Page 645 to 650

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Realized Heritability and Genetic Characterization in *Camelina sativa* (L.) Crantz.

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Abstract

Camelina sativa (L.) Crantz is a drought and cold tolerant crop and has high amount of α-linolenic acid. But its full potential has not been explored yet because of little breeding work done for its genetic improvement. In present study, a moderate realized heritability (39%) was obtained for yield indicating that direct selection for yield could be effective for making improvement. Seed yield was also found to be positively correlated with plant height, leaf area and oil contents. Hence selection on the basis of these morphological traits would also be valuable for improvement of *camelina* lines. A successful breeding program depends on the presence of genetic variability within population. So to judge variation between the available lines CV and Principal Component Analysis (PCA) were used. Maximum coefficient of variation (CV) was exhibited by number of capsules followed by numbers of inflorescence, secondary branches and leaf area. This showed the existence of sufficient variation for these traits among camelina lines. First three PCs of Principal Component Analysis exhibited more than one eigenvalue and they contributed 63.5% variability which was given importance for further explanation. The PC1, PC2 and PC3 showed 35.5%, 14.4% and 13.5% variability respectively among traits under study.

Keywords: *Correlation; False flax; PC analysis; Response to selection; Selection differential*

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Introduction

Camelina sativa (L) Crantz is a brassicaceae family plant commonly known as false flax, gold of pleasure and leindotter. It is a fall or spring planted oilseed crop. This crop has been cultivated since Bronze Age in Europe. Camelina seeds were also recovered from the stomach of a Tollund man in Denmark (Pilgeram., *et al.* 2007). Camelina oil was used as lamp oil, massage oil, cooking oil and as meal for food or feed by Romans. Camelina like Brassicaceae plants germinates in early spring before cereal grains. This is very useful for effective spring moisture utilization and competitiveness with weeds. It was cultivated in Europe and Russia till World War II. Its production is low due to less attention given to it. Currently camelinais attracting the world attention due to its high value edible oil and for biodiesel production. The oil percentage in camelina seed is about 30-40%. It also contains Omega-3 fatty acid and gamma tocopherol. Gamma-tocopherol is anti-oxidant due to which its shelf life is long (Pilgeram., *et al*. 2007, Zhang., *et al*. 2017). Protein and fibre contents in camelina seeds are important with respect to nutritional value of oil cakes. The crude protein and fibre contents in camelina seeds are 25-45% and 10% respectively (Plessers., *et al*. 1961; Marquard and Kuhlmann, 1986). Seed meal is a good source of protein for animals, but Brassica oilseeds have high amount of glucosinolate which limits its use (Schuster and Friedt, 1998). *Camelina* seeds have low amount of glucosinolates as compared to other crucifers (Schuster and Friedt, 1998). All these things make it suitable for the edible purposes and beneficial for human health.

Camelina stalks can be used to produce fibre pulp, paper and boards (Zubr, 1997). *Camelina* is such a plant which needs little irrigations and inputs so it can tolerate desert conditions. It can give financial assistance to desert people but being low yielder, it is not economical crop. Keeping all these facts in view, there is dire need of breeding intervention to enhance its yield for possible adoption. Present study was planned to determine correlation between morphological characters contributing to seed which will help in the selection of plants with better combination of morphological traits contributing towards seed yield and to compute realized heritability to estimate the genetic gain in the progeny of the selected plants.

Material and Methods

A total no. of 3000 camelina M_5 progenies introduced from University of California, United States of America were sown at the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad (UAF). Out of these 3000 progeniesa total number of 225 high yielding plants were selected at maturity. The seeds of parental population and selected plants were weighed and were kept separately. Next year, seeds of 225 plants selected from individual lines were sown in field. At maturity, seeds were harvested and weighed. The selection differential, response to selection and realized heritability were calculated as follows:

Selection Differential = Parent population mean – Selected plants mean
Response to selection = Parent population mean – Selected plants second generation mean
Realized heritability = (h2) = Response to selection/Selection differential
(Falconer and Mackay, 1996).

Thereafter, a set of randomly selected 50 camelina M6 lines were sown in the field till maturity and the data were recorded on different morphological traits like plant height, number of primary and secondary branches, leaf area, 1000 seed weight, oil contents and seed yield from randomly selected plants. The oil percentage of different lines was measured by using Soxhlet extraction method.

Correlation analysis was performed to determine the association of different traits with seed yield (Dewey and Lu, 1959). PCA (Principal Component Analysis) technique was also applied to observe variation among the desired characters (Broschat, 1979).

Result and Discussion

In present study realized heritability of seed yield was found to be 39%, selection differential was 0.834g and response to selection was 0.332g as indicated in Table 1.

This moderate estimated value of realized heritability indicated that 39% of the total phenotypic variation for seed yield could be attributed to heritable additive genetic effects. The existence of additive genetic variability implies that selection of camelina lines on the basis of seed yield would be very effective. If a character has high narrow sense heritability it means the influence of genes is more as compared to environment (Kopsell and Randle, 2001, Lstiburek., *et al*. 2018). So selection based on such a character will be beneficial. While low narrow sense heritability means that character is more affected by the environment and selection will be ineffective or less important for that character. Realized heritability is also a type of narrow sense heritability. High realized heritability of a character indicates that genetic effect is dominating over environmental effect (Falconer and Mackay, 1996, Saeed and Khalil, 2017).

The results of response to selection (Table-1) indicated that by making selection in Camelina sativa population the mean yield of the offspring of the selected parents would be expected to increase 0.834 g over the mean phenotype of offspring produced in the absence of selection. High yield is associated with high oil contents but the magnitude is very low. A good association between these traits is very important for biodiesel production. Currently biodiesel production is low and prices are high. Due to which its use is limited. The increase in camelina oil production would also boost up biodiesel production and keep its prices lower or equal to mineral oil. This would also provide an option to the diesel consumers whether to use mineral diesel or biodiesel. The use of biodiesel is economical and it also decreases pollution level.Similar results were shown by (Ahmad., *et al*. 2017, Mirza., *et al*. 2011; Kant., *et al*. 2005; Martin., *et al.* 2010; White., *et al*. 1994) indicating moderate to high heritability estimates for seed yield.

Parent Population Mean (a)	Selected Plants Mean (b)	Selected Plants Second Generation Mean (c)	Selection Differential S = (a-b)	Response to Selection R = (a-c)	Realized Heritability h^2_R = R/S
8.957	8.123	8.625	0.834 g	0.332 g	0.398

Table 1: *Realized heritability calculations.*

Estimates of means, SD, range and CVs are presented in Table 2. Maximum CV was exhibited by number of capsules followed by numbers of inflorescence, secondary branches and leaf area. This showed the existence of sufficient variation for these traits among camelina lines.

Variable	Mean	SD	CV	Range
Plant height	65.37	7.43	11.37	30.00
Inflorescence no.	54.98	27.99	50.91	161.00
Capsule no.	1305	849	65.04	5290
Primary Branches	12.470	4.348	34.86	22.000
Secondary branches	29.71	13.50	45.45	57.50
Leaf area	2.368	1.043	44.05	5.170
1000 seed weight	0.9133	0.1155	12.64	0.5360
Oil contents	37.295	1.494	4.01	7.440
Seed yield	9.900	2.028	20.48	8.000

Table 2: *Mean, SD, Range and Coefficient of Variation of different morphological traits of Camelina.*

Correlation studies are very important for cultivar development in plant breeding (Chaudhary and Sharma, 2003; Laiding., *et al*. 2017; Tadesse., *et al*. 2009). Positive and significant correlations (Table 3) were exhibited by plant height in combination with no. of inflorescences, no. of capsules and no. of secondary branches; inflorescence no. in combination with no. of capsules, no. of primary branches and no. of secondary branches; capsule no. in combination with no. of primary branches and no. of secondary branches and no. of primary branches in combination with no. of secondary branches. The results indicated that taller plants have more no. of inflorescence, no. of capsules, no. of primary branches and no. of secondary branches. Hence, the selection of taller plants would be effective for the improvement of different traits. However, seed yield had positive association with plant height, leaf area and oil contents while negative association with numbers of inflorescence, no. of capsules, no. of primary branches, no. of secondary branches and 1000 seed weight. These findings further implied that selection of taller plants with broad leaves also might be beneficial for increasing seed yield.

The presence of variability is important for crop improvement and the extent of variability for a specific trait determines the scope of genetic improvement for that trait (Sharma., *et al.* 2003). The variation among the lines was studied by the application of Principal Component Analysis (PCA). In this study, first three PCs exhibited more than one eigenvalue and they contributed 63.5% variability and were given importance for further explanation (Table 4). The PC1, PC2 and PC3showed 35.5%, 14.4% and 13.5% variability among traits under study.

	Plant height (cm)	Inflorescence no.	Capsule no.	Number of primary branches	Number of secondary branches	Leaf area	1000 seed weight (g)	Oil contents %
Inflorescence no.	0.313*							
Capsule no.	0.362*	0.922**						
Number of primary branches	0.048	0.480**	0.442**					
Number of secondary branches	0.335*	0.773**	0.748**	0.547**				
Leaf area (cm^2)	0.023	-0.191	-0.115	-0.124	-0.204			
1000 seed weight (g)	0.048	-0.100	-0.162	0.064	0.014	-0.061		
Oil contents %	-0.146	0.012	-0.059	-0.094	-0.007	-0.150	-0.142	
Seed yield (g)	0.064	-0.128	-0.026	-0.219	-0.029	0.021	-0.127	0.072

Table 3: *Correlation coefficients among morphological characters in camelina.*

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Eigenvalues	3.1949	1.2999	1.2191	0.9954	0.7663	0.7213	0.4966	0.2418	0.0647
Proportion	0.355	0.144	0.135	0.111	0.085	0.080	0.055	0.027	0.007
Cumulative	0.355	0.499	0.635	0.745	0.831	0.911	0.966	0.993	1.000

	Eigenvectors								
Variables	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Plant height	**0.241**	0.037	**-0.528**	**-0.368**	**-0.502**	**-0.208**	**-0.473**	0.076	-0.028
Inflorescence number	**0.522**	-0.085	0.017	0.070	-0.068	-0.003	**0.346**	**0.276**	**-0.717**
Capsule number	**0.513**	**-0.123**	**-0.118**	0.087	-0.000	-0.014	**0.336**	**0.340**	**0.687**
Primary branches	**0.362**	**0.253**	**0.249**	**0.204**	**0.329**	**0.288**	**-0.669**	**0.250**	0.001
Secondary branches	**0.499**	-0.023	0.017	-0.089	0.057	**0.172**	0.029	**-0.841**	0.042
Leaf area	-0.134	**0.130**	**-0.539**	**0.545**	**-0.199**	**0.573**	0.073	-0.048	-0.039
1000 seed weight	-0.033	**0.594**	**0.116**	**-0.571**	-0.099	**0.455**	**0.269**	**0.125**	0.039
Oil content	-0.035	**-0.541**	**0.447**	-0.070	**-0.533**	**0.441**	**-0.127**	0.063	0.054
Seed yield	-0.073	**-0.499**	**-0.375**	**-0.417**	**0.546**	**0.338**	-0.040	**0.109**	-0.074

The bold values are greater than the arithmetic mean of the highest and lowest absolute values of eigenvectors within the column.

Table 4: *Percentage of explained and cumulative variances and eigenvectors on the first nine principal components for morphological characters in 50 camelina lines.*

Among different plant traits, association was displayed by plant height with PC1 and PC3 to PC7. Number of inflorescences is associated with PC1 and PC7 to PC9. Numbers of capsules are associated with PC1 to PC3 and PC7 to PC9. Number of primary branches is associated with PC1 to PC8. Number of secondary branches is associated with PC1, PC6 and PC8. Leaf area is associated with PC2 to

PC6. 1000 seed weight is associated with PC2 to PC4 and PC6 to PC8. Oil contents are associated with PC2 to PC3 and PC5 to PC7. Seed yield is associated with PC2 to PC6 and PC8 (Table 2).

A high degree of variation 100 % was observed for nine PC axes. However, higher coefficients for a certain trait depict association of that trait to respective PC axes (Sneath and Sokal, 1973). Characters with high coefficients in PC1 to PC3 are more important because these axes had 63.5% total variation. Similar results were shown by Gana., *et al*. (2013) in rice. The PC analysis indicated that all morphological characters studied had maximum variation. These characters are more important for the study of variation among the camelina population.

Conclusions

Camelina sativa (L.) Crantz has moderate realized heritability indicating that selection on the basis of seed yield is effective for generation of high yielding varieties.

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