Australian Journal of Crop Science AJCS
AJCS 4(8):598-602 (2010) ISSN:1835-2707

Assessment of selection criteria in sesame by using correlation coefficients, path and factor analyses

Engin Yol[1], Emre Karaman[2], Şeymus Furat[1] and Bülent Uzun[1*]

[1]Department of Field Crops, Faculty of Agriculture, Akdeniz University, TR-07058, Antalya, Turkey
[2]Department of Biometry and Genetics, Faculty of Agriculture, Akdeniz University, TR-07058, Antalya, Turkey

[*]Corresponding author: bulentuzun@akdeniz.edu.tr

Abstract

The study was conducted in West Mediterranean Agricultural Research Institute's fields of Antalya at 2008-2009 to evaluate character associations using correlation coefficients, path and factor analyses with 345 sesame accessions originating from 29 different sesame producing countries covering worldwide. The correlation coefficient analysis indicated that plant height, number of branches, number of capsules per plant and 1000 seed weight had the significant positive effect on seed yield. The characters related to maturity, days to first flowering and 50% flowering, showed negative correlation with seed yield. The path coefficient analysis based on seed yield, as a dependent variable implicated that plant height had the highest positive direct effect on seed yield. This character was followed by days to first flowering, number of capsules and 1000 seed weight. Number of branches and number of capsules per plant had powerful indirect effect over plant height on seed yield. The overall results demonstrated that plant height, number of capsules per plant, number of branches and 1000 seed weight were the most contributing characters on sesame seed yield and these characters was of great importance in making indirect selection for seed yield. Factor analysis divided the 9 measured variables into 3 factors and these three factors had close contributions. Factor 1 (22.73%) strongly influenced days to first flowering and days to 50% flowering. Second factor (18.82%) was affected strongly by stem length to first capsule and plant height. Third factor (18.72%) was associated with number of capsules per plant, number of branches, seed yield and 1000 seed weight. According to factor analysis, plant height, number of branches and number of capsules per plant were the important attributes in sesame. Three different analyses proposed that sesame breeding for higher seed yield could be based on these characters as selection criteria.

Keywords: Breeding, Character association, Germplasm, *Sesamum indicum* L., World collection

Introduction

Sesame (*Sesamum indicum* L.) has lots of demand owing to high and quality oil, protein and antioxidants (Arslan et al., 2007; Erbas et al., 2009; Uzun et al., 2002; 2007; 2008). Seeds are used as raw food as well as in confectionery, sweets, bakery products and also oil is used for industry in preparation of soap, perfume, and carbon papers as well as in vegetable oil (Khan et al. 2001). Beside this consumption benefits, sesame has also many agricultural attributes: It grows well tropical and subtropical climates, it can grow on only soil moisture without rainfall or irrigation, and be grown in mixed stands with diverse crops (Ashri, 2007). Although it is highly favorable advantages, sesame production is insufficient compared to the other oilseed crops like that soybean, sunflower and peanut. Comparatively, low seed yield is one of the most important reasons that sesame needs breeding to provide more yield (Furat and Uzun, 2010). Especially in Mediterranean and Mediterranean type environments, sesame is an important option for the second crop production. Nevertheless, sesame growing areas are decreasing due to low seed yield compared to the other second crops such as corn. Selection for good yield types should be very useful and contribute to breeding programs in this area. Breeding process in sesame is not very easy because its seed yield is a complex phenomenon entailing several contributing factors which are highly correlatively with environmental interactions and thus these factors influence seed production both directly and indirectly (Rauf et al., 2004). Yield components also have complex features and they are affected together strongly (Bidgoli et al., 2006). The understanding of the relationship between yield and its components is crucial for selection process and this relationship can be explained by means of correlation, factor and path coefficient analyses. Factor analysis provides more information than a simple correlation matrix because it discriminates between groups of variables (factors) and indicates percentage contribution of variables (Biabani and Pakniyat, 2008). Path coefficient analysis permits the separation of direct effects from indirect effects and gives more realistic relationship of the characters and helps in effective selection (Sumathi et al., 2007). Some researchers (Subramanian and Subramanian 1994; Shim et al. 2001; Yingzhong and Yishou, 2002; Biabani and Pakniyat, 2008) have worked out character associations to create proper database for breeding practices. Their results differ widely for trait to trait which could be attributed due to differences in genetic material used for their studies (Gnanasekaran et al., 2008). Therefore, assessment of character interactions in a wide range of sesame accessions is very important and can be generalized for the sesame breeding programs. With this view, we evaluated seed yield, yield components and their

Table 1. Monthly temperature. humidity and rainfall values in the growing periods of 2008 and 2009

Months	Temperature ^{O}C			Humidity (%)			Rainfall (mm)		
	2008	2009	Long-term averages*	2008	2009	Long-term averages*	2008	2009	Long-term averages*
June	27.1	26.8	25.3	57.3	56.4	59.0	0.6	0.3	7.9
July	29.5	29.4	28.3	56.4	57.0	56.0	0	0.6	2.0
August	30.2	29.2	27.8	60.8	55.3	59.0	20.4	0	2.1
September	26.0	25.4	24.3	64.2	58.9	60.0	6.6	60.6	8.6
October	22.1	23.0	19.5	52.0	60.3	61.0	13.0	31.3	76.2

*30 years

Table 2. Correlation coefficients among 9 quantitative descriptors in the sesame collection

Traits	DFF	DF50	SLFC	PH	NB	NCP	NSPC	TSW
DF50	0.961**							
SLFC	0.366**	0.361**						
PH	-0.019	-0.029	0.695**					
NB	-0.041	-0.028	0.357**	0.441**				
NCP	-0.260**	-0.249**	0.072	0.469**	0.478**			
NSPC	-0.156**	-0.143**	-0.005	0.183**	0.207**	0.224**		
TSW	-0.392**	-0.414**	-0.015	0.338**	0.198**	0.354**	0.214**	
SY	-0.335**	-0.360**	0.027	0.388**	0.174**	0.387**	0.067	0.381**

** $p<0.01$

DFF is stand for days to first flowering; DF50 is stand for days to 50% flowering; SLFC is stand or stem length to the first capsule; PH is stand for plant height; NB is stand for number of branches: NCP is stand for number of capsules; NSPC is stand for number of seeds per capsules; TSW is stand for 1000 seed weight; SY is stand for seed yield.

associations in 345 sesame genotypes originated from all around the world and produced in the true Mediterranean type environment.

Material and methods

The research was carried out in West Mediterranean Agricultural Research Institute's fields of Antalya (36°52'N. 30°50'E. 15 m elevation) at the 2008 and 2009 growing seasons. 345 sesame accessions from 29 different sesame producing countries were used for a genetic material. The experimental design consisted of a randomized complete blocks design with two replications and four checks. Each accessions occupying two rows of 5 m length at a distance of 70 cm between the rows and 10 cm between the plants within the rows. Annealing was provided by means of furrow irrigation before sowing. After ploughing for a good seed preparation, fertilizer was applied as 6 kg N, 6 kg P_2O_5 and 6 kg K_2O. Following to fertilization, field was harrowed twice. The accessions were sown on clay loam soil which was analyzed that 15% sand, 55% silt and 30% clay. All accessions were sown 20 June 2008 and 22 June 2009. Irrigation and hand weeding were done when necessary. First flowering was observed 22-25 July at the 2008 and 2009 growing seasons, respectively. Capsules formation was observed between about 31 July and 3 August in two consecutive years. Harvesting processes were started at the beginning of October. Climatic data for 2008 and 2009 was taken by State Meteorology Station including monthly temperature, precipitation and moisture (Table 1). Two experimental years showed similar trends in air temperatures with the highest temperatures in June, July and August and the lowest in October. The growing year of 2008 had received slightly less rainfall than 2009 which was higher than long term averages with the months of September and October. No rainfall was observed in months of July and August in 2008 and 2009, respectively. Similar results were monitored in long term averages. Humidity was generally similar in 2008 and 2009 growing periods and the results were highly conformable to long term averages. Sesame descriptors according to IPGRI and NBPGR (2004) were used for recording quantitative observations; days to first flowering (DFF), 50% flowering date (DF50), stem length to the first capsule (SLFC), plant height (PH), number of branches (NB), number of capsules per plant (NCP), number of seeds per capsules (NSPC), 1000 seed weight (TSW) and seed yield (SY). Seed yield in grams per rows for each accession was recorded and then converted to kg/ha. Thousand seed weight in gram was calculated by weighing 200 seeds. Analysis of variance was conducted on mean values of varieties monitored in each block. In two experimental years, no significant replication effects were observed therefore mean values for the two years were calculated and used for the analyses (Gupta et al., 2009). The correlation coefficient was carried out by using the formulae suggested by Kwon and Torrie (1964). Factor analysis was performed according to maximum likelihood method with SPSS 17.0 (2008). Path analysis was used for exhibiting the direct and indirect effects on seed yield according to the method suggested by Dewey and Lu (1959).

Results and discussion

Correlation coefficients of seed yield and yield components were displayed in Table 2. The combined data over the two years in Table 2 showed that PH, NB, NCP and TSW had the significant positive correlation with SY. With regard to positive correlation, similar results are in concurrence with the results of Uzun and Cagirgan (2001), Khan et al. (2001) and Sumathi et al. (2007). SLFC and NSCP indicated positive correlation but not statistically significant. Two related characters, DFF (r= -0.335**) and DF50 (r= -0.360**) showed negative and significant contribution to SY. These characters highly related to days to maturity because of early flowering in sesame provides early capsule developing. In our study, these characters had negative effect on seed yield and similar negative relation was obtained by Gnanasekaran et al. (2008). The path coefficient analysis provides a more realistic picture of the relationship, as it considers direct as well as indirect effects of the variables by partitioning the correlation coefficients (Sodavadiya et al., 2009; Ali et al, 2009). Thus it provides a clear idea about the highest contributing character to seed yield and relative importance of each character can then be estimated. The direct and

Table 3. Path coefficients for measured traits in sesame

Days to first flowering vs seed yield	*r* = -0.335**		Number of branches vs seed yield	*r* = 0.174**	
Direct effect	0,146	22,19%	Direct effect	-0,016	3,85%
Indirect effect via DF50	-0.324	49,29%	Indirect effect via FFD	-0.006	1,42%
Indirect effect via SLFC	-0.086	13,02%	Indirect effect via DF50	0.009	2,19%
Indirect effect via PH	-0.009	1,34%	Indirect effect via SLFC	-0.084	19,64%
Indirect effect via NB	0.001	0,10%	Indirect effect via PH	0.208	48,81%
Indirect effect via NCP	-0.033	4,95%	Indirect effect via NCP	0.060	14,09%
Indirect effect via NSPC	0.015	2,25%	Indirect effect via NSPC	-0.020	4,63%
Indirect effect via TSW	-0.045	6,85%	Indirect effect via TSW	0.023	5,36%
Days to 50% flowering vs seed yield	*r* = -0.360**		Number of capsules per plant vs seed yield	*r* = 0.387**	
Direct effect	-0,338	50,47%	Direct effect	0,125	22,57%
Indirect effect via FFD	0.140	20,97%	Indirect effect via FFD	-0.038	6,84%
Indirect effect via SLFC	-0.085	12,63%	Indirect effect via DF50	0.084	15,18%
Indirect effect via PH	-0.014	2,05%	Indirect effect via SLFC	-0.017	3,05%
Indirect effect via NB	0.001	0,07%	Indirect effect via PH	0.221	39,77%
Indirect effect via NCP	-0.031	4,67%	Indirect effect via NB	-0.008	1,41%
Indirect effect via NSPC	0.014	2,03%	Indirect effect via NSPC	-0.021	3,84%
Indirect effect via TSW	-0.048	7,12%	Indirect effect via TSW	0.041	7,34%
Stem length to the first capsule vs seed yield	*r* = 0.027		Number of seeds per capsules vs seed yield	*r* = 0.067	
Direct effect	-0,234	31,03%	Direct effect	-0,095	30,72%
Indirect effect via FFD	0.054	7,09%	Indirect effect via FFD	-0.023	7,35%
Indirect effect via DF50	-0.122	16,18%	Indirect effect via DF50	0.048	15,62%
Indirect effect via PH	0.327	43,42%	Indirect effect via SLFC	0.001	0,40%
Indirect effect via NB	-0.006	0,78%	Indirect effect via PH	0.086	27,81%
Indirect effect via NCP	0.009	1,20%	Indirect effect via NB	-0.003	1,10%
Indirect effect via NSPC	0.001	0,07%	Indirect effect via NCP	0.028	9,07%
Indirect effect via TSW	-0.002	0,23%	Indirect effect via TSW	0.025	7,94%
Plant height vs seed yield	*r* = 0.388**		1000 seed weight vs seed yield	*r* = 0.381**	
Direct effect	0,471	61,31%	Direct effect	0,115	21,18%
Indirect effect via FFD	-0.003	0,36%	Indirect effect via FFD	-0.057	10,56%
Indirect effect via DF50	0.010	1,28%	Indirect effect via DF50	0.140	25,77%
Indirect effect via SLFC	-0.163	21,16%	Indirect effect via SLFC	0.004	0,66%
Indirect effect via NB	-0.007	0,94%	Indirect effect via PH	0.159	29,29%
Indirect effect via NCP	0.059	7,64%	Indirect effect via NB	-0.003	0,60%
Indirect effect via NSPC	-0.017	2,26%	Indirect effect via NCP	0.044	8,18%
Indirect effect via TSW	0.039	5,05%	Indirect effect via NSPC	-0.020	3,75%

**p<0.01 , DFF is stand for days to first flowering; DF50 is stand for days to 50% flowering; SLFC is stand for stem length to the first capsule; PH is stand for plant height; NB is stand for number of branches: NCP is stand for number of capsules; NSPC is stand for number of seeds per capsules; TSW is stand for 1000 seed weight; SY is stand for seed yield.

indirect effect values from path analysis are shown in Table 3. The combined data indicated that PH had the highest positive direct effect on SY (p = 0.471, 61.31%). This was in accordance with the findings of Uzun and Cagirgan (2001) and Yingzhong and Yishou (2002). This character was followed by DFF (p= 0.146), NCP (p= 0.125) and TSW (p= 0.115) however these characters had lower direct effect on SY (Table 3). DF50 had the highest negative direct effect on SY (r =-0,338, 50.47%). Similarly, in correlation coefficient, this character indicated negative correlation with SY. In addition, SLFC (r= -0,234), NSPC (r= -0,095) and NB (r= -0,016) indicated negative direct effect on SY, 31.03%, 30.72% and 3.85%, respectively. PH is the most contributing character for seed yield in sesame because it has indeterminate growth habit (Uzun and Cagirgan, 2002; 2006; 2009). Although this wildish character prevents mechanized harvesting and the expansion of its cultivation, PH provides permanent branching and capsule production. Thus, PH, NB

Table 4. Loadings of the first three most principal from a factor analysis of quantitative traits of sesame accessions

Variables	Factors 1	2	3
DF50	0.967	-	-
DFF	0.923	-	-
SLFC	-	0.972	-
PH	-	0.733	-
NCP	-	-	0.748
SY	-	-	0.501
TSW	-	-	0.480
NB	-	-	0.434
NSCP	-	-	0.301

DFF is stand for days to first flowering; DF50 is stand for days to 50% flowering; SLFC is stand for stem length to the first capsule; PH is stand for plant height; NB is stand for number of branches: NCP is stand for number of capsules; NSPC is stand for number of seeds per capsules; TSW is stand for 1000 seed weight; SY is stand for seed yield.

and NCP traits should be considered for obtaining higher seed yield and assessed together in sesame breeding programs. As expected, correlation coefficients demonstrated the positive relationship among these three characters (PH, NCP, NB) (Table 2).

These results suggested that improvement of seed yield in sesame is linked with these traits and selection of these characters might have good impact on seed yield. In path analysis, similar effective interaction was observed for PH/NB and PH/NCP. NCP with PH showed the highest indirect effect on SY (Yingzhong and Yishou, 2002; Sumathi et al., 2007). Similarly, NB/PH showed strong positive indirect effect on SY. This situation indicated that although NB and NCP had not high direct effect on seed yield, these traits had powerful indirect effect over PH and therefore they may evaluate together in selection studies. The characters of SLFC and NSPC indicated positive correlation with SY whereas in path analysis, negative direct effect was observed on SY for each of them. According to Sing and Chaudhary (1977), indirect effects can be explained by the result of correlation for these traits. Hence, the characters of SLFC and NSPC should be considered with their indirect effects. SLFC through PH was indicated high and positive indirect effect (43.42%). Similarly, NSPC had positive indirect effect with PH (27.81%) on seed yield. Factor analysis was used to determine the factors which contributed to the variation of quantitative traits in sesame. The results of factor analysis indicated three factors explaining 60.27% of total variation (Table 4). Factor 1 had 22.73% contribution to the total variation, strongly influenced by DFF and DF50. In addition the traits of DFF and DF50 showed close relationship in each factor. According to Biabani and Pakniyat (2008), these types of traits may be influenced by the same gene or genes and therefore may be beneficial for suitable sesame genotypes screening. Second factor had 18.82% contribution which was affected strongly by SLFC and PH. Third factor had 18.72% contribution to the total variation which was associated with NCP, NB SY and TSW. Although there is no major difference between factor contributions, results of factor analysis indicated that, DFF, DF50, SLFC, PH and NCP may be evaluated as selection criteria in breeding programs. Three different analyses were used for assess accurately to the relationship among the characters in sesame. In correlation analysis, except for DFF and days to DF50, other characters indicated positive correlation with SY. In path analysis, deeper relations revealed and amount of direct and indirect effects of the casual component on the SY was determined. According to path analysis, PH indicated very high direct effect on SY. Also PH showed high indirect effect via NB and NCP. These results were encouraged by factor analysis which was indicated that PH and NCP may be more efficient for eligible sesame genotype searching. Therefore, PH instead of many selection criteria should firstly be used in selection to increase the seed yield in sesame breeding programs. Indirect effects of PH with NCP and NB should also be considered for the breeding programs to increase sesame yield.

Acknowledgements

This work was supported with a grant coded 2010.02.0121.001 by the Akdeniz University Coordination Unit of Scientific Research Projects and the second year of the work was based on the M.Sc., thesis submitted to the Graduate School of the University by Engin Yol. This work was also supported in part by the Scientific and Technological Research Council of Turkey (TUBITAK) under the project number of TOVAG 107O912.

References

Ali MA, Nawab NN, Abbas A, Zulkiffal M, Sajjad M (2009) Evaluation of selection criteria in *Cicer arietinum* L. using correlation coefficients and path analysis. Aust J Crop Sci 3:65-70.

Arslan C, Uzun B, Ulger S, Cagirgan MI (2007) Determination of Oil Content and Fatty Acid Composition of Sesame Mutants Suited for Intensive Management Conditions. J Am Oil Chem Soc 84:917-920.

Ashri A (2007) Sesame (*Sesamum indicum* L.). In: Singh RJ (ed) Genetics Resources, Chromosome Engineering, and Crop Improvement, Vol.4, Oilseed Crops, CRC Press, Boca Raton, FL, USA.

Biabani AR, Pakniyat H (2008) Evaluation of seed yield-related characters in sesame (*Sesamum indicum* L.). Pakistan J Biol Sci 11:1157-1160.

Bidgoli AM, Akbari GA, Mirhadi MJ, 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.

Dewey DR, Lu KH (1959) A correlation and path analysis of components of crested wheat grass seed production. Agron J 51:515-518.

Erbas M, Sekerci H, Gül S, Furat S, Yol E, Uzun B (2009) Changes in total antioxidant capacity of sesame (*Sesamum* sp.) by variety. Asian J Chem 21:5549-5555.

Furat S, Uzun B (2010) The use of agro-morphological characters for the assessment of genetic diversity in sesame (*Sesamum indicum* L). Plant Omics J 3:85-91.

Gnanasekaran M, Jebaraj S, Muthuramu S (2008) Correlation and Path co-efficient analysis in sesame (*Sesamum indicum* L.). Plant archives 8:167-169.

Gupta A, Mahajan V, Kumar M, Gupta HS (2009) Biodiversity in the barnyard millet (*Echinochloa frumentacea* Link, Poaceae) germplasm in India. Genet Resour Crop Evol 56:883-889.

Khan NI, Akbar M, Sabir KM, Iqbal S (2001) Characters association and path coefficient analysis in sesame (*Sesamum indicum* L.). Online J Biol Sci 1:99-100.

Kwon SH, Torrie JH (1964) Heritability and interrelationship of traits of soybean populations. Crop Sci 4:196-198.

Rauf S, Khan MT, Sadaqat HA, Khan AI (2004) Correlation and path coefficient analysis of yield components in cotton (*Gossypium hirsutum* L.). Int J Agr Biol 6:686-688.

Shim KB, Kang CW, Lee SW, Kim DH, Lee BH (2001) Heritabilities, genetic correlations and path coefficients of some agronomic traits in different cultural environments in sesame. Sesame and Safflower News 16:16-22.

Singh KB, Chaudhary BD (1977) Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers. New Delhi-India.

Sodavadiya PR, Pithia MS, Savaliya JJ, Pansuriya AG, Korat VP (2009). Studies on characters association and path analysis for seed yield and its components in pigeonpea (*Cajanus cajan* (l.) Millsp.). Legume Res 32:203-205.

Subramanian S, Subramanian M (1994) Correlation Studies and Path Coefficient Analysis in Sesame (*Sesamum indicum* L.). J Agron Crop Sci 173:241-248.

Sumathi P, Muralidharan V, Manivannan N (2007) Trait association and path coefficient analysis for yield and yield attributing traits in sesame (*Sesamum indicum* L). Madras Agric J 94:174-178.

SPSS Statistics 17.0.0 (2008). SPSS for Windows. SPSS Inc. 2008.

Uzun B, Cagirgan M.I (2001) Path-coefficient analysis for seed yield and related characters in a population of determinate and indeterminate types of sesame (*Sesamum indicum* L.) Turk. J Field Crops 6:76-80.

Uzun B, Ulger S, Cagirgan MI (2002) Comparison of determinate and indeterminate types of sesame for oil content and fatty acid compositions. Turk J Agric For 26:269-274.

Uzun B, Cagirgan MI (2006) Comparison of determinate and indeterminate lines of sesame for agronomic traits. Field Crops Res 96:13-18.

Uzun B, Arslan C, Karhan M, Toker C (2007) Fat and fatty acids of white lupin (*Lupinus albus* L.) in comparison to sesame (*Sesamum indicum* L.). Food Chem 102:45-49.

Uzun B, Arslan Ç, Furat S (2008) Variation in fatty acid compositions, oil content and oil yield in a germplasm collection of sesame (*Sesamum indicum* L.). J Am Oil Chem Soc 85:1135-1142.

Uzun B, Cagirgan MI (2009) Identification of molecular markers linked to determinate growth habit in sesame. Euphytica 166:379-384.

Yingzhong Z, Yishou W (2002) Genotypic correlations and path coefficient analysis in sesame. Sesame and Safflower News 17:10-12.