Global Journal of Science Frontier Research
Agriculture and Veterinary
Volume 13 Issue 8 Version 1.0 Year 2013
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Determination of Efficiency of Yield Components on Oil Yield Per Plant in Safflower Breeding by Different Statistical Methods

By Duran Katar
Eskişehir Osmangazi University, Turkey

Abstract - The aim of this study was to determine relationship oil yield and yield components and to show efficiency of components on oil yield by using statistical procedures under rainfed conditions in safflower (Carthamus tinctures L.). Data of oil yield and yield components over the two years in the study were evaluated by statistical procedures; correlation and path analysis, regression analysis (multiple linear regression and best subsets regression), factor analysis, principal component analysis and cluster analysis. Results in this study revealed that hhigh yielding new cultivars are evaluated, selected by using various yield components such as seed yield per capitalism, thousand kernel weight, oil content, yield per plant are getting used more and more for high grain/oil yield and for resistance to drought conditions.

Keywords : safflower (carthamus tinctures l.), oil content, seed yield, oil yield per plant.

GJSFR-D Classification : FOR Code: 820403, 820302, 070602

Strictly as per the compliance and regulations of :

© 2013. Duran Katar. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecommons.org/licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Determination of Efficiency of Yield Components on Oil Yield Per Plant in Safflower Breeding by Different Statistical Methods

Duran Katar

Abstract - The aim of this study was to determine relationship oil yield and yield components and to show efficiency of components on oil yield by using statistical procedures under rainfed conditions in safflower (Carthamus tinctures L.). Data of oil yield and yield components over the two years in the study were evaluated by statistical procedures; correlation and path analysis, regression analysis (multiple linear regression and best subsets regression), factor analysis, principal component analysis and cluster analysis. Results in this study revealed that hhigh yielding new cultivars are evaluated, selected by using various yield components such as seed yield per capitalism, thousand kernel weight, oil content, yield per plant are getting used more and more for high grain/oil yield and for resistance to drought conditions.

Keywords : safflower (carthamus tinctures l.), oil content, seed yield, oil yield per plant.

I. Introduction

Being an oil seed crop, safflower *(Carthamus tinctures L.)* is known as drought tolerant plant and is grown wide semiarid climates in the world (Christos and Seoul's, 2008). Due to deeper roots, this crop could be tolerant to water stress could join rotation with other crops and these phenomena make this crop drought tolerant (Usual et al., 2006). Safflower has been cultivated in the world for its oil content that is rich in polyunsaturated fatty acids playing important role to decrease blood cholesterol level (Bayar and Turgot, 1999). Moreover, this crop has about 75% linoleum acid, higher than corn, soybean, cottonseed, peanut or olive oils. This crop is therefore used first of all for edible oil products such as salad oils and soft margarines. High-quality oil feature makes safflower an important crop for vegetable oil (Conge et al., 2007).

The need of new cultivars having higher oil quality/content of oil leads to the objective of safflower breeding programs to develop new cultivars having higher oil quality/content, greater yielding ability and eventually resistance to drought and diseases (Volkmann and Raj can, 2009). Grain yield and oil quality/content are important characters and subject to many variables affecting plant growth. Increasing genetic association between agronomic and quality characters could improve the efficiency of breeding programs by determining and effectively using markers in selection of safflower genotypes (Volkmann and Raj can, 2009).

Grain yield and naturally oil yield per plant in safflower are in general under effect of some components (the number of capitulate per plant, seed yield per capitalism, 1000 seed yield and seed yield per plant) that seem to be important elements for breeding programs (Aslant et al., 2008; Bonham et al., 2011). Usual (2006) stated that under rained conditions some components (seed yield per plant, oil content and 1000 seed weight) have been evaluated by several researchers and are considered as important measures for oil yield per plant. Several researchers evaluated components affecting oil yield per plant and plant adaptations for semi arid climatic conditions and drought stress may cause a reduction in certain components but particularly in seed yield per plant and seed oil content (Yılmazlar, 2008, Sade et al., 2012).

In addition, there are various statistical techniques covering correlation and path analysis, multiple linear regression, Factor Analysis, Principal component analysis, Best subsets regression and cluster analysis to evaluate yield and yield components for breeding programs (Massmart et al., 1997; Oldsmar, 1999; Slavonic et al., 2004; Skis et al., 2006). Correlation and path analyses are important procedures to examine dependent variable, and direct and indirect contribution of components and both correlation and path analyses could successfully be used in breeding programs (Massmart et al., 1997; Oldsmar, 1999; Hilt runner et al., 2007). Regression analyses, including multiple linear regression, best subsets regression are efficiently used in modeling crop yield analyses (Oldsmar, 1999; Skis et al., 2006). Principal component and factor analyses are multivariate statistical techniques for analyzing and making simplification in complex plant data sets (Slavonic et al., 2004).The characteristic of this statistical technique is to transform variables correlated in to simplified variables and to show features of components (Oldsmar, 1999). Cluster analysis is often used to reveal characteristics of components and classify components in to distinct groups and subgroups in the characteristics of similarity and dissimilarity levels (Otto, 1999; Beltane and Ojai, 2007). This study was carried

Author : Eskişehir Osmangazi University, Faculty of Agriculture, Bağlar Campus, Ziraat Street, Eskişehir-Turkey.
E-mail : durankatar6060@gmail.com

© 2013 Global Journals Inc. (US)

out to help breeders, researching to reveal main components and their influences on oil yield per plant and plant productivity. The aim of this study was to determine relationship oil yield per plant and yield components and to show efficiency of components on oil yield per plant by using statistical procedures under rained conditions.

II. Materials and Methods

This study was carried out in research area of Central Research Institute for Field Crops in Hayman-Ankara (32^0 51 E; 39^0 57 N; 860 m above sea level)/Turkey in 2010 and 2011 years. Soil characteristics in research area had lime-loamy soil structure, having 7.19 pH, 0.037 % salt, 1.30 % organic matter and 2.48 % lime. Hayman-Ankara/turkey where the trials were performed has a typical steppe climate with high temperature differences between day and night. Summers are dry and winters are relatively rainy. Total rainfall in 2010 and 2011 (379,9 mm and 401,5 mm, respectively) were lower than long-term years rainfall (402,1 mm). In 2010 period, total rainfall (March-September) was 176 mm so doing 213.2 mm in 2011 period. Rainfall in tailoring stage (in May), important for yield, was 22 mm in 2010 and 86 mm in 2011 period. Besides, mean temperatures in 2010 and 2011 (11.8°C and 10,5°C, respectively) were lower than long-term-years temperature (12.0°C).

Dancer (spineless), Remzibey (spiny), Yen ice and Shiva (spineless) cultivars and TAEK-sulk line (spiny) were used in trial as plant materials. Yen ice, Dancer and Remzibey cultivars were developed at Translational Zone Agricultural Research Institute in Turkey. Shiva cultivar was obtained from Tajikistan. TAEK-sulk pure line was developed at The Turkish Atomic Energy Authority by mutation. Field experiments in 2010 and 2011 growing seasons were conducted with four replications as 'Randomized Complete Block Design' in Ankara-Turkey ecological conditions. The cultivars and pure line (Dancer, Remzibey, Yenice, Shiva and pure line TAEK-sulk) were randomized into plots. Seeds were sown with 30 cm row spacing on plots of 6 m^2 harvest area (1.20 m width x 5 m length) on 25 March 2010 and 28 March 2011. After intra-row spacing was stabilized at 10 cm by thinning in both first and second years (Kızıl vet ark. 1999). Weed controls were made by means of manual weeding in rows. A total of 50 kg $ha^{-1}$of P_2O_5 and 40 kg $ha^{-1}$of nitrogen were applied with sowing and 20 kg $ha^{-1}$of nitrogen was applied as a top dressing at the beginning of stem elongation. On 10 September and 17 September at full maturity of the seeds plant harvests were made in 2010 and 2011, respectively. Thirty plants per plot were selected as randomly and made by hand. Seeds obtained from these plants were used for experiments. For all statistical analyses, SAS and Minitab 15 package programs were used. Means of data taken from oil yield per plant and yield components during crop growing periods of 2010 and 2011 years are given in Table 1.

Data of oil yield per plant and yield components for the two years in the study were evaluated by statistical procedures; correlation and path analysis, regression analysis (multiple linear regression and best subsets regression), factor analysis, principal component analysis and cluster analysis.

III. Result and Discussion

Minimum, maximum, mean and standard deviation of all characters in safflower (Carthamus tinctures L.) cultivars is shown in Table 2.

Correlation and path analyses between oil yield per plant and yield components and relationship between oil yield per plant and yield components are given Table 3 and Figure 1. Correlations close to 1 denotes that almost positive/similar results are taken from two variables and value close to -1 show that results in two characters are so opposite/dissimilar. Value close to zero also assign that two characters are so independent from each other (Ozdamar, 1999).

Table 3 and Figure 1 show that significant and positive relationship between oil yield per plant and capitalism yield, thousand kernel weight, yield per plant; significant and negative relationship between oil yield per plant and hull content. Path analysis is also a useful analysis to understand formation dependent variable and the effect of independent variables on dependent variable (Kang, 1990). In path analysis, direct and indirect effects of components having significant correlation in oil yield per plant per plant were considered (Table 3). Results revealed that capitalism yield (-0.1186 and 8.0866%) and thousand kernel weight (-0.2983 and 14.2114%) had negative direct effects, positive direct effects were taken from hull content (0.1151 and 8.7204%) and (0.1194 and 6.9851%). Nevertheless, the highest indirect effects were determined via capitalism number, capitalism yield, thousand kernel weight, yield per plant and hull content and these can considered as important characters. Studies emphasized that owing significant and positive relationship with oil or plant grain yield; capitalism number, capitalism yield, thousand kernel weights, could safely be used breeding programs (Badoglio et al., 2006). Sandal (1988) pointed out that oil yield per plant under rained climatic conditions was determined by capitalism number, capitalism yield, thousand kernel weight.

Multiple linear regression analysis, given in Table 4, explains the regression coefficients, the probability of the variables on estimation of oil yield per plant in safflower (Carthamus tinctures L.).

T-test showed that capitalism yield and seed yield per plant had significant effect in oil yield per plant.

© 2013 Global Journals Inc. (US)

This formula show 95.8 variation in variables and the remaining 4.2 % assign residual effects. Yield estimation Formula is also shown below:

Oil yield per Plant (Ŷ) = - 2.71 - 0.00615 Plant Height + 0.0055 Branch Number - 0.0478 Capitalism Number + 0.068 Capitalism Yield - 0.0183 Thousand Kernel Weight + 0.400 Yield per Plant + 0.0309 Hull Content + 0.0598 Oil Content

These results show that capitalism yield and yield per plant are important variables and should be used in bread wheat breeding programs. Regression analysis is the better way to make crop yield/oil yield per plant prediction (Bonham et al., 2011) and linear regression model is one of best method to determine crop yield/oil yield per plant in safflower (Carthamus tinctures L.) (Badoglio et al., 2006).

Best subsets regression determines the best-fitting regression models, constructed with the predictor characters specified. Best subsets regression is an important analysis to clarify models achieving targets with as less predictors as possible. Subset models could easily guess the regression coefficients and predict future responses with smaller variance than the full model using all predictors (Press and Wilson, 1978). The model with the highest adjusted R, low Mallows' value and the lowest S value is assumed as the best model for determination of best characters (Bonham et al., 2011).

Table 6 shows best subset regression explaining the best predictor characters. With 99.7 adjusted R^2, 3.2 Mallows' values variable 5 including plant height, capitalism yield, thousand kernel weight, and yield per plant, hull content and oil content appeared the best predictors and could be used for in safflower (*Carthamus tinctures* L.) breeding programs. Best subset regression is widely used to determine best subsets and to describe dependent variables (Press and Wilson, 1978; Sachem et al., 2007) such as oil yield per plant.

Principal component analysis is so common procedure to alter observed and correlated variables to linearly uncorrelated variables by using orthogonal transformation. This analysis is a linear transformation, shifting the data to a new coordinate system that the greatest variance (called the first principal component), the second greatest variance on the second coordinate, then so. (Crosse et al., 1991; Potgieter et al., 2002).

Principal component analysis in Table 7 and relatively ballot analysis of safflower *(Carthamus tinctures L.)* show that decrease in Eigen values is associated with increase of component numbers and maximum component number is determined at three factors.

According to results, variables could be grouped in three components and these components account for 93.6% of the total variation of oil yield per plant of safflower (Carthamus tinctures L.). PC_1 correlated with capitalism yield, thousand kernel weight, and oil content. Besides, PC_2 correlated with yield per plant. PC_3 correlated with plant height. PC1, PC2 and PC3 account for 53.8%, 80.9 and 93.6% of the variation in oil yield per plant (Table 7 and Figure 2). So, capitalism yield, thousand kernel weight, oil content, yield per plant and plant height showed up to be important characters for oil yield of safflower (*Carthamus tinctures* L.). Studies revealed that correlation between oil yield per plant and capitalism yield, thousand kernel weight, oil content, yield per plant and plant height (Badoglio et al., 2006).

Factor analysis describes variance among observed, correlated variables for potentially lower number of unobserved variables. Factor analysis seeks joint variations related to unobserved latent variables. The observed variables are modeled as linear combinations of the potential factors, plus "error" terms (Harmon, 1976; Joreskog, 1977; Anderson, 1984). Factor analysis of characters in safflower (*Carthamus tinctures* L.) is given in Table 8. Factor analysis revealed that factor variances in Factor I, Factor II Factor III and Communality were 45.00, 27.30, 12.60 and 84.90%, respectively. According to results, yield per plant in Factor I, thousand kernel weight in Factor II and plant height in Factor III seemed important characters on oil yield per plant. As a result of factor analysis yield per plant, thousand kernel weight and plant height are important components in oil yield per plant. Oil yield per plant is important character and should be taken into consideration on selection of genotypes in breeding programs (Knowles, 1982). Besides seed yield and oil content are both efficient characters for oil yield per plant (Volkmann and Raj can, 2009). It was stressed that capitalism yield, yield per plant, thousand kernel weight and oil content had significant correlation with oil yield per plant (Golparvar, 2011, Behnam et al., 2011).

Cluster technique is an agglomerative hierarchical method that begins with all variables separate, each forming its own cluster (Milligan, 1980; Murphy et al., 1986; Martin et al., 1995). In this study cluster analysis and den do gram are given in Table 9 and Figure 3. In cluster analysis, distance of each variable related to the others are calculated and groups observed are established by agglomeration process in which all variables start individually in one's group. Groups closed to each other gradually merged until all variables come to a single group. Repeated splitting of groups result in all evaluated variables being in groups of their own. For quantitative characters, cluster numbers are chosen from hierarchical analysis (Martin et al., 1995). Table 9 and Figure 3 denotes that both similarity level and cluster number increase. In distance of 70.1 % and similarity level of 88.33 %, all variables could be agglomerated in four clusters.

Cluster I includes plant height, while branch number and capitalism number belonged to Cluster II.

© 2013 Global Journals Inc. (US)

Cluster III constituted of oil yield per plant, capitalism yield, thousand kernel yield, oil content and yield per plant; hull content appeared in Cluster IV.

Cluster analysis showed that, capitalism yield, thousand kernel yield, oil content and yield per plant could be considered as important characters for high oil yielding genotypes in safflower (*Carthamus tinctures* L.) breeding programs.

Results of explained the effect of oil yield components are given in Table 10. Results in this study revealed that capitalism yield, thousand kernel weight, yield per plant and oil content are most important characteristics and they are highly effective in grain yield (Table 10). Safflower (*Carthamus tinctures* L.) breeding programs have been carried out all around the world. High yielding new cultivars are evaluated, selected by using various yield components such as capitalism yield, thousand kernel weight, oil content, yield per plant are getting used more and more for high grain/oil yield and for resistance to drought conditions.

References References References

1. Anderson, T.W., 1984. An Introduction to Multivariate Statistical Analysis, Second Edition. John Wiley and Sons.
2. Arslan, B., Esendal, E. and Paşa, C., 2008. The economically important traits of safflower (*Carthamus tinctorius* L.) cultivars and lines cultivated in Tekirdag, Turkey. VIIth International Safflower Conference, Wagga Wagga, Australian Journal of Agronomy 6 (3): 415-420.
3. Baydar, H.ve Turgut, İ., 1999. Yağlı tohumlu bitkilerde yağ asitleri kompozisyonununbazı morfolojik ve fizyolojik özelliklere ve ekolojik bölgelere göre değişimi. Turkish Journal of Agriculture and Forestry, 23(suppl.1):81-86.
4. Behnam, T., Said, A., Mohamadreza, S., Alireza, B.B. and Gafari, G., 2011. Path analysis of seed and oil yield in safflower (*Carthamus tinctorius* L.). International Journal of Agriculture and Crop Sciences (IJACS), 3-4/114-122.
5. Behnam, T., Said, A., Mohamadreza, S., Alireza, B.B. and Gafari, G., 2011. Path analysis of seed and oil yield in safflower (*Carthamus tinctorius* L.). International Journal of Agriculture and Crop Sciences (IJACS), 3-4/114-122.
6. Bidgoli, A.M., 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 Volume 148, Issue 3, pp 261-268.
7. Biljana, S., Onjia, A., 2007, Multivariate analyses of microelement contents in wheat cultivated in Serbia. Food Control, 18, 338–345.
8. Coşge, B., Gürbüz, B. ve Kıralan, M., 2007. Oil Content and Fatty Acid Composition of Some Safflower (*Carthamus tinctorius* L.) Varieties Sown in Spring and Winter. International Journal of Natural and Engineering Sciences 1 (3): 11-15.
9. Crossa, J., Fox, P.N., Pfeiffer, W.H., Rajaram,S., Gauch, H.G., 1991, AMMI adjustment for statistical analysis of an international wheat yield trial. 81(1): 27-37.
10. Esendal, E., 1988. Aspir (*Carthamus* sps.) Türleri Üzerine Bir Monografi I. *Carthamus tinctorius* L. Üzerindeki Islah Çalışmaları. Ondokuz Mayıs Ünv. Zir. Fak. Derg. 3 (1): 139-150.
11. Golparvar, A. R., 2011. Genetic Improvement of Oil Yield in Spring Safflower Cultivars under Drought and Non-drought Stress Conditions. Electronic Journal of Biology, Vol. 7(2):40-43.
12. Harmon, H., 1976. *Modern Factor Analysis*, Third Edition. University of Chicago Press.
13. Hiltbrunner, J., Streit, B., Liedgens, M., 2007, Are graining densities an opportunity to increase grain yield of winter wheat in a living mulch of white clover? Field Crops Research 102, 163–171.
14. İkiz, F., Puskulcu, H., Eren S., 2006, Introduction to Statistics, Barıs Press, Bornova, Izmir, pp 548.
15. Joreskog, K., 1977. "Factor Analysis by Least Squares and Maximum Likelihood Methods," *Statistical Methods for Digital Computers,* ed. K. Ensley, A. Ralston and H. Wolf, John Wiley & Sons.
16. Kang, M.S., 1990, Genotype-By-Environment Interaction and Plant Breeding, Louisiana State University Press, Louisiana, pp 392.
17. Massart, D. L., Vandeginste, B. G. M., Buydens, L. M. C., de Jong, S., Lewi, P. J., Smeyers-Verbeke, J., 1997, Straight line regression and calibration. In Handbook of chemometrics and qualimetrics, Part A, pp 171–231, Amsterdam, The Netherlands: Elsevier.
18. Milligan, G.W., 1980, An Examination of the Effect of Six Types of Error Pertubation on Fifteen Clustering Algorithms. Psychometrika, 45, 325-342.
19. Murphy, J.P., Cox, T.S., Rodgers, D.M., 1986, Cluster analysis of red winter wheat cultivars based upon coefficients of parentage. Crop Science, 26, 672-676.
20. Otto, M., 1999, Chemometrics statistics and computer application in analytical chemistry. Weinheim, Germany: Wiley-VCH.
21. Ozdamar, K., 1999, Statistical Data Analysis with Computer Programs, Vol: I-II, Kaan Press, 2nd Edition, Eskisehir, pp: 548.
22. Potgieter,A.B., Hammer, G.L.,Butler, D., 2002, Spatial and temporal patterns in Australian wheat yield and their relationship with ENSO *Australian Journal of Agricultural Research* 53(1) 77–89.
23. Press, S.J. and Wilson, S., 1978, Choosing Between Logistic Regression and Discriminate Analysis. Journal of the American Statistical Association, 73, 699-705.

© 2013 Global Journals Inc. (US)

24. Shacham, M., Brauner, N., Shore, H., 2007, A new procedure to identify linear and quadratic regression models based on signal-to-noise-ratio indicators. Mathematical and Computer Modelling, 46, 235–250.
25. Slavkovic, L., Skrbic, B., Miljevic, N., Onjia, A., 2004, Principal component analysis of trace elements in industrial soils. Environmental Chemistry Letters, 2, 105–108. Martin, J.M., Talbert, L.E., Lining, S.P., Blake, N.K., 1995, Hybrid performance in wheat as related to parental diversity. Crop Science, 35, 104-108.
26. Uysal N. H. Baydar ve S. Erbaş, 2006. Isparta populasyonundan geliştirilen aspir (*Carthamus tinctorius* L.) hatlarının tarımsal ve teknolojik özelliklerinin belirlenmesi. Süleyman Demirel Üniversitesi Ziraat Fakültesi Dergisi, 1(1): 52-63.
27. Vollmann, J. and Raj can,I., 2009. Oil Crops. In. Vollmann, J. and Raj can, I. (Ed.), Oil Crop Breeding and Genetics. Chapter 1,Volume 4 pp: 1-30, ISBN 978-0-387-77593-7 e-ISBN 978-0-387-77594-4 DOI 10.1007/978-0- 387-77594-4 Springer Dordrecht Heidelberg London New York.
28. Yılmazlar, B., 2008. Konya Şartlarında Farklı Ekim Zamanlarının Bazı Aspir Çeşitlerinde Önemli Tarımsal Karakterler Üzerine ve Verime Etkisi. Ankara Üniversitesi Fen Bilimleri Enstitüsü. Doktora Tezi.
29. Zadeh, K. N., Naseri, R., Mirzaei and Soleymanifard, A., 2012. Effect of Planting Pattern on Yield, Its Components, Oil Contain and Some İmportant Agronomic Traits of Safflower (*Carthamus tinctorius* L.) in Dry Land Conditions. International Journal of Agriculture and Crop Sciences (IJACS/4-2), pp: 86-91.

Table 1 : Means of data from oil yield per plant and yield components during on safflower (*Carthamus tinctures* L.) in crop growing periods of 2010 and 2011 years

	Pl.He.	Br.Num.	Cp.Num.	Cp. Yld.	Th.Ke.W.	Yi.per Pl.	Hull Co.	Oil Co.	Oil Yld.
Yenice	100,75	5,85	11,70	0,68	35,92	7,95	56,82	25,00	1,98
Remzibey	78,40	6,60	12,90	0,80	37,95	10,30	51,52	29,20	3,01
Dinçer	84,90	5,45	9,60	0,92	41,46	8,50	54,05	28,85	2,46
Shifa	103,10	5,20	7,45	1,59	44,98	11,50	47,00	30,45	3,50
Taek	80,00	6,55	12,85	0,80	38,45	10,25	49,54	28,85	2,96
Mean	89,43± 11,69	5,93± 1,44	10,90± 2,78	0,95± 0,36	39,75± 3,54	9,70± 1,63	51,78± 3,66	28,47± 2,01	2,77± 0,61

Pl. He : plant height, Br. Num.: number of branch per plant, Cp. Num.: number of capitalism per plant, Cp. Old.: seed yield per capitalism, Th. Key. W.: thousand kernel weight, Yi. per Pl.: seed yield per plant, Hull Co.: hull content, Oil Co.: oil content and Oil Old.: oil yield.

Table 2 : Minimum, maximum, mean and standard deviation of all characters in safflover (*Carthamus tinctorius* L.) cultivars

Traits	Minimum	Maximum	Mean
Plant Height	76,73	109,10	89,43±11,09
Branch Number	4,10	8,10	5,93±1,37
Capitulum Number	6,10	14,30	10,90±2,63
Capitulum Yield	0,65	1,79	0,96±0,35
Thousand Kernel Weight	35,12	46,85	39,70±3,35
Yield per Plant	7,30	12,10	9,70±1,55
Hull Content	46,80	57,01	51,78±3,48
Oil Content	0,00	30,80	28,43±2,01

© 2013 Global Journals Inc. (US)

Table 3 : Correlation matrix and path analysis for characters in safflower (*Carthamus tinctures* L.) cultivars

Traits	Oil yield per plant	Plant Height	Branch Number	Capitulum Number	Capitulum Yield	Thou. Ker.We.	Yieldper Plant	Hull content
Plant Height	0,055							
BranchNumber	0,343	-0,031						
Capit.Num.	-0,024	-0,317	0,827**					
Capit. Yield	0,705*	0,367	-0,448	-0,811**				
Thsnd. Ke.We.	0,778**	0,218	-0,387	-0,760**	0,921**			
Yield per Plant	0,976**	0,141	0,488	0,115	0,456	0,440		
Hull Content	-0,905**	0,020	0,001	0,273	-0,703*	-0,679	-0,837**	
Oil Content	0,005	0,245	-0,491	-0,422	0,307	0,415	-0,066	-0,217

Capitulum Yield	Path Coefficient	%	Correlation Coefficient
Direct Effect	-0.1186	8.0866	
Indirect Effect	Path Coefficient	%	
Plant Height	0.1909	13.0184	
Branch Number	-0.0053	0.3605	0,705*
Capit. Number	-0.2669	18.1973	
Thsnd. Ke.We.	-0.2106	14.3573	
Yield per Plant	0.0288	1.9619	
Hull Content	-0.0539	3.6745	
Oil Content	0.5917	40.3435	

Thsnd. Ke.We.	Path Coefficient	%	Correlation Coefficient
Direct Effect	-0.2983	14.2114	
Indirect Effect	Path Coefficient	%	
Plant Height	0.1797	8.5610	
Branch Number	-0.0052	0.2480	0,778**
Capit. Number	-0.3209	15.2856	
Capitulum Yield	-0.0837	3.9884	
Yield per Plant	0.0457	2.1771	
Hull Content	-0.0797	3.7944	
Oil Content	1.0860	51.7340	

Hull Content	Path Coefficient	%	Correlation Coefficient
Direct Effect	0.1151	8.7204	
Indirect Effect	Path Coefficient	%	
Plant Height	0.0716	5.4250	
Branch Number	0.0051	0.3875	0,976**
Capit. Number	0.0792	6.0033	
Capitulum Yield	-0.0297	2.2466	
Thsnd. Ke.We.	-0.1185	8.9744	
Yield per Plant	-0.1019	7.7199	
Oil Content	0.7989	60.5228	

© 2013 Global Journals Inc. (US)

Yield per Plant			Correlation Coefficient
Direct Effect	Path Coefficient	%	
	0.1194	6.9851	-0,905**
Indirect Effect			
	Path Coefficient	%	
Plant Height	0.0194	1.1349	
Branch Number	0.0004	0.0248	
Capit. Number	0.0970	5.6736	
Capitulum Yield	0.0535	3.1332	
Thsnd. Ke.We.	0.1991	11.6473	
Hull Content	-0.0982	5.7486	
Oil Content	-1.1220	65.6524	

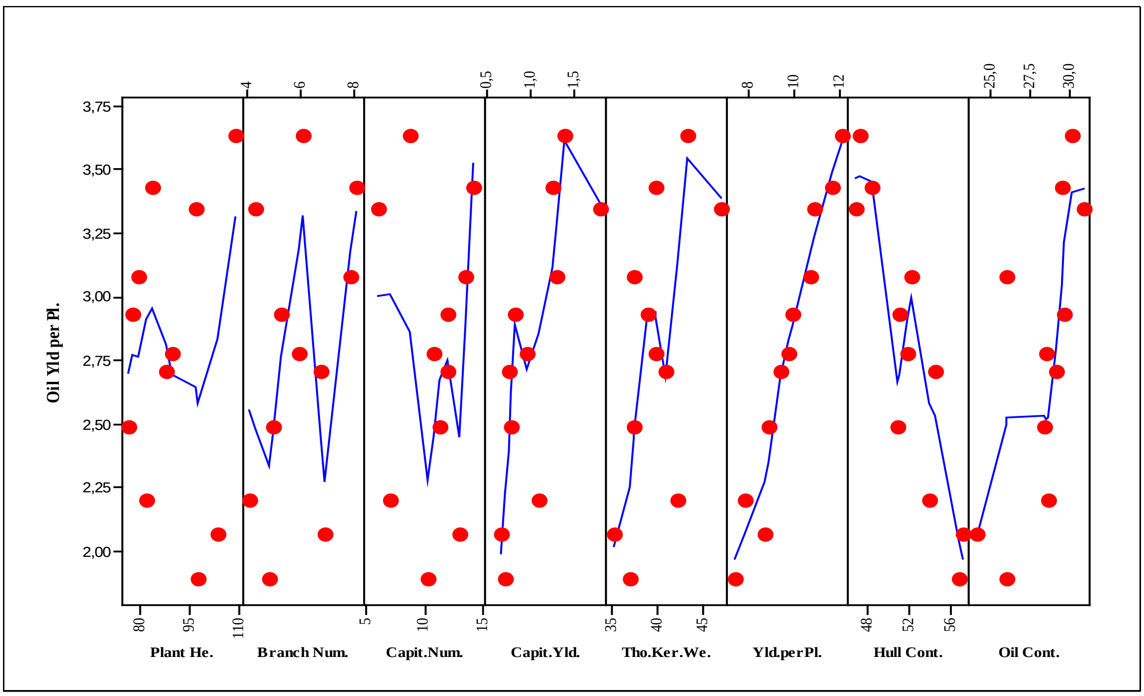

Figure 1 : Relationship between oil yield per plant and yield components in safflower (Carthamus tinctures L.)

Table 4 : The regression coefficient (*b*), standard error (SE), *T*-value and probability of the characters in estimation of oil yield per plant in safflower (*Carthamus tinctures* L.)

Source	Deg. of Freedom	M.S.	F_{auve}		
Regression	8	0.414	80.97**		
$Error_{Resudial}$	2	0.005			
Total	10				
R^2: 95,8%					
Traits	D.F.	Coef. of Regr.(B)	Std. Error (S_E)	T	P value
Plant Height	1	-0.0061	0.0036	-1.69	0.233ns
Branch Number	1	0.0054	0.0877	0.06	0.956ns
Capitulum Number	1	-0.0047	0.0633	-0.75	0.529ns
Capitulum Yield	1	0.1670	0.1673	2.57	0.042*

© 2013 Global Journals Inc. (US)

Thsnd Kernel Weight	1	-0.0182	0.0480	-0.38	0.740ns
Yield per Plant	1	0.3999	0.0874	4.57	0.017*
Hull Content	1	0.0309	0.0350	0.88	0.470ns
Oil Content	1	0.059	0.0472	1.27	0.333ns

Oil yield per Plant ($\hat{Y}$) = - 2.71 - 0.00615 Plant Height + 0.0055 Branch Number - 0.0478 Capitalism Number + 0.068 Capitalism Yield - 0.0183 Thousand Kernel Weight + 0.400 Yield per Plant + 0.0309 Hull Content + 0.0598 Oil Content

* And **: r is significant at 5% and 1%, ns: not significant

Table 5 : Coefficient of determination (R^2 and Adjusted R^2), measure of goodness of prediction (Mallows') and estimating the best characters by the best subsets regression analysis in safflower (*Carthamus tinctures* L.)

Vars	R^2	Mallows Cp	Plant Height	Branch Number	Capit. Number	Capit. Yield	Thousand Ker. We.	Yield per Plant	Hull Content	Oil Content
1	95,2	24,1						X		
1	82,0	110,1							X	X
2	99,1	1,1					X	X		
2	97,9	8,5						X		
3	99,2	2,0					X	X		
3	99,2	2,0	X			X		X		X
4	99,5	2,0	X		X			X		X
4	99,5	2,3	X				X	X		X
5	**99,7**	**3,2**	**X**			**X**	**X**	**X**	**X**	**X**
5	99,6	99,1	X	X	X	X	X	X		X
6	99,7	99,2	X		X	X	X	X	X	X
6	99,7	99,2	X	X	X	X		X	X	X
7	99,7	99,0	X		X	X	X	X	X	X
7	99,7	98,9	X	X	X	X	X	X	X	X
8	99,7	98,5		X	X	X	X	X	X	X

Table 6 : Eigen value of the correlation matrix for the characters in safflower (Carthamus tinctures L.) by the principal component analysis

	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6	PC_7	PC_8	PC_9
Plant He.	0,033	0,323	**0,908**	-0,067	-0,060	-0,375	-0,061	-0,009	-0,082
Branch Num.	-0,036	-0,407	0,162	0,374	-0,302	0,244	-0,397	-0,394	0,006
Capit.Num.	-0,197	-0,358	-0,133	-0,092	-0,188	-0,453	0,002	0,595	-0,168
Capit.Yield	**0,411**	-0,010	-0,153	0,647	0,332	-0,518	0,044	-0,090	0,025
Thd. Ke.We.	**0,391**	0,269	0,086	0,353	-0,379	0,358	-0,149	0,582	-0,098
Yld per Pl.	0,358	**0,463**	0,191	-0,149	0,142	0,169	0,294	0,173	0,718
Hull Cont.	-0,354	0,096	0,060	0,417	-0,392	-0,014	0,669	-0,067	0,156
Oil Content	**0,403**	0,116	-0,234	-0,301	-0,664	-0,357	-0,010	-0,297	0,149
Eigenbalue	4,8404	2,4400	1,1437	0,2619	0,1889	0,0928	0,0232	0,0078	0,0013
Proportion	0,538	0,271	0,127	0,029	0,021	0,010	0,003	0,001	0,000
Cumulative	0,538	0,809	0,936	0,965	0,986	0,996	0,999	1,000	1,00

© 2013 Global Journals Inc. (US)

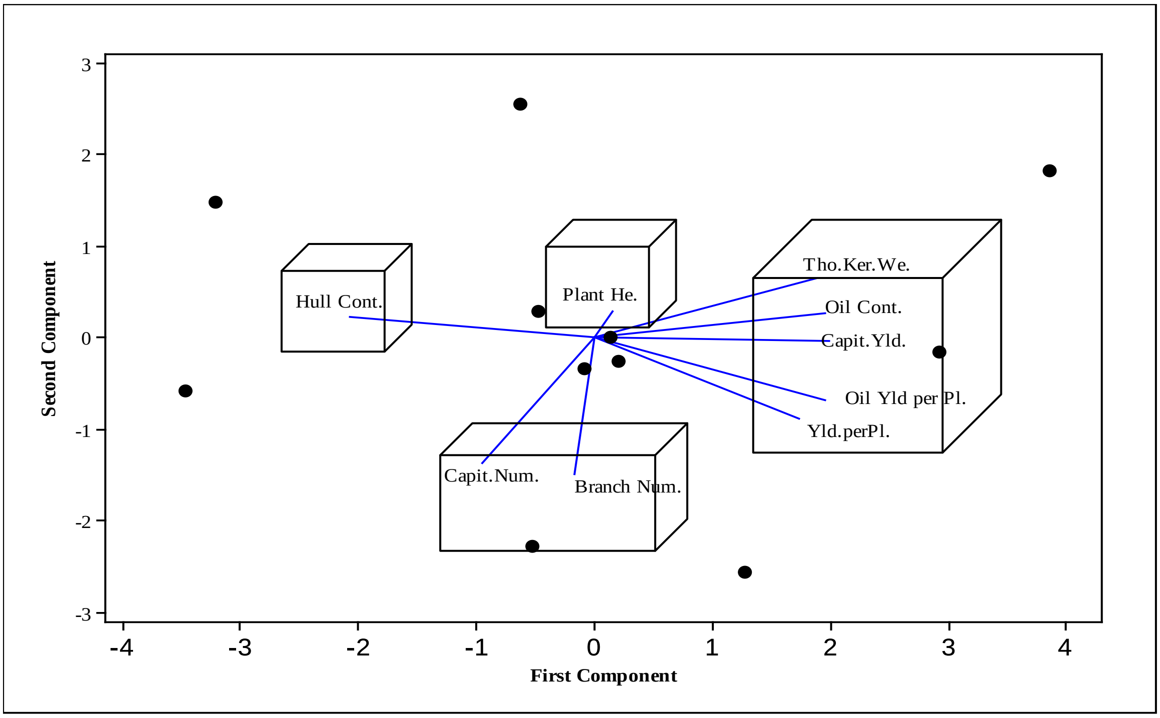

Figure 2 : Biplot analyses of safflower (*Carthamus tinctures* L.)

Table 7 : Relationships of characters in safflower (*Carthamus tinctures* L.) by the factor analysis

Characters	Factor I	Factor II	Factor III	Communality
Plant Height	0,024	0,106	0,993	0,58
Branch Number	0,205	0,301	0,060	0,65
Capitulum Number	-0,094	-0,239	-0,220	0,87
Capitulum Yield	0,726	0,217	0,456	0,77
Thousand Kernel Weight	0,543	0,569	0,158	0,79
Yield per Plant	0,935	0,287	0,651	0,88
Hull Content	-0,253	-0,199	0,056	0,62
Oil Content	0,674	0,389	-0,156	0,74
Latent Root	2,760	1,431	1,998	6,789
Factor Variance (%)	45,00	27,30	12,60	84,90

Characters	Loading	% Total Community	Suggested Factor
Factor I		45,00	Yield per Plant
Branch Number	0,205		
Capitulum Yield	0,726		
Thousand Kernel Weight	0,543		
Yield per Plant	0,935		
Hull Content	0,246		
Factor II		27,30	Thousand Kernel Weight
Branch Number	0,301		
Thousand Kernel Weight	0,569		
Yield per Plant	0,287		
Oil Content	0,389		
Factor III		12,60	Plant Height
Plant Height	0,993		
Yield per Plant	0,651		

© 2013 Global Journals Inc. (US)

Table 8 : Similarity and distance level of characters

Step	Clusters (No.)	Similarity Level	Distance Level
1	8	98,788	0,024
2	7	91,325	0,173
3	6	91,082	0,178
4	5	88,728	0,225
5	**4**	**88,336**	**0,701**
6	3	74,420	0,712
7	2	63,661	0,727
8	1	60,894	0,782

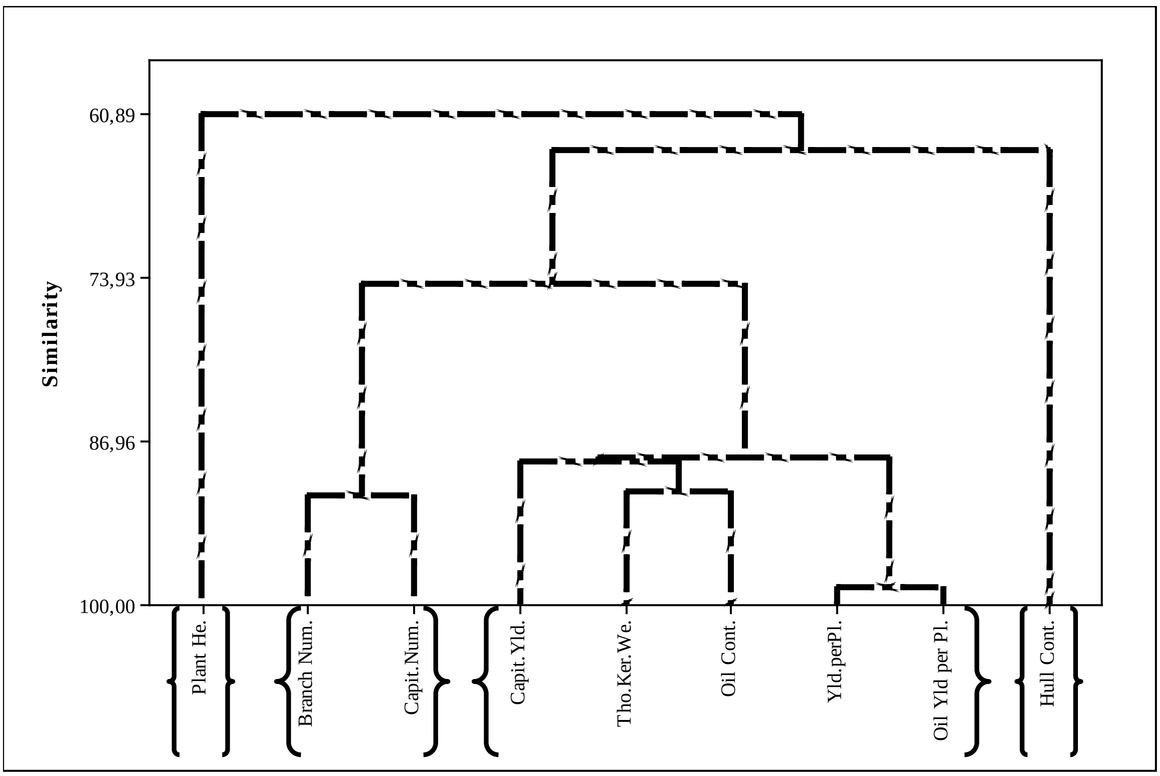

Figure 3 : Similarity levels of the variables

Table 9 : Essential variables effective on grain yield in safflover (*Carthamus tinctorius* L.)

	1	2	3	4	5	6
Plant Height			☺		☺	
Branch Number						
Capitulum Number	☺					
Capitulum Yield	☺	☺		☺	☺	☺
Thsnd Kernel Weight	☺		☺	☺	☺	☺
Yield per Plant	☺	☺	☺	☺	☺	☺
Hull Content	☺				☺	
Oil Content				☺	☺	☺

1: Correlation and path analysis, 2: multiple linear regression, 3: Factor Analysis, 4: Principal component analysis 5. Best subsets regression, 6: Cluster analysis.

© 2013 Global Journals Inc. (US)