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Pollinators diversity and pollination effects on yield attributes of sunflower (*Helianthus annuus* Linnaeus) in Odisha, India

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ABSTRACT: In the study on the diversity of pollinators and their pollination efficiency in sunflower (*Helianthus annuus* L.) under field condition of Odisha during 2021-22, recorded 18 species of pollinators. Indian honeybee, *Apis cerana indica* F. (Hymenoptera, Apidae) was found to be the major one among the insect pollinators. The experiment conducted for two years with three different treatments *viz*., open pollination (OP), managed *A. cerana indica* pollination (HB) and pollinator exclusion (PE) for better yield and quality revealed that both quantitative and qualitative parameters were significantly higher in OP sunflower crops followed by crops pollinated by *A. cerana indica.* Significantly higher seed yield, 1000 seed weight, percentage of seed filling and number of seed per capitulum were recorded in these treatments. These findings indicate OP and HB increase 33 per cent more yield in sunflower.

KEY WORDS: Species, *Apis cerana indica*, open pollination, seed yield, seed filling, capitulum

INTRODUCTION

Healthy population of pollinators is essential to maintain biodiversity and healthy natural ecosystems. They are vital for the pollination of cultivated plants including agricultural crops and horticultural plants. Furthermore, the plants and wildlife supported directly and indirectly through diversity of pollinators and provide other ecosystem services. Sunflower (*Helianthus annuus* L.) is an important edible oilseed crop, being a diploid having chromosome number, 2n = 34 belong to the family Asteraceae (Compositae). Presently, sunflower is cultivated in India in an area of 2.240 lakh ha with

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a production of 2.045 lakh tonnes and yield of 913 kg ha^{-1} (Directorate of Oilseed Development, 2020). The crop is having desirable attributes such as short photoperiod insensitivity, duration, drought tolerance, low seed rate, high multiplication ratio, and highquality edible oil having high degree of polyunsaturated fatty acid content for which it has been grown in large by farmers. It is highly essential to enhance the productivity of oilseed crops like sunflower to bridge the gap of edible oil availability and demand. Improper pollination is a reason for poor seed set and filling (Free *et al.*, 1964; Seetharam *et al.*, 1976) where as Seetharam and Kusuma Kumari (1974) has shown shorter pollen viability as the constraint of poor seed setting. Inadequacy of pollinators and their activity to pollinate all the florets in sunflower capitulum is the major cause for poor seed setting in sunflower. The problem of poor seed setting is mostly due to lack of sufficient number of pollinators and their activity in field conditions (Seetharam *et al.,* 1976 and Singh *et al.*, 1977). Therefore, it is essential to know the possibility of utilization of honey bee colonies for the purpose of hybrid seed production in Odisha ecosystem. Therefore, this study was undertaken.

MATERIALS AND METHODS

The present study was undertaken during two cropping seasons *i.e.* first season (September-December, 2021) and second season (January-April, 2022) in the Experimental Station of Entomology located in the upland area of Experimental Research Field, M.S. Swaminathan School of Agriculture, Paralakhemundi, Centurion University of Technology and Management, Odisha.

The seeds of HYV sunflower cv. HY SUNFLOWER MSFH-17 were sown during 20th September, 2021 and 13th of January of Rabi 2022. The inter and intra row spacing were maintained at 45 cm and 25 cm respectively and the plot size of 4 m×5 m was maintained. A recommended dose of N_2: P_2O_5: K_2O at 120:60:60 kg ha^{-1} was applied. Necessary agronomic practices were followed to maintain proper plant population and normal growth of plants. A prophylactic spraying of the insecticide Profenophos @ 2ml L^{-1} against the infestation of early season pests at 15 and 30 days after sowing prior to onset of flowering was implemented to keep the crop away from pest and diseases infestation. The experiments were held in Randomized Block Design with three treatments replicated seven times. The performance of pollinators assessed by comparing the yields of Open Pollination (OP), *Apis cerana indica* pollination (HB) and Pollinator Exclusion (PE) treatments. The OP treatments were allowed for open pollination of the flowers without any restriction. The HB treatments were restricted with pollination of sunflowers only with managed *A. cerana indica* colonies inside the replications. The PE treatments were restricted completely from pollinators to prevent pollination by the pollinators.

Keen observation on OP treatments was taken during flowering period of sunflower where diversity of pollinators was recorded. The identification of insects was done from a large number of samples by following fixed plot survey in selected experimental sites. The collected adult insects were killed and dry preserved in the laboratory of Department of Entomology, MSSSoA (Borror *et al.*, 1981) and identified referring the identified specimen maintained in collections of AICRP on Honeybees and pollinators, Odisha University of Agriculture and Technology, Bhubaneswar. The common name, scientific name, family, order, habitat of the specimens were recorded with their foraging behaviour.

The observations on effect of the pollinators on yield attributing characters of sunflower crop *viz*., plant height (cm), disc diameter (cm), number of seeds per capitulum, thousand (1000) seed weight (g), seed yield of plots (kg ha^{-1}), oil content (%) and germination (%) of sunflower were recorded. The heights and disc diameters were counted by measuring tape. The number of seeds per capitulum and germination percentage was counted manually. For analyzing the 1000 seed weight, the mechanical device was used followed by weighing in weighing balance. The oil content was analyzed by Soxhlet extraction method. After getting the value in ml they were converted to percentage value for proper value representation.

RESULTS AND DISCUSSION

The results of the study revealed that the activity of different pollinators started at 10 per cent flowering stage coinciding with 45 DAS and the activity continued till the late flowering stage i.e. 84 DAS in the first season, whereas pollinators started arriving at 10 per cent flowering stage coinciding with 48 DAS and the activity continued till the late flowering stage *i.e.* 88 DAS in the second season. A great majority of sunflower plants flowered between 65 DAS to 80 DAS and the diversified activities of pollinators mostly observed during the period were recorded. Studies on pollinator diversity during both the seasons at different locations of Gajapati District, Odisha, revealed that the crop was visited by 18 types of pollinators belonging to order Hymenoptera and Lepidoptera (Apidae 66%, Nymphalidae 21%, Crambidae 7% and piridae 6%). Hymenopterans were the dominant pollinators. Adult lepidopteran pollinators also visited the plants to fulfill their dietary nectar requirement.

Stray populations of ants and true flies were also observed visiting the sunflower for their dietary requirements. The pollinators include, rock bees (*Apis dorsata*), Indian honeybees (*Apis cerana indica*), European bees (*A. mellifera*), little bees (*A. florea*), stingless bee (*Tetragonula iridipennis*), two species of carpenter bee (*Xylocopa latipes* and *X. aestuans*), digger bee (*Amegilla zonata*), two species under family vespidae *i.e.* Oriental hornet (*Vespa orientalis*) and a wasp species (*V. tropica*). Apart from the hymenopteran pollinators, some lepidopteran pollinators were also found visiting sunflower flowers. The butterflies *viz*., tawny coster (*Acraea terpsicore*), common crow (*Euploea core*), grey pansy (*Junonia atlites*), blue glassy tiger (*Idiopsis vulgaris*), plain tiger (*Danaus chrysippus*), lemon pansy (*Junonia lemonias*), common/lemon emigrant (*Catopsilia pomona*), and cucumber moth (*Diaphania indica*), were recorded during the present investigation. Similarly major pollinators observed by Nayak *et al.* (2021) in Odisha were two honey bee species (*Apis dorsata* and *A. cerana indica*) and one Carpenter bee (*Xylocopa* sp) associated with sunflower crop. Similar observations were recorded by Yasmeen *et al.* (2021) in Tamil Nadu found a total of eight species of pollinators (*Apis mellifera* Linnaeus, *A. dorsata*, *A. cerana indica* F., *Trigona iridipennis* Smith, *Vespa tropica* L. and a Hesperidae species).

Effect of pollination treatments on different yield attributing characters of sunflowers analyzed by imposing OP, HB and PE condition over two seasons revealed significant results (Table 1). The number of seeds per capitulum of sunflower showed significant variation among the treatments. The number of seeds per capitulum was maximum in the OP (398.11) followed by HB (371.71) and it was low in the PE (358.98). There was an overall increase of 10.90 per cent in OP and 3.54 per cent in HB against PE. Hemanth Kumar *et al.* (2020) also reported similar findings.

Similarly, the percentage of seed filling was highest in OP (92.98%) followed by HB (89.18%) and PE (86.71%) leaving the central area unfilled. An overall increase of 7.23 per cent in OP and 2.85 per cent in bee pollination against pollination exclusion plot was recorded. The 1000 seed weight of sunflower showed significantly higher variation among the treatments. The seed weight of 1000 seeds were more in the OP plot (53.42g) followed by the HB plot (51.48g) and PE plot (45.40g). An overall increase of 17.66 per cent in OP and 13.37 per cent in HB against PE was recorded. Similar observations were recorded by Hemanth Kumar *et al.* (2020) and he has revealed that Open pollinated sunflower recorded significantly higher seed index (100 seed weight) (5.82g) which was at par with sunflower pollinated with *A. cerana indica* (5.62g) and the lowest was reported from sunflower enclosed to avoid pollinators (5.27g). Similarly, Mehmood *et al.* (2018) revealed that weight of 100 seeds was maximum in case of open pollinated heads (5.04g) followed by *A. mellifera* pollination (4.63g). Likewise, Basavaraj *et al.* (2016) revealed that seed index was higher in unbagged plants of DRSF-108 (7.77g/ 100 seeds) as compared to the bagged ones (5.07g/100 seeds).

The seed yield of sunflower during both the seasons showed significantly higher variation among the treatments. OP recorded highest yield (1735.06 kg

Table 1. Effect of pollination treatments on different parameters of sunflower in both the seasons

Parameters	Year/ Treatment	Open Pollination	Bee pollination	Pollination exclusion	SE (m)±	CD (0.05)
Plant height (cm)	2021	104.62	102.99	102.48	0.67	NS
	2022	107.21	105.12	104.9	0.95	NS
	Increase over Pollination exclusion (%)	2.14	0.35			
Disc diameter (cm)	2021	12.41	11.25	11.16	0.45	NS
	2022	14.21	13.62	13.02	0.4	NS
	Increase over Pollination exclusion (%)	10.09	2.81			
Number of seeds per capitulum	2021	395.01	368.92	356.75	6.7	20.67
	2022	401.21	374.49	361.21	6.04	18.62
	Increase over Pollination exclusion (%)	10.9	3.54			
1000 Seed eight (g)	2021	53.02	51.32	45.28	0.59	1.82
	2022	53.82	51.63	45.53	0.87	2.68
	Increase over Pollination exclusion (%)	17.66	13.37			
Total yield (kg/ha)	2021	1713.15	1577.62	1290.32	24.18	74.5
	2022	1756.97	1605.01	1309.18	22.11	68.12
	Increase over Pollination exclusion (%)	33.49	22.43			
Oil Content (%)	2021	39.71	35.14	34.57	2.07	NS
	2022	40.57	35.14	34.57	1.56	NS
	Increase over Pollination exclusion (%)	10.7	0.85			
Germination (%)	2021	78.57	77.43	76.29	1.79	NS
	2022	80	79.71	76.86	1.49	NS
	Increase over Pollination exclusion (%)	3.55	2.61			

ha^{-1}) followed by HB plot (1591.32 kg ha^{-1}) and PE plot (1299.75 kg ha^{-1}). An overall increase of 33.49 per cent in OP and 22.43 per cent in HB against PE plot. Thomas *et al.* (2018) revealed that pollinators played a major role in increasing sunflower yield up to 40 per cent. Basavaraj *et al.* (2016) revealed that seed yield was higher in open pollinated DRSF-108 plants (0.95 kg/34 plants) as compared to the bagged plants (0.07 kg/34 plants). Nderitu *et al.* (2008) also revealed that the plots where insect visitors had access produced on average 53 per cent more seed yield compared with plots where insect visitors were excluded. Mehmood *et al.* (2007) have recorded bee pollination increased sunflower seed number by 59 per cent. Significantly highest seed yield of sunflower with honey bee colonies at Dharwad was recorded by Patil (2013). Suryanarayana *et al.* (1987) reported significant increase in seed yield, number of filled seeds and percent seed set due to pollination by honey bees.

Effects of pollination treatments on plant height of sunflower and disc diameter of the capitulum was done by covering the respective treatment plots with nylon mesh but the plants of different treatments were not having any significant differences among the treatments. Oil content and germination percentage also showed no significant variation among the pollination treatments. The oil content percentage was recorded highest in the open pollination plot (40.14%) followed by the bee pollination plot (36.58%) and pollination exclusion plot (36.26%). Hemanth Kumar *et al.* (2020) reported similar observations on sunflower hybrid KBSH-44 with no significant difference in oil content. Though Basavaraj *et al.* (2016) recorded higher oil content in the unbagged DRSF108 plants (40.41%) as compared to the bagged plants (38.81%) but they were at par statistically.

The germination percentage among different treatments showed no significant variation where it was recorded highest in the open pollination plot with 79.29 per cent germination followed by the bee pollination plot (78.57%) and pollination exclusion plot (76.57%). These finding are in corroboration with the findings of Nderitu *et al.* (2008). Hemanth Kumar *et al.* (2020) recorded similar trend in germination percent. These finding are in corroboration with the findings of Nderitu *et al.* (2008).

The oil seed crop sunflower is an important source of pollinators' dietary requirement attracting 18 numbers of pollinators. The production capacity of sunflowers can be easily increased by a minimum of 33 per cent by conserving the natural pollinators. Pollination by the honeybees showed positive impact on increasing the number of seeds per capitulum, seed filling percentage, test weight and seed yield of sunflower. The Indian honeybees, *Apis cerana indica* colonies can be recommended to utilize effectively inside the sunflower ecosystem to enhance the productivity of the crop.

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