

Original Research Article

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Character Association and Path Analysis Studies at Genotypic Level on Some Genotypes of Safflower (*Carthamus tinctorius* L.)

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ABSTRACT

Safflower is one of the old domesticated crops and mostly cultivated for oil purpose. Large numbers of variability were found in this crop and through the successful breeding programme the problems can be eradicated. The experiment was conducted at BTC College of Agriculture and Research station, Bilaspur (C.G.) in Rabi season during 2017-18. The experimental material consisted of a population of 26 genotypes included two checks A1 (NC) and PBNS-12 (C) with laid out in Randomized block design. Genotypic correlation studies show that seed yield had exhibit highest significant positive correlation with harvest index (0.806) followed by Biological yield (0.801), 100 seed weight (0.677), volume weight (0.563), branches /plant (0.474). Whereas non -significant but positive with rosette period (0.360), plant height (0.351), days to maturity (0.324), days to flowering (0.306), capitulum per plant (0.285), seeds per capitulum (0.254). At the genotypic level path analysis results shows that seed yield had maximum direct positive effect with biological yield (0.682) followed by harvest index (0.524), rosette period (0.087), capitulum per plant (0.056), plant height (0.012). Whereas 100 seed weight (-0.100), days to 50% flowering (-0.050), branches per plant (-0.042), days to maturity (-0.035) seeds per capitulum (-0.037) volume weight (-0.016) had negative direct effect on seed yield.

Keywords

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Introduction

Safflower (*Carthamus tinctorius* L.) is one of the oldest domesticated crops. It has been grown since ancient times both as a dye as well as an oilseed crop in a wide range of geographical regions (Knowles, 1976). It is a member of the family Compositae or Asteraceae, genus- *Carthamus*, tribe- *Tubiflorae*, sub division- *Angiosperm* of division- *Phanerogams*.

It is mainly grown in Maharashtra, Karnataka and parts of Andhra Pradesh, Madhya Pradesh, Orissa, Bihar, etc. Maharashtra and Karnataka are the two most important safflower growing states accounting for 72 and 23 per cent of area and 63 and 35 per cent of production, respectively. Safflower is cultivated in an area of 600 hectares with a production of 200 tonnes and a productivity of 333 kg/ hectare in Chhattisgarh. Whereas in India the Safflower is grown in an area of 1,

78,000 hectares with production of 1, 14,000 tonnes and productivity of 641 kg/hectare in the year 2013-14 (Anonymous, 2015).

It is multi used oilseed crop *i.e.* cooking oil, bird seed, petals used as natural dyes and medicinal use etc. It is mainly grown for oil purpose in India. Safflower, a multipurpose crop, has been grown for centuries in India and for its quality oil rich in polyunsaturated fatty acids (linoleic acid, 78%). Safflower flowers are known to have many medicinal properties for curing several chronic diseases.

Correlation coefficient analyses help researchers to distinguish significant relationship between traits. Stepwise regression can reduce effect of non-important traits in regression model, in this way traits accounted for considerable variations of dependent variable are determined (Agrama, 1996). Path analysis has been extensively used for segregating correlation between yield and its components in field crops. Path analysis is used to determine the amount of direct and indirect effects of the variables on the dependent variable. It confirms the magnitude of correlation by partitioning the effects into direct and indirect effects. The core objective of current research was to find out the dependence association of grain yield with yield related characters in safflower genotypes and to recognize the most important indirect selection criteria for genetic improvement of these characters through path analysis.

Materials and Methods

The present research work was carried out at the Research cum Instructional farm of BTC College of Agriculture and Research station, Bilaspur (C.G.), Rabi, 2017-18. The experimental material consisted of a population of 26 genotypes included two checks A-1 (Annigeri-1) Spiny (National Check) and PBNS-12 (Check) and 24

genotypes *viz.* GMU-7368, GMU-3635, AKS-94 -2 x GMU- 3821, NARI-118, SSF-995 X GMU-3806, GMS-NARI-57 (Cross-13), AKS-91-1-1 x GMU- 3802, AKS-91-1-1 x GMU- 3809, MS-06 X PBNS-72(CROSS-15), RVS-12-13 X PBNS-12, Manjeera X GMU-7403, AKS-91-1-1 X GMU-3806, PBNS-12 X GMU-4055, RSS-11-17 X GMU-4037, GMU-6106 X Manjeera, GMU-7403 X JSF-1, RVS-12-13 X Manjeera, GMU 7403 X Manjeera

The crop was raised in the month of November 2017 in Randomized Block Design (RBD) with three replications with the plot size for each entries was of 4 rows of 4 meter length spaced 50 cm apart make a plot size of 8 m². The dose of fertilizer application will be 60:40:30 kg/ha. Nitrogen was applied in two split doses whereas P and K were applied as basal dose. Observations were recorded on five randomly selected competitive plants from each plot in each replication. The characters selected for the observations are Rosette period (Days), Days to 50% flowering, Days of maturity, Plant height (cm), No. of capitulum per plant, No. of seeds per capitulum, No. of branches per plant, 100 seed weight (gms.), Volume weight (gms./100 ml), Biological yield per plot (kg), Harvest index (%), Seed yield / plot (kg).

Statistical Analysis: Correlation coefficient analysis (Character association)

Correlation coefficient (r) was calculated for all possible combination of yield and its component parameters by using the standard procedure given by Searle *et al.*, (1961).

Correlation coefficient between two characters X and Y were calculated using the following formula:

$$r(XY) = \text{Cov.}(XY) / \sqrt{V(X) \cdot V(Y)}$$

where,

$r(XY)$ = correlation coefficient between x and y characters

Cov.(XY) = covariance between X and Y

V(X) = variance of X

V(Y) = variance of Y

Correlation estimates at genotypic level were computed by using the formula given by (Snedecor and Cochran, 1989)

$$r_g = \text{COV}_{gxy} / (\sigma^2_{gx} \times \sigma^2_{gy})^{1/2}$$

Path coefficient analysis

The path analysis was originally developed by Wright (1921) and elaborated by Dewey and Lu (1959). Path coefficient analysis splits the genotypic correlation coefficient into measures of direct and indirect effects. It measures the direct and indirect contribution of independent variables on dependent variable.

After calculation the value of path coefficient i.e. the residual effect was estimated by the method suggested by Singh and Chaudhary (1985)

$$\text{Residual effect (R)} = \sqrt{1 - \sum d_i \cdot r_{Xi} \cdot X_j}$$

Where,

d_i = direct effect of i^{th} character

$r_{Xi} \cdot X_j$ = correlation coefficient of i^{th} character with j^{th} character

The results of path coefficient analysis were interpreted as per following scale suggested by Lenka and Mishra (1973).

Results and Discussion

Correlation analysis of genotypic level for yield and other yield characters are presented in Table 1. Seed yield per plot (kg) is taken as dependent variable whereas other traits were selected as independent variable for the

correlation analysis. The results are discussed character wise.

Seed yield

Table 1 resulted that seed yield per plot (kg) had highest significant positive correlation with harvest index % (0.806) followed by biological yield per plot (kg) (0.801), 100 seed weight (gms) (0.677), volume weight (gms/100 ml water volume) (0.563) and number of branches per plant (0.474). Whereas non significant but positive correlation with rosette period (0.360), plant height (cm) (0.351), days to maturity (0.324), days to 50% flowering (0.306), number of capitulum per plant (0.285) and number of seeds per capitulum (0.254).

Rosette period

It had significant positive correlation with days to 50 % flowering (0.777) followed by days to maturity (0.734). Similar results were found by Perveen (2016), Pavithra *et al.*, (2016) and Manjhi (2017). Rosette period had positive non-significant correlation with harvest index % (0.363), seed yield per plot (kg) (0.360), 100 seed weight (gms) (0.344), volume weight (gms./100 ml water volume) (0.324), biological yield per plot (kg) (0.255), plant height (cm) (0.205), number of seeds per capitulum (0.108) and number of capitulum per plant (0.102). Similar results were found by Perveen (2016) and Pavithra *et al.*, (2016).

Rosette period had negative non significant correlation with number of branches per plant (-0.070).

Days to 50% flowering

It had significant positive correlation with days to maturity (0.897) followed by plant height (cm) (0.460). This result is supported by the results of Golker *et al.*, (2011), Paikara

(2013), Ahmadzadeh (2013), Kairimi *et al.*, (2014), Bagri (2014), Pattar (2014), Puspavalli *et al* (2015), Nag (2015), Achhale (2016), Kumar (2016), Perveen (2016) and Manjhi (2017). Days to 50% flowering had positive non-significant correlation with number of capitulum per plant (0.379) followed by seed yield per plot (kg) (0.306), biological yield per plot (kg) (0.285), 100 seed weight (gms.) (0.244), harvest index % (0.228), volume weight (gms/100 ml water volume) (0.186), number of branches per plant (0.183) and number of seeds per capitulum (0.126). Similar results were found by Golker *et al.*, (2011), Paikara (2013), Gopal *et al.*, (2014), Nag (2015), Puspavalli *et al.*, (2015), Achhale (2016), Kumar (2016), Perveen (2016) and Manjhi (2017).

Days to maturity

It had significant positive correlation with plant height (cm) (0.503) followed by number of capitulum per plant (0.418). This result is supported by results of Golker *et al.*, (2011), Ahmadzadeh (2013), Achhale (2016) and Manjhi (2017).

Days to maturity had positive non- significant correlation with seed yield per plot (kg) (0.324), 100 seed weight (gms.) (0.307), biological yield per plot (kg) (0.298), number of seeds per capitulum (0.275), harvest index % (0.255), volume weight (gms /100 ml water volume) (0.174) and number of branches per plant (0.093). Similar results were found by Golker *et al.*, (2011), Pavithra (2013), Bagri (2014), Gopal *et al.*, (2014), Puspavalli *et al.*, (2015), Achhale (2016), Perveen (2016) and Kumar (2016).

Plant height (cm)

It had significant positive correlation with number of capitulum per plant (0.976) followed by number of branches per plant

(0.714), number of seeds per capitulum (0.669), 100 seed weight (gms.) (0.466) and biological yield per plot (kg) (0.413). Similar results were found by Roopa and Ravikumar (2008), Shivani *et al.*, (2010), Pavithra (2013) Karimi *et al.*, (2014), Nezhad and Talebi (2015), Sirel and Aytac (2016) and Manjhi (2017).

Plant height (cm) had positive non significant correlation with seed yield per plot (kg) (0.351) followed by harvest index % (0.182) and volume weight (gms./100 ml water volume) (0.146). Similar results were found by Karimi *et al.*, (2014) and Nag (2015).

Number of capitulum per plant

It had significant positive correlation with number of branches per plant (0.732) followed by number of seeds per capitulum (0.693). Similar results were found by Roopa and Ravikumar, (2008), Perveen (2016) and Manjhi (2017).

Number of capitulum per plant had found positive non-significant correlation with 100 seed weight (gms.) (0.375), biological yield per plot (kg) (0.323), seed yield per plot (kg) (0.285) harvest index % (0.174) and volume weight (gms./100 ml water volume) (0.059). Similar results were found by Roopa and Ravikumar, (2008), Pattar (2014), Bagri (2014), Gopal *et al.*, (2014), Puspavalli *et al.*, (2015), Perveen (2016), Puspavalli *et al.*, (2017), Manjhi (2017) and Mohamed and Elmogtaba (2018).

Number of seeds per capitulum

It had positive non-significant correlation with biological yield per plot (kg) (0.354), seed yield per plot (kg) (0.254), 100 seed weight (gms) (0.347), number of branches per plant (0.321), volume weight (gms /100 ml water volume) (0.319) and harvest index % (0.061).

Similar results were found by Roopa and Ravikumar, (2008), Gopal *et al.*, (2014), Pattar (2014), Kumar (2016) and Manjhi (2017).

Number of branches per plant

It had significant positive correlation with biological yield per plot (kg) (0.478), seed yield per plot (kg) (0.474) and 100 seed weight (gms) (0.434) and similar results were found by Perveen (2016) and Achhale (2016).

Number of branches per plant had positive non- significant correlation with harvest index % (0.346) and volume weight (gms /100 ml water volume) (0.147). This result is also supported with the findings of Roopa and Ravikumar (2008) and Gopal *et al.*, (2014).

100 seed weight (gms)

It had significant positive correlation with biological yield per plot (kg) (0.783), seed yield per plot (kg) (0.677) and volume weight (gms./100 ml water volume) (0.399). Our results are supported with the findings of Hoshang *et al.*,(2013), Hussain *et al.*, (2014), Tamoor *et al.*, (2014), Nag (2015), Kumar (2016), Achhale (2016), Semahegn and Tesfaye (2016), Manjhi (2017), Valli (2016) and Puspavalli *et al.*,(2017)

100 seed weight (gms.) had positive non-significant correlation with harvest index % (0.362).

Volume weight (gms /100 ml water volume)

It had significant positive correlation with biological yield per plot (kg) (0.641) and seed yield per plot (kg) (0.563). Similar result was found by Manjhi (2017).

Volume weight (gms /100 ml water volume) had non-significant positive correlation with harvest index % (0.253). Similar result was found by Pavithra (2013).

Biological yield per plot (kg)

It had positive significant correlation with seed yield per plot (kg) (0.887) and harvest index % (0.438). Similar results were found by Kumar (2010), Maryam *et al.*, (2011), Salmati *et al.*,(2011), Ahmadzadeh (2013), Hoshang *et al.*,(2013), Kumar (2016) and Achhale (2016).

Harvest index%

It had significant positive correlation with seed yield per plot (kg) (0.801). This result is supported with the results of Shivani *et al.*, (2010), Maryam *et al.*, (2011), Nezhad and Talebi (2015), Kumar (2016) and Manjhi (2017), Jadhav *et al.*, (2018).

Path analysis (Genotypic) results

Path analysis of genotypic level when seed yield taken as dependent trait at genotypic level.

Table 2 resulted that seed yield per plot (kg) had maximum direct positive effect with biological yield per plot (kg) (0.682) followed by harvest index % (0.524), rosette period (0.087), number of capitulum per plant (0.056) and plant height (cm) (0.012). Whereas 100 seed weight (gms.) (-0.100), days to 50% flowering (-0.050), number of branches per plant (-0.042), days to maturity (-0.035), number of seeds per capitulum (-0.037) and volume weight (gms /100 ml water volume) (-0.016) had negative direct effect on seed yield per plot (kg) (Table 2). The characters under path analysis are discussed character wise.

Rosette period

It had positive direct positive effect(0.087) on seed yield per plot (kg) (0.360) but it had indirect positive effect through days to 50% flowering (0.069), days to maturity (0.068),

plant height (cm) (0.027), number of capitulum per plant (0.017), number of seeds per capitulum (0.022), 100 seed weight (gms.) (0.046), volume weight (gms /100 ml water volume) (0.036), biological yield per plot (kg) (0.038) and harvest index % (0.032) (Table 2).

Days to 50% flowering

It had direct negative effect (-0.050) on seed yield per plot (kg) (0.306) but it had indirect negative effect through days to maturity (-0.045) followed by plant height (cm) (-0.025), number of capitulum per plant (-0.021) and number of branches per plant.

Days to maturity

It had direct negative effect (-0.035) on seed yield per plot (kg) (0.324) but it had indirect negative effect through plant height (cm) (-0.017), number of capitulum per plant (-0.014), 100 seed weight (gms) (-0.011) and biological yield per plot (kg) (-0.010).

Plant height (cm)

It had direct positive effect (0.012) on seed yield per plot (kg) (0.351) but it had indirect positive effect through number of capitulum per plant (0.012).

Number of capitulum per plant

It had direct positive effect (0.056) on seed yield per plot (kg) (0.285) but it had indirect positive effect through number of seeds per capitulum (0.037) followed by number of branches per plant (0.039), 100 seed weight (gms.) (0.015), biological yield per plot (kg) (0.012) and harvest index % (0.012).

Number of seeds per capitulum

It had direct negative effect (-0.037) on seed yield per plot (kg) (0.254) but it had indirect negative effect through plant height (cm) (-

0.024) and number of capitulum per plant (-0.024).

Number of branches per plant

It had direct negative effect (-0.042) on seed yield per plot (kg) (0.474) but it had indirect negative effect through plant height (cm) (-0.029), number of capitulum per plant (-0.029), harvest index % (0.017) and biological yield per plot (kg) (-0.015).

100 seed weight (gms.)

It had direct negative effect (-0.100) on seed yield per plot (kg) (-0.100) but it had indirect negative effect through biological yield per plot (kg) (-0.071) followed by harvest index % (-0.046), rosette period (-0.053) and days to 50% flowering (-0.032).

Volume weight (gms /100 ml water volume)

It had direct negative effect (-0.016) on seed yield per plot (kg) (-0.016) but it had indirect negative effect through biological yield per plot (kg) (0.010).

Biological yield per plot (kg)

It had direct positive effect (0.682) on seed yield per plot (kg) (0.887) but it had indirect positive effect through volume weight (gms /100 ml water volume) (0.410), harvest index % (0.386), rosette period (0.303) and days to 50% flowering (0.203).

Harvest index %

It had direct positive effect (0.524) on seed yield per plot (kg) (0.801) but it had indirect positive effect through biological yield per plot (kg) (0.297), 100 seed weight (gms.) (0.243), number of branches per plant (0.214) and rosette period (0.194).

Table.1 Genotypic correlation coefficient of yield and its contributing traits

S.No.	Character	Rosette Period	Days to 50% Flowering	Days to Maturity	Plant Height	Capitulum /Plant	Seeds/ Capitulum	Branches/ Plant	100 Seed Weight	Volume weight	Biological Yield	Harvest /Index	Seed Yield
1	RP	1.000	0.777**	0.734**	0.2057	0.102	0.108	-0.070	0.344	0.324	0.255	0.363	0.360
2	DF		1.000	0.897**	0.460*	0.379	0.126	0.183	0.242	0.186	0.285	0.228	0.306
3	DM			1.000	0.503**	0.418*	0.275	0.093	0.307	0.174	0.298	0.255	0.324
4	PH				1.000	0.972**	0.669**	0.714**	0.466*	0.146	0.413*	0.182	0.351
5	CP					1.000	0.693**	0.732**	0.375	0.059	0.323	0.174	0.285
6	SC						1.000	0.321	0.347	0.319	0.354	0.061	0.254
7	BP							1.000	0.434*	0.147	0.478*	0.346	0.474*
8	SW								1.000	0.399*	0.783**	0.362	0.677**
9	VW									1.000	0.641**	0.253	0.563**
10	BY										1.000	0.438*	0.887**
13	HI											1.000	0.801**

Abbreviations used : (Rosette Period-RP) , (Days to 50% Flowering- DF) , (Days to Maturity-DM) , (Plant Height -PH) , (Capitulum/ Plant -CP) , (Seeds /Capitulum -SC) , (Branches/Plant -BP) (100 Seed Weight -SW) , (Volume Weight -VW) , (Biological Yield -BY) ,(Harvest Index -HI)

1(**) and 5(*) % significance respectively. If r value = >0.388 at 5% (*), If r value = >0.496 at 1% (**)

Table.2 Path correlation matrix of yield and its contributing traits at genotypic level

Character	Corr. With yield	Direct Effect	Indirect effect										
			RP	DF	DM	PH	CP	SC	BP	SW	VW	BY	HI
Rosette Period	0.360	0.087	--	0.069	0.068	0.027	0.017	0.022	0.001	0.046	0.036	0.038	0.032
Days to 50% Flowering	0.306	-	-0.039	--	-	-0.025	-	-	-0.012	-0.016	-0.011	-0.019	-0.011
Days to Maturity	0.324	-	-0.027	-	--	-0.017	-	-	-0.002	-0.011	-0.005	-0.010	-0.009
Plant Height	0.351	0.012	0.004	0.006	0.006	--	0.012	0.008	0.009	0.005	0.001	0.004	0.003
Capitulum/ Plant	0.285	0.056	0.011	0.024	0.023	0.055	--	0.037	0.039	0.015	-0.002	0.012	0.012
Seeds /Capitulum	0.254	-	-0.009	-	-	-0.024	-	--	-0.006	-0.006	-0.008	-0.005	-0.004
Branches/ Plant	0.474*	-	-0.001	-	-	-0.029	-	-	--	-0.013	-0.002	-0.015	-0.017
100 Seed Weight	0.677**	-	-0.053	-	-	-0.039	-	-	-0.031	--	-0.031	-0.071	-0.046
Volume Weight	0.563**	-	-0.007	-	-	-0.001	0.000	-	-0.001	-0.005	--	-0.010	-0.005
Biological Yield	0.887**	0.682	0.303	0.262	0.203	0.215	0.140	0.095	0.244	0.486	0.410	--	0.386
Harvest Index	0.801**	0.524	0.194	0.116	0.138	0.123	0.110	0.062	0.214	0.243	0.153	0.297	--

Abbreviations used : (Rosette Period-RP) , (Days to 50% Flowering- DF) , (Days to Maturity-DM) , (Plant Height -PH) , (Capitulum/ Plant -CP) , (Seeds /Capitulum -SC) , (Branches/Plant -BP) (100 Seed Weight -SW) , (Volume Weight -VW) , (Biological Yield -BY) ,(Harvest Index -HI)

R² = 1.001 Residual effect =1.001

It could be concluded from the present investigation that the characters like harvest index %, biological yield per plot (kg), rosette period, number of capitulum per plant and plant height (cm) possessed strong positive association and high magnitude of positive direct effects on seed yield per plot (kg) and the indirect effects of most of the characters *via.*, these characters were positive and some characters were found negative during the investigation.

The results of the present investigations are also confirmed by the findings of Roopa and Ravikumar (2008), Pavithra (2013), Nag (2015), Perveen (2016), Achhale (2016) and Jadhav *et al.*, (2017).

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