)	IE (Pxr)	CC (r)	DE (P)	IE (Pxr)	CC (r)
Petiole angle (PA) X_1	-0.6849			-0.2071		
Indirect effect PL		0.3159			0.1029	
Indirect effect TLN		0.2938			0.0692	
Indirect effect TLA		0.4977			0.0483	
Indirect effect PH		-0.0190			0.0370	
Indirect effect HD		0.4095			0.1302	
Total			-0.3773*			-0.4885**
Petiole length (PL) X_2	0.0648			-0.1973		
Indirect effect PA		-0.0299			0.098	
Indirect effect TLN		-0.0014			0.0012	
Indirect effect TLA		0.0202			-0.0714	
Indirect effect PH		0.0450			-0.1609	
Indirect effect HD		0.0424			-0.1415	
Total			0.4288*			0.7164**
Total leaf number (TLN)X_3	-0.3436			-0.0121		
Indirect effect PA		0.1474			0.0041	
Indirect effect PL		0.0074			0.0001	
Indirect effect TLA		-0.1524			-0.0026	
Indirect effect PH		0.0268			0.0004	
Indirect effect HD		-0.0545			-0007	
Total			-0.0562			0.1298
Total leaf area (TLA)X_4	0.3490			0.3198		
Indirect effect PA		-0.2536			-0.0746	
Indirect effect PL		0.1086			0.1158	
Indirect effect TLN		0.1547			0.0691	
Indirect effect PH		-0.0304			0.0997	
Indirect effect HD		0.1435			0.0856	
Total			0.3673*			0.5575**
Plant height (PH) X_5	0.5822			0.5604		
Indirect effect PA		0.0162			-0.1002	
Indirect effect PL		0.4039			0.4569	
Indirect effect TLN		-0.0453			-0.0176	
Indirect effect TLA		-0.0507			0.1746	
Indirect effect HD		0.1297			0.2364	
Total			0.4438*			0.6766**
Head diameter (HD) X_6	-0.7214			0.3319		
Indirect effect PA		0.4275			-0.2088	
Indirect effect PL		-0.4718			0.2381	
Indirect effect TLN		-0.1144			0.0200	
Indirect effect TLA		-0.2966			0.0889	
Indirect effect PH		-0.1607			0.1400	
Total			-0.0544*			0.6419**
Residual effect	0.52			0.52		
Coefficient of R^2 determination	0.73			0.73		

In both generations, the largest positive direct effect on SY was that of PH ($F_1 = 0.5822$, F2 = 0.5604), which explains the significant and highly significant correlations between these two traits in F1 and F2, respectively. These results support those of Marinković (1988), Ashok (2000) and Tahir (2002). Total leaf area (TLA) had a positive direct effect on SY in both generations (F1 = 0.349, F2 = 0.3198). Total leaf number (TLN), on the other hand, had a negative one (F1 = -0.3436, F2 = -0.0121). These results concur with those reported by Marinković (1988) but not with those of Tahir (2002), who determined that TLN had a positive effect on SY. The direct effects of PA on SY were negative in both generations, which is in agreement with the negative correlation coefficient. High positive values of indirect effects on SY were recorded for HD and TLA in the F_1 generation (Table 3).

Positive direct effects on SY were exerted by PH and TLA, whereas PA and TLN had a negative direct effect on yield in both generations. In F1 , PL had a positive and HD a negative direct effect PL on SY, while in F2, these traits behaved in the opposite way.

The values of the coefficient of determination (R=0.73) obtained in the two generations indicate that about 73% of the total variability of seed yield as the dependent variable may be accounted for by the effects of the independent variables, whereas the remaining 27% can be attributed to the effects of other factors.From the above results it would be reasonable to suggest that a breeder engaged in the improvement of sunflower PS should pay special attention to PH, TLA and PA.

Conclusions

The path coefficient analysis conducted has partitioned the direct and indirect effects of the yield components studied on sunflower seed yields. It allowed us to detect those components that exibit the greatest influence on yield expression. The data obtained in this study along with various data in the literature indicate that the morphophysiological characters of plant height, total leaf area per plant and petiole length are the main yield components that breeders should pay close attention to. The coefficient of determination (R) was 0.73 in both generations. Path coefficient analysis produced a somewhat different picture than correlation analysis did.

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