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RESEARCH ARTICLE

GENETIC GAIN FROM HALF-SIB RECURRENT SELECTION IN SAFFLOWER (*Carthamus tinctorius* L.)

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ABSTRACT

The present study was undertaken to determine the expected genetic gain for seed yield and its components from half-sib selection method, to assess the effect of intermating on genetic correlation and to assess the frequency of half-sib families significantly superior over Bhima and A1. The 200 half-sib families were developed and evaluated in rabi 2008, along with five check varieties. Expected genetic advance was 39.68 per cent and 45.68 per cent at 10 per cent selection intensity over population mean and Bhima respectively for the seed yield per plant. Days to 50% flowering and maturity exhibited negative correlation with seed yield per plant indicating breaking of positive correlation to negative correlation. Therefore, selection of high yielding families with early maturity is possible. This indicate that the half-sib recurrent selection is effective for increasing population mean and extraction of superior recombinant lines better than check varieties. There are ten half-sib families significantly superior over Bhima and eight half-sib families significantly superior over A1.

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INTRODUCTION

Safflower (*Carthamus tinctorius* L.) traditionally grown for its flowers which were used for colouring, flavoring and making dyes. The medicinal use of flower in China has become known to the rest of the world in last five years. Safflower has been gaining importance in recent years, in several parts of the country, because of its superior adaptability under drought conditions. Besides, it contains 30% oil in Indian varieties. The oil constitutes 76 per cent of Linoleic acid (PUFA) which helps in reducing cholesterol level in human blood. Safflower (*Carthamus tinctorius* L.) is a member of the composite, family Asteraceae. There are twenty five species in the genus. Out of which only *Carthamus tinctorius* L. (2n = 24) is cultivated and used for oil production, the rest are wild species. Vavilov (1949), suggested India, Iran and Afghanistan as centers of origin.

Importance of study

The safflower improvement programmed in India was started in 1931 and N-630, the first variety released in 1940. Since then 17 varieties and three hybrids were released in the country viz. DSH-129, MKH-11 and NARISH-1. These varieties have the genetic potential to give yield of 15-20 q/ha with oil content of about 30% under optimal condition.

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However attempts to further improve the yield and oil content were not successfully for the last three decades. Similarly there is no breakthrough in the improvement of oil content in the last seven decades. This is mainly due, to the use of pedigree selection technique in population derived from two line crosses, negative correlation between seed yield and oil content. The conventional breeding methods have been very useful only recombining simple inherited characters. Therefore, these conventional breeding methods have not been very efficient for improving quantitatively inherited characters like seed yield, oil content, tolerance to stresses and horizontal resistance to diseases and insects. Moreover, the crossing and record keeping procedure are often both money and time consuming for the rate of progress attained. Conventional method have several limitations such as limited use of available genetic variability resulting in the development of varieties with a narrow genetic base, successive loss of genes in the segregating generation with no chance of recombination for genes linked for yield and oil content (Jensen, 1970). These limitations can be overcome by application of recurrent selection method in self pollinating crops including safflower.
Therefore, the present investigation was planned to evaluate the response to recurrent half-sib selection for yield improvement in random mating population developed by using HUS-305 MS-2 genetic male sterile line.

MATERIALS AND METHODS

Material required and methods adopted

The experimental material consisted of safflower population segregating for genetic male sterility. The random mating population was developed by crossing HUS-305 MS-2 genetic male sterile line with 12 parental lines viz. Bhima, A1, N-7, AKS-152, AKS-207, BLY-652, Sharda, S-251, JLSF-88, PH-39, AKS-68 and AKS-215, in 2003. 200 half-sib families were grown in *rabi* 2008 along with check varieties viz. Bhima, A1, AKS-207, HUS-305 and Phulekusum for evaluation in augmented block design in five blocks. Each block consists of 40 half-sib and 5 checks. The data were recorded on five competitive fertile plants for each type of family for following characters.

- Days to 50% flowering
- Days to maturity
- Plant height (cm)
- Number of branches plant^{-1}
- Number of capitula plant^{-1}
- Number of seeds capitulum^{-1}
- 100 seed weight (g)
- Seed yield plant^{-1} (g)

Statistical methods

The mean of five plants in each family was used for statistical analysis. These have been presented under the following subheads.

- Analysis of variance for the experimental design.
- Estimation of family components.
- Estimation of heritability in narrow sense.
- Estimation of expected genetic advance.
- Simple correlations.

RESULTS

Objective of the study were to determine the expected genetic gain for seed yield and its components from half-sib recurrent selection method, to assess the effect of intermating on genetic correlation and to assess the frequency of half-sib families significantly superior over Bhima and A1.

Analysis of variance and mean performance of half- sib families

Mean value of agronomic characters measured on selected half-sib families presented in table 1. The maximum range was recorded by plant height (64.4 cm) followed by seed yield per plant (51.54 g), number of seeds per capitulum (37), number of capitula per plant (30), days to 50% flowering (29), days to maturity (24), number of primary branches per plant (11) and 100 seed weight (4.16 g) indicating considerable amount of genetic variance in random mating population which will facilitate selection of superior families. Reddy (2002), Naole (2004), Goyal (2006), Pavithran (2007) also identified significant variance for half-sib families in safflower.

Half- sib family components of variance and heritability

The estimates of half- sib family components of variance and heritability for each agronomic trait have been presented in table 2. The genetic variance among half- sib families ($\sigma^2_{H.S}$) and additive variance (σ^2_A) was highest and significant for seed yield per plant in (g) (73 and 292) followed by number of capitula per plant (29.09 and 116.36), plant height (23.6 and 94.4), days to 50 % flowering (10.97 and 43.88), number of seeds per capitulum (10.01 and 40.04),days to maturity (9.81 and 39.24), number of primary branches per plant (2.83 and 11.32) and 100 seed weight (0.28 and 1.12) respectively. The significant and high genetic variance among half-sib families was reported by Reddy (2002), Mummaneni (2003), Naole (2004), Panchbhai (2004) and Goyal (2006). In the present study, the narrow sense heritability estimates on family means basis were highest for seed yield per plant (0.64) followed by), number of capitula per plant (0.59), days to 50% flowering (0.58), days to maturity (0.57) and number of primary branches per plant (0.57), plant height (0.56), 100 seed weight (0.53) and for number of seeds per capitulum (0.52) respectively. High estimates of heritability has been reported in safflower for several agronomic traits by Reddy (2002), Mummaneni (2003), Naole (2004), Goyal (2006), Pavithran (2007) and Metkar(2008). Similarly high estimates of heritability has been reported in sorghum for several agronomic and quality traits by Eckebil *et al*. (1977); Ross *et.al*. (1981); Ross and Hookstra (1983); Lothrop *et al*. (1985); Fores *et al*. (1986) and Kwolek *et al*. (1986).

Expected genetic advance with half-sib selection

The expected genetic advance with half-sib selection has been presented in table 3 The expected genetic advance from single trait- selection at 5 and 10 per cent of half-sib families was highest for seed yield per plant (14.14 and 12.08) followed by number of capitula per plant (8.56 and 7.31), plant height (7.52 and 6.42), days to 50% flowering (5.21 and 4.45),days to maturity (4.91 and 4.20), number of seeds per capitulum (3.34), days to 50% flowering (3.12), number of seeds per capitula (4.75 and 4.06), number of primary branches per plant (2.69 and 2.25) and 100 seed weight (0.79 and 0.68). The expected genetic advance expressed as per cent of population mean at 5 and 10 per cent was highest for seed yield per plant (46.45 and 39.68) followed by number of capitula per plant (32.22 and 27.52), number of primary branches per plant (27.62 and 23.63), number of seeds per capitulum (19.34 and 16.53), 100 seed weight (17.47 and 15.04), plant height (9.44 and 8.05), days to 50% flowering (6.02 and 5.14) and days to maturity (3.74 and 3.20).

The expected genetic advance per cent over Bhima at 5 and 10 per cent selection intensity was highest for seed yield per plant (53.47 and 45.68) followed by number of capitula per plant (32.82 and 28.02), number of primary branches per plant (28.02 and 23.43), number of seeds per capitulum (21.01 and 17.96), 100 seed weight (19.17 and 16.50), plant height (9.22 and 7.87), days to 50 % flowering (6.36 and 5.44) and days to maturity (4.13 and 3.54). In safflower, Reddy (2002) reported 9.483 per cent genetic advance in seed yield per plant from at 10 per cent selection intensity in random mating population of safflower after one cycle of recurrent selection. The expected genetic advance obtained from second cycle of recurrent selection was 23.99 percent at 10 percent selection intensity (Naole, 2004). In third cycle Goyal (2006) reported 42.29 percent genetic advance from 10 percent selection intensity. This clearly indicates the accumulation of favourable genes for yield.

Table 1. Mean value of agronomic characters measured on selected half-sib families

Charecters	Days to 50 % flowering	Plant height (cm)	Days to maturity	No. of primary branches per plant	No. of capitula per plant	No. of seeds per capitulum	100 seed weight (g)	seed yield per plant (g)
Maximum	102	93.2	133	15	42	45	7.10	57.46
Mimimum	73	28.8	109	04	12	08	2.94	5.92
Range	29	64.4	24	11	30	37	4.16	51.54
Mean (H.S.)*	86.50	79.67	131.04	9.52	24.55	26.5	4.52	30.44
				Check Varieties				
A1	79.8	122.2	80.68	8.40	21.2	25.40	4.65	29.72
AKS-207	81.4	119.6	73.68	9.40	22.2	25.40	4.45	29.76
Bhima	81.8	118.6	81.56	9.60	22.6	26.08	4.12	27.44
HUS-305	78.8	115.6	77.32	9.00	20.4	22.80	4.04	26.15
Phulekusum	64.8	102.8	95.60	7.20	21.2	23.80	3.28	33.22

*Mean performance of 200 half-sib families **mean performance of 5-lines of check from five blocks

Table 2. Estimation of half-sib family components of variance and heritability for different agronomic traits

Half-sib family component	Days to 50 % flowering	Plant height (cm)	Days to maturity	No. of primary branches per plant	No. of capitula per plant	No. of seeds per capitulum	100 seed weight (g)	Seed yield per plant (g)
$\sigma^2_{H.S}$	10.97	23.6	9.81	2.83	29.09	10.1	0.28	73
$\sigma^2_A = 4\ \sigma^2_{H.S.}$	43.88	94.4	39.24	11.32	116.36	40.4	1.12	292
$\sigma^2_P = ¼\ \sigma^2_A + \sigma^2_e$	18.83	41.76	16.96	4.89	49.11	19.12	0.52	113.04
$h^2\ (n.s.) = \frac{¼\sigma^2_A}{¼\sigma^2_A + \sigma^2_e}$	0.58	0.56	0.57	0.57	0.59	0.52	0.53	0.64

Table 3. Expected genetic advance per cycle from single trait selection using half-sib family selection system

Unit of evaluation and selection	Gc	(#)Selection intensity	Days to 50 % flowering	Plant height (cm)	Days to maturity	No. of primary branches per plant	No. of capitula per plant	No. of seeds per capitulum	100 seed weight (g)	Seed yield per plant (g)
Half-sib	2	5	5.21	7.52	4.91	2.69	8.56	4.75	0.79	14.14
		10	4.45	6.42	4.20	2.25	7.31	4.06	0.68	12.08
			Expected genetic advance as per cent mean of population							
Half-sib	2	5	6.02	9.44	3.74	27.62	32.22	19.34	17.47	46.45
		10	5.14	8.05	3.20	23.63	27.52	16.53	15.04	39.68
			Expected genetic advance as per cent mean over Bhima							
Half-sib	2	5	6.36	9.22	4.13	28.02	32.82	21.01	19.17	53.47
		10	5.44	7.87	3.54	23.43	28.02	17.96	16.50	45.68

Response to selection of top 5 per cent (K=2.06), 10 per cent (K=1.76) of large number of families where K is standardized selection differential.

Table 4. Simple correlation among eight quantitative characters for half-sib family selection:

Characters	Plant height (cm)	Days to maturity	No. of primary branches per plant	No. of capitula per plant	No. of seeds per capitulum	100 seed weight (g)	seed yield per plant (g)
Days to 50 % flowering	-0.11	0.03	-0.27**	-0.24**	-0.08	-0.17*	-0.21**
Plant height (cm)		-0.12	0.38**	0.46**	0.16*	0.05	0.41**
Days to maturity			-0.09	-0.07	-0.10	0.03	-0.07
No. of primary branches / plant				0.85**	0.41**	0.21**	0.63**
No. of capitula/ plant					0.46**	0.19*	0.72**
No. of seeds/ capitulum						0.10	0.57**
100 seed weight (g)							0.19*

*Significance level at 5% (0.138); **Significance level at 1% (0.181)

Table. 5. Performance of promising half-sib families

Sr. No.	Half-sib families	Mean for Seed yield per plant (g)
1	HS-10	51.60**
2	HS-21	53.70**
3	HS-23	51.68**
4	HS-47	57.46**
5	HS-54	48.48*
6	HS-55	50.84*
7	HS-57	56.06**
8	HS-60	50.98**
9	HS-129	55.86**
10	HS-171	54.94**
11	Bhima	26.44
12	A1	29.72
	SE (diff) ±	10.73
	CD 5 %	21.13

*,** Significantly superior over Bhima and A1 respectively.

The significant genetic advance for yield has been reported in sorghum which ranged from 13.8 to 40.4 per cent per cycle (Lathrop *et al.* 1985, Obilana and El-rouby 1980) and 6.2 to 16.3 91 q/ha (Bittinger *et al.* 1981, Eckebil *et al.* 1977). Brim (1978) and Burton and Brim (1978) reported increase in protein per cent in soybean from 42.8 to 46.3 per cent after five cycles of selection. Brim (1978) reported 16 per cent increase in soybean yield and C_3 composite yielded 20 per cent more than check variety. Onim (1981) reported average increase in grain yield was 2.3 to 4.3 per cent per cycle. Kadappa (1995) reported 106 per cent increase in yield in improved population than original population.

Simple Correlations

The simple correlations among different traits were estimated and have been presented in table 4. Patil *et al.* (1994) reported that positive and significant correlation observed between seed yield per plant and days to maturity, capitula per plant, seed index, 100 seed weight and seeds per plant capitulum. Pandya *et al.* (1996) reported that positive and significant correlation observed between seed yield per plant and days to maturity capitula/ plant, seed index, 100 seed weight and seeds per capitulum. Mummaneni (2003) reported in S_1 family (selfed progrenies) testing selection that seed yield per plant showed positive and significant correlations for 50 percent flowering (0.875**), plant height (0.865**), days to maturity (0.879**), number of primary branches per plant (0.672**) and number of capitula per plant (0.802**). Naole (2004) reported in random-mating population of safflower, seed yield per plant showed positive and significant correlations with number of capitula per plant, number of seeds per capitulum and 100 seeds weight. However, seed yield per plant and days to maturity has negative and significant correlation (-0.377**). Goyal (2006) reported in random-mating population of safflower seed yield per plant showed positive and significant correlation with days to maturity (0.316**) and number of seed per capitulum (0.372**).

Identification of promising half-sib families over Bhima and A1

Identification of promising half-sib families over Bhima and A1 have been presented in table 5. The objective of any recurrent selection method is to increase the frequency of desirable genes thereby increase frequency of lines than check varieties. In the present study, ten half-sib families are significantly superior over Bhima and eight are significantly superior over A1 for the seed yield per plant (g).

Conclusion

The genetic variance among half- sib families ($\sigma^2_{H.S}$) and additive variance (σ^2_A) was highest and significant for seed yield per plant in (g) (73 and 292) followed by number of capitula per plant (29.09 and 116.36), plant height (23.6 and 94.4), days to 50 % flowering (10.97 and 43.88), number of seeds per capitulum (10.01 and 40.04),days to maturity (9.81 and 39.24), number of primary branches per plant (2.83 and 11.32) and 100 seed weight (0.28 and 1.12) respectively. The narrow sense heritability estimates on family means basis was highest for seed yield per plant (0.64) followed by), number of capitula per plant (0.59), days to 50% flowering (0.58), days to maturity (0.57) and number of primary branches per plant (0.57), plant height (0.56), 100 seed weight (0.53) and for number of seeds per capitulum (0.52) respectively. Expected genetic advance is 39.68 per cent and 45.68 per cent at 10 per cent selection intensity over population mean and Bhima respectively for the seed yield per plant which indicates that accumulation of desirable genes for seed yield. The half-sib recurrent selection is effective for increasing population mean and extraction of superior recombinant lines better than check varieties. The selection for seed yield has resulted in non-significant and negative correlation with days to maturity and yield contributing traits which may be due to breaking of positive correlation between maturity and yield due to intermating, suggesting that selection of recombinant lines with high yield and earliness. In present study, ten half-sib families (HS-10**, HS-21**, HS-23**, HS-47**, HS-54*, HS-55*, HS-57**, HS-60**, HS-129** and HS-171**) significantly superior over Bhima and eight lines significantly superior over A1, which will be utilized for next cycle of recombination and selection i. e. for pre breeding programme and finally develping high yielding varieties.

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