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Original scientific paper

CORRELATIONS AND PATH ANALYSES OF YIELD AND OTHER SUNFLOWER SEED CHARACTERS

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Ten sunflower commercial female parental lines were evaluated for various parameters under field conditions to estimate genetic parameters, correlation coefficient, and path analyses. Interactions of seed germination, 1000 seed weight, oil and protein content with seed yield were examined. After three years of observations, positive significant correlations were found while comparing seed yield with 1000 seed weight. Negative significant correlations were found by comparing seed yield and seed germination. Positive but not significant correlation was found while comparing seed yield with oil content in sunflower seed. Path coefficient analysis indicates that 1000 seed weight has maximum positive and seed germination maximum negative direct effect on yield.

Key words: sunflower, seed and yield components, simple correlation coefficient, path coefficient analysis

INTRODUCTION

Knowledge of genetic parameters is essential for understanding of any crop improvement breeding programs (ARSHAD *et al.,* 2007).

PUNIA and GILL (1994); KAYA and ATAKISI (2003); SHANKAR *et al*. (2006); DARVISHZADEH *et al.* (2011) and MALEKI *et al.* (2011), comparing simple correlation coeficient and path-coefficient analyses, concluded that path-coefficient analyses provided more information about direct and indirect effetcs of the examined characteristics 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 is influencing the yield substantially.

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These researchers also concluded that with this information, selection can be based on that criterion in limited time (FARHATULLAH *et al.,* 2006).

Main objectives of this given study are: 1) estimation of genotype correlation coefficient between sunflower seed yield and other observed seed characters and 2) determination of direct and indirect effects by path analyses. Study on the relationships between observed characters could help in improving the efficiency of breeding program by determining appropriate selection criteria.

MATERIALS 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 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 method of testing authorised by Handbook of Vigour Test Methods (published by ISTA-International Seed Testing Association, 1995) was used. 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 conten t- Determined by classical method by Ruškovski and expressed in relative value.

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

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

RESULTS AND DISCUSSION

Correlation coefficient

By calculation of simple correlation coefficients, highly significant positive correlation was determined between seed yield and 1000 seed weight (Table 1). These results are in agreement with the studies of TAHIR *et al*. (2002); Dušanić et al. (2004) and Yasin and Singh (2010). TAHIR *et al*. (2002) also concluded that seed yield mainly depends upon 1000 seed weight, number of filled seed per plant and seed filling percentage, and that this information can be used as as selection criteria to improve seed yield. MIKLIČ *et al.* (2012) reported that 1000

seed weight may have negative impact (in case of early harvesting or early desication) on seed yield, oil content and seed quality.

Significant and positive correlation was also found between seed yield and seed oil content. Our results are in agreement with the studies of CHIKKADEVAIAH *et al. (*2002); SHANKAR *et al*. (2006) and FARHATULLAH *et al*. (2006). CHIKKADEVAIAH *et al.* (2002) also concluded that this correlation was in positive association with yield per plant, oil content per plant and oil yield, and in negative association with husk percentage. BALALIĆ *et al.* (2012) reported significant correlation between seed yield, oil yield and oil content.

Higly significant negative correlation was determined between seed yield and seed germination. These results are in agreement with the studies of RADIĆ, (2008a).

Table 1. Simple correlation coefficients between different observing seed characters

Characters	1000 seed weight	Oil content	Protein content	Seed germination
Seed yield	0.395**	0.265*	0.146	-0.313**
1000 seed weight		0.168	0.048	-0.028
Oil content			0.056	0.067
Protein content				0.192

Negative but not significant correlation was determined between 1000 seed weight and seed germination. RADIĆ, (2008a) concluded that, in some years, smaller and medium seed can have better germination then large seed. On the other side GRIEVE and FRANCOIS, (1992) concluded that large seed has more reserve in cotyledons than smaller seed has. Since a quantity of reserves is in direct relationship with embryo development, they also concluded that large seed has more energy for germination process than smaller seed.

Correlation between seed yield and seed protein content was positive but not significant. Correlations between 1000 seed weight and seed oil and protein content were also positive but not significant. In their research, JOKSIMOVIĆ *et al*. (1999) and DAGUSTU (2002) found correlation of seed protein content with seed yield, 1000 seed weight and some other yield components. They concluded that there is a significant association of protein content with seed yield and 1000 seed weight.

Not significant positive correlation was found between oil and protein content in sunflower seed in our experiment, while RADIĆ *et al*. (2009) determined the existance of negative higly significant correlation. Negative correlation was also determined between seed protein content and seed germination. Positive correlation was determined between seed oil content and seed germination. This correlation was not significant, while RADIĆ *et al*. (2008b) reported existence of significant positive correlation between seed germination and oil content in sunflower seed.

Path-coefficient analysis

Cause and effect relationships between seed characters and yield components with seed yield or with seed germination could not be established on the basis of simple correlation coefficient. Therefore, 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 2 and 3).

Seed yield

In first path-coefficient analysis coefficient of determination was 33.0% (Table 2). The study of direct effects on seed yield showed that the 1000 seed weight had high effect (0.339; as confirmed by the high correlation coefficient - 0.395**). These results are in agreement with the studies DUŠANIĆ *et al*. (2004) and RADIĆ (2008a). TAHIR *et al.* (2002) concluded that increasing 1000 seed weight may result in higher yield. As opposed to this, 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.

Seed germination (high correlation coefficient of -0.313**) had the highest but negative direct effect on seed yield. Other two characters had positive direct effects on seed yield but both of them were not significant (Table 2). On the other side, PUNIA *et al*. (1994) and FARHATULLAH *et al.* (2006) concluded in their research that oil content had maximum direct effect on seed yield.

In the study of indirect effects, the existence of negative indirect effects (oil and protein content through seed germination and seed germination through 1000 seed weight) on seed yield in three cases was determined. All three effects were not significant. Other indirect effects were positive and not significant (Table 2).

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

Character	Direct effect	Indirect effect via:				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

Seed germination

In first path-coefficient analysis coefficient of determination was 18.8%. The study of direct effects on seed germination showed that 1000 seed weight; oil and protein content had positive but not significant effect (Table 3).

Seed yield had the highest negative direct effect on seed germination (-0.429*; as confirmed by the high correlation coefficient of -0.313**). These results are in agreement with the studies of RADIĆ (2008a). MRĐA *et al* (2011) concluded that seed germination play a direct role in determing plant number per hectare, which is one of three main components of yield. In their research, MARINKOVIC *et al.* (2003) and RONDANINI *et al*. (2006) concluded that seed germination depends on several factors. These factors are connected with climate, genotype, year, location of production, plant density, etc. RADIĆ *et al.* (2009) reporterd that climatic factors, year, and location of production also had influence on seed germination.

Table 3. – Analysis of direct and indirect effects of observed characters on seed germination

Character	Direct effect	Indirect effect via:				Total
		Seed yield	1000 seed weight	Oil content	Protein content	
Seed yield	-0.429*		0.042	0.040	0.035	-0.313
1000 seed weight	0.105	-0.170*		0.025	0.012	-0.028
Oil content	0.241	-0.114	0.018		0.014	0.067
Protein content	0.149	-0.063	0.005	0.008		0.192

Coefficient of determination R^2=0.188

In our study of indirect effects, high negative effect of 1000 seed weight through seed yield on seed germination was determined. Negative indirect effect was determined with oil and protein content through seed yield on seed germination. Both of these effects were not significant. All other indirect effects were positive and not significant (Table 3).

CONCLUSION

On the basis of our examination, it can be concluded that yield has positive and higly significant association with 1000 seed weight, positive and significant association with seed oil content, and negative significant association with seed germination. Path coefficient analysis indicates that 1000 seed weight has maximum positive, and seed germination maximum negative direct effect on seed yield.

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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PAT I ANALIZA KORELACIJA IZMEĐU PRINOSA I DRUGIH OSOBINA SEMENA SUNCOKRETA

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Izvod

U poljskim uslovima su ispitivani različiti parametri kod 10 komercijalnih linija majke u cilju određivanja genetičkih parametara, koeficijenta korelacije i pat analize. Ispitivana je i interakcija između klijanja semena, mase 1000 semena, sadržaja ulja i proteina i prinosa. Nakon tri godine ispitivanja utvrđena je značajna pozitivna korelacija između prinosa semena i mase 1000 semena. Postojala je i značajna negativna korelacija između prinosa i klijavosti semena. Korelacija između prinosa i sadržaja ulja je bila pozitivna, ali ne i statistički značajna. Pat analiza je pokazala da masa 1000 semena ima najveći pozitivan, a klijavost najveći negativan uticaj na prinos semena.

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