PATH COEFFICIENT ANALYSIS OF SOME YIELD COMPONENTS OF SUNFLOWER

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Abstract

In this study we examined mutual relationships among eight biological traits of sunflower (dry matter at flowering, leaf area, stature, stem and head diameters, number of filled seeds, 1000-seed mass and hull content) and their correlations with seed yield per plant. Path-coefficient analysis supplied information on direct and indirect effects of the traits on seed yield. Highly significant positive correlations between seed yield and the number of filled seeds were found in all three stand densities. Positive correlations existed between 1000-seed mass and seed yield, but a highly significant one was found only in the maximum density. The number of filled seeds and 1000-seed mass had the highest positive effects on seed yield. Direct effects of the other traits were low and their high total effects were masked by the indirect effects of the number of filled seeds and 1000-seed mass.

Introduction

Sunflower (*Helianthus annuus* L.) hybrids differ among themselves in stem height, number, size and position of leaves, resistance to lodging and disease spread, efficiency of utilization of nutrients and water, photosynthetic activity, etc. Because of that, whenever a new hybrid is introduced into commercial production, it is necessary to determine its optimum stand density. Sunflower hybrids also differ in their reaction to environmental factors, i.e., the factors differently affect the realization of the hybrids' genetic yield potential.

Seed yield is a complex trait which is influenced by a large number of factors which act individually or jointly. It is therefore important to study relationships between the various traits and seed yield (Marinković et al., 2003).

Merrien et al. (1982) pointed out that the number of filled seeds and 1000-seed mass exert the highest direct effects on seed yield. This is quite normal because these two traits are characteristic and important seed components. Leaf area and head diameter too have a positive direct effect on seed yield, as reported by a large number of researchers (Fick et al., 1974; Alba et al., 1979; Green, 1980; Lakshmanrao et al., 1985; Sarno et al., 1992).

Path coefficients are standardized values of regression coefficients, allowing us to compare the intensity of effects of independent variables. They neutralize the effects of units

of measure and value ranges of independent variables. Path coefficients show direct effects of independent variables on dependent variables. Indirect effect of an independent variable on a dependent variable via another independent variable is a product of coefficients of simple correlation between the two independent variables and their individual direct effects. Total effect of an independent variable expressed by a simple correlation coefficient is a sum of its direct and indirect effects via the other independent variables.

The objective of this study was to examine the extent and nature of simple correlation coefficients between some biological traits and seed yield per plant and their direct and indirect effects.

Materials and Methods

Field experiments were conducted at the Rimski Šančevi experiment field of the Institute of Field and Vegetable Crops in 1994, 1995 and 1996. The experiments were established on a chernozem soil, in a six-crop rotation, following a two-factorial split-plot design. The main plot was three approved or experimental hybrids: NS-Dukat, NS-H-111 and NS-H-103.

NS-Dukat is an early hybrid that matures in 90-95 days. The average stem height is 145 to 155 cm, the genetic potential for seed yield 4 t/ha, the oil content in seed from 47 to 49%. The hybrid is genetically resistant to downy mildew, broomrape and the sunflower moth. It is recommended for late sowing (15 May to 15 June), in fields that could not be sown timely for any reason.

NS-H-111 is a new, medium-early hybrid that matures in 105 to 115 days. The stem is firm, 165 to 185 cm tall on the average. The genetic potential for seed yield is 5 t/ha, the oil content in seed from 48 to 50%. The hybrid is genetically resistant to downy mildew, rust, broomrape and the sunflower moth, and tolerant to *Phomopsis*. The hybrid is adaptable to a wide range of agroecological conditions.

NS-H-103 is an experimental hybrid that matures in 120 to 130 days. The stem is firm, 90 to 100 cm tall on the average. The genetic potential for seed yield is 4 t/ha, and the oil content in seed ranges up to 50%. The hybrid is genetically resistant to downy mildew, rust, broomrape and the sunflower moth. Because of a short stem, it needs chemical treatment during the growing season.

The experiment subplots were six stand densities: 30,000, 40,000, 50,000, 60,000, 70,000 and 80,000 plants per hectare. In this paper, only three densities were considered, minimum, medium and maximum. Manual planting was done in early April, by placing 3-4 seeds per hill. At the stage of 1-2 pairs of leaves, the stand was thinned to one plant per hill, to obtain the desired number of emerged plants. Cultural practices were performed in a timely manner, applying the conventional technology. The experiment was conducted in four replicates. The elementary plots consisted of six 10-meter rows.

For determination of dry matter at flowering, an average sample was made for each variant and then dried at 105C until a constant weight. Leaf area at flowering was measured with a DMP Area Meter, Model 3100. Plant height at flowering was measured with a graduated rod, in 10 plants per variant. Stem diameter was measured at full flower, near root crown, with calipers, in 10 plants per variant. Head diameter was measured at the stage of seed forming with a measuring tape, in 10 plants per variant. Filled and empty seeds were counted in 10 plants per variant. 1000-seed mass was calculated from the mass of filled seeds

per head. Hull content was determined by manually dehulling 5 g samples per variant and replicate.

Relationships between the traits were determined by correlation analysis, the aim of which is to express the degree of accord between traits assumed to be in linear dependence via simple correlation coefficients. Direct and indirect effects of some traits on seed yield, oil content and oil yield were calculated by the method of Wright (1921) and the procedure of Dewey and Lu (1959).

Results and Discussion

Relationships Between the Traits. Highly significant positive correlations between seed yield and the number of filled seeds were found in all three stand densities (Table 1).

Table 1. Correlation coefficients among the studied traits.

Variable	Density	Total DM at flower	Leaf area	Plant height	Stem diameter	Head diameter	No. of filled seeds	1000-seed mass	Hull content
Seed yield	Min.	0.424**	0.112	0.015	0.217	0.590**	0.617**	0.243	-0.262
	Opt.	0.284	0.331*	0.761**	-0.080	0.571**	0.899**	0.308	0.327*
	Max.	-0.445**	-0.263	0.207	-0.406*	-0.194	0.512**	0.507**	0.462**
Total DM at flowering	Min.		0.663**	0.081	0.356*	0.524**	0.672**	-0.417*	-0.372*
	Opt.		0.823**	0.164	0.578**	0.737**	0.338*	-0.084	-0.368*
	Max.		0.557**	-0.167	0.468**	0.245	-0.340*	-0.097	-0.522**
Leaf Area at flowering	Min.			-0.053	0.267	0.439**	0.446**	-0.467**	-0.113
	Opt.			0.346*	0.494**	0.767**	0.472**	-0.271	-0.133
	Max.			-0.334*	0.511**	0.562**	-0.092	-0.169	-0.350*
Plant height	Min.				-0.469**	-0.269	0.104	-0.092	0.476**
	Opt.				-0.329*	0.586**	0.765**	0.063	0.569**
	Max.				-0.640**	-0.213	0.315	-0.099	0.485**
Stem diameter	Min.					0.548**	0.479**	-0.372*	-0.677**
	Opt.					0.405*	-0.028	-0.127	-0.621**
	Max.					0.704**	-0.268	-0.148	-0.774**
Head diameter	Min.						0.679**	-0.255	-0.531**
	Opt.						0.588**	0.012	-0.025
	Max.						-0.090	-0.093	-0.451**
No. of filled seeds	Min.							-0.604**	-0.483**
	Opt.							-0.135	0.217
	Max.							-0.478**	0.426**
1000-seed mass	Min.								0.295
	Opt.								0.286
	Max.								0.058

*Significant at 5% level, **significant at the 15 level.

Positive correlations existed between 1000-seed mass and seed yield, but a highly significant correlation was found only in the maximum density. Similar results were reported by Merrien et al. (1982) and Marinković (1992). High correlations between 1000-seed mass and seed yield were obtained by other authors.

Highly significant positive correlations between head diameter and seed yield were found in the minimum and medium densities. The correaltion was negative in the maximum density. Similar results had been reported by Sarno et al. (1992). Positive correlations between head diameter and seed yield had been obtained by Green (1980) and Merrien et al. (1982).

The simple correlation coefficient between seed yield and total dry mass was positive and highly significant in the minimum density, negative and highly significant in the maximum density. Positive correlations between seed yield and total dry mass had been obtained by Merrien et al. (1982) and Lakshmanrao et al. (1985).

Correlation coefficients between plant height and seed yield were positive in all stand densities, but high significance was observed only in the medium density. Similar results had been reported by Green (1980) and Lakshmanrao et al. (1985). However, contrasting results had been reported too. Negative correlations between plant height and seed yield were obtained by Alba et al. (1979) and Sarno et al. (1992).

The correlation coefficient between stem diameter and seed yield was positive in the minimum density, negative in the medium density and significantly negative in the maximum density. A positive correlation between these two traits had been found by Lakshmanrao et al. (1985).

The correlation coefficient between leaf area at flowering and seed yield was positive in the minimum density, positive and significant in the medium density and negative in the maximum density. Positive correlations between these two traits had been obtained by Jocić (1974), Lakshmanrao et al. (1985) and Merrien et al. (1982).

Highly significant positive correlations were also found between total dry matter at flowering, stem diameter and head diameter. The number of filled seeds was highly significantly and positively correlated with total dry matter at flowering, leaf area, plant height, and head diameter, especially in the medium and minimum densities.

Path Coefficient Analysis. The analysis of direct effects on seed yield showed that the number of filled seeds and 1000-seed mass had the highest and positive effects in all three stand densities (Tables 2, 3, 4).

In the minimum stand density, total dry matter at flowering had a significant positive effect on seed yield. Stem diameter and head diameter exhibited positive direct effects and leaf area and plant height negative direct effects on seed yield. This confirms the results of Škorić (1974), Fick et al. (1974) and Marinković (1992). Direct effects had low values with all traits; however, there was a high positive indirect effect via the number of filled seeds and a high negative indirect effect via 1000-seed mass.

Table 2. Analysis of direct and indirect effects of eight traits on sunflower seed yield per plant in minimum stand density.

Trait	Direct effect	Indirect effect via:								Total (ry)
		DM at flower	Leaf area	Plant height	Stem diameter	Head diameter	No. of filled seeds	1000-seed mass	Hull content	
DM at flower	**0.061***		-0.018	-0.006	0.003	0.020	0.803	-0.397	-0.042	0.424
Leaf area	**-0.027**	0.040		0.004	0.002	0.016	0.534	-0.445	-0.013	0.112
Plant height	**-0.068***	0.005	0.001		-0.004	-0.010	0.124	-0.087	0.054	0.015
Stem diameter	**0.008**	0.022	-0.007	0.032		0.021	0.573	-0.354	-0.076	0.217
Head diameter	**0.038**	0.032	-0.012	0.018	0.004		0.812	-0.242	-0.060	0.590
No. of filled seeds	**1.195****	0.041	-0.012	-0.007	0.004	0.025		-0.575	-0.054	0.617
1000-seed mass	**0.952****	-0.025	0.013	0.006	-0.003	-0.010	-0.722		0.033	0.243
Hull content	**0.112****	-0.023	0.003	-0.032	-0.005	-0.020	-0.577	0.281		-0.262
Residual effect: 0.122									*Coefficient of determination R^2=0.985*	

Table 3. Analysis of direct and indirect effects of eight traits on sunflower seed yield per plant in medium stand density .

Trait	Direct effect	Indirect effect via:								Total (ry)
		DM at flower	Leaf area	Plant height	Stem diameter	Head diameter	No. of filled seeds	1000-seed mass	Hull content	
DM at flower	**-0.018**		-0.002	0.001	0.001	0.012	0.323	-0.037	0.005	0.284
Leaf area	**-0.003**	-0.015		0.001	0.001	0.012	0.452	-0.119	0.002	0.331
Plant height	**0.004**	-0.003	-0.001		0.000	0.009	0.732	0.028	-0.007	0.761
Stem diameter	**0.001**	-0.010	-0.001	-0.001		0.006	-0.027	-0.055	0.008	-0.080
Head diameter	**0.016**	-0.013	-0.002	0.002	0.000		0.563	0.005	0.000	0.571
No. of filled seeds	**0.957****	-0.006	-0.001	0.003	0.000	0.009		-0.059	-0.003	0.899
1000-seed mass	**0.438****	0.002	0.001	0.000	0.000	0.000	-0.129		-0.004	0.308
Hull content	**-0.013**	0.007	0.000	0.002	-0.001	0.000	0.207	0.125		0.327
Residual effect: 0.062									*Coefficient of determination R^2=0.996*	

Table 4. Analysis of direct and indirect effects of eight traits on sunflower seed yield per plant in maximum stand density.

Trait	Direct effect	Indirect effect via:								Total (ry)
		DM at flower	Leaf area	Plant height	Stem diameter	Head diameter	No. of filled seeds	1000-seed mass	Hull content	
DM at flower	**-0.058****		0.019	-0.006	0.024	-0.016	-0.332	-0.095	0.018	0.424
Leaf area	**0.034***	-0.032		-0.012	0.027	-0.036	-0.090	-0.165	0.012	0.112
Plant height	**0.035***	0.010	-0.011		-0.033	0.014	0.307	-0.097	-0.016	0.015
Stem diameter	**0.052****	-0.027	0.017	-0.022		-0.045	-0.262	-0.146	0.026	0.217
Head diameter	**-0.064****	-0.014	0.019	-0.007	0.037		-0.088	-0.092	0.015	0.590
No. of filled seeds	**0.976****	0.020	-0.003	0.011	-0.014	0.006		-0.469	-0.014	0.617
1000-seed mass	**0.980****	0.006	-0.006	-0.003	-0.008	0.006	-0.466		-0.002	0.243
Hull content	**-0.034***	0.030	-0.012	0.017	-0.040	0.029	0.415	0.057		-0.262
Residual effect: 0.066									*Coefficient of determination R^2=0.995*	

In the medium stand density, direct effects on seed yield were low with all traits except the number of filled seeds and 1000-seed mass. The total effects of plant height, head diameter, leaf area and total dry matter were intensified by the high positive indirect effect via the number of filled seeds. Contrary to the minimum density, direct effects of dry matter and hull content on seed yield were negative and the direct effect of plant height was positive.

Unlike in the previous two densities, the direct effect of head diameter on seed yield was negative and the direct effect of leaf area was positive in the case of the maximum stand density. Direct effects of dry matter and hull content were negative. Similar results had been reported by Marinković (1992).

Direct effects of the other traits on seed yield were low and their high total effects were masked by the indirect effects via the number of filled seeds and 1000-seed mass. Similar results had been obtained by Merrien et al. (1982).

Conclusions

Highly significant positive correlations between seed yield and the number of filled seeds were found in all three stand densities. Positive correlations existed between 1000-seed mass and seed yield, but a highly significant correlation was found only in the variant of maximum stand density. The number of filled seeds and 1000-seed mass had highest positive effects on seed yield. Direct effects of the other traits were low and their high total effects were masked by the indirect effects via the number of filled seeds and 1000-seed mass.

References

Alba, E., Benvenuti, A., Tuberosa, R., and Vannozzi, G. P. 1979. A path-coefficient analysis of some yield components in sunflower. Helia. 2:25-29.

Alba, E., and Greco, I. 1978. An analysis of the association factors influencing seed yield in sunflower *(Helianthus annuus L.)*. The Sunflower Newsletter. 2(3):13-15.

Dewey, D. R., and Lu, K. H. 1959. A correlation and path-coefficient analysis of components of crested wheat grass seed production. Agron. J. 51:515.

Fick, G. N., Zimmer, D. E., and Zimmerman, D. C. 1974. Correlation of seed and oil content in sunflower with other plant and seed characteristics. Crop Science. 14:755-757.

Giriraj, K., Vidyashankar, T. S., Venkataram, M. N., and Seetharam, S. 1979. Path coefficient analysis of seed yield in sunflower. The Sunflower Newsletter. 3(3):10-12.

Green, V. E. 1980. Correlation and path coefficient analysis of the components of yield in sunflower cultivars, *Helianthus annuus* L.. Proc. 9th Inter. Sunflower Conf. p. 12-21.

Jocić, B. 1974. Međusobni odnos lisne površine, sadržaja pojedinih elemenata u biljnom tkivu i prinosa, pri različitim uslovima ishrane suncokreta. Savremena poljoprivreda, 1:57-68

Lakshmanrao, N. G., Shambulingappa, K. G., and Kusumakumari, P. 1985. Studies on path-coefficient analysis in sunflower. Proc. 11th Inter. Sunfl. Conf. p. 733-735.

Marinković, R. 1992. Path-coefficient analysis of some yield components of sunflower *(Helianthus annuus L.)*. Euphytica. 60:201-205.

Marinković, R., Marjanović-Jeromela, A., Crnobarac, J., and Lazarević, J. 2003. Path-coefficient analysis of yield components of rapeseed (*Brassica napus* L.). Proc.11th Inter. Rapeseed Congress, Vol. III, AP5.15., Copenhagen, Denmark, 6-10 July 2003.

Merrien, A., Blanchet, R., Gelfi, N., Rellier, J. P.,and Rollier, M. 1982. Voies d élaboration du rendement chez le tournesol sous différents stress hydriques. Proc. 10th Inter. Sunflower Conf. Vol 1:1-14.

Sarno, R., Leto, C., Carrubba, A. and Cibella, R. 1992. Correlation between some yield factors in sunflower. Proc. 13th Inter. Sunflower Conf. Vol 1:366-389.

Škorić, D. 1974. Correlation among the most important characters of sunflower in F1 generation. Proc. 6th Inter. Sunflower Conf. p. 283-289.

Wright, S. 1921. Correlation and causation. J. Agric. Res. 20:557-585.