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Effect of bee attractants on population of non-*Apis* pollinators and yield of niger, *Guizotia abyssinica* (L.f.) Cass

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Abstract
A study was conducted at experimental farm of PC Unit Sesame and Niger, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, during *Kharif* 2022. A field experiment was conducted to evaluate the effect of different bee attractants on the foraging activity of non-*Apis* pollinators (*Xylocopa violacea, Amata cyssea, Eristalinus megacephalus, Parnada guttatus, Danaus genutia, Zizina otis, Musca domestica*) and productivity of niger. Nine treatments comprising flower extract of *Madhuca longifolia* 10%, sugarcane juice 10%, jaggery solution 10%, honey solution 10%, fruit extract of *Phoenix dactylifera* 10%, sugar solution 10%, rose water 10%, water spray and untreated control were evaluated. The attractants were applied twice, at 10% and 50% flowering. The population of non-*Apis* pollinators was recorded at 1 day before spraying and at 1, 3, 5 and 7 days after spraying. The results demonstrated considerable variation in pollinator visitation among treatments. *M. longifolia* flower extract recorded a high mean pollinator population of 11.25 pollinators m^{-2} 5 min^{-1} after the first spray, while fruit extract of *P. dactylifera* recorded the highest mean population of 10.58 pollinators m^{-2} 5 min^{-1} after the second spray. Rose water 10% also promoted consistently high pollinator activity and recorded the highest numerical seed yield of 6.90 q ha^{-1}. The lowest pollinator population and seed yield were recorded in the untreated control. Overall, bee-attractant treatments enhanced pollinator visitation during flowering and were associated with improved niger productivity. The findings indicate the potential of suitable floral attractants as an ecological approach for enhancing pollination services and productivity in niger.

Keywords: Honey solution, insect pollinators, sugarcane juice, sugar solution and rose water honey solution, insect pollinators, sugarcane juice, sugar solution and rose water

Introduction

Niger, *Guizotia abyssinica* (L.f.) Cass., is an important minor oilseed crop belonging to the family Asteraceae (Compositae) and is native to tropical Africa. In India, it constitutes an important component of tribal agriculture and rural livelihoods owing to its adaptability to marginal and sub-marginal soils, low-input production systems and predominantly rainfed environments (Ranganatha *et al.*, 2009) [17]. According to available statistics, niger was cultivated on approximately 112.8 thousand hectares in India, with a production of about 40.3 thousand tonnes and an average productivity of 357.2 kg ha^{-1}. Madhya Pradesh accounted for approximately 16.0 thousand hectares, producing 4.9 thousand tonnes with an average productivity of 308.8 kg ha^{-1} (Anonymous, 2021–22). Although niger occupies a relatively small share of the national oilseed sector, its oil is valued for its favourable edible and nutritional properties and contributes to the edible oil supply of the country (Getinet and Sharma, 1996). Niger seeds generally contain 32–40% oil and 18–24% protein. The oil is pale yellow, mildly nutty in flavour and possesses a pleasant odour, while the seed and oil are considered free from known toxic constituents (Dwarka *et al.*, 2024[a,b,c,d,e]) [7, 8, 9]. Niger is predominantly self-incompatible and therefore depends substantially on insect-mediated cross-pollination for effective fertilization, seed set and yield formation (Dwarka *et al.*, 2022) [4]. Consequently, pollinating insects constitute an important biological component of niger production systems. Efficient insect-mediated pollination can enhance pollen transfer, reproductive success and seed formation, thereby contributing to improved crop productivity and potentially more uniform seed development. Previous studies have reported substantial reductions in niger yield, ranging from 11 to 78%, when honey bees and other natural pollinators were excluded, emphasizing the importance of insect pollination in this crop. Furthermore, integration of beekeeping with niger cultivation can provide an additional source of farm income through honey production and associated apicultural products (Anonymous, 2005) [1].

Among insect pollinators, honey bees are particularly effective because of their floral fidelity, efficient foraging behaviour and capacity to visit numerous flowers during the crop's flowering period. However, the effectiveness of pollinator-mediated crop production depends not only on pollinator abundance but also on their ability to locate and preferentially exploit the target crop in the presence of competing floral resources. Therefore, enhancing the attractiveness of niger flowers to pollinators may increase visitation frequency, improve pollen transfer and ultimately enhance pollination efficiency and seed production. Several commercial and locally available bee attractants, including

Bee Line, Bee Here, Bee Scent, Bee Scent Plus, Fruit Boost, Bee-Q, sugar solution, sugarcane juice, jaggery solution and molasses, have been evaluated or utilized to stimulate bee foraging activity in niger-growing areas of Jabalpur, Madhya Pradesh (Dwarka *et al.*, 2022; 2023[a,b,c]) [4, 10]. However, systematic information on the comparative efficacy of naturally derived attractants in enhancing the visitation and foraging activity of individual non-*Apis* pollinator species remains limited under Indian agro-ecological conditions. In particular, quantitative information linking attractant-mediated enhancement of non-*Apis* pollinator activity with subsequent improvement in niger seed productivity is inadequate.

The critical role of insect pollinators in niger production and the increasing emphasis on pollinator conservation, ecological intensification and sustainable crop-management practices, the present investigation was undertaken to evaluate the efficacy of different bee attractants in enhancing the foraging activity of non-*Apis* pollinators, namely *Xylocopa violacea*, *Amata cyssea*, *Eristalinus megacephalus*, *Parnada guttatus*, *Danaus genutia*, *Zizina otis* and *Musca domestica*, and to assess their subsequent influence on niger seed productivity. The study further aimed to identify effective and locally accessible attractants that could be incorporated into pollinator-management strategies for enhancing pollination services and improving the productivity of niger under field conditions.

Material and methods

The field experiment investigating the influence of different bee attractants on the foraging activity of non-*Apis* in niger was conducted during the *Kharif* season of 2021 at the experimental farm of the PC Unit (ICAR) on Sesame and Niger, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India. Jabalpur is located along the Narmada River in central Madhya Pradesh and lies approximately between 22°49′ and 24°08′ N latitude and 78°21′ E longitude, at an elevation of about 411.78 m above mean sea level.

The experiment was laid out in a Randomized Block Design (RBD) with three replications to assess the relative effectiveness of different bee attractants in enhancing non-*Apis* visitation to niger flowers. The study was conducted under field conditions with the objective of identifying suitable attractants capable of increasing pollinator activity during the crop flowering period and thereby contributing to improved reproductive performance and seed yield of niger.

Table. 1: List of attractants

S. No	Treatments/attractants
1.	T_1- Flower extract of *Madhuca longifolia* 10%
2.	T_2 –Juice of *Sachharum officinarum* 10%
3.	T_3 -Jaggery solution 10%
4.	T_4 -Honey solution 10%
5.	T_5 -Fruit extract of *Foenix dactylifera* 10%
6.	T_6-Sugar solution 10%
7.	T_7 -Rose water (Marketed) 10%
8.	T_8 -Water spray.
9.	T_9-Control

The selected bee attractants were applied as foliar sprays on two occasions, corresponding to the 10% and 50% flowering stages of the niger crop. Standard recommended agronomic practices were adopted throughout the experiment to maintain uniform and healthy crop growth. To quantify pollinator activity, a 1 m² observation area was randomly selected within each experimental plot, and the number of non-*Apis* pollinators visiting the flowers was counted. Pollinator observations were recorded at one day before spraying (1 DBS) and subsequently at 1, 3, 5 and 7 days after spraying (DAS) following both applications. The observations were used to assess the temporal response of non-*Apis* pollinators to the different attractant treatments. At crop maturity, seed yield from each treatment plot was harvested, measured separately and expressed as q ha^{-1}. Representative insect specimens collected during the investigation were preserved and submitted for taxonomic confirmation. The identity of the pollinator was verified with the assistance of taxonomic experts at the Regional Centre, Zoological Survey of India (ZSI), Jabalpur, Madhya Pradesh and the specimens were confirmed as non-*Apis* pollinators.

Results and discussion

The data presented in the table revealed considerable variation in the population of non-*Apis* pollinators and seed productivity of niger in response to different bee-attractant treatments. The population of non-*Apis* pollinators was recorded at 1 day before spraying (1 DBS) and at 1, 3, 5 and 7 days after each spray (DAS). Overall, all the bee-attractant treatments showed a positive influence on pollinator visitation compared with the water-spray and untreated control treatments.

Before the first spray, the population of non-*Apis* pollinators varied from 1.00 to 3.67 pollinators m^{-2} 5 min^{-1} among the treatments. The highest initial population was recorded in T6 (sugar solution 10%) (3.67 m^{-2} 5 min^{-1}), followed by T2 and T7 (3.00 each), whereas the lowest population was observed in T3 (jaggery solution 10%) (1.00 m^{-2} 5 min^{-1}). Following application of the attractants, a marked increase in pollinator activity was observed in most treatments. At 1 DAS, the highest pollinator population was recorded in T1 (flower extract of *Madhuca longifolia* 10%) (8.00 m^{-2} 5 min^{-1}), closely followed by T4 (honey solution 10%) (9.00) and T7 (rose water 10%) (9.33). The population in T8 (water spray) and T9 (control) remained comparatively low, at 5.00 and 3.33 pollinators m^{-2} 5 min^{-1}, respectively. At 3 DAS, the pollinator population increased further in several treatments. The highest population was observed in T4 (13.67 m^{-2} 5 min^{-1}), followed by T1 (11.33), T7 (13.00), and T5 (9.67). The lowest population was recorded in T9 (2.00), indicating substantially lower pollinator activity in the untreated control. At 5 DAS, T1 recorded the highest population of 13.33 pollinators m^{-2} 5 min^{-1}, followed by T4 (12.67) and T7 (11.33). The populations under T8 and T9 were only 2.67 and 1.33 pollinators m^{-2} 5 min^{-1}, respectively. At 7 DAS, the highest population was recorded in T1 (12.33 m^{-2} 5 min^{-1}), followed by T7 (9.00), T5 (9.00), T4 (5.67), and T8 (3.67). The control treatment recorded only 2.67 pollinators m^{-2} 5 min^{-1}.

Based on the mean population after the first spray, T1 (flower extract of *M. longifolia* 10%) recorded the highest mean population (11.25 pollinators m^{-2} 5 min^{-1}). It was followed by T7 (rose water 10%) with 10.67, T4 (honey solution 10%) with 10.25, T5 (fruit extract of *Phoenix dactylifera* 10%) with 8.58, T2 (sugarcane juice 10%) with 7.42, T6 (sugar solution 10%) with 6.25, T3 (jaggery solution 10%) with 6.08, T8 (water spray) with 3.58, and T9 (control) with 2.33 pollinators m^{-2} 5 min^{-1}. Present findings

are supported by the findings of Painkra *et al.,* (2015) [15] 15 species of insect pollinators were found visiting on niger flowers. Present findings supported that the finding of Nath, 2008 [14]; Kumar *et al.,* 2024 [12]; Chaudhary, 1998 [3]; Kumari and Rana, 2018 [13]; Sreedhara *et al.,* 2012 [18]; Pandit *et al.,* 2026 [16]; Kumar, 2023 [11].

A similar response pattern was observed following the second spray. At 1 DAS, the highest population was recorded in T7 (rose water 10%) (10.67 pollinators m^{-2} 5 min^{-1}), followed by T5 (8.33), T1 (7.00), and T4 (6.33). The lowest population was recorded in the control (2.67). At 3 DAS, the maximum population was recorded in T7 (13.67 pollinators m^{-2} 5 min^{-1}), followed by T1 (12.33), T5 (12.00), and T4 (9.67). In comparison, only 4.00 pollinators m^{-2} 5 min^{-1} were recorded in the control. At 5 DAS, T1 recorded the highest population (12.67 m^{-2} 5 min^{-1}), followed by T5 (10.00), T3 (10.67), T4 (9.00), and T7 (9.00). The population in the control was only 3.00 pollinators m^{-2} 5 min^{-1}. At 7 DAS, the population declined in most treatments; however, the attractant-treated plots continued to support greater pollinator activity than the control. The highest population was recorded in T5 (8.67 m^{-2} 5 min^{-1}), followed by T3 (8.33), T1 (8.33), T4 (7.33), and T7 (6.33), whereas the control recorded only 2.67 pollinators m^{-2} 5 min^{-1}. The mean population after the second spray was highest in T5 (fruit extract of *P. dactylifera* 10%) with 10.58 pollinators m^{-2} 5 min^{-1}, followed by T1 (10.33), T7 (9.92), T4 (8.58), T3 (9.25), T6 (7.92), T2 (5.92), T8 (4.58) and T9 (3.25). Present findings supported that the finding of Nath, 2008 [14]; Kumar *et al.,* 2024 [12]; Chaudhary, 1998 [3]; Kumari and Rana, 2018 [13]; Sreedhara *et al.,* 2012 [18]; Pandit *et al.,* 2026 [16]; Kumar 2023 [11].

Effect on niger productivity

The data further demonstrated considerable treatment-wise variation in niger productivity. Among the different treatments, T6 (sugar solution 10%) recorded the highest yield of 6.70 q ha^{-1}, followed by T1 (flower extract of *M. longifolia* 10%) with 6.30 q ha^{-1}, T2 (sugarcane juice 10%) with 5.82 q ha^{-1}, T7 (rose water 10%) with 6.90 q ha^{-1}, T5 (fruit extract of *P. dactylifera* 10%) with 6.00 q ha^{-1}, T4 (honey solution 10%) with 5.45 q ha^{-1}, T8 (water spray) with 4.80 q ha^{-1} and T3 (jaggery solution 10%) with 4.40 q ha^{-1}. The untreated control (T9) recorded the lowest yield of 3.15 q ha^{-1}. Thus, the data indicated that treatments attracting greater numbers of pollinators generally tended to be associated with improved niger productivity. T7 (rose water 10%) showed particularly high pollinator activity and recorded the highest numerical yield (6.90 q ha^{-1}), while T1 (*M. longifolia* flower extract 10%) consistently maintained high pollinator activity across both sprays and produced 6.30 q ha^{-1} seed yield. The substantially lower pollinator population and yield under the untreated control indicated the importance of enhancing pollinator visitation during the flowering period of niger. The SEm± and CD at 5% values indicated that the observed treatment differences were statistically assessable, with CD values varying among observations. Therefore, the variation in pollinator abundance and crop productivity can be interpreted in relation to the respective critical differences rather than solely on the basis of numerical differences. Present findings closely related to Dwarka *et al.,* 2022 [4];Dwarka *et al.,* 2023[a,b,c] [5, 6, 10].

The results clearly demonstrated that application of bee attractants enhanced the visitation of non-*Apis* pollinators to niger flowers compared with water spray and untreated control. Flower extract of *M. longifolia* 10% (T1) was particularly effective in maintaining a high pollinator population after the first spray, whereas fruit extract of *P. dactylifera* 10% (T5) performed strongly after the second spray. Rose water 10% (T7) also produced consistently high pollinator activity and the highest numerical seed yield. The findings suggest that enhancement of pollinator visitation through suitable floral attractants can contribute to improved pollination and, consequently, greater seed productivity of niger.

Table 2: Effect of different attractants on the attraction of non-Apis pollinators and their impact of seed yield in niger crop.

Treatment	Population of non-*Apis* pollinators/m^2/5 minutes												Yield (q/ha)
	1st spray at 10% flowering						2nd spray at 50% flowering						
	1DBS	Days after spray				Mean	1DBS	Days after spray				Mean	
		1DAS	3DAS	5DAS	7DAS			1DAS	3DAS	5DAS	7DAS		
T_1-Flower extract of *M. longifolia* 10%	1.67 (1.46)	8.00 (2.83)	11.33 (3.42)	13.33 (3.67)	12.33 (3.54)	11.25 (3.42)	7.00 (2.67)	8.00 (2.88)	12.33 (3.54)	12.67 (3.55)	8.33 (2.95)	10.33 (3.28)	6.30 (2.61)
T_2-Juice of *S. officinarum* 10%	3.00 (1.81)	5.00 (2.30)	8.00 (2.86)	9.00 (3.06)	7.67 (2.85)	7.42 (2.80)	5.00 (2.28)	7.67 (2.77)	8.00 (2.86)	5.33 (2.12)	2.67 (1.74)	5.92 (2.47)	5.82 (2.51)
T_3-Jaggery solution 10%	1.00 (1.17)	5.67 (2.48)	7.00 (2.58)	8.00 (2.84)	3.67 (1.94)	6.08 (2.54)	5.33 (2.35)	7.67 (2.81)	10.33 (3.27)	10.67 (3.34)	8.33 (2.94)	9.25 (3.12)	4.40 (2.21)
T_4-Honey solution 10%	2.67 (1.74)	9.00 (3.01)	13.67 (3.75)	12.67 (3.62)	5.67 (2.46)	10.25 (3.28)	6.33 (2.49)	8.33 (2.96)	9.67 (3.19)	9.00 (3.06)	7.33 (2.76)	8.58 (3.01)	5.45 (2.44)
T_5- Fruit extract of *F. dactylifera* 10%	2.33 (1.64)	6.33 (2.47)	9.67 (3.18)	9.33 (3.06)	9.00 (3.08)	8.58 3.00)	8.33 (2.94)	11.67 (3.43)	12.00 (3.53)	10.00 (3.24)	8.67 (2.99)	10.58 (2.32)	6.00 (2.55)
T_6-Sugar solution 10%	3.67 (2.03)	6.33 (2.51)	7.67 (2.85)	6.00 (2.54)	5.00 (2.30)	6.25 (2.60)	5.00 (2.23)	8.33 (2.93)	9.67 (3.18)	7.67 (2.83)	6.00 (2.53)	7.92 (2.90)	6.70 (2.68)
T_7-Rose water 10%	3.00 (1.86)	9.33 (3.12)	13.00 (3.66)	11.33 (3.44)	9.00 (3.02)	10.67 (3.34)	7.67 (2.81)	10.67 (3.31)	13.67 (3.76)	9.00 (3.02)	6.33 (2.59)	9.92 (3.22)	6.90 (2.72)
T_8-Water spray	2.67 (1.77)	5.00 (2.34)	3.00 (1.86)	2.67 (1.72)	3.67 (2.02)	3.58 (2.01)	4.00 (2.10)	5.00 (2.32)	5.67 (2.48)	4.00 (2.11)	3.67 (2.04)	4.58 (2.25)	4.80 (2.30)
T_9-Control	2.33 1.38)	3.33 (1.88)	2.00 (1.43)	1.33 (1.34)	2.67 (1.72)	2.33 (1.65)	2.67 (1.77)	3.33 (1.95)	4.00 (2.08)	3.00 (1.82)	2.67 (1.77)	3.25 (1.93)	3.15 (1.92)
SEm±	0.31	0.31	0.33	0.32	0.29	0.17	0.34	0.26	0.24	0.38	0.25	0.17	0.03
CD at 5%	0.92	0.92	1.00	0.95	0.87	0.52	1.03	0.72	0.73	1.15	0.75	0.51	0.09

Conclusion

The study concluded that application of suitable bee attractants during the flowering period enhanced non-*Apis* pollinator visitation in niger. *M. longifolia* flower extract was particularly effective after the first application, whereas *P. dactylifera* fruit extract showed strong performance after the second application. Rose water 10% produced high and consistent pollinator activity and recorded the highest numerical seed yield of 6.90 q ha^{-1}. Therefore, bee-attractant application can be considered a promising component of pollinator-friendly crop management for improving pollination and productivity of niger.

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