PATH ANALYSES OF YIELD IN SUNFLOWER (*HELIANTHUS ANNUUS* L.) PARENTAL LINES

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ABSTRACT

Seed yield is very complex trait; it depends on genotype, environmental conditions, on various plant traits etc. Eighteen sunflower commercial parental lines were evaluated for various parameters under field conditions to estimate genetic parameters and path analyses. The ten female and eight restorer line were chosen for the experiment. Observed parameters were seed yield, 1000 seed, seed germination, oil and protein content. Objective of this study was determination of direct and indirect effects by path analysis; to compare given results of path analysis from female lines with results from restorer lines in order to identify research priorities in sunflower breeding. Path coefficient analysis, in observed female lines, indicates that 1000 seed weight has maximum positive and seed germination maximum negative direct effect on yield. In restorer lines, path coefficient analysis indicates that seed germination and 1000 seed weight have negative direct effect on yield, but effect of seed germination was highly significant.

Key words: Sunflower parent lines, Seed and yield components, Path coefficient analysis

INTRODUCTION

Seed yield is a very complex trait, has low heritability and it is very dependent on environmental conditions. It depends on various plant traits and it is very important for plant breeders to find out the association between the traits themselves and with the seed yield (Škorić, 1974; 2012). The main goal in sunflower breeding is to develop hybrids with high seed yield and high oil content and therefore to improve productivity of this important oil crop (Jocković at al., 2015).

As the aproach proved to be ineffective, numerous researchers (Shankar et al., 2006; Darvishzadeh et al., 2011; Radić at al., 2013) concluded that path-coefficient analyses provided information about direct and indirect effetcs of the examined characters on seed yield per plant. Yasin and Singh (2010) also concluded that path-coefficient is helpful in partitioning the correlation into direct and indirect effects. In this way, relative contribution of each component character to the yield can be assessed. In other words, path analysis measures direct and indirect contribution of various independent characters to a dependent character. Using path-coefficient analysis, it is easy to determine which yield component influences the yield substantially. These researchers also concluded that with this information, selection can be based on that criterion in limited time (Farhatullah et al., 2006).

This study was conducted in order to obtain information about interrelationship (direct and indirect effects by path analyses) between seed yield and other observed seed characters as well as to identify research priorities in sunflower breeding.

MATERIAL AND METHODS

Experiment was carried out in field conditions throughout three years on plots where seed production of sunflower parental lines was established. Ten genotypes were examined which represent lines that were based on cytoplasmic mail sterility (CMS). All examined genotypes represent parental components of the best-selling sunflower hybrids of the Institute of Field and Vegetable Crops, Novi Sad, Serbia.

The following parameters were studied:

Seed yield – upon maturity, 10 plants were picked manually, from different locations on the plot, and seed yield per plant was determined. By the application of previously determined plant density *(50.000 plants ha^{-1})*, obtained seed yield per plant was redetermined in kg ha^{-1} with 9% of moisture.

Upon seed drying, specimens were purified and cleaned. Seed for determining the remaining observed parameters were picked from the given specimens:

Seed germination- Standard laboratory method for seed germination testing was used (ISTA, 2014). Examination of seed germination was repeated 4 times. Each time 100 seeds were used. Germination was determined after 10 days. Only naturally formed germed seeds were used for determination of this parameter. Germination was expressed in relative values.

1000 seed weight- Examination of 1000 seed weight was repeated 4 times. Each time 100 seeds were used. Obtained value was applied to 1000 seed weight and was specified in grams.

Oil content- Determined by nuclear - magnetic resonance (NMR) according to Granlund and Zimmerman (1975) and expressed in relative value.

Protein content- Determined by standard Kjeldahl method with the help of VAP-50-Gerhardt apparatus. This parameter is also expressed in relative value.

Analysis of variance of two-factorial experiment, simple correlation coefficient and path-coefficient analysis for examined characters were done using GENSTAT computer program.

RESULTS AND DISCUSSION

The data were processed by the path-coefficient analysis which enabled the partitioning of direct and indirect effects of individual yield components and identification of yield components applicable as selection criteria in sunflower breeding (Table 1 and 2).

Relatively low coefficient of determination (R^2) at trait of sterile lines (0.330) and restorer lines (0.211) level give rise to high residual effects (0.818 and 0.888) meaning that besides parametrs used in this study other causal variables are also responsible for seed yield.

Seed germination, in both traits, had the highest negative direct effect on seed yield (-0,354). Only differences between this two effects was that in restorer traits this effect was more significant (-0,485). These results are in agreement with the studies of Radić et al. (2013). In the study of indirect effects, the existence of negative indirect effects was determined in sterile lines (seed germination *via* 1000 seed weight) while in restorer lines this effect was determined as positive. In both traits this indirect effects were not significant.

The study of direct effects on seed yield showed that the 1000 seed weight had high positive direct effect (0.339) in sterile lines, while in restorer lines this parameter had also high direct effect on seed yield, but this effect was negative. In the study of indirect effects, the existence of positive not significant indirect effects on seed yield was determined. Škorić

(1974) and Joksimović et al. (1999) concluded that is necessary that 1000 seed weight has negative direct effect on restorer lines, since this restorer plant has a lot of branches (purpose of exciting of restorer is to have a lot of polen for polination). These results are in agreement with the studies of Merrien et al. (1982), Marinković (1992) and Dušanić (1998, 2004). These researchers also concluded that 1000 seed weight has higher effect on seed yield than number of filled seed per head and other yield components. Vanishree et al. (1988) and Tahir et al. (2002) concluded that increasing 1000 seed weight may result in higher yield. As opposed to this, Alba and Greco (1978) and Lakshmanrao et al. (1985) reported that 1000 seed weight has significant direct effect on seed yield, but this is, based on their research, a negative effect.

Table 1. Analysis of direct and indirect effects of observed characters on seed yield in sterile lines

Character	Direct effect	Indirect effect:				Total
		Seed germination	1000 seed weight	Oil content	Protein content	
Seed germination	-0.354	-	-0.010	0.015	0.036	-0.313
1000 seed weight	0.339	0.010	-	0.037	0.009	0.395
Oil content	0.221	-0.024	0.057	-	0.010	0.265
Protein content	0.185	-0.068	0.016	0.012	-	0.146

Coefficient of determination R^2=0.330

Oil content had positive direct effect on seed yield and negative indirect effect *via* seed germination on seed yield at both traits. Other indirect effects were positive and also not significant, except indirect effect of oil content *via* 1000 seed weight on seed yield. This effect was negative. Punia and Gill (1994), Husain et al. (1995) and Chikkadevaiah et al. (2002) concluded in their research that oil content had maximum direct effect on seed yield. On the other side, Habib et al. (2007) confirmed positive direct effect of oil content on seed yield. Arshad et al. (2007) and Kaya et al. (2009) found that oil content had negative direct effect on seed yield as well as negative indirect effect *via* plant height.

Protein content had positive direct effect in sterile line traits but also had negative direct effect in restorer line traits. Both effects are not significant. In both traits two negative indirect effects on seed yield were determined. One of them is in sterile line trait *via* seed germination and other one is *via* oil content in restorer line trait. All other indirect effects are positive. All indirect effects are not significant. Jocković at al. (2015) in their research concluded the same.

Table 2. Analysis of direct and indirect effects of observed characters on seed yield in restorer lines

Character	Direct effect	Indirect effect:				Total
		Seed germination	1000 seed weight	Oil content	Protein content	
Seed germination	-0,485*	-	0,112	0,018	0,005	-0,321
1000 seed weight	-0,337	0,162	-	0,006	0,005	-0,164
Oil content	0,153	-0,150	-0,014	-	0,008	-0,003
Protein content	-0,065	0,035	0,026	-0,018	-	-0,022

Coefficient of determination R^2=0.211

CONCLUSION

Bringing these observed characters into optimal balance with seed yield is one of main principal for succsesfull sunflower breeding program. In this report, path coefficient analysis revealed that the greatest improvement in sunflower seed yield can be achieved through selection on seed germination and 1000 seed weight, because they have the highest direct effect on seed yield. Difference between observed parametrs is that effect of seed germination is negative while in 1000 seed weight is positive in sterile line trait and negative in restorer line trait.

Further research should be aimed at observation of the relationship between certain characters of seed quality, with the intention of obtaining high quality sunflower seed.

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