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Genetic Variability and Inter-relationship for Yield and Its Components in Safflower (*Carthamus tinctorius* L.)

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Authors' contributions

This work was carried out in collaboration between the two authors. The two authors read and approved the final manuscript.

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ABSTRACT

Present work was carried out to evaluate 19 genotypes of safflower in a randomized block design with three replications. Observations were recorded for nine quantitative traits. Appreciable variability was displayed by all traits, especially seed yield per plant and seed yield. The heritability estimates range between 1.9 and 81.8 %. seed yield kg/ha correlated positively and not significant with all other traits except days to 50% flowering correlated negatively with seed yield. Seed yield per plant correlated positively and highly significant with number of heads/ plant, number of seeds/plant and number of seeds/head. 1000-seed weight was significantly negatively correlated with the number of seeds/head and days to 50% flowering. The correlation coefficient between seed yield/plant and five other traits were partitioned into direct and indirect effects. Maximum direct and positive effect on seed yield per plant was recorded by number of seeds per plant which had also a positive indirect effects with all other traits. Our results indicated that the genetic material studied had a considerable level of variability

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that could be exploited in future breeding programs. The study proposed the traits number of seeds per plant, number of heads per plant and number of seeds per head as a selection criteria.

Keywords: Genetic variability; safflower; heritability; path analysis.

1. INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is a temperate zone plant grown in arid and semiarid regions of world. Safflower is a potential oil-seed crop for the irrigated as well the rain-fed areas in the Sudan.

Genetic divergence among the genotypes plays an important role in selection of parents having wider variability for different characters [1]. Therefore, a logical way to start any breeding program is to survey the variation present in the breeding material. Further, for a rational improvement of seed yield, knowledge of the inter-relationships among characters is important to the breeder. Genetic diversity of some safflower germplasm has been previously investigated based on a morphological traits [2]; [3].Information on correlation coefficient between yield and yield contributing characters has always been helpful as a basis for selection in breeding program. Path coefficient analysis partitions the components of correlation coefficient into direct and indirect effect and visualize the relationship in a more meaningful way.

Therefore, the present study was undertaken to find the genetic variability, character association and contribution of yield contributing traits on seed yield and thereby to establish appropriate plant attributes for selection to improve the seed yield of safflower genotypes in Sudan.

2. MATERIALS AND METHODS

Nineteen genotypes of safflower introduced from different countries (Table 1) were sown in the experimental farm of the Faculty of Agriculture and Natural Resources, University of Bakht Alruda, EDduim, Sudan in 2016. The area lies within an arid climate of summer rains and relatively cool winter with mean minimum and maximum temperatures of 14 and 41°C, respectively. Average annual rainfall is 320 mm in the last 10 years; however, the total annual rain varies from year to year. The rainy season lasts from June to October, with a well-defined peak in August. Relative humidity is generally low with a peak of 60% in August and decreases to about 10% in April. Some physic-chemical properties of soil at the experimental site were given in (Table 2). The experimental was laid out in a randomized complete block design with three replications. Each genotype in a replication was planted in a plot consisting of five ridges, each 5 m long. The inter-row and interplant spacings were 80 cm and 40 cm, respectively. Five plants of each genotype, selected at random from the central two rows in each replications, were used for recording the observations, and their mean values were utilized for statistical analysis.

Observations were recorded on nine characters, namely days to 50% flowering, plant height (cm), head width (cm), number of heads/plant, number of seeds/head, number of seeds/plant, seed yield/plant (g), 1000-seed weight (g) and seed yield kg/ha.

Analysis of variance for the data was carried out by using computer program Statistical Analysis System (SAS). Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), heritability in broad sense (h2B) and genetic advance (GA) were estimated by the formula as suggested by [4]. Simple linear correlation coefficient between the nine pairs of traits was calculated by using SPSS computer program version 16.

The path analysis was used to portioning the genotypic correlation coefficients between seed yield/plant and five other characters ,namely plant height, number of heads/plant, head width, number of seeds/pant and 1000-seed weight.

Table 1. Safflwoer genotypes evaluated at EDduim in Winter season 2016

Accession number	Country	Extend of leaf spininess	Corolla color at flowering
1	India	Manyspines	Yellow-orange
2	Portugal	Few spines	Yellow
3	Usa	Manyspines	Yellow
4	India	Manyspines	Yellow
5	India	Manyspines	Red-orange
6	India	Manyspines	Yellow-orange
7	Germany	Manyspines	Yellow-orange
8	Germany	Manyspines	Yellow-orange
9	Iran	Manyspines	Yellow
10	India	Non- spiny	Yellow-orange
11	Jordan	Manyspines	Yellow
12	Kenya	Non –spiny	Yellow-orange
13	Paraguay	Non- spiny	Yellow
14	Poland	Manyspines	Yellow
15	Sweden	Non- spiny	Yellow-orange
16	Spain	Manyspines	Yellow
17	Turkey	Non- spiny	Yellow
18	England	Manyspines	Yellow
19	Sudan	Manyspines	Red-orange

Table 2. Selected physico–chemical properties of experimental soil

Soil characteristic	Values
PH	8.3
Organic matter % (0.m)	0.45
Total N%	0.016
Available(p)(ppm)	10 mg/kg
CEC	56 c mol/kg
K+	0.55c mol/kg
$CaCO_3$	6.2 %

3. RESULTS AND DISCUSSION

3.1 Genotypic Variability

The variability obtained by the nine traits under study is shown in Table 3.There were significant differences ($P<0.01$) among the genotypes in all the traits except days to 50% flowering, head diameter and seed yield kg/ha suggesting that the experimental material possessed considerable variability and selection for many of these traits may be effective. The highest coefficient of variation (CV) was shown by seed yield per plant followed by seed yield kg/ha and number of seed per plant indicating these traits were most variable. The least value was shown by plant height and days to 50% flowering.

The phenotypic and genotypic coefficients of variation (PCV and GCV), estimates of the components of variance, heritability and genetic advance are shown in Table 4. The PCV generally higher than the GCV for all traits indicating the significant effect of environment. Similar results for PCV and GCV were reported by Choulwar et al. 2005 [5] and Patil et al., 2006[6].The highest values were shown by seed yield per plant and number of seeds per plant and the lowest estimate was given by days to 50% flowering.

The high estimates of heritability were observed for plant height, 1000-seed weight and number seeds per head while, for rest of the traits, heritability was medium to low. Similar findings for 1000-seed weight were reported by Beena et al. [7] and Akbar and Kamran [8]. The fact that heritability estimate for seed yield was lower in magnitude than those for other traits suggests that environmental effects constituted a major portion of the total phenotypic variation. A trait possessing high GCV with high heritability will be valuable in a selection program.

High genetic advance was recorded for number of heads/plant, number of seeds/plant and plant height. Senapati et al. [9] also reported high estimates of genetic gain for number of capituum per plant though Bikash et al. [10] reported high genetic gain for seed yield per plant. Johanson et al. [4] suggested that characters having higher quantum of genetic variability along with heritability and greater genetic gain can be easily improved through selection. High heritability and genetic gain may

Table 3. Phenotypic variation in 9 traits of 19 safflower genotypes

Character	Range	General mean	S. E(±)	CV %	F Value for genotypes
Plant height /cm	54.0- 93.0	76.0	2.01	7.94	14.48**
Days to 50% flowering	64.6-83.3	76.8	2.28	8.92	1.03^{NS}
Number of heads/plant	27.0-116.0	58.4	5.96	30.6	4.29**
Head diameter/cm	1.6-2.1	1.92	0.07	12.0	1.16^{NS}
Number of seeds/plant	396.3-1630.0	876.8	6.5	43.4	2.23*
Number of seeds/head	10.6-25.6	16.1	1.1	20.5	5.01**
Seed yield/plant (g)	12.1-65.1	30.6	4.74	46.3	3.25**
1000-seed weight (g)	17.6-42.1	27.8	1.68	18.2	6.02**
Seed yield kg/ha	312.3-970.7	568.7	5.4	46.2	0.42^{NS}

Table 4. Phenotypic and genotypic coefficient of variation, components of variance, heritability (H) and genetic advance (GA) of 9 traits of safflower

Character	*PCV* (%)	*GCV* (%)	$^{2}_{ph}\sigma$	$^{2}_{g}\sigma$	$^{2}_{e}\sigma$	*(H%)*	*GA*
Plant height /cm	18.64	16.86	200.7	164.2	36.5	81.8	23.8
Days to 50% flowering	8.9	0.93	47.55	0.52	47.03	1.09	0.15
Number of heads/plant	44.3	32.09	671.7	351.4	320.3	52.3	27.9
Head diameter/cm	12.1	2.8	0.053	0.003	0.05	5.6	0.02
Number of seeds/plant	51.6	27.8	204972.1	59676.4	145295.7	29.1	27.1
Number of seeds/head	31.49	23.8	25.71	14.6	11.01	57.1	5.97
Seed yield/plant (g)	61.4	40.2	354.1	151.8	202.3	42.8	16.6
1000-seed weight (g)	29.8	23.5	68.7	43.0	25.7	62.5	10.6
Seed yield kg/ha	46.7	6.52	70566.1	1378.7	69187.4	1.9	10.6

$^{2}_{ph}\sigma$=Phenotypic variance, $^{2}_{g}\sigma$=Genotypic variance, $^{2}_{e}\sigma$=Error variance.

be attributed to the additive gene effect. Panse, 1957 [11] suggesting that direct selection for these traits would be possible. Lowest values were shown for head diameter and days to 50% flowering. Similar findings for days to flowering was recorded by Bikash et al. [10].

3.2 Correlation between Traits

The correlation study (Table 5) showed that seed yield kg/ha correlated positively and not significant with all other traits except days to 50% flowering correlated negatively with seed yield. To enhance yield, number of capitula plant-1 is an important trait Lahane et al. [12]. Following reports of Eslam et al. [13]; Safavi, [14]; Ahmadzadeh et al. [15], were focused on seed related characters e.g. seeds/plant, 100 kernel weight, and seed yield. For improvement of seed yield and oil content, they recommended to select traits such as seeds/plant and thousand kernel weights.

Seed yield per plant correlated positively and highly significant with number of heads/plant, number of seeds/plant and number of seeds/head. 1000-seed weight was significantly negatively correlated with the number of seeds/head and days to 50% flowering. Similar findings were reported by Solanki et al. 1997 [16].

The number of seeds/head was highly significant positively correlated with number of seeds/plant. Plant height exhibited negative association with number of heads/plant, number of seeds/plant and seed yield per plant but its correlation coefficient with days to 50% flowering was highly significant ($P<0.01$).

3.3 The Path Analysis

Table 6 reveals direct and indirect contribution of component traits on seed yield per plant. Maximum direct and positive effect on seed yield per plant was recorded by number of seeds per plant which had also positive indirect effects with

Table 5. Correlation coefficients among various pairs of 9 traits in safflower

	Plant height	Days to 50% flowering	Number of heads/plant	Head diameter/cm	Number of seeds/plant	Number of seeds/head	Seed yield/plant (g)	1000-seed weight (g)	Seed yield kg/ha
Plant height	-								
Days to 50% flowering	0.33*	-							
Number of heads/plant	-0.24	0.10	-						
Head diameter/cm	0.04	-0.03	-0.04	-					
Number of seeds/plant	-0.12	0.22	0.70**	0.17	-				
Number of seeds/head	0.15	0.18	-0.12	0.20	0.43**	-			
Seed yield/plant (g)	-0.12	0.17	0.53**	0.24	0.71**	0.47**	-		
1000-seed weight (g)	0.02	-0.05	-0.33*	0.09	0.04	0.20	0.09	-	
Seed yield kg/ha	0.02	-0.10	0.14	0.01	0.24	0.10	0.10	0.14	-

Table 6. Path coefficients of some traits in safflower using simple linear correlation coefficients

	Plant height	Number of heads/plant	Head diameter/cm	Number of seeds/plan	1000-seed weight (g)
Plant height	-0.025	-0.041	0.005	-0.069	0.002
Number of heads/plant	0.006	0.168	-0.005	0.399	-0.037
Head diameter/cm	-0.001	-0.006	0.143	0.100	0.010
Number of seeds/plan	0.003	0.118	0.025	0.566	0.005
1000-seed weight (g)	-0.001	-0.056	0.013	0.026	0.112

Direct effects= the diagonal
Indirl Indirect effects= off diagonal

all other traits. The direct effect of number of heads per plant was positive and the indirect effect via plant height and number of seed/plant was positive. This trait also showed a negative indirect effect via head diameter and 1000-seed weight. The direct effect of plant height was negative although this trait exhibited negative indirect effect with the number of heads/plant and number of seeds/plant.

Head diameter attained positive direct effect as well positive indirect effect via number of seeds/plant and 1000-seed weight. But this trait showed a negative indirect effect with plant height and number of heads/plant, respectively. The direct effect of 1000-seed weight was positive as was its indirect effect via head diameter and number of seeds per plant. However, it has a negative indirect effect with the plant height and number of heads per plant. Number of seeds per plant, number of heads per plant seem to be good morphological criteria for seed yield per plant.

4. CONCLUSION

Our results indicated that the genetic material studied had a considerable level of variability that could be exploited in future breeding programs. The study proposed the traits number of seeds per plant, number of heads per plant and number of seeds per head as a selection criteria due to the positive direct effects exhibited by these traits with seed yield/plant. The study will be repeated for more seasons and locations to obtain more reliable results.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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