Determination of the Best Indirect Selection Criteria for Genetic Improvement of Seed Yield in Sunflower (*Helianthus annus* L.) Genotypes

Ahmad Reza GOLPARVAR (✉)
Sayyed Mohammad Reza Hejazi DEHAGHANI

Summary

Correlation and path coefficient analyses were studied on three diverse genotypes of sunflower in order to understand the relationship and contribution on eight characters towards the seed yield. The seed yield exhibits highly significant and positive correlation with plant height, oil yield and total number of seeds per head. Days to full flowering and head diameter showed significant and negative relation with seed yield. Path coefficient analysis revealed that total number of seeds per head had the highest and positive direct effect on seed yield. On the other hand, days to full flowering and head diameter showed the highest and negative direct effect on seed yield. Hence, the study revealed the importance of total number of seeds per head, days to full flowering and head diameter as indirect selection criteria for genetic improvement of seed yield in sunflower breeding programs especially in early generations.

Key words

sunflower, correlation analysis, step-wise regression, path analysis, selection

Department of Agronomy and Plant Breeding, Khorasgan (Isfahan) Branch, Islamic Azad University, P.O.Box;81595-158, Isfahan, Iran
✉ e-mail: dragolparvar@gmail.com

Received: April 26, 2011 | Accepted: June 18, 2011

Introduction

The abundant food value of oily sunflower seeds as the richest sources of vegetable oil and protein production in nature has drawn the attention of most developed industrial countries to produce these plants. Sunflower as one of the major sources of vegetable oil is of special importance throughout the world (Arshi, 1992).

The selection of one desirable planting arrangement and suitable density for sunflower cultivars provides an ideal combination of environmental conditions to achieve the highest yield (Jannati, 2002).

Taghdiri et al. (2006) have suggested that the number of plants is the main and effective factor in creating seed yield. Since the most of sunflower agronomic cultivars have only one head per plant, the plant density should cause the yield to increase until it doesn't affect the total number of seeds per head and weight of 1000-seeds (Robinson et al., 1980; Holt and Zenter, 1985).

The study of correlation between seed yield and yield components and other important agronomic traits is very important to choose the desirable cultivars. The analysis of indices allows the direct effects of each trait on seed yield to be separated from indirect effects existing in mutual relations of different traits (Mokhtassi Bidgoli et al., 2006).

The results obtained by Teklewold et al. (2006) showed that the head diameter had the highest direct effect on seed yield and also the seed filling percentage and plant height had the highest indirect effect on seed yield through head diameter.

Earlier in sunflower, Punia and Gill (1994), Shankar et al. (2006) and Farratullah et al. (2006) applied path coefficient by partitioning the genotypic correlations into direct and indirect effects of the traits. Moreover, other researchers (Arshad et al., 2004 and 2006; Ghafoor and Ahmad, 2005) have used these techniques along with diversity study for investigating genetic parameters.

The present study was conducted in order to investigate the relationship among seed yield and its components as well as to determine the best indirect selection criteria to improve seed yield in sunflower genotypes.

Materials and methods

The research was carried out at agricultural experiment station in Kabootar Abad, Isfahan during agronomic year of 2009. This station is located 25 km northeast of Isfahan (32 53' N, 51 38' E and 1620 meter above sea level). This location is a arid and warm area (according to the Koppen climate classification) characterized by warm and dry summers (Khajepour and Seyyedi, 2001). The long-term (30 years) mean annual rainfall and temperature of area was 121.1 mm and 33.4 centigrade degrees, respectively. The experiment was a split factorial in a randomized complete block with three replications. In this research, one-row cultivation with 60 cm row spacing and two-row cultivation with 75 cm row spacing were considered as main plot and the combination of Master, Lakumka and Hisun 36 cultivars together with the plant density of 8, 10 and 12 plants per square meter considered as subplot.

In order to obtain the intended densities in one-row cultivation, the plant spacing of 21, 17 and 15 cm were chosen in the middle of 60 cm beds. In two-row cultivation the plant spacing of 33, 26.5 and 22 cm were chosen in both sides of 75 cm beds like the farmers' procedure. Each subplot included 4 planting lines with 5 meters in length.

The traits such as days to budding, days to flowering, days to 70% flowering, days to full flowering, days to ripening, plant height, head diameter, total number of seeds per head, weight of 1000-seeds, seed yield, seed oil rate, oil yield and harvest index were measured. Mean values were subjected to different statistical and biometrical analysis. Simple correlation coefficients were estimated according to Pearson's method and path coefficient analyses were done as according to Dewey and Lu (1959). The data analysis was achieved by using $SPSS_{16}$ and $path_2$ softwares.

Results and discussion

Correlation analysis (Table 1) indicated that traits: plant height, oil yield and total number of seeds per head has positive and highly significant relationship with seed yield. Further, days to full flowering and head diameter showed a negative relation with seed yield. The correlation of other traits with seed yield weren't significant (Table 1).

The regression analysis of seed yield as dependant variable according to step-wise method demonstrated that just traits such as total number of seeds per head and weight of 1000-seeds entered to regression model and totally justified 95.9% of the variation that existed in seed yield. At last, the following regression model was obtained for indicating the relationship between the seed yield and these traits as independent variables:

Seed yield = -2631.068 + 5.545 total number of seeds per head + 46.323 weight of 1000-seeds

The path analysis for seed yield was conducted based on traits; days to full flowering, plant height, head diameter and total number of seeds per head that have a meaningful correlation with seed yield (Table 1). Among these traits, total number of seeds per head had the highest and positive direct effect on seed yield. Therefore, selection for the highest amounts of total number of seeds per head can improve the seed yield in sunflower genotypes. These results are inconsistent with the results given by Anwar-al hag et al. (2005) and Ghafoor and Ahmad (2005).

On the other hand, days to full flowering and head diameter have a negative correlation as well as direct and negative effect on seed yield. Thus, selection for the lowest amounts of this trait can increase the seed yield. In other words, it is possible that the choice of genotype that enter the generative stage sooner and also terminate the flowering stage faster, causes the plant to escape preventing it from encountering the heat of end of the season. This mechanism leads to enhancement of the yield in stress conditions of the end of season (Richards, 1996).

Furthermore, the smaller head diameter in these conditions would be followed by the fewer hollow floret, increasing the seed yield. Meanwhile, just the plant height has a direct negative effect on the seed yield. This negative effect is negligible and on the other hand, the indirect effects of this trait, especially via total

Table 1. Simple correlation coefficients among studied traits

	1	2	3	4	5	6	7	8	9	10	11	12	13
1–Days to bud stage	1												
2–Days to flowering	.421**	1											
3–Days to 70% flowering	.529**	.764**	1										
4–Days to full flowering	.674**	.696**	.862**	1									
5–Days to ripening	.319*	.551**	.711**	.655**	1								
6–Plant height	–.232	.395**	.222	.025	.131	1							
7–Head diameter	–.282*	–.425**	–.336*	–.382**	–.259	–.401**	1						
8–Total number of seeds per head	–.193	.146	–.139	–.179	–.255	.555**	–.257	1					
9–Weight of 1000–seeds	.013	–.251	–.113	–.073	.131	–.311*	–.097	–.625**	1				
10–Seed yield	–.242	.024	–.239	–.270*	–.228	.503**	–.393**	.809**	–.076	1			
11–Seed oil rate	–.232	–.011	–.105	–.214	–.149	.360**	.372**	.455**	–.590**	–.158	1		
12–Oil yield	–.298*	.013	–.247	–.320*	–.251	.571**	–.191	.875**	–.298*	.911**	.542**	1	
13–Harvest index	–.267	–.179	–.285*	–.353**	–.279*	.013	.012	.141	.048	.262	.079	.238	1

*, **: Significant at 0.05 and 0.01 probability levels, respectively

Table 2. Path analysis of seed yield in sunflower genotypes

	Days to full flowering	Plant height	Head diameter	Total number of seeds per head	Total effects
Days to full flowering	–0.315	–0.003	–0.184	–0.138	–0.271
Plant height	–0.008	–0.108	0.193	0.424	0.503
Head diameter	0.120	0.042	–0.482	–0.075	–0.394
Total number of seeds per head	0.056	–0.060	0.046	0.765	0.809
Residual effects	0.400				

number of seeds per head on seed yield are positive. In this case, choosing the dwarf plants through increasing the total number of seeds per head can lead to genetic improvement the seed yield.

The reason might be the better remobilization that occurs in dwarf sunflower cultivars and causes the seeds to be filled better. Although, for considering the traits such as the plant height as selection criteria more care must be taken. Because, if the plant is too dwarf, it might lead to reduction of the competition of plant to get light and other environmental parameters, thus the seed yield would diminish. Therefore, it is necessary that the best plant height is studied more carefully. Shankar et al. (2006) and Sowmya et al. (2010) obtained the same results in sunflower genotypes.

Conclusion

In conclusion, the results demonstrate that efficacy of selection for the lowest amount of head diameter, days to full flowering as well as dwarf genotypes to obtain the highest seed yield in sunflower genotypes. Indirect selection for these traits in sunflower as a heterogamous and free polliniferous plant can result in more genetic gain than the direct selection for seed yield per se, because the heritability of these traits is more than seed yield and it can be measured easily, quickly and cost effectively.

References

Anwar-ul-Haq A., Rashid M.A., Butt A. S., Aslam. M. (2005). Association and path study of some agronoic characters in sunflower. J Agric Res 43(4): 323-329.

Arshad M., Ali N., Ghafoor A. (2006). Character correlation and path coefficient in soybean (*Glycine max* L.). Pak J Bot 38(1): 121-130.

Arshad M., Bakhsh, A., Ghafoor A. (2004). Path coefficient analysis in chickpea (*Cicer arietinum* L.) under rainfed conditions. Pak J Bot 36(1): 75-81.

Arshi Y., Jafari H.R. (1992). Review and determine the most suitable variety of sunflower plant population Mehr in water conditions. Seed Plant J Agric Res 403: 1-6.

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

Farratullah F.A., Khalil I.H. (2006). Path analysis of the coefficients of sunflower (*Helianthus annuus* L.) hybrids. Int J Agri Bio 8(5): 621-625.

Ghafoor A., Ahmad Z. (2005). Diversity of agronomic traits and total seed protein in Black gram [*Vigna mungo* (L.) Hepper]. Acta Biologica Cracoviensia Series Botanica Poland 47(2): 69-75.

Holt N.W, Zenter R.P. (1985). Effect of plant density and row spacing on agronomic performance and economic returns of oilseed sunflower in southeastern Saskatchewan. Canada J Plant Sci 65: 501-509.

Jannati M.R. (2002). Effect of planting arrangement on growth, yield and yield components of sunflower, Hinsun 33 hybrid. A thesis of M.Sc. of Agronomy, faculty of agriculture, Isfahan Industrial University.

Mokhtassi Bidgoli A., Akbari G.A., Mirhadi M.J., Zand E., Soufizadeh S. (2006). Path analysis of the relationships between seed yield and some morphological and phenological traits in safflower (*Carthamus tinctorius* L.). Euphytica 148: 261-268.

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

Robinson R.G., Ford J.H., Luedchen W.E., Rabas D.L., Smith L.J, Warnes D.D., Wiersman J.V. (1980). Response of sunflower to plant population. Agronomy J 72: 869 –871.

Richards R.A. (1996). Defining selection criteria to improve yield under drought. Plant Growth Reg 20: 157-166.

Shankar V.G., Ganesh M., Ranganatha A.R.G., Bhave M.H.V. (2006). A study on correlation and path analysis of seed yield and yield components in sunflower (*Helianthus annuus* L.). Agric Sci Digest 26(2): 87-90.

Taghdiri B., Ahmadvand G., Mazaherilaghab H. (2006). Distance effects on plant and yield components of sunflower cultivars. Agric res water soil and plant agric 6 (1): 26-35.

Teklewold A., Jayaramaiah H., Jagadeesh D.N. (2000). Correlations and path analysis of physiomorphological characteristics of sunflower (*Helianthus annuus* L.) as related to beeding method. Helia 23 (32): 105-114.

acs77_18