Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.4, No.3, 2014

Genetics And Interrelationship of Yield and Yield Related Attributes in Some Genotypes of Safflower (Carthamus Tinctorius L.) Under Rainfed Conditions

Muhammad Tariq[1], Muammad Azeem Tariq[1], Muhammad Kausar Nawaz Shah[2], Muhammad Ijaz[1], Muhammad Fida Hassan[1], Muhammad Aftab[1], Nasrullah Khan Aadal and Tamoor Hussain[1*]
[1]Barani Agricultural Research Institute, Chakwal, Pakistan
[2]PMAS, University of Arid Agriculture Rawalpindi, Pakistan
* E-mail of the corresponding author: saleemkhansaleem90@gmail.com

Abstract

In order to estimate variability, heritability, genetic advance and relationship of grain yield with other yield related attributes, the experiments were carried out in field research Area of Barani Agricultural Research Institute, Chakwal, Pakistan during two rabi growing seasons 2011-12 and 2012-13. The experimental materials were comprised of 40 genotypes of safflower and were sown in randomized complete block design with three replications each year. The analysis of variance showed that all the safflower genotypes were significantly different for all the traits studied except days to physiological maturity. Among the attributes studied the estimates of phenotypic coefficient of variation (PCV) were generally higher than the genetic coefficient of variation (GCV). Highest GCV was found in grain filing rate plant^{-1} (49.34 & 48.25) followed by seed yield plant^{-1} (49.09 & 48.18) during 2011-12 & 2012-13 respectively. Grain filing rate plant^{-1} showed maximum PCV (49.78 & 48.96) followed by seed yield plant^{-1} (49.64 & 49.44) during both years (2011-12 & 2012-13) respectively. The high heritability coupled with high genetic advance was measured in biological yield plant^{-1}, harvest index (%), number of heads plant^{-1}, and seed yield plant^{-1}. These results revealed that high estimates of heritability and genetic advance for these traits would be helpful for the plant breeders to select the suitable combination and to achieve the enviable level of seed yield potential in safflower under arid environment conditions. The correlation results of two year studies revealed that seed yield plant^{-1} had significant and positive relationship with days to maturity, plant height, biological yield plant^{-1}, number of seeds head^{-1}, 1000-grain weight, grain filing rate plant^{-1}, effective head weight, number of primary branches plant^{-1} and plant height. On the other hand, days to 50% flowering, days to physiological maturity, number of seeds head^{-1}, seed weight head^{-1} and 1000- grain weight showed low heritability with low genetic advance.

Key words: Safflower, Rainfed, Variability, Heritability, Genetic Advance, Correlation

Introduction

Safflower is one of the most important annual oilseed crop which have a high adaptation to various soil conditions such as salinity, drought and viable to be grown in rainfed and irrigated areas Safavi *et al*. (2012). It is a multipurpose crop for oil, medicinal and industrial uses Ahmadzedeh *et al*. (2012). In Pakistan, the production of safflower is low as compared to other oilseed crops due to lack of resources and non-availability of high yielding cultivars. The development of new varieties is based principally on the collection, identification, assembly, multiplication, assessment and conservation of genetic materials, which are used for the breeding of desirable characters of safflower. The final objective of most of breeding program is to raise the seed yield. Golkar (2011).

Appearance of several traits often changes as the changing breeding material and environment. Consequently, the information of characters association between the traits themselves and with seed yield is important for the breeding program subject to selection for high yielding genotypes Iqbal *et al*. (2006), Omidi Tabrizi (2002). As certain trait are more affected from genotypic and environmental difference. Each breeder is tackled with various environments in which his or her breeding program is to attain results Arsalan (2007). Hence, an assessment of heritability should be determined for the optimum breeding program Camas and Esendal (2006). Kuvani *et al*.(2001) and Camas and Esendal (2006) found heritability for plant height, number of primary branches per plant, head diameter, seed per head and 1000-grain weight in safflower as 93, 45, 21, 69 and 81% respectively. Manju and Sreelathkumary (2002) reported that h^2 (broad sense heritability) value for plant height, Primary branches per Plant, 1000 grain weight and yield in safflower as 87, 39, 93 and 98% respectively. Arsalan (2007) computed broad sense heritability for yield and yield related attributes in safflower and found that plant height, primary branches per plant, heads per plant. Head diameter, seeds per head, 1000 grain weight and seed yield have high heritability (h^2).

Cassato *et al*. (1997) observed positive and significant correlation between seed yield and number of heads per plant in safflower. Omidi Tabrizi et al. (2002) studied that grain yield had positive and significant association with grain weight and number of heads per plant in safflower. Plant height, number of primary branches per plant, number of heads per plant, number of seed per head, seed weight per head and 1000 grain weight are the most imperative characters in safflower for improvement of grain yield Omidi Tabrizi (2005); Rao and Ramachandram (1997) examined positive and significant relationship of grain yield with heads per plant and 1000 grain weight, also emphasized to the vital role of the number of heads plant^{-1} and head weight in enhancement of yield in safflower.

The present study was carried out for the assessment of heritability in broad sense (h^2), genetic advance and interrelationship between grain yield and other related attributes and thereby to identify suitable plant attributes for selection to improve the grain yield of safflower under rainfed conditions.

Materials and Methods

In order to assess the relationship of grain yield with other yield related attributes, the field experiments were carried out in the research Area of Barani Agricultural Research Institute, Chakwal, Pakistan during two rabi growing seasons 2011-12 and 2012-13. The prevailing weather conditions during two rabi season are summarized in Table-1. The experimental materials were comprised of 40 genotypes of safflower and were sown in randomized complete block design with three replications and a plot size of 5×1.2m. Seeds were sown at 30 cm spacing between the rows on 10thand3rdOctober each year respectively. Plant to plant distance was kept 10cm within rows by performing the thinning process after four weeks of sowing. As per requirement of crop, cultural practices such as weeding, hoeing, pest and insect control were carried out during whole growing seasons. The data on following traits were recorded: days to 50% flowering (DFF), days to physiological maturity (DM), plant height in cm (PH), number of primary branches plant^{-1} (PBP), stem diameter in cm (SD), number of heads plant^{-1}(HP), head diameter in cm (HD), effective head weight in gram (EHW), number of seeds head^{-1}(SH), seed weight head^{-1} in gram (SWH), grain filling duration in days (GFD), grain filling rate plant^{-1}in gday^{-1} (GFRP), 1000 grain weight in gram (TGW), harvest index in percentage (HI), biological yield plant^{-1} in gram (BYP), and seed yield plant^{-1} in gram (SYP). Grain filling duration was computed as days from flowering to physiological maturity. Grain filling rate (g/day) determined by dividing the seed yield to grain filling duration. Harvest index (%) was also calculated by dividing the seed yield to biological yield.

Analysis of variance (ANOVA) and correlation coefficient for characters studied was performed by using Statistix software version 8.1.The heritability and genetic advance were measured by following Singh and Chaudhry (1979).

Heritability in Broad sense (h^2) = GV/PV

Where, GV is genotypic variance and PV is phenotypic variance.

Genotypic, phenotypic and environmental coefficients of variation were calculated by using formula as under;

Genotypic Coefficient of Variation (GCV) = $\sqrt{GV}/Mean\ of\ X \times 100$

Phenotypic Coefficient of Variation (PCV) = $\sqrt{PV}$/Mean of $X \times 100$

Environmental Coefficient of Variation (ECV) = $\sqrt{EV}/Mean\ of\ X \times 100$

Where X is the grand mean of the particular attribute

Genetic advance was calculated by formula following Singh and Chaudhary (1979).

Genetic Advance (G.A) = K. $h^2.\sqrt{PV}$

Where K is Constant = 2.06 at 5% selection intensity. Genetic advance expressed as percentage of mean by using formula;

Genetic Advance (GA %) = GA/ $Mean\ of\ X \times 100$

Results and Discussions

The results of analysis of variance (ANOVA) separately for each year are presented in Table-2.The analysis of variance showed that all the safflower genotypes were significantly different for all the traits studied except days to physiological maturity. This investigation revealed that high genetic variability is present among the genotypes under rainfed conditions. Though, we emphasized on traits that have significant relationship with grain yield in the rainfed conditions. Significant variation in all investigated attributes are more important source for selection among genotypes and helpful for the other breeding programmes. Individually, all the traits studied have particular role in the rainfed conditions. Number of heads per plant, number of seeds per head, seed weight per head, effective head weight and 1000 grain weight are the most prominent yield associated traits and would be more effective to upturn the grain yield in safflower Alizadeh (2005). Phenotypic coefficient of variation (PCV), genotypic coefficient of variation(GCV), environmental coefficient of variation (ECV), heritability in broad sense (h^2),genetic advance (GA) and genetic advance as percent of mean (GA %) for the characters studied during 2011-12 &2012-13 are summarized in Table-3. Genetic coefficient of variation (GCV) ranged

from (0.34) to (49.34) and (0.13) to (48.98) among the traits studied during 2011-12 & 2012-13 respectively whereas phenotypic coefficient of variation (PCV) ranged from (0.85) to (49.78) and (0.52) to (49.44) respectively (Table-3). Among the attributes studied during both the year, the estimates of phenotypic coefficient of variation (PCV) were generally higher than the Genetic coefficient of variation (GCV). Highest GCV was found in GFRP (49.34& 48.25) followed by Seed Yield Plant^{-1} (49.09& 48.18) during 2011-12& 2012-13 respectively. GFRP showed maximum PCV (49.78 &48.96) followed by Seed yield Plant^{-1}(49.64 & 49.44) during both years (2011-12 & 2012-13) respectively (Table-3).

The high heritability coupled with high genetic advance was measured in biological yield plant^{-1}, harvest index, heads plant^{-1}, and seed yield plant^{-1} studied during 2011-12 &2012-13 (Table-3). This result revealed that high estimates of heritability and genetic advance for these traits would be helpful for the plant breeders to select the suitable combination and to achieve the enviable level of seed yield potential under arid environment conditions. The present results are confirmatory with the findings of Akbar and Kamran (2006); Arsalan (2007) and Kuvani *et al*. (2001). Also high heritability assessments were found in effective head weight, grain filling duration, head diameter, number of primary branches palnt^{-1} and stem diameter. The high heritability estimates indicated that these traits are under additive genetic effects and careful selection will definitely lead towards improvement for greater productivity. These results support the findings of Kuvani *et al*. (2001) and Camas and Esendal (2006). On the other hand, days to 50% flowering, days to maturity, number of seeds head^{-1}, seed weight head^{-1} and 1000 grain weight showed low heritability with low genetic advance. This investigation indicates that the selections for these traits must be delayed till late generations. Akbar and Kamran (2006) also reported low heritabilities for these traits in safflower.

The results pertaining to association of first year studied (2011-12) showed that seed yield plant^{-1} had highly significant & positive relationship with days to maturity, plant height, biological yield plant^{-1}, number of seeds head^{-1}, 1000 grain weight and significant & positively correlated with grain filling rate plant^{-1}, effective head weight, number of primary branches plant^{-1} and number of heads plant^{-1} (Table-4). There was a positive and significant correlation between biological yield plant^{-1} and days to maturity, grain filling rate plant^{-1}, plant height, seed weight head^{-1} and seed yield plant^{-1}. This result revealed that indirect selection through enlightening these traits would be helpful for boost in grain yield in the safflower genotypes under rainfed conditions. Some earlier researcher Arslan (2007); El-Lattief (2012); Golkar *et al*.(2011); Golparvar (2011); Golkar, *et al*. (2012); Mozaffari and Asadi (2006) and Naserirad *et al*. (2013) also observed the similar results in safflower.

On the other hand, in second year results (2012-13) grain yield correlated highly significantly & positively with effective head weight, grain filling rate plant^{-1}, 1000 grain weight, heads plant^{-1}, number of primary branches plant^{-1}, plant height and significant & positive with biological yield Plant^{-1}, days to maturity and number of seeds heads^{-1} (Table-5). This result showed any positive improvement in these attributes in the superior genotypes would enhance the grain yield. Similar trend for these attributes were also observed by El-Lattief (2012); Eslam *et al*. (2010); Begwan and Ravikumar (2011); Golparvar, (2011) and Omidi Tabrizi (2006). However, negative correlation amongst grain yield and days to 50% flowering is justifiable in the arid conditions because the genotypes endure warmth and drought stress due to lengthier lifespan of crop. Alizadeh (2005) also showed the similar inference in his studies on safflower genotypes in dry land conditions.

Conclusion

From the consequence of current investigations, it is concluded that grain yield in safflower can be enhanced by selecting the superior genotypes having more number of primary branches plant^{-1}, plant height, number of heads plant^{-1}, effective head weight, number of heads plant^{-1} as well as number of seeds head^{-1}, 1000-seed weight and biological yield plant^{-1}.

References

Ahmadzadeh, A. R., B. Alizadeh, H. A. Shahryar and M. Narimani. 2012. Path analysis of the relationships between grain yield and some morphological characters in spring safflower (*Carthamustinctorius*) under normal irrigation and drought stress condition. J. Medi. Plants Res., 6(7): 1268-1271

Akbar, A. A. and M. Kamran. 2006. Relationship among components and selection criteria for improvement in Safflower (*Carthamus tinctorius* L.), J. Appl. Sci., 6(13): 2853-255.

Alizadeh, K.,2005. Evaluation of Safflower Germplasm by Some Agronomic Characteristics and Their Relationships on Grain Yield Production in the Cold Dry Land of Iran. Int. J. Agric. Biol.7(3): 389–391.

Arslan, B. 2007. Assessing of heritability and variance components of yield and some agronomic traits of different safflower cultivars. Asian. J. Plant. Sci, 6 (3): 554-557.

Begavan, I. and R. L. Ravikumar, 2011. Strong undesirable linkages between seed and oil yield and path analysis for grain and oil yield in spring safflower. Proceedings of the Vth International Safflower Conference, July 23-27, 2011, America, pp: 95-98.

Camas, N. and E. Esendal, (2006).Estimation of broad-sense heritability for seed yield and yield components of safflower (*Carthamus tinctorius* L.).Hereditas 143:55-57.

Cassato, E., P. Ventricelli and A. Corleto. 1997. Response of hybrid and open pollinated safflower to increasing doses of nitrogen fertility. IV International safflower conf. Italy.98-103.

El- Lattief, E. A., 2012. Evaluation of 25 Safflower Genotypes for Seed and Oil Yields Under Arid Envirnmen in Upper Eygypt. Asian J. Crop Sci., 4 (2): 72-79.

Eslam, B. P., H. Monirifar and M. T. Ghassemi, 2010. Evaluation of late season drought effects on seed and oil yield in spring safflower genotypes. Turk. J. Agric. For., 34: 373-380.

Golkar, P., A.Arzani and A.Rezaei. 2012. Genetic Analysis of Agronomic Traits in Safflower (*Carthamus tinctorious* L.) Not Bot HortiAgrobo, 40(1):276-281

Golparvar, A. R., 2011. Assessment of Relationship between Seed and Oil Yield with Agronomic Traits in Spring Safflower Cultivars under Drought Stress Condition. J. Res. Agric. Sci. 7 (2): 109-113.

Golkar, P., A. Arzani and A. M. Rezaei. 2011. Determining relationships among seed yield, yield components and morpho-phenological traits using multivariate analyses in safflower(*Carthamus tinctorious* L.) Annals Biol. Res. 2 (3):162-169

Iqbal, M., K. Hayat, R. S. A. Khan, A. Sadiq and N. Islam, 2006.Correlation and path coefficient analysis for earliness and yield traits in cotton (*G. hirsutum*).Asian. J. Plant. Sci., 5: 341-344.

Kuvani, R. H., P.T. Shukla and R. B. Madariya, 2001. Analysis of variability for seed yield and related characters in (*Carthamus tinctorius* L.). Madras Agric. J., 87: 449-452.

Mozaffari, K. and A.A. Asadi. 2006. Relationships among traits using correlation, principal components and path analysis in safflower mutants sown in irrigated and drought stress condition. Asian J. Plant Sci., 5(6): 977-983.

Manju, P.R and I. Sreelathakumray, 2002. Genetic variability, heritability and genetic advance in hot chilli (Capsicum Chinese Jacq,). J. Trop. Agric.,40: 4-6.

Naserirad, H., A. Soleymanifard, R. Naseri and S.Nasiri. 2013. Study of correlation between important agronomic traits and path analysis for grain and oil yield in safflower. Int. J. Agro. P. Prod., 4 (4): 670-673,

Omidi Tabrizi, A. H. 2006.Stability and adoptability estimates of some safflower cultivars and lines in different environment conditions. J. Agric. Sci. Technol., 8: 141-151.

Omidi Tabrizi, A.H., 2005. Study of some important agronomic traits in spring safflower genotypes using principal components analysis. In: Proceedings 6th Internatinal Safflower Conference, 6-10 June 1997, Istanbul, Turkey.

Omidi Tabrizi, A.H. 2002.Correlation between traits and path analysis for seed and oil yield in spring safflower. J. Plant Seed, 18(2): 229-240.

Rao V. and M. Ramachandram. 1997. An analysis of association of yield and oil in safflower. Fourth International Safflower Conference. Italy, Bari, 2-7 June, pp: 185-191.

Safavi, S. M., S.S. Pourdad and S.A.Safavi. 2012. Assessment of Genetic Diversity in Safflower (*Carthamustinctorius* L.)Genotypes Using Agro-Morphological Traits. Annals of Biol. Res. (5):2428-2432.

Singh, R. K., and B. D. Chaudhary. 1979. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publ., New Dehli. 33pp.

Table-1: Rainfall (mm), Minimum & Maximum Temperature (^{0}C) and Humidity Mean (%) data during two Rabi growing season 2011-12 & 2012-13

	Rainfall (mm)	Minimum Temp.(^{0}C)	Maximum Temp.(^{0}C)	Humidity Mean (%)
Rabi Season 2011-12				
October	16.50	14.75	29.95	54.70
November	12.70	9.11	24.89	70.36
December	0.00	2.28	19.31	69.80
January	22.10	0.53	13.50	69.95
February	19.85	1.86	16.82	66.31
March	4.10	7.33	24.50	47.99
April	23.05	15.08	26.22	59.23
Rabi Season 2012-13				
October	16.30	13.31	27.69	60.99
November	01.00	14.99	28.83	53.46
December	28.30	03.25	15.58	55.39
January	00.00	01.50	15.86	62.05
February	213.40	07.61	16.82	79.71
March	17.90	10.76	23.99	65.30
April	20.95	06.38	23.65	58.85

Table-2: Analysis of Variance for yield and yield related attributes in Safflower genotypes studied during 2011-12 and 2012-13

Source	DF	Year	BYP	DFF	DM	EHW	GFD	GFRP	TGW	HD	HI	HP	PBP	PH	SH	STD	SWH	SYP
Rep	2	2011-12	348.93	17.66	35.21	0.61	3.33	1.38	3.70	0.19	267.91	1298.57	1.98	191.43	6.83	0.07	0.23	1617.70
		2012-13	44.81	4.93	6.01	0.01	0.18	0.02	25.20	0.02	0.56	228.76	6.03	23.36	15.11	0.04	0.26	483.10
Var	39	2011-12	3712.00**	5.21*	4.75	1.48**	13.44**	7.76**	19.43**	0.53**	462.55**	1294.29**	3.50**	339.42**	75.66**	0.07**	0.77**	11426.10**
		2012-13	4386.44**	4.05*	2.41*	1.79**	12.22**	7.22**	28.36**	0.56**	274.61**	1644.70**	8.14**	384.88**	130.49**	0.07**	0.71**	14536.00**
Error	78	2011-12	23.40	3.91	3.99	0.25	3.09	0.15	4.85	0.03	31.54	99.83	0.45	42.08	26.19	0.01	0.29	252.60
		2012-13	14.37	2.34	2.36	0.27	1.93	0.21	5.88	0.01	15.29	70.31	0.60	31.97	29.17	0.01	0.34	270.10
CV%		2011-12	5.68	1.67	1.34	18.38	4.55	11.79	5.31	8.73	8.63	15.66	16.63	6.08	16.23	8.55	19.00	12.78
		2012-13	4.00	1.13	0.93	16.04	3.10	14.40	5.69	5.26	5.25	12.50	17.21	5.27	15.70	7.17	20.08	11.67

* and ** Significant at 0.05 and 0.01 level respectively Biological Yield Plant^{-1} (BYP), Days to 50% flowering (DFF), Days to Physiological Maturity (DM), Effective Head Weight (EHW), Grain Filling Duration (GFD), Grain Filling Rate Plant^{-1} (GFRP), 1000-Grain Weight (TGW), Head Diameter (HD), Harvest Index (HI), No. of Heads Plant^{-1} (HP), No. of Primary Branches Plant^{-1} (PBP), Plant Height (PH), No. of Seeds Head^{-1} (SH), Stem Diameter (STD), Seed Weight Head^{-1} (SWH), Seed Yields Plant^{-1} (SYP).

Table-3: Genotypic Coefficient of Variation (GCV), Phenotypic Coefficient of Variation (PCV), Environmental Coefficient of Variation (ECV), Heritability in broad sense (h^2),Genetic Advance (GA) and Genetic Advance as percent of mean (GA %) for the characters studied during 2011-12 & 2012-13 in Safflower genotypes

Source	Year	BYP	DFF	DM	EHW	GFD	GFRP	TGW	HD	HI	HP	PBP	PH	SH	STD	SWH	SYP
GCV	2011-12	41.210	0.550	0.340	23.570	4.800	49.340	5.320	18.88	18.410	31.280	24.810	9.330	12.880	12.97	14.040	49.090
	2012-13	40.250	0.560	0.130	21.840	4.130	48.250	6.430	19.53	12.490	34.160	35.290	10.120	16.900	11.01	12.260	48.180
ECV	2011-12	5.680	1.670	1.340	18.400	4.550	11.990	5.310	8.180	8.630	15.660	16.560	6.080	16.230	9.170	18.900	12.780
	2012-13	4.000	1.130	0.930	15.990	3.100	14.470	5.690	4.600	5.250	12.500	17.250	5.270	15.700	7.790	20.220	11.670
PCV	2011-12	41.340	1.110	0.850	25.850	5.470	49.780	6.140	20.00	19.070	32.560	26.660	9.970	15.930	14.21	17.750	49.640
	2012-13	40.320	0.860	0.520	23.730	4.500	48.960	7.220	20.10	12.850	34.910	36.660	10.560	19.180	11.81	16.880	49.440
h^2	2011-12	99.372	24.760	15.790	83.160	76.990	98.248	75.023	88.90	93.183	92.286	86.650	87.599	65.380	83.33	62.500	97.789
	2012-13	99.679	42.370	19.270	84.710	84.220	97.119	79.285	94.70	94.431	95.726	92.650	91.699	77.660	86.96	52.740	98.142
G.A	2011-12	72.010	0.670	0.410	1.200	3.360	3.250	3.930	0.770	23.840	39.490	1.930	19.190	6.760	0.270	0.650	124.320
	2012-13	78.520	1.010	0.110	1.350	3.500	3.100	5.020	0.840	18.610	46.170	3.140	21.400	10.550	0.270	0.530	140.730
G.A %	2011-12	84.630	0.570	0.280	44.170	8.690	100.620	9.480	36.40	36.620	61.900	47.650	17.980	21.440	24.77	22.810	100.000
	2012-13	82.790	0.750	0.080	41.540	7.800	97.870	11.780	38.70	24.990	68.840	69.910	19.960	30.680	21.02	18.380	99.960

Table-4: Correlation coefficient for yield and yield related characters in safflower genotypes studied during 2011-12

	BYP	DFF	DM	EHW	GFD	GFRP	TGW	HD	HI	HP	PBP	PH	SH	STD	SWH
DFF	-0.028														
DM	0.174*	0.094													
EHW	0.188*	0.107	0.183*												
GFD	-0.196*	0.089	-0.096	0.073											
GFRP	0.206	0.017	0.203*	0.529**	0.144*										
TGW	0.108	-0.099	0.017	0.067	-0.231*	0.225*									
HD	0.278**	-0.048	0.157*	0.089	-0.181	0.106	-0.135								
HI	0.250**	0.181*	0.109	0.057	-0.050	0.008	0.223*	0.109							
HP	0.076	-0.050	0.296**	0.319**	0.025	0.673**	0.121	0.096	0.042						
PBP	-0.133	-0.043	0.105	0.117	0.155*	0.456**	0.123	-0.036	0.063	0.496**					
PH	0.145*	-0.004	0.131	0.045	0.175*	0.163*	0.146	-0.056	0.274**	0.338**	0.243**				
SH	0.092	-0.028	0.228**	-0.063	0.101	0.179*	0.061	0.009	0.157**	0.353	0.125	0.263**			
STD	-0.217*	0.036	-0.067	-0.228*	0.195*	-0.108	0.237**	-0.072	0.260	-0.053	0.012	0.209*	-0.023		
SWH	0.188*	0.074	0.170**	0.757**	0.094	0.508**	0.055	0.115	-0.037	0.305**	0.092	0.031	0.003	-0.188*	
SYP	0.175*	0.028	0.186*	0.547**	-0.006	0.988**	0.198**	0.089	0.001	0.683**	0.484**	0.189*	0.194*	0.088	0.526**

* and ** Significant at 0.05 and 0.01 level respectively. Biological Yield Plant^{-1} (BYP), Days to 50% Flowering (DFF), Days to Physiological Maturity (DM), Effective Head Weight (EHW), Grain Filling Duration (GFD), Grain Filling Rate Plant^{-1} (GFRP), 1000-Grain Weight (TGW), Head Diameter (HD), Harvest Index (HI), No. of Heads Plant^{-1} (HP), No. of Primary Branches Plant^{-1} (PBP), Plant Height (PH), No. of Seeds Head^{-1} (SH), Stem Diameter (STD), Seed Weight Head^{-1} (SWH), Seed Yields Plant^{-1} (SYP).

Table-5: Correlation coefficient for yield and yield related characters in safflower genotypes studied during 2012-13

	BYP	DFF	DM	EHW	GFD	GFRP	TGW	HD	HI	HP	PBP	PH	SH	STD	SWH
DFF	-0.115														
DM	0.058	-0.134													
EHW	0.165*	-0.013	-0.007												
GFD	-0.219*	0.119	0.009	0.045											
GFRP	0.154*	-0.082	0.155*	0.576**	-0.059										
TGW	-0.061	-0.143*	0.018	0.246**	-0.192*	0.329**									
HD	0.281**	-0.123	0.037	-0.003	-0.231*	0.115	-0.100								
HI	-0.593**	0.163*	-0.078	-0.085	0.111	-0.133	0.196*	-0.183*							
HP	0.047	-0.063	0.285*	0.189*	0.122	0.669**	0.172*	0.070	-0.076						
PBP	-0.045	-0.001	0.136	0.0901	0.082	0.529**	0.251**	0.019	0.099	0.602**					
PH	0.131	0.069	0.217*	0.144	0.181*	0.331**	0.139	-0.089	-0.055	0.478**	0.318**				
SH	-0.011	-0.018	0.109	-0.062	0.103	0.168*	0.102	0.005	0.072	0.354**	0.128	0.298**			
STD	-0.219*	0.112	0.028	-0.047	0.228*	-0.035	0.176*	-0.139	0.233*	-0.045	0.043	0.166	0.006		
SWH	0.109	-0.044	-0.004	0.051	0.092	0.069	0.039	0.068	-0.105	-0.066	-0.071	-0.118	0.075	-0.105	
SYP	0.165*	-0.065	0.159	0.551**	0.029	0.932**	0.292**	0.075	-0.176*	0.695**	0.559**	0.319**	0.185*	-0.058	0.092

* and ** Significant at 0.05 and 0.01 level respectively. Biological Yield Plant^{-1} (BYP), Days to 50% Flowering (DFF), Days to Physiological Maturity (DM), Effective Head Weight (EHW), Grain Filling Duration (GFD), Grain Filling Rate Plant^{-1} (GFRP), 1000-Grain Weight (TGW), Head Diameter (HD), Harvest Index (HI), No. of Heads Plant^{-1} (HP), No. of Primary Branches Plant^{-1} (PBP), Plant Height (PH), No. of Seeds Head^{-1} (SH), Stem Diameter (STD), Seed Weight Head^{-1} (SWH), Seed Yields Plant^{-1} (SYP).