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Correlation and path coefficient analysis for the yield components of Safflower germplasm *(Carthamus tinctorius* L.*)*

SNCVL Pushpa Valli*, C. Sudhakar, Jyothi Rani and R. Raja Rajeswari

Agricultural Research Station, PJSTAU, Tandur-501 141

*****Email ID: pvalli75@yahoo.co.in

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Abstract
Twenty safflower germplasm lines were evaluated during *Rabi* 2013-14 to determine the relationship among yield and yield components. The genetic parameters like genotypic and phenotypic variability, genotypic and phenotypic coefficient of variation, heritability and genetic advance were studied. Besides these parameters, correlation coefficient and path analysis were also studied for seed yield and its component traits in safflower. Significant differences existed among the germplasm lines for all the characters studied. The estimate of broad sense heritability was highest for 100-seed weight. Seed yield/plant exhibited positive and significant correlation with number of seeds/capsule and 100-seed weight. Path coefficient analysis indicated that 100-seed weight exhibited maximum direct effect followed by number of seed/capsule.

Key words: Safflower, Yield, Path coefficient analysis, Correlation, Germplasm

Introduction

Safflower (*Carthamus tinctorius* L.) is an important oilseed crop which belongs to the family Compositae or Asteraceae. It is a drought tolerant multi-purpose crop where in it is grown not only for oil but also for petals from which orange-red dye (carthamin) is extracted. The petals have several medicinal properties and are useful in curing several chronic ailments (Li and Mundel, 1996). The safflower oil is a rich source of polyunsaturated fatty acids (78% linoleic acid) and widely preferred by consumers across the world. Breeding for high seed yield and oil content is the major thrust of safflower research in India. Earlier studies have clearly indicated that seed yield and oil content are inversely related (Ramachandram, 1985; Parameshwarappa et al., 1984). Studying correlation among different traits and how yield components are associated with complex trait such as yield is highly useful for selection in the breeding program. The main objective of this study was to investigate the phenotypic correlation among different agronomic traits and the direct and indirect effects of yield components on seed yield of safflower germplasm.

Materials and Methods

Twenty safflower germplasm lines obtained from Directorate of Oilseeds Research, Hyderabad were sown in Random Block Design at Agricultural Research Station, Tandur during rabi 2013-14. The entries were sown in 5m long four row plots with a spacing of 45cm between the rows and 20cm between the plants. The recommended agronomic practices and plant protection methods have been followed to raise a good crop. Five plants were randomly selected for recording data on the following six characters *viz*, days to 50% flowering, days to maturity, Number of effective capitula/plant, number of seeds/capitula, test weight (g) and seed yield/plant (g) in each treatment across all replications. The data ~~has been~~ subjected to statistical analysis to calculate genotypic (GCV) and phenotypic (PCV) coefficients of variation, heritability and genetic advance as per cent of mean. Phenotypic coefficient of correlation was computed according to Al-Jibouri *et al*. (1958). The phenotypic correlation was partitioned into direct and indirect effects as suggested by Dewey and Lu (1959).

Results and Discussion

Analysis of variance (data not presented) revealed that significant differences exist among the germplasm lines for all the characters studied. Range of variation was highest for seed yield per plant followed by number of capsules per plant and number of seeds per capsule. Genotypes had least

range of variation for 100-seed weight (Table 1). Estimates of genetic parameters like genotypic and phenotypic variability, genotypic and phenotypic coefficient of variation, heritability and genetic advance as percent of mean are presented in Table 2. High coefficients of variation were observed for seed yield per plant followed by 100-seed weight. Genotypic coefficient of variation closely followed the phenotypic coefficient of variation in all the characters studied. Phenotypic coefficient of variation revealed relatively high values in comparison to corresponding genotypic coefficient of variation for all the characters, indicating the effect of environment in the expression of the traits. A range of PCV was observed from 4.12 to 42.34% for the traits studied which provides a picture of the extent of phenotypic variability in the population. The PCV was observed moderate for characters like 100-seed weight (18.75%) and number of capsules/plant (18.12%). Characters like days to 50% flowering, days to maturity and number of seeds per capsules exhibited low PCV. Genotypic coefficient of variation which indicates the extent of genetic variability ranged from 5.11% to 38.34%. The maximum GCV was observed for seed yield/plant (38.34%), followed by 100-seed weight (18.75%) and number of capsules per plant (18.12%).Thus these traits further provide an opportunity for genetic improvement. Low estimates of GCV and PCV were recorded for days to 50% flowering and days to maturity. Genetic coefficient of variation along with heritability provides a clear picture on the efficiency of selection (Burton, 1952). Broad sense heritability estimates was highest for 100-seed weight (96.5%) followed by days to maturity (88.7%), days to 50% flowering (88.4%), seed yield/plant (82.0%) and number of capsules/plant (74.1%). In the present study 100-seed weight, days to maturity, days to 50% flowering, seed yield/plant and number of capsules/plant ~~have~~ had shown high magnitude of heritability in broad sense indicating that these characters were least affected by environmental variation and hence selection for these characters based on phenotype may be more effective for safflower improvement. The estimated genetic advance was high for seed yield/plant (71.5%) and moderate for 100 seed weight, number of capsules and number of seeds per capsule. Earlier studies have also reported that genotypic component of variation was greater than the environmental component for all the traits except for branches/plant, capitula/plant and oil content. Genetic advance as percentage of mean was moderate for seed yield/ plant, plant height, height of branching from base and 100-seed weight, whereas it was low for the remaining traits (Anjani, 2005) (Table 2).

Phenotypic correlations were estimated among the six traits in twenty safflower genotypes and these indicated inherent association between any two variables which might have occurred due to the pleiotropic action of genes, linkage or more likely both. Seed yield/plant was positively and significantly correlated with number of seeds/capsule (0.329) and 100-seed weight (0.415). Ekshing et al., 1994 and Rafiei (2002) reported a high and positive correlation between seed yield/plant and number of seeds per head in their studies. Rafiei (2002) found negative but Abulhasani (2003) reported a positive correlation between seed yield and 100-seed weight. Strong association of number of capitula per plant and 100-seed weight with seed yield/plant was also observed by Parameshwarappa (1981), Malleshappa (2000) and Bidgoli et al (2001). Days to maturity was significantly correlated with days to 50% flowering. Seed yield/plant was positively correlated with days to 50% flowering, days to maturity and number of capsules/plant but the correlation was not significant. Number of seeds/capsule was negatively correlated with 100-seed weight. Genotypes with bold seeds had less number of seeds/capsule (Table 3). There existed significant positive correlation between days to 50% flowering and days to maturity (0.995). This indicated that genotypes which flowered earlier matured earlier. Similar results were reported by earlier researchers (Rafiei, 2002 and Abulhasani, 2003).

In the present investigation the path coefficient analysis was performed to estimate the direct and indirect contribution of various plant characters to seed yield/plant. Compartmentalization of correlation coefficients into direct and indirect effects differentiated the true nature of association observed among various characters. 100-seed weight (0.385) exhibited maximum direct effect followed by number of seed/capsule, days to 50% flowering and number of capsules/plant (Table 4). These characters are principal components of seed yield and may be helpful in increasing the seed yield of safflower. Earlier studies by Malleshappa *2000*) and Pandya *et al* (1996) observed that the direct effect of number of capitula was more pronounced followed by test weight, plant height and capitulum diameter on seed yield/plant. Days to maturity had negative direct effect on seed yield/plant. The component characters namely 100 seed weight and number of seeds/capsule are very important characters for seed yield because they ~~have had~~ shown positive and significant correlation with seed yield/plant. Both these

characters also had positive and strong direct effects on seed yield/plant. Results of correlation and path analysis suggested that all the characters having positive association with grain yield ~~are~~ might also directly contributing to seed yield and hence of selection of genotypes ~~may~~ reliably done based on these characters.

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Table 1. Mean performance of various characters of safflower germplasm

Genotype	Days to 50% Flowering	Days to maturity	Number of capsules/plant	Number of seeds/capsule	Test weight (g)	Seed yield/ plant (g)
GMU 3876	72.0	105.5	35.40	19.46	3.20	12.47
PBNS-12	79.0	113.5	35.40	15.50	4.30	15.91
GMU 3856	79.0	113.5	31.20	20.08	4.60	13.55
GMU 3816	73.5	107.5	16.90	17.98	4.10	5.01
A1	82.5	118.0	27.10	21.52	4.50	21.15
Manjira	81.5	115.5	24.60	20.22	4.35	18.54
GMU 3796	81.5	116.5	17.10	23.48	3.30	8.78
GMU 3781	79.5	114.5	32.00	18.50	3.05	21.72
GMU 3719	83.0	117.5	29.20	18.74	6.05	16.50
GMU 3716	84.0	119.0	25.90	19.00	4.20	17.09
GMU 3708	73.0	107.0	27.80	14.44	4.25	11.06
GMU 3663	87.0	121.5	32.90	18.54	3.85	9.28
GMU 2366	81.5	116.0	39.10	17.92	4.20	20.50
GMU 3924	81.5	115.5	26.50	18.52	3.10	19.06
GMU 3963	81.0	115.0	25.00	16.12	5.40	29.10
GMU 2551	74.0	107.5	21.80	24.86	3.85	22.69
GMU 3638	77.0	111.5	34.50	21.28	3.50	14.23

GMU 3923	78.5	112.5	28.80	20.46	4.40	29.13
GMU 3438	73.5	108.0	37.00	25.50	5.60	34.72
GMU 3971	85.0	120.5	30.60	20.90	4.30	30.07
Mean	79.3	113.8	28.94	19.65	4.20	18.53
CV (%)	2.62	1.96	15.16	13.46	5.02	25.41
S.E	1.47	1.57	3.10	1.87	0.14	3.33

Table 2 Estimation of GCV, PCV, h^2_b and Genetic Advance of six characters of safflower

Characters	Variance		Coefficient of variation		h^2_b (%)	GA	GA as
	Genotypic	Phenotypic	GCV (%)	PCV (%)		Mean (%)	
Days to 50% Flowering	16.48	18.65	5.11	5.44	88.4	7.86	9.90
Days to Maturity	19.49	21.98	3.88	4.12	88.7	8.56	7.52
No. of Capsules/plant	27.52	37.15	18.12	21.06	74.1	9.30	32.14
No. of seeds/ Capsule	4.53	8.03	10.83	14.42	56.4	3.29	16.76
100-seed weight (g)	0.622	0.64	18.75	19.09	96.5	1.59	37.96
Seed Yield/ Plant (g)	50.48	61.57	38.34	42.34	82.0	13.25	71.52

Table 3: Phenotypic correlation coefficients among the six characters of safflower

Characters	Days to Maturity	No. of capsules/ plant	No. of seeds/ capsule	100 seed weight (g)	Grain yield/ plant (g)
Days to 50% Flowering	0.9954***	0.0034	-0.1102	0.0913	0.0757
Days to Maturity		-0.0849	0.0153	0.0915	0.0865
No. of Capsules/plant			-0.1170	0.0995	0.2895
No. of seeds/ Capsule				-0.0093	0.3297*
100-seed weight (g)					0.4157**

*, **, *** Significant at P=0.05, 0.01 and 0.005 respectively

Table 4 Phenotypic path coefficient showing direct and indirect effect of characters on grain yield per plant in safflower germplasm

Characters	Days to 50% Flowering	Days to Maturity	No. of capsules/ plant	No. of seeds/ capsule	100 seed weight (g)	Correlation with Grain yield / plant (g)
Days to 50% Flowering	**0.3652**	0.3635	0.0012	-0.0402	0.0333	0.0757
Days to Maturity	-0.2872	**-0.2885**	-0.0044	0.0245	-0.0264	0.0865
No. of Capsules/plant	0.0010	0.0046	**0.2974**	-0.0348	0.0296	0.2895
No. of seeds Capsule	-0.0423	-0.0326	-0.0449	**0.3836**	-0.0036	0.3297*
100-seed weight (g)	0.0349	0.0350	0.0381	-0.0035	**0.3825**	0.4157**

Figures in bold letters indicate the direct effects, Residual effect = 0.7903