PATH COEFFICIENT ANALYSIS OF SOME HEAD AND SEED CHARACTERISTICS IN SUNFLOWER

Jovan Joksimovic, Jovanka Atlagic, Dejan Jovanovic, Radovan Marinkovic, Nenad Dušanic, and **Vladimir Miklic,** Institute of Field and Vegetable Crops, M. Gorkog 30, 21000 Novi Sad, Serbia and Montenegro
E-mail: jovanj@ifvcns.ns.ac.yu
E-mail: atlagic@ifvcns.ns.ac.yu
E-mail: dejan@ifvcns.ns.ac.yu
E-mail: radomar@ifvcns.ns.ac.yu
E-mail: dusanicn@ifvcns.ns.ac.yu
E-mail: miklicv@ifvcns.ns.ac.yu

Abstract

The 1000-seed mass is one of the three most important yield components in sunflower. Using correlation analysis, we studied the interrelationship of several yield components (1000-seed mass, test weight, head diameter, head dry matter mass, percentage seed set, oil content and protein content) in eight sunflower inbred lines and 15 F1 hybrids (line x tester). Path coefficient analysis was used to separate direct and indirect effects of the traits on 1000-seed mass. Highly significant positive correlations were found between 1000-seed mass and head diameter (0.7665) and percentage seed set (0.6026). Highly significant and significant negative correlations were observed between 1000-seed mass and protein content (-0.7065) and 1000-seed mass and test weight (-0.4546), respectively. Oil content had a highly significant positive direct effect on 1000-seed mass, while protein content and test weight had a highly significant negative direct effect on this trait. The coefficient of determination was 0.8302 and the residual factor in path analysis 0.4120.

Introduction

The 1000-seed mass is a highly variable trait influenced by genetic and environmental factors alike. It varies from one genotype to another in a single location as well as in a single genotype in different locations (Marinković et al., 2003). Selection for increased 1000-seed mass can significantly increase sunflower seed yields. According to Omran et al. (1976), selection for head size, seed number per head and 1000-seed mass go in the same direction as selection for yield. Seed oil and protein content are quantitative traits which are influenced not only by genetic factors but also, to a large extent, by environmental ones. Most authors have found a negative correlation between these two traits.

Simple correlation coefficients have not been able to shed enough light on the relationships between traits, so path coefficient analysis had to be used for more successful breeding work. It has made it possible for breeders to determine the extent to which independent variables affect dependent ones by enabling separation of direct from indirect effects. This statistical model has been used by many sunflower researchers (Alba et al., 1979;

Ivanova and Stoyanova, 1980; Lakshmanrao et al., 1985; Marinković, 1992; Punia and Gill, 1994; Joksimovic et al., 1999, and others).

The 1000-seed mass, test weight and oil percentage are the ultimate components of seed yield and oil per unit area in sunflower (Škorić, 1989). Head diameter, head dry matter mass and percentage seed set are also major agronomic traits that have significant influence on seed formation. Because of the importance of the traits involved, the objective of our paper was to use path coefficient analysis to determine the relations between and separate direct and indirect effects of 1000-seed mass and head diameter, head dry matter mass, percentage seed set, oil content, protein content and test weight.

Materials and Methods

Used in this study were eight inbred lines of different genetic origin and 15 of their F1 hybrids. A two-year trial with these F1s and their parental components was set up at the Rimski Šančevi Experiment Field of the Institute of Field and Vegetable Crops in Novi Sad using four replicates and a randomized block design. Sowing was done manually with a row-to-row spacing of 70 cm and a plant-to-plant spacing of 25-30 cm. The basic sample for trait analysis consisted of 10 plants per replicate. The following traits were analyzed. The 1000-seed mass (g) was determined on a random sample of absolutely pure and air-dried seed. Test weight (kg/hl), or the mass of seed one hectoliter in volume expressed as percentage, was determined on a Schopper's scale. Head diameter (cm) was measured at physiological maturity. Head dry matter mass (g) was the difference between the masses of a fresh sample and one dried at 105C to a constant weight. Percentage seed set was the ratio of total flower number to seed number per head. Seed oil content (%) was determined by nuclear magnetic resonance (NMR), while seed protein content (%) was determined by the Trebor method.

To determine the interrelationships of the traits and their direct and indirect effects on 1000-seed mass, analysis of partial correlation coefficients (Path Coefficient Analysis) was performed according to the method designed by Wright (1921) and applied by Dewey and Lu (1959). The significance of simple correlation coefficients was tested by the method developed by Snedecor (1959) according to Hadživuković (1991).

Results and Discussion

A highly significant positive correlation was found between 1000-seed mass and head diameter (0.7665) and percentage seed set (0.6026). Highly significant and significant negative correlations were found between 1000-seed mass and protein content (-0.7065) and test weight (-0.4546), respectively (Table 1).

The 1000-seed mass is given extreme importance in sunflower selection. Morozov (1970) argues that an increase in 1000-seed mass of a single gram increases yield by 40 kg/ha. Similarly, Shabana (1974) argues that this trait plays a crucial role in seed yield formation. In contrast to the findings of many authors (Škorić, 1974; Alba et al., 1979; Marinković, 1987) who found highly significant influence of 1000-seed mass on test weight, the results of the present study indicate a significant negative correlation between these two traits.

We found highly significant positive correlations between the independent variables oil content and protein content and oil content and test weight (0.5403 and 0.6881, respectively) and significant positive ones between head diameter and head dry matter mass (0.4262) and percentage seed set (0.5246). Highly significant negative correlations were determined between protein content and head diameter (-0.7199) and head dry matter mass (-0.5959) (Table 1).

Table 1. Simple correlation coefficients of biophysical traits and 1000-seed mass.

Trait	Head dry matter mass X2	Percent seed set X3	Oil content X4	Protein content X5	Test weight X6	1000-seed mass
Head diameter-X1	0.4262*	0.5246*	-0.1170	-0.7199**	-0.02190	0.7665**
Head dry matter mass X2		0.1074	-0.2247	-0.5959**	0.0651	0.3112
Percentage seed set X3			-0.2491	-0.3985	-0.3887	0.6026**
Oil content X4				0.5403**	0.6881**	-0.2442
Protein content X5					0.2614	-7065**
Test weight X6						-0.4546*

*,**Significant (n=21) at 0.05=0.413; at 0.01=0.526

Many authors have reported significant negative correlations between oil content and protein content of sunflower seeds. Djakov (1986), however, has provided experimental proof that there is no antagonism between oil synthesis and protein synthesis in sunflower seeds, which is supported by the results of the present study. Stanojević et al. (1992) found a negative correlation when studying the relationship between oil and protein contents in sunflower inbreds of different origin (Spain, Argentina, Russia, local populations from eastern Serbia). The same paper also reported a positive correlation between the two traits in the case of lines from Bulgaria and the domestic high-protein variety Kolos. In lines of the S6 generation of self pollination, Jovanović (1995) found a very slight positive correlation between oil content and protein content of sunflower seed.

As the causal relationships between 1000-seed mass and the other traits under study could not be seen from the values of simple correlation coefficients, because they show mutual agreement, path coefficient analysis was done to determine the extent of influence of the independent variables on the dependent one. This analysis enabled the separation of direct and indirect effects of the traits on 1000-seed mass in order to identify traits that could be used as selection criteria in sunflower breeding.

Looking at the simple correlation coefficients, it can be concluded that of all the traits in the study it was head diameter that played the decisive role in 1000-seed mass formation in sunflower. The nature of this interrelationship was analyzed via direct and indirect effects of the independent variables and it was determined that the direct effect of head diameter was positive (0.0130) and masked by indirect positive effects of protein content (0.6050), test weight (0.1381) and percentage seed set (0.0993) (Table 2).

Path coefficient analysis showed that the positive direct effect of percentage seed set on 1000-seed mass was a result of positive indirect effects of protein content (0.3349), test weight (0.2451), oil content (0.1714) and head diameter (0.0068).

Oil content had a highly significant positive direct effect on 1000-seed mass, which was in disagreement with the negative correlation previously detected by simple coefficients of correlations. Contributing to such a high positive value of the direct effect of oil content on 1000-seed mass was the positive indirect effect of head dry matter mass (0.0045), while the negative indirect effects of protein content (-0.4541), test weight (-0.4339), percentage seed set (-0.0471) and head diameter (-0.0015) concealed it.

Protein content had the highest and highly significant negative direct effect on 1000-seed mass (-0.8404), which was in agreement with the highly significant negative correlation found based on simple correlation coefficients. Such a high negative value of the direct effect of protein content on 1000-seed mass was augmented by the negative direct effects of test weight (-0.1649), percentage seed set (-0.0754) and head diameter (-0.0094) and reduced by the positive indirect effects of oil content (0.3718) and head dry matter mass (0.0118).

Test weight had a highly significant negative direct effect on 1000-seed mass (-0.6306), which was augmented by the negative direct effects of protein content (-0.2197), percentage seed set (-0.0736), head diameter (-0.0029) and head dry matter mass (-0.0013) and decreased by the positive indirect effect of oil content (0.4734).

Significant differences were revealed after comparing the correlation coefficient values of the six independent variables and the dependent one and the direct effects of the former on the latter. Looking at the values of correlation coefficients only, it could be concluded that head diameter and percentage seed set had a highly significant influence on 1000-seed mass. However, path coefficient analysis, being a more precise method that takes into account the interrelationship of independent variables and their direct and indirect effects on the dependent variable, showed that only oil content had a highly significant direct effect on 1000-seed mass.

The coefficient of determination was 0.8302, representing the portion of variance concerned with the effects of independent variables. The residual factor in path analysis was 0.4120 and stood for inexplicable influence caused by error or some other variables not studied in this paper (Table 2).

Conclusions

Highly significant positive correlations were found between 1000-seed mass, head diameter and percentage seed set. Highly significant and significant negative correlations were observed between 1000-seed mass and protein content and 1000-seed mass and test weight, respectively. Oil content had a highly significant positive direct effect on 1000-seed mass, while protein content and test weight had a highly significant negative direct effect on this trait.

Table 2. Analysis of direct and indirect effects of the six traits on 1000-seed mass.

Trait	Direct effect	Indirect effects via						Total
		Head diameter X1	Head dry matter mass X2	Percent seed set X3	Oil content X4	Protein content X5	Test weight X6	
Head diameter-X1	0.0130	1	-0.0084	0.0993	-0.0805	0.6050	0.1381	0.7665
Head dry matter mass X2	-0.0198	0.0055	1	0.0203	-0.1546	0.5008	-0.0411	0.3112
Percent seed set X3	0.1893	0.0068	-0.0021	1	0.1714	0.3349	0.2451	0.6026
Oil content X4	0.6680**	-0.0015	0.0045	-0.0471	1	-.04541	-0.4339	-0.2442
Protein content X5	-0.8404**	-0.0094	0.0118	-0.0754	0.3718	1	-0.1649	-0.7065
Test weight X6	-0.6306**	-0.0029	-0.0013	-0.0736	0.4734	-0.2197	1	-0.4546

Residual effect =0.4120; Coefficient of determination =0.8302.

References

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

Dewey, D. R. and K. H. Lu. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J. 51:515-518.

Djakov, A. B. 1986. Related variability of trait complex in the course of sunflower selection (in Russian). Selskohozjastvenaja biologija. 1:77-83.

Hadživuković, S. 1991. Statistički metodi. Poljoprivredni fakultet u Novom Sadu.

Ivanova, P. and Y. Stoyanova, 1980. Studies on the genotypic and phenotypic variability and some correlation in sunflower (*Helianthus annuus* L.). Proc. 9th Inter. Sunflower Conf., 8-13 June, Torremolinos-Malaga, Spain. p. 336-342.

Joksimović, J., J. Atlagić, and D. Škorić. 1999. Path coefficient analysis of some oil yield components in sunflower (*Helianthus annuus* L.). Helia. 22:35-42.

Jovanović, D. 1995. Variabilnost sadržaja proteina i nekih komponenti prinosa semena kod samooplodnih linija suncokreta. Magistarski rad, Poljoprivredni fakultet u Novom Sadu.

Lakshmanrao, N. G., K. G. Shaambulingappa and P. Kusumakumari. 1985. Studies on path-coefficient analysis in sunflower. Proc. 11th Inter. Sunflower Conf, 10-13 March, Mar del Plata, Argentina. p. 733-735.

Marinković, R. 1987. Analiza komponenti prinosa semena suncokreta (*H. annuus* L.) koeficijentom putanje I. Abstracts, III Kongres genetičara Jugoslavije s medjunarodnim učešćem, 31. maj - 04. jun, Ljubljana, 95.

Marinković, R. 1992. Path coefficient analysis of some yield components of sunflower. Euphytica. 60:201-205.

Marinković, R., B. Dozet, and D. Vasić. 2003. Oplemenjivanje suncokreta. (Monografija). Skolska knjiga, Novi Sad.

Morozov, V. K. 1970: O selekciji podsolnečnika na urožajnost. Selekcija i semenarstvo. p. 18-25.

Omran, A. O, A. A. Abdel-Zahad and M. A. Haikal. 1976. Evaluation of sunflower cultivars. Heritability and variability of metric traits. Proc. of 7th Inter. Sunflower Conf., I, 27 June – 3 July 1976, Krasnodar, U.S.S.R. p. 361-375

Punia, M.S. and H.S. Gill. 1994. Correlations and path coefficient analysis for seed yield traits in sunflower (*Helianthus annuus* L.). Helia. 17(20):7-12.

Shabana, R. 1974. Genetic Veriability of the Yield Components of Oil in Different Sunflower Varieties and Inbred Lines. Doctor Thesis, Novi Sad.

Stanojević, D., S. Nedeljković and D. Jovanović. 1992. Oil and protein concentration in seed of diverse high-protein inbred lines of sunflower. Proc. 13th Inter. Sunfl. Conf., 7-11 September, Pisa, Italy. p. 1263-1268.

Škorić, D. 1974. Correlation among the most important characters of sunflower in F_1 generation. Proc. 6th Inter. Sunflower Conf, 22-24 July, Bucharest. p. 283-289.

Škorić, D. 1989. Dostignuća i dalji pravci u oplemenjivanju suncokreta. 285-392. Suncokret (monografija), "Nolit", Beograd.

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