

Effect of Different Modes of Pollination in Sunflower (*Helianthus annuus* L.) Hybrid Seed Production

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ABSTRACT

A field experiment to study the effect of different modes of pollination in hybrid (RSFH 1887) seed production of sunflower (*Helianthus annuus* L.) was carried out at Main Agricultural Research Station, UAS, Raichur during *rabi* 2020-21. The experiment was laid out in randomized complete block design in three replications with seven treatments. Study recorded maximum hybrid seed production traits *viz.*, yield (1284.25kg / ha & 1245.75 kg / ha), test weight (8.64 g and 8.32 g), kernel percentage (76.21 and 75.97), shoot length (12.09 cm and 11.59 cm), root length (20.53 cm and 19.73 cm), seed vigour index (1229.20 and 1178.40) in the treatment, hand + open pollinated sunflower heads followed by the crop pollinated with three colonies of *Apis cerana* F. per acre, respectively. However, the highest oil content (36.85%) and benefit cost ratio (2.22) was recorded in plot treated with three colonies of *Apis cerana* F. per acre, compared to hand + open pollinated plot.

Keywords : Sunflower, Hybrid seed production, *Apis cerana* F., Seed yield, Oil content

SUNFLOWER (*Helianthus annuus* L.) is one of the important annual oilseed crops widely grown in Karnataka and is ranked first among different oilseed crops in terms of area (1.89 lakh ha) and production (0.99 lakh tonnes) in the country. During 2017-18, the area under sunflower cultivation in India was 2.86 lakh ha with a total annual production of 2.11 lakh tonnes and productivity of 738 kg/ha (Anonymous, 2019).

Being an allogamic plant sunflower requires external agency for pollination such as honeybees or mechanical means during flowering, especially for seed production. Wind plays a minor role in pollen transfer from one plant to the other, as pollen grains of sunflower are heavy and sticky in nature (Furgula, 1954 and Free, 1963). Therefore, pollen is transferred from male lines to female lines by either insects or through mechanical way such as hand pollination. Earlier studies suggested that sunflower heads foraged by honey bees resulted higher seed set (Parker, 1981 and Paiva *et al.*, 2002).

Hence, the study was conducted to determine the pollination efficiency of honeybee species, *Apis cerana* and other modes of pollination in general,

and hand pollination in particular on qualitative and quantitative seed characters in sunflower hybrid (RSFH 1887) seed production at MARS, UAS, Raichur.

MATERIAL AND METHODS

Field experiment was conducted during *rabi* 2020-21 at the Main Agricultural Research Station, UAS, Raichur (16°12' N altitude, 77°20' E longitude, 389 m above mean sea level) in a black soil with 511 kg / ha available nitrogen, 46.48 kg / ha available phosphorus, 236.32 kg / ha available potassium and 0.93 organic carbon.

The cytoplasmic male sterile line, CMS 38A and fertility restorer line, R 127-1 were used as the parent in this study. The CMS 38A and restorer line R 127-1 were developed by the AICRP-Sunflower, MARS, UAS, Raichur. The R 127-1 lines were sown on 08.11.2020 and CMS 38A lines were sown on 11.11.2020 in the ratio of 3 : 1 in three replications with seven treatments *viz.*, T1: Two colonies of *Apis cerana* / acre, T2: Three colonies of *A. cerana* /acre, T3: Four colonies of *A. cerana* / acre, T4: Hand pollination, T5: Open

pollination, T6: Hand + open pollination and T7: Control (Bagged condition). The sunflower crop was raised with all recommended agronomic package of practices including plant protection measures. The following qualitative and quantitative parameters were recorded and analyzed by using RCBD statistical method.

Per cent seed filling : The total number of filled and unfilled seeds was counted from ten randomly tagged sunflower heads after the harvest in each treatment. The ratio of number of filled seeds to the total number of seeds per head was expressed in percent.

Test weight : Hundred filled seeds were separated from harvested, ten randomly tagged sunflower heads in all treatments under each replication and its mean weight was expressed in grams.

Volume weight : Hundred ml of filled seeds were collected from ten plants from each hybrid in all replications under each treatment and its mean weight was expressed in g /100 ml.

K/H Ratio, Husk and Kernel per cent : Hundred seeds were manually dehusked from harvested, ten randomly tagged sunflower head in all treatments in

each replications. The weight of kernel and husk was determined and used to calculate the husk percentage, kernel percentage and kernel to husk ratio.

Total seeds and weight : In each treatment, total number of filled and unfilled seeds from the randomly tagged ten sunflower heads were manually counted and expressed in percent filled seeds. The 100 seed weight was taken by using an electronic balance and expressed in grams.

Germination per cent : The 100 seeds were placed on moist blotting paper placed in Petri plates and kept for observation. The germination counts were taken after five days and per cent seed germination was computed.

Seed vigour Index : It was calculated by using the following formula,

$$VI = RL + SL \times GP$$

where in RL=Root length; SL=Shoot length and GP=Germination percentage

Per cent oil content : The oil content of filled 100 seeds from all treatments in each replication was



Plate 1: General view of the experiment and different treatments

estimated by using NMR at AICRP (Sunflower), MARS, UAS, Raichur. The oil content was expressed in percentage (%).

Benefit cost ratio : BC ratio of all the treatments in each replication was calculated by dividing gross returns with cost of cultivation / expenditure.

RESULTS AND DISCUSSION

The maximum sunflower hybrid seed yield was recorded in the plots of hand + open pollinated sunflower heads (1284.25 kg / ha), followed by the plots exposed with four colonies of *A. cerana* per acre (1258.12 kg / ha), three colonies (1245.75 kg / ha), two colonies (1130.25 kg / ha), hand pollination (1128.88 kg / ha) which are statistically on par with each other. Significantly lowest hybrid seed yield was recorded in control (114.13 kg / ha) and in open pollinated plot (508.67 kg / ha) compared to other treatments (Table 1). The present findings are in agreement with the study conducted by Patil (2013) who reported that, sunflower crop with four honey bee colonies / acre produced highest seed yield (2550 kg / ha) and was on par with three colonies per acre (2353 kg / ha) and two colonies per acre (2139 kg / ha). The sunflower without honey bee colony, recorded lowest seed yield (1517 kg / ha). Thus, there was an

increase in the seed yield to the extent of 27 to 68 per cent over control due to pollination by bees.

Maximum per cent filled seeds (96.81) was obtained in three colonies of *A. cerana* per acre followed by two colonies of *A. cerana* (96.88), hand + open pollinated (96.13), four colonies of *A. cerana* per acre (95.90), hand pollination (95.85) which were on par with each other. Significantly lowest percent filled seeds was recorded in open pollination (75.83) and no seed set was recorded in control. The findings are in agreement with the results of Mehmet *et al.* (2009) who reported from Turkey that, the use of honeybees for sunflower hybrid seed production improve seed ratio, 1000 seed weight, number of filled seed per head and seed yield per head. The study conducted by Rao *et al.* (1995) also showed that, seed set was higher in insect pollinated sunflower when compared to hand pollinated plants. Similar results were also reported by Rajagopal *et al.* (1999) who recorded greatest seed weight (25.42 g / head) in honeybee pollinated plots followed by hand and bee pollinated (24.73 g / head), other pollinators (13.59 g / head) and exclusively hand pollinated (12.98 g / head) plots in the female parent.

The maximum per cent filled seeds were recorded in the plots caged with three colonies of *A. cerana* per

TABLE 1

Effect of different pollination conditions on hybrid seed yield and yield attributing characters of RSFH 1887

Treatments	Seed yield (kg/ha)	Per cent filled seeds	Test weight (g)	Volume weight (g/100ml)	Kernel (%)	Husk (%)	K:H ratio
T1: 2 colonies of <i>Apis cerana</i> / acre	1130.25 ^c	96.22 ^c	8.08 ^{cd}	45.33 ^c	74.33 ^c	25.67 ^b	2.89 ^c
T2: 3 colonies of <i>Apis cerana</i> / acre	1245.75 ^c	96.81 ^c	8.32 ^{cd}	47.33 ^d	75.97 ^c	24.03 ^a	3.16 ^c
T3: 4 colonies of <i>Apis cerana</i> / acre	1258.12 ^c	95.90 ^c	8.05 ^{cd}	46.66 ^{cd}	75.59 ^c	24.41 ^{ab}	3.09 ^c
T4: Hand pollination	1128.88 ^c	95.85 ^c	7.55 ^c	45.00 ^c	74.81 ^c	25.19 ^{ab}	2.96 ^c
T5: Open pollination	508.67 ^b	75.83 ^b	6.13 ^b	29.67 ^b	65.64 ^b	34.36 ^c	1.91 ^b
T6: Hand + open pollination	1284.25 ^c	96.13 ^c	8.64 ^d	48.00 ^d	76.21 ^c	23.73 ^a	3.21 ^c
T7: Control	114.13 ^a	0.00 ^a	0.97 ^a	9.00 ^a	0 ^a	100 ^d	0 ^a
Mean	952.86	79.53	6.82	38.71	64.33	35.17	2.48
CD at 5%	326.26	5.38	0.81	1.97	3.96	1.46	0.32
Sem±	105.88	1.75	0.26	0.64	1.28	0.47	0.10



Plate 2: Experimental plot visited by RAWE students and Scientist

acre (96.81%) followed by two colonies of *A. cerana* per acre (96.22%), hand + open pollinated sunflower heads (96.13%), four colonies of *A. cerana* per acre (95.90%), hand pollinated sunflower heads (95.85%). The per cent filled seeds recorded in untreated plots were nil (0%) and was significantly lowest compared to open pollinated sunflower heads (75.83%) (Fig.1 & Table 1). The findings of present study are similar with that of Mehmet *et al.* (2009) that recorded significantly highest filled seeds per head (1136) in crop caged with bees compared to hand pollination (1015 filled seeds /head), while only 68 filled seeds per head were recorded in cages without bees.

Significantly maximum (8.64 g) test weight of seeds was recorded in the plots of hand + open pollinated heads and lowest test weight of seeds was recorded in the sunflower heads obtained from control plots (0.97 g) followed by hand pollinated heads (6.13 g). The test weight of seeds obtained from the plots caged with three colonies of *A. cerana* per acre (8.32 g), two colonies of *A. cerana* per acre (8.08 g) and four colonies of *A. cerana* per acre (8.05 g) were statistically on par with each other (Table 1). These results were similar with findings of Mehmet *et al.* (2009) that recorded significantly highest 100 seed

weight in crop caged with bees (6.08 g) and hand pollination (5.96 g) compared with crop caged without bees (1.68 g). Kumar and Singh (2003) recorded highest 1000 seed weight in hand + insect pollinated sunflower heads compared to that of heads pollinated by all insects.

The volume weight of hybrid seeds was significantly highest in the plots of hand + open pollinated sunflower heads (48.00 g) followed by the plots caged with three colonies of *A. cerana* per acre (47.33g), four colonies of *A. cerana* per acre (46.66g) compared with other treatments (Table 1). The significantly lowest volume weight of hybrid seeds was recorded in the sunflower heads obtained in the control (9.00 g) and in the plots of open pollinated sunflower heads (29.67 g). Devaramane (2018) evaluated different modes of pollination in three sunflower hybrids *i.e.*, KBSH 41, KBSH 44 and KBSH 53, the results revealed that, weight of hundred ml seeds (volume weight) in all the three hybrids was significantly higher in open pollinated condition followed by hand pollinated condition and when crop was enclosed with *A. cerana* colony, which were all on par with each other and significantly lowest volume weight was recorded when capitula were kept in bagged condition.

Highest kernel percentage (76.21%) was recorded in the plots of hand + open pollinated sunflower heads followed by plots caged with three colonies of *A. cerana* per acre (75.97%), four colonies of *A. cerana* per acre (75.59%), hand pollinated heads (74.81%) and two colonies of *A. cerana* per acre (74.33%) which were on par with each other. Significantly lowest kernel percentage was recorded in the plots of open pollinated sunflower heads (65.64%) and the heads obtained in the plots of control (0.0%) compared with other treatments. The lowest husk percentage (23.73%) was recorded in the plots of hand + open pollinated sunflower heads, followed by the plots caged with three colonies of *A. cerana* per acre (24.03%), four colonies of *A. cerana* per acre (24.41%) and hand pollinated sunflower heads (25.19%) which were on par with each other. Significantly highest husk percentage was recorded in the plots of control (100%) and open pollinated

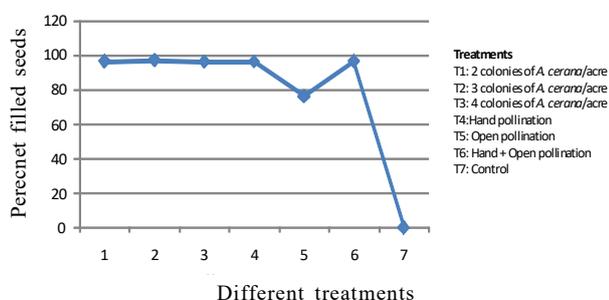


Fig.1: Percent increase in filled seeds over control in different treatments



Plate 3: Measurement of shoot and root length

sunflower heads (34.46%) compared with other treatments (Table 1).

Highest kernel to husk ratio was recorded in the plots of hand + open pollinated sunflower heads (3.21) followed by the plots caged with three colonies of *A. cerana* per acre (3.16), four colonies of *A. cerana* per acre (3.09), hand pollinated heads (2.96) and two colonies *A. cerana* per acre (2.89) which were on par with each other and significantly lowest kernel to husk ratio was recorded in the heads obtained from control (0.00) and open pollinated plots (1.91).

The hundred per cent hybrid seed germination was recorded in the plots caged with three colonies of *A. cerana* per acre, followed by hand pollinated

sunflower heads, open + hand pollinated heads. The plots caged with two colonies of *A. cerana* per acre (98.67%) and four colonies of *A. cerana* colonies per acre (98%) were on par with each other. The hybrid seed germination was zero in the seeds obtained from the heads of control plots compared to that of open pollinated plots (80.67%) (Table 2). The present results are endorsed with the findings of Rajasri *et al.* (2012) who reported significantly highest germination in hybrid sunflower seed obtained from honeybee pollination coupled with hand pollination (99%), followed by open pollination (96%) and bee pollination (95%), compared to control plot without bees (93%).

Significantly maximum shoot length was recorded in the seeds obtained from open + hand pollinated heads (12.09 cm) followed by three colonies of *A. cerana* per acre (11.59 cm), four colonies of *A. cerana* per acre (11.15 cm), two colonies of *A. cerana* per acre (11.14 cm). The shoot length was significantly lowest in the open pollinated crop (10.11 cm) and number of filled seeds obtained in the plots of control was zero and hence the germination and shoot length was nill in untreated plots. Highest root length was recorded in the seeds obtained from the plots of open + hand pollinated heads (20.53 cm) which is on par with all the treatments with the exception of the root length

TABLE 2

Effect of different pollination conditions on seed quality and its associated parameters of sunflower hybrid seed (RSFH 1887)

Treatments	Germination (%)	Shoot length (cm)	Root length (cm)	Seed vigour index	Oil Content (%)
T1: 2 colonies of <i>Apis cerana</i> / acre	98.67 ^c	11.14 ^d	19.27 ^c	1118.60 ^c	35.80 ^c
T2: 3 colonies of <i>Apis cerana</i> / acre	100.00 ^c	11.59 ^e	19.73 ^c	1178.40 ^d	36.85 ^c
T3: 4 colonies of <i>Apis cerana</i> / acre	98.00 ^c	11.15 ^d	19.47 ^c	1108.39 ^c	36.02 ^c
T4: Hand pollination	100.00 ^c	10.63 ^c	18.27 ^{bc}	1081.60 ^c	35.59 ^c
T5: Open pollination	80.67 ^b	10.11 ^b	16.63 ^b	831.78 ^b	25.03 ^b
T6: Hand + open pollination	100.00 ^c	12.09 ^f	20.53 ^c	1229.20 ^e	36.74 ^c
T7: Control	0.00 ^a	0.00 ^a	0.00 ^a	0.00 ^a	10.37 ^a
Mean	82.48	9.53	16.27	935.42	30.92
CD at 5%	2.54	0.41	2.27	39.93	1.68
Sem±	0.82	0.13	0.74	12.96	0.55

obtained from the seeds of open pollinated heads (Table 2). The results of the present study are in agreement with the findings of Rajasri *et al.* (2012) who recorded the highest root length, shoot length and seedling vigour index in the seeds obtained from plots pollinated by bees + hand pollination (10.5 cm, 16.1 cm and 2614) compared with that of open pollination (10.2 cm, 14.27 cm and 2346), four frame honey bee colony (9.2 cm, 15.1 cm and 2351), eight frame honey bee colony (9.8 cm, 15.6 cm and 2456) and crop covered by net without bees (9.1 cm, 15.37 cm and 2320), respectively.

Significantly maximum seedling vigour index was recorded in the seeds of hand + open pollinated sunflower heads (1229.2) followed by the plots caged with three colonies of *A. cerana* per acre (1178.4) compared with other treatments. Statistically lowest seed vigour was recorded in the seeds of open pollinated heads (831.78) (Table 2). Results of present study are similar to the findings of Lingappa *et al.* (1999) which also recorded increased seedling vigour of safflower due to bee pollination. Maximum oil content was recorded in the seeds obtained from the plots caged with three colonies of *A. cerana* per acre (36.85%) which was on par with the oil content of seeds obtained from open + hand pollinated heads (36.74%), four colonies of *A. cerana* per acre (36.02%), two colonies of *A. cerana* per acre (35.8%), hand pollinated heads (35.59%). Significantly lowest oil content was recorded in the seeds obtained from

control plots (10.37%) followed by the oil content obtained from open pollinated heads (25.03%) (Table 2). These findings are in confirmity with the findings of Rajagopal *et al.* (1999) which also recorded greatest filled grain percentage (92.95%) and oil content (53.10%) in bee pollinated plots. Further, Rajasri *et al.* (2012) also recorded highest oil content with the honey bee + hand pollinated heads (39.6%) followed by 8 frame honeybee colony (37.1%), four frame honeybee colony (36.7%), compared to open pollination (35.6%) and control plot without bees (31.6%).

Gross returns recorded was maximum in hand + open pollinated heads (Rs.1,28,425.33) followed by the plot caged with four colonies of *A. cerana* per acre (Rs.1,25,812.33), three colonies of *A. cerana* per acre (Rs.1,24,575.33) and two colonies of *A. cerana* per acre (Rs.1,13,025) which were on par with each other. Lowest gross returns was recorded with control plots (Rs.11,413) followed by open pollinated plots (Rs.50,866.67). The highest net returns was recorded in the plots of hand + open pollinated heads (Rs.68,675.33) followed by the plots caged with three colonies of *A. cerana* per acre (Rs.68,575.33), four colonies of *A. cerana* per acre (Rs.64,812.33), two colonies of *A. cerana* per acre (Rs.62,025) and hand pollinated plots (Rs.53,137.67) which were on par with each other. The negative net returns were recorded with control plots (Rs.-29,587) and lowest net return was recorded in the open pollinated plots

TABLE 3

Cost economics of different pollination modes in seed production of sunflower hybrid (RSFH-1887)

Treatments	Expenditure (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T1: 2colonies of Apis cerana / acre	51000	113025.00	62025.00	2.21
T2: 3 colonies of Apis cerana / acre	56000	124575.33	68575.33	2.22
T3: 4 colonies of Apis cerana / acre	61000	125812.33	64812.33	2.06
T4: Hand pollination	59750	112887.67	53137.67	1.89
T5: Open pollination	41000	50866.67	9866.67	1.23
T6: Hand + open pollination	59750	128425.33	68675.33	2.15
T7: Control	41000	11413.00	-29587.00	0.28
Mean		95286.48	42500.76	1.72

(Rs.9,866.67). The highest cost benefit ratio was recorded in the plots caged with three *A. cerana* colonies per acre (2.22) (Table 3). Singh (2020) reported that, farmers using honeybees for crop pollination got a net profit of Rs.34,620 / ha with an investment of Rs.17,480 / ha with B:C ratio of 2.98.

The effect of honeybee pollination in sunflower hybrid RSFH 1887 seed production using two, three, four colonies of *A. cerana* were compared with hand pollination, hand + open pollination. The hand + open pollination was very effective in the production of highest quantity and good quality of sunflower (RSFH 1887) hybrid seeds. The plots cages with three colonies of *A. cerana* per acre increased the oil content in the seeds with maximum benefit cost ratio. In this study also higher net returns was obtained in hand + open pollinated treatment. However, as the availability of labourers for agriculture operation (hand pollination) is limited, minimum of three colonies of *A. cerana* per acre can be recommended for obtaining optimum seed yield of sunflower hybrid RSFH 1887.

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