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EVALUATION OF SUNFLOWER INBREDS, HYBRIDS AND POPULATIONS FOR SELF-COMPATIBILITY OVER SEASONS

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ABSTRACT

Sunflower inbreds, hybrids and populations were evaluated for self-compatibility during monsoon and summer seasons. Evaluation was based on seed yield, number of filled seeds and seed set under different treatments, viz., cloth bag, cloth bag with hand pollination, and open pollination. All genotypes, in general, recorded higher seed yield, number of filled seeds, seed set, autogamy, and self-compatibility during summer as compared to monsoon season. In both seasons, hybrids were comparatively more self-compatible than inbreds and varietal populations. CMS 234 and PR-1 amongst inbreds, CMS 234 × PR-1 and F-97 × RHA 265 amongst hybrids, and CGP-1 and Surya amongst the varietal populations appeared to be more self-compatible than other genotypes. Importance of evaluating the lines for self-compatibility in population improvement and heterosis breeding has been discussed.

Key words: *Helianthus annuus*, self-compatibility, seed yield, seed set, autogamy.

Cross pollination in sunflower (*Helianthus annuus* L.) is primarily attributed to the self-incompatibility mechanism operating in the crop. The self- incompatibility is sporophytic in nature although complete S allele dominance was not observed [1, 2]. Several workers [3–8] have reported that the degree of incompatibility varies with genotype, environmental factors, pollination, location, etc. The present study aims to assess self-compatibility of sunflower inbreds, hybrids and populations over two seasons considering various parameters.

MATERIALS AND METHODS

The material comprised six inbreds, including two cytoplasmic male sterile lines (CMS 234 and F-97) and four restorer lines (RHA 274, RHA 801, RHA 265 and PR-1); eight hybrids derived by crossing the above two CMS lines with four restorer lines; and four populations, viz., EC-68415 (Armaviriski 3497), Morden (Cernianka-66), CGP-1 and Surya. in lieu of CMS lines, their maintainer lines (CMS 234B and F-97B) were planted. All the six inbreds, eight hybrids, and four populations were

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planted in July 1985 and January 1986 by adopting RCBD factorial design, replicated four times. In a replication, each genotype was planted in five 4.2 m long rows at 60 × 30 cm spacing. Each experimental block was bordered with BSH-1 as nonexperimental row. In both seasons, the crop was raised under irrigation with the recommended package of practices.

Ten random plants of each genotype were covered with cloth bags soon after the first ray florets opened in the capitulum. In five of these covered heads, hand pollination was done (8 times in all genotypes) by gently rubbing the cloth bag cover against the florets. Five open-pollinated plants were labelled randomly. Data on seed yield and number of filled (viable) seeds were recorded in the heads covered with cloth bags, those covered with cloth bags and hand pollinated, and open pollinated. Seed filling, autogamy and self-compatibility were calculated as shown below.

$$\text{Seed set (\%)} = \frac{\text{No. of filled seeds}}{\text{Total seed}} \times 100 \text{ [6]}$$

$$\text{Autogamy (\%)} = \frac{\text{Seed set under autogamous pollination (\%)}}{\text{Seed set under open pollination (\%)}} \times 100 \text{ [9]}$$

$$\text{Self-compatibility (\%)} = \frac{\text{Seed set under hand pollination (\%)}}{\text{Seed set under open pollination (\%)}} \times 100 \text{ [9]}$$

RESULTS

The data on seed yield and number of filled seeds for inbreds, hybrids and populations (Table 1) revealed that all genotypes recorded higher seed yield and more filled seeds in summer as compared to rainy season. In general, both seed yield and number of filled seeds were affected adversely in the heads covered with cloth bags. However, seed yield and number of filled seeds improved when the covered heads were hand pollinated. In some genotypes, both these traits even recorded higher values than under open pollination. Mean seed yield and number of filled seeds over seasons were higher in the hybrids, followed by inbreds and populations in all the three pollination treatments. However, there was no significant difference between hybrids and populations for mean seed yield and number of filled seeds under open pollination.

The data presented in Table 2 reveal that the genotypes recorded higher seed set, autogamy and self-compatibility in summer as compared to monsoon season. Mean seed set of populations over seasons in cloth bags (11.2%) differed significantly

Table 1. Seed yield and number of filled seeds of sunflower genotypes over seasons in different treatments

Genotype	Seed yield (g)						Number of filled seeds					
	cloth bag		cloth bag + hand pollination		open pollination		cloth bag		cloth bag + hand pollination		open pollination	
	monsoon	summer	monsoon	summer	monsoon	summer	monsoon	summer	monsoon	summer	monsoon	summer
Inbreds:												
CMS 234B	4.6	7.8	15.0	29.7	18.0	26.0	61.6	255.7	315.5	570.0	498.2	596.7
F-97B	1.9	3.8	9.6	11.8	9.0	10.1	36.4	65.3	214.1	240.0	254.2	147.3
RHA 274	4.7	7.2	5.3	11.4	4.4	11.8	187.7	299.5	308.2	408.3	240.5	430.2
RHA 801	2.8	5.6	4.6	24.1	4.0	9.5	128.7	111.7	248.9	573.0	226.7	330.7
PR-1	6.1	6.9	6.8	14.6	11.1	13.8	178.2	170.3	299.4	466.3	375.1	460.5
RHA 265	7.7	10.6	9.7	23.2	11.1	15.6	237.8	710.5	416.7	667.5	454.4	522.3
Mean	4.6	7.0	8.5	19.1	9.6	14.5	138.4	268.8	300.5	487.5	341.5	414.6
Mean over seasons	5.8		13.8		12.1		203.6		394.0		378.1	
Hybrids:												
CMS 234B × RHA 274	1.6	25.9	18.5	34.4	32.0	38.6	31.8	588.2	507.7	723.0	741.9	924.0
CMS 234B × RHA 801	3.3	24.0	25.9	34.6	32.2	43.4	67.3	374.0	617.7	694.7	719.1	875.0
CMS 234B × PR-1	11.1	24.9	22.7	58.1	37.0	45.4	175.9	449.8	506.1	862.3	810.0	671.8
CMS 234B × RHA 265	2.7	25.2	22.9	40.4	33.2	23.4	35.1	478.8	477.0	851.8	752.4	621.0
F-97B × RHA 274	1.7	16.9	17.4	36.4	23.6	36.2	34.2	257.1	440.8	646.0	495.6	609.8
F-97B × RHA 801	2.1	7.1	13.5	17.6	25.6	29.1	38.6	227.3	341.1	362.0	512.7	421.7
F-97B × PR-1	2.6	11.2	19.4	35.4	20.0	36.9	41.9	205.8	364.3	531.9	666.2	563.5
F-97B × RHA 265	11.9	29.9	21.2	35.0	28.4	44.0	216.2	426.4	564.8	779.5	654.7	915.2
Mean	4.6	20.6	20.2	36.5	29.1	37.1	80.1	375.9	477.4	681.4	669.1	700.3
Mean over seasons	12.6		28.4		33.1		228.0		579.4		684.7	
Populations:												
E.C. 68415	0.5	2.1	9.1	6.0	32.9	52.1	10.2	58.0	166.3	98.7	635.1	806.7
Morden	0.2	4.3	2.7	6.3	28.9	13.3	4.9	87.0	59.2	106.7	560.2	342.3
CGP-1	1.7	13.0	13.5	45.7	31.4	29.3	30.3	259.5	244.5	710.7	611.4	475.5
Surya	0.7	3.1	3.1	23.8	37.3	44.4	10.2	85.8	49.1	380.3	684.3	983.3
Mean	0.8	5.6	7.1	20.5	32.6	34.8	13.9	122.6	129.8	324.1	622.8	651.9
Mean over seasons	3.1		13.8		33.7		68.3		227.0		641.4	
	Genotypes (G)		Pollinations (P)		G × P		Genotypes (G)		Pollinations (P)		G × P	
	monsoon	summer	monsoon	summer	monsoon	summer	monsoon	summer	monsoon	summer	monsoon	summer
SEm	0.2	0.5	0.1	0.2	0.5	1.0	13.1	31.7	5.4	12.9	22.7	54.9
CD, 5%	0.6	1.3	0.3	0.7	1.4	2.9	36.4	88.7	14.9	36.2	63.0	153.8
CD, 1%	0.8	1.7	0.8	0.9	1.8	3.7	47.8	117.5	19.5	48.0	82.8	203.4

from the one with hand pollination in cloth bags (41.2%) and in open pollination (76.1%). The trend was similar for inbreds and hybrids. For all the three categories of genotypes, viz., inbreds, hybrids and populations, mean seed set over seasons was highest under open pollination, followed by cloth bag + hand pollination. Under cloth bags, the inbreds recorded highest seed set over seasons (44.8%), followed by hybrids (36.4%) and populations (11.2%), while in both cloth bag + hand pollination and open pollination, the hybrids gave highest seed set, followed by inbreds and the varietal populations.

Table 2. Seed set, autogamy and self-compatibility per cent of sunflower genotypes over seasons

Genotype	Seed set, %						Autogamy, %		Self-compatibility, %	
	cloth bag		cloth bag + hand pollination		open pollination					
	monsoon	summer	monsoon	summer	monsoon	summer	monsoon	summer	monsoon	summer
Inbreds:										
CMS. 234B	10.0	89.1	46.3	80.4	71.0	82.6	14.1	107.9	65.3	97.3
F-97B	5.2	36.4	29.0	31.3	36.9	40.0	14.1	91.1	78.6	78.4
RHA 274	45.6	25.7	58.6	80.3	50.9	79.8	89.6	31.8	115.3	107.7
RHA 801	37.6	61.7	55.4	79.4	46.5	84.2	80.9	73.3	108.5	94.3
PR-1	38.4	70.8	56.2	79.3	67.9	88.2	56.6	80.3	82.8	89.9
RHA 265	42.8	73.7	59.3	82.6	66.7	80.3	64.2	91.8	89.0	77.1
Mean	29.9	59.6	50.8	72.2	56.7	75.9	53.3	79.4	89.9	90.8
Mean over seasons	44.8		61.5		66.3		66.4		90.4	
Hybrids:										
CMS 234B × RHA 274	4.5	75.7	63.0	75.3	71.0	76.7	6.3	98.4	88.6	98.1
CMS 234B × RHA 801	8.7	54.9	73.2	79.6	76.4	78.9	11.5	84.0	95.9	100.8
CMS 234B × PR-1	23.4	77.3	74.1	83.1	81.4	91.2	28.7	84.8	91.2	91.2
CMS 234B × RHA 265	4.8	72.6	51.4	89.7	76.1	91.2	6.3	79.7	67.0	98.4
F-97B × RHA 274	3.8	47.3	49.9	81.9	53.8	88.1	7.0	53.7	92.7	93.0
F-97B × RHA 801	3.8	56.9	35.2	73.2	52.7	70.8	7.2	80.4	66.8	103.3
F-97B × PR-1	5.0	54.8	40.3	86.7	70.3	92.5	7.1	59.3	57.4	93.7
CMS 234B × RHA 265	25.1	62.8	68.3	9.4	64.9	86.4	38.7	72.8	105.2	105.9
Mean	9.9	62.8	56.9	72.4	68.3	84.5	14.1	76.6	83.1	98.1
Mean over seasons	36.4		64.7		76.4		45.4		90.6	
Populations:										
EC 68415	1.4	17.1	33.4	42.9	74.0	79.0	1.9	21.7	45.1	54.4
Morden	0.7	24.6	8.5	46.0	66.9	86.2	1.1	28.6	12.7	53.3
CGP-1	3.8	28.8	30.4	78.2	69.4	81.9	5.5	35.2	43.8	95.6
Surya	1.2	11.6	7.6	82.0	65.4	85.8	1.8	13.6	11.7	95.6
Mean	1.8	20.5	20.0	62.3	68.9	83.2	2.6	24.8	28.3	74.7
Mean over seasons	11.2		41.2		76.1		13.7		51.5	

	Genotypes (G)		Pollinations (P)		G × P		Genotypes		Genotypes	
	monsoon	summer	monsoon	summer	monsoon	summer	monsoon	summer	monsoon	summer
SEm	0.4	0.5	0.2	0.3	0.3	1.1	1.1	1.7	2.5	1.5
CD, 5%	1.0	1.3	0.5	0.7	2.3	3.0	3.1	4.7	6.9	4.1
CD, 1%	1.3	1.8	0.7	0.9	3.0	3.9	4.1	6.4	9.1	5.3

Similar to seed set, the genotypes recorded highest autogamy in summer (Table 2). Autogamy over seasons was highest for inbreds (66.4%), followed by hybrids (45.4%) and populations (13.7%). The estimates of self-compatibility in monsoon and summer season differed significantly for majority of hybrids and populations. Inbreds and hybrids were on par for mean self-compatibility over seasons and differed significantly from populations.

DISCUSSION

One of the important constraints limiting productivity in sunflower since its introduction in 1969 is the high percentage of empty and partially filled seeds. Seed set in sunflower is a complex phenomenon and several workers ascribed it to nutrition, self- or cross-compatibility, pollination, competition among developing seeds, temperature, relative humidity, location and seasonal influence [3, 5, 10, 11]. Seed filling problem often assumes serious dimension in monsoon season when the peak flowering phase coincides with heavy rains, resulting in pollen wash out and/or low pollinator activity. Under such situations the self-fertile populations/hybrids assume great importance [12].

There was significant influence of season on genotypes, as summer season favoured higher seed yield and better seed filling in comparison to monsoon. Significant reduction in seed yield and number of filled seeds, particularly during monsoon, in the heads covered with cloth bags may be attributed to higher relative humidity, low temperature, lower intensity of solar radiation, and poor pollen movement inside the cloth bags. Based on mean seed yield and seed filling over seasons it may be concluded that hybrids are more self-compatible than inbreds and populations. These results support the earlier reports [4, 5, 12]. Line CMS 234 is more self-compatible than F-97. Amongst restorers, RHA 265 was comparatively more self-fertile than all others. Two hybrids, F-97 × RHA 265 and CMS 234 × PR-1, appeared to be promising for self-compatibility. Among the four populations, CGP-1 was more self-compatible.

Seed set (Table 2), determined as percentage of filled seeds out of total seeds, has been used to assess self-compatibility of genotypes [9]. The results with this parameter also confirm the superiority of hybrids over inbreds and populations for self-compatibility in both seasons. Besides, the data further supported higher self-compatibility of CMS 234, RHA 265, CMS 234 × PR-1, F-97 × RHA 265, and CGP-1.

Although a genotype is considered as self-fertile if it sets seed under bagging, George et al. [9] pointed out that this procedure does not ensure potential self-pollination in some genotypes which, however, can be achieved by manual self-pollination, therefore, the latter method should be included in self-compatibility studies. Hence, they estimated self-compatibility as the ratio between seed set under manual self-pollination and open pollination. In the present study, estimates of self-compatibility of genotypes (Table 2) revealed some interesting facts. The genotypes with low autogamy recorded higher self-compatibility. Thus, autogamy does not reflect self-compatibility. George et al. [9] also obtained similar results. The simple correlation coefficient calculated between these two parameters was very low and nonsignificant. It is also evident that even an incompatible genotype can exhibit higher self-compatibility under induced pollination [3]. As reported earlier, self-pollination in the covered heads was ensured in this study by hand pollination eight times uniformly during peak flowering to ensure that all the florets in the capitulum had equal opportunity to receive pollen for fertilization. This may be the main reason for more than 100% self-compatibility recorded in some of the genotypes and crosses, viz., CMS 234B, RHA 274, RHA 801, CMS 234 × RHA 801, F-97 × RHA 274, and F-97 × RHA 265. In these genotypes, the seed set was higher under bagging + hand pollination than under open-pollination. The seed set under open pollination is mainly determined by the activity of insect pollinators, particularly honey bees. George and Shein [13] attributed variable seed set to bee attractiveness among the hybrids. The differencs may be probably due to difference in nectar quantity, quality, and availability. According to these authors, even under marginal bee activity, an attractive hybrid may outyield a less attractive type though self-compatibility and autogamous pollination levels are similar in both. In the present study, even the varietal populations, (CGP-1 and Surya) recorded 95.6% self-compatibility during summer. The populations had lower self-compatibility in monsoon season, but some hybrids and inbreds had greater autogamy and self-compatibility which may be attributed to a relatively higher level of autogamous pollination.

In the sunflower growing countries of the temperate region, seed set is not a serious problem as hybrids are cultivated. Nevertheless, even in those countries, breeders lay considerable emphasis on selecting self-fertile hybrids. According to Roath and Miller [6], the ability of a hybrid to set adequate seed under all conditions is important, particularly in areas of marginal bee activity. In India, the low productivity of sunflower (less than 6 q/ha) may be attributed to large scale cultivation of populations with low level of self-compatibility, as is evident from the present study. Hence in sunflower breeding programmes, greater emphasis should be laid on evaluating the genotypes for self-compatibility. For the development of populations, highly self-compatible lines with uniform plant height and flowering, high seed yield and oil content should be utilised. This may further enable us to accumulate self-compatible genes in the population. In heterosis breeding also, it is desirable to evaluate the inbred lines for self-compatibility, as it ultimately influences self-compatibility in the hybrids as well.

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REFERENCES

1. E. C. H. Habura. 1957. Parasterilitatbei Sonnenblumen. Z. Pflanzenzuchtg., **37:** 280–298.
2. I. G. Ivanov. 1975. Study on compatibility and incompatibility display in crossing selfed sunflower lines. Rastenievod. Nauk., **12:** 30–35.

3. A. V. Vranceanu, F. M. Stoenescu and A. Scarlet. 1978. The influence of different genetic and environmental factors on pollen self-compatibility in sunflower. Proc. 8th Intern. Sunflower Conf., Minneapolis, USA: 453–465.

4. R. G. Robinson. 1980. Artifact autogamy in sunflower. Crop Sci., **20:** 814–815.

5. S. K. Chaudhary and I. J. Anand. 1981. Seasonal influence on seed filling in sunflower. Proc. 4th Intern. SABRAO Congr., Kaula-Lumpur: 22–24.

6. W. W. Roath and J. F. Miller. 1982. Environmental effects on seed set in oilseed sunflower (*Helianthus annuus* L.). Canad. J. Pl. Sci., **62:** 867-873.

7. D. L. George, S. E. Shein and P. F. Knowles. 1982. Effect of isolation bags on seed set in sunflower. Proc. 10th Intern. Sunflower Conf., Queensland, Australia: 224–225.

8. D. L. George, S. E. Shein and P. F. Knowles. 1982. Effect of stigmatic manipulation on pollination and seed set in sunflower. Proc. 10th Intern. Sunflower Conf., Queensland, Australia: 226–227.

9. D. L. George, S. E. Shein and P. F. Knowles. 1980. Compatibility, autogamy and environmental effects on seed set in selected sunflower hybrids and their inbred parents. Abstr. 9th Intern. Sunflower Conf., Malaga, Spain: 14.

10. K. R, Khanna. 1972. Factors affecting the production of filled seeds in sunflower. Euphytica, **21:** 384–387.

11. A. Seetharam. 1982. Strategy for improving sunflower production in India. Proc. 20th All India Convention of Oilseeds and Oils Trade and Industry, ICAR, New Delhi: 53–59.

12. N. Shivaraju, K. Giriraj, Shanta R. Hiremath and A. Seetharam. 1987. Autogamy in sunflower. J. Oilseeds Res., **4:** 292–294.

13. D. L. George and S. E. Shein. 1980. Effect of pollination and compatibility on seed set. The Sunflower., May/June: 12–14.