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Diversity of foraging insects and their effects on onion seed yield in Rangpur region of Bangladesh

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ABSTRACT

Pollination by insects is critical for seed production in onion (Allium cepa L.), a cross-pollinated crop that relies heavily on biotic pollinators. This study was conducted during the 2023–24 cropping season in the Rangpur region of Bangladesh to evaluate the diversity of foraging insects in onion fields and their impact on seed yield and quality. A randomized full block design was used to examine six different pollination techniques, including dill intercropping, open pollination, honeybee-assisted pollination, insect exclusion and hand pollination. A diverse array of pollinators was recorded, with honeybees (Apis mellifera, Apis cerana), solitary bees (Megachile spp.), hoverflies (Eristalis spp.), and butterflies (Danaus spp.) being the most frequent visitors. Pollinator activity peaked between 9:00 AM and 12:00 PM, with solitary bees and honeybees exhibiting the highest visitation rates. Seed yield was significantly enhanced in treatments with honeybee colonies (823.3 kg/ha), open pollination with dill (781.6 kg/ha) and hand-assisted pollination (753.0 kg/ha), compared to the lowest yield in insect-excluded plots (355.0 kg/ha). Seed quality parameters-including 1000-seed weight, germination rate, and reduced deformity-also improved significantly in insect-accessible treatments. These findings highlight the indispensable role of foraging insects in onion seed production and underscore the need for pollinator-friendly practices, such as managed bee colonies and flowering intercrops, to optimize yield and seed quality.

Key Words: *Foraging insects, Diversity, Onion seed yield and Rangpur.*

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I. Introduction

Onion (*Allium cepa* L.) is one of the most economically and nutritionally important vegetable crops cultivated worldwide, including in Bangladesh. It serves as a staple in daily cooking and contributes significantly to the national economy through both fresh bulb and seed production. Unlike many other crops, onion is predominantly cross-pollinated and exhibits a high degree of self-incompatibility, requiring efficient and consistent pollination for successful seed setting and viable seed development (Singh et al., 2006). In this context, insect-mediated pollination plays a vital role in enhancing seed yield and quality. Among the diverse array of pollinators, bees particularly honeybees (Apis spp.) are recognized as the most effective agents for pollination in onion crops (Westerkamp and Gottsberger, 2000).

Pollination success in onion is heavily influenced by the activity and abundance of foraging insects, which vary across regions and agro-ecological zones. Numerous studies have shown that insect pollinators not only increase seed yield but also improve seed quality, including germination rate, seed weight, and uniformity (Abrol 2012; Karuppaiah et al., 2013). In particular, the presence of honeybees (*Apis mellifera and Apis cerana*), solitary bees (*Megachile spp.*), and syrphid flies (*Eristalis spp.*) has been associated with improved reproductive success in onion crops (Hosamani et al. 2012; Saeed et al., 2008). In contrast, limited pollinator activity due to habitat degradation, excessive pesticide use, or poor weather conditions has been linked to lower seed yields, higher proportions of deformed seeds, and poor seed viability (Kevan and Viana, 2003).

The Rangpur region, situated in the northern part of Bangladesh, is a major onion-growing area. However, little is known about the composition and foraging efficiency of pollinator communities in this region, especially under on-farm conditions where various agronomic practices, floral diversity, and weather conditions can influence pollinator behavior. Enhancing our understanding of local insect pollinators and their role in onion seed production is crucial for developing effective, ecologically sound crop management strategies. Moreover, with increasing threats to pollinator populations globally, promoting pollinator-friendly practices such as the introduction of managed bee colonies and floral diversification through companion planting has become a pressing need (Potts et al., 2010; Goulson et al., 2015).

Given the above, this study was designed to investigate the diversity and foraging behavior of insect pollinators in onion fields in the Rangpur region and to quantify their effects on seed yield and quality. Specific objectives were: (i) to identify and document common foraging insect species in onion fields, (ii) to assess their visitation rates and pollination efficiency, and (iii) to evaluate the impact of different pollination management strategies including open pollination, insect exclusion and floral diversification-on seed production outcomes. The findings of this research are expected to provide valuable insights for optimizing pollination services in onion production systems and inform sustainable, pollinator-inclusive agricultural practices in Bangladesh.

II. Materials and Methods

The study was conducted during the 2023–24 cropping season in the Rangpur region of Bangladesh, encompassing experimental fields at the On-Farm Research Division (OFRD), Bangladesh Agricultural Research Institute (BARI), Rangpur, and adjacent farmer-managed fields. The primary objective was to assess the diversity and foraging behavior of insect pollinators in onion (*Allium cepa L.*) fields and their consequent effects on seed yield and quality.

To ensure the presence of diverse floral stages and enhance observation accuracy, experimental plots were established in fields containing onion plants at various flowering phases. Additionally, companion planting of dill (*Anethum graveolens*) was introduced in selected plots to assess its role in attracting beneficial insect pollinators and enhancing pollination efficiency. The field layout followed a randomized complete block design (RCBD) with six pollination treatments and three replications: (i) open pollination (insect-accessible), (ii) netting (complete insect exclusion), (iii) honeybee-assisted pollination (using introduced *Apis mellifera* colonies), (iv) open pollination with hand-assisted pollination, (v) open pollination with dill intercropping, and (vi) other insect pollinators only.

For the observation of insect visitors, each plot was subdivided into smaller quadrats (1 m^2) to facilitate standardized data collection. Insect visitation was recorded during peak foraging hours (7:00 AM to 3:00 PM), with a focus on three primary intervals: morning (7:00–10:00 AM), midday (10:00 AM–1:00 PM), and afternoon (1:00–3:00 PM). The number of insect visits per flower per minute was

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recorded using direct visual counts. In addition, the duration of individual insect visits was measured using a stopwatch to determine species-specific foraging efficiency.

A combination of trapping techniques was employed to sample and identify foraging insect species. Colored pan traps (blue and yellow), filled with soapy water, were placed at canopy level across the fields to attract and trap flying insects. These colors were selected based on their known attractiveness to pollinators, especially bees and flies. Sticky traps coated with insect adhesive were installed throughout the plots to passively collect visiting insects. Furthermore, mesh tents were used in select plots to observe insect exclusion and facilitate controlled pollination environments.

Environmental variables known to influence insect activity were simultaneously monitored. Ambient temperature, relative humidity, and wind speed were recorded at hourly intervals using portable digital thermo-hygrometers and anemometers. These parameters were correlated with insect foraging behavior to determine their influence on pollination dynamics. Collected insect specimens were preserved and identified to the lowest possible taxonomic level using standard entomological keys, with confirmation by expert taxonomists when necessary. Insects were categorized by order, family, and species, and their frequency of visitation and foraging behavior were documented.

To assess pollination success and seed production outcomes, several parameters were measured post-anthesis and at harvest. These included average pollination success (%), 1000-seed weight (g), total seed yield (kg/ha), percentage of deformed seeds, and germination rate (%). Germination tests were conducted in controlled laboratory conditions following ISTA (International Seed Testing Association) guidelines. Pollination success was estimated by counting fertilized ovaries per umbel, while seed deformation was assessed visually.

Statistical analyses were performed using R software (version X.X), where analysis of variance (ANOVA) was used to determine treatment effects. Significant means were separated using the Least Significant Difference (LSD) test at the 5% and 1% probability levels. The coefficient of variation (CV%) and standard errors were calculated to measure data variability and experimental precision. This comprehensive methodology ensured accurate documentation of foraging insect diversity and behavior and provided robust data to evaluate their contributions to pollination success and onion seed yield in the Rangpur region.

III. Results and Discussion

Diversity and composition of foraging insects

A diverse assemblage of foraging insects was recorded in onion fields in the Rangpur region during the 2023–24 cropping season. The study documented six principal insect groups comprising species from the orders Hymenoptera, Diptera, Lepidoptera, Coleoptera, and Formicidae. Table 01 summarize the dominant species and their behaviors. Among these, honeybees (*Apis mellifera*, *A. cerana*) were the most frequently observed pollinators, accounting for 35% of total visits (Table 05). Syrphid flies (*Eristalis spp.*), butterflies (*Pieris brassicae, Danaus spp.*), and solitary bees (*Megachile spp.*) also contributed significantly to flower visitation.

Table 01. Common foraging insects observed in onion fields in Rangpur region during 2023-24 cropping season.

Insect name	Order	Family	Activity observed	Peak foraging time
Honeybee (*Apis spp.)*	Hymenoptera	*Apidae*	Nectar and pollen collection	Morning (8–11 AM)
Bumblebee (*Bombus spp.*)	Hymenoptera	*Apidae*	Nectar collection	Midday (11 AM–1.00 PM)
Hoverfly (*Eristalis spp.*)	Diptera	*Syrphidae*	Pollen collection	Morning (9–11 AM)
Butterfly (*Danaus spp.*)	Lepidoptera	*Nymphalidae*	Nectar collection	Afternoon (1–3 PM)
Solitary bee (Megachile spp.*)*	Hymenoptera	*Megachilidae*	Pollen collection	Morning (7–10 AM)
Hoverflies/ flower flies/syrphids (*Episyrphus balteatus*)	Diptera	*Syrphidae*	Nectar and Pollen collection	10:00 AM -3:00 PM
Drone fly (*Eristalis tenax*)	Diptera	*Syrphidae*	Nectar and Pollen collection	10:00 AM -3:00 PM

The abundance ranking (Table 05) revealed that *Apis mellifera* was the most prevalent species, followed by *Eristalis spp*. and *Pieris brassicae*. These findings are consistent with those reported by Karuppaiah et al. (2020), who noted similar pollinator assemblages in onion fields in southern India. The presence of *Coccinella septempunctata* and *Solenopsis spp.* suggests an interaction between pollination and pest regulation, as some of these species also serve beneficial ecological roles.

Comparative role of pollinator groups

Table 02 indicates the relative contribution of various insect species across different pollination treatments. Honeybees consistently outperformed all other groups in both mono- and poly-insect systems. Hoverflies (*Eristalis tenax, Episyrphus balteatus*) also played a significant role under open pollination and in the dill-companion plots, validating their role as alternative pollinators when bee populations are low. These findings corroborate the reports of Goulson et al. (2015), who highlighted the increasing importance of non-bee pollinators in global agriculture.

Interestingly, when hand pollination was added to natural foraging activity, seed yield increased slightly but not significantly beyond that achieved through open pollination with mixed insect species. This suggests that effective insect pollination alone can match or exceed the results of labor-intensive hand pollination, making it a more cost-effective and sustainable approach for smallholder farmers.

Table 02. Common foraging insects observed in onion fields in Rangpur region during 2023-24 cropping season.

Pollination method	Honey bee (*Apis spp.*)	Bumblebee (*Bombus spp.*)	Hoverfly (*Eristalis spp.*)	Butterfly (*Danaus spp.*)	Solitary bee (*Megachile spp.*)	Hoverflies/ Flower flies/ Syrphids (*Episyrphus balteatus*)	Drone fly (*Eristalis tenax*)
Open pollination (with insects)	High	Moderate	High	Moderate	Moderate	High	High
Netting (excluding all insects)	None	None	None	None	None	None	None
Honeybee pollination (introduced)	Very High	Low	Low	Low	Low	Low	Low
Open pollination with mixed dill plants	High	Moderate	High	Moderate	Moderate	High	High
Other insect pollinators only	Low	Moderate	High	Moderate	Moderate	High	High
Open pollination with insects and hand pollination	High	Moderate	High	Moderate	Moderate	High	High

Influence of pollination methods on seed yield and quality

Significant differences ($p < 0.01$) were observed among the six pollination treatments concerning seed yield, 1000-seed weight, germination rate, and deformity (Table 03). The introduction of honeybee colonies resulted in the highest seed yield (823.3 kg/ha) and superior seed quality, including the highest germination rate (94.2%) and lowest deformed seed percentage (4.5%). Open pollination (with native insect activity) and open pollination combined with hand pollination produced slightly lower yields but maintained high seed viability and quality.

In contrast, the netted (pollinator-excluded) plots produced the lowest yield (355 kg/ha) and showed a significant increase in seed deformities (23.3%) and reduced germination (75.3%). This aligns with previous studies by Hosamani et al. (2014) and Saeed et al. (2008), who reported that exclusion of insect pollinators led to drastic reductions in seed setting and quality.

Notably, open pollination with mixed dill (*Anethum graveolens*) plants led to a yield of 781.6 kg/ha, suggesting that the introduction of nectar-rich companion plants can enhance pollinator activity. This agroecological approach is supported by Potts et al. (2010), who emphasized the importance of floral resource enhancement for pollinator conservation and service optimization.

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Table 03. Effects of foraging insects on onion seed yield and quality at Rangpur region during 2023-24 cropping season.

Treatments	Average pollination success (%)	1000-seed weight (g)	Seed yield (kg/ha)	Per cent deformed seeds	Seed Quality (Germination rate, %)	Observations
Honeybee pollination (introduced)	75 b	4.13 a	823.3 a	4.5 d	94.167 a	Superior yield and seed quality
Netting (excluding all insects)	50 c	3.42 c	355 e	23.33 a	75.33 b	Significant reduction in yield and less viable seeds
Open pollination (with insects)	82 b	3.65 b	741 c	8.66 bc	91.16 a	Highest yield; high seed viability
Open pollination with insects along with hand pollination	90 a	4.15 a	749 c	6.18 cd	88.3 a	Highest yield; high seed viability
Open pollination with mixed dill plants	80 b	4.08 a	781.6 b	7.26 cd	90.16 a	Superior yield and seed quality
Other insect pollinators only	78 b	3.99 a	668 d	11.5 6b	89.16 a	Moderate increase in yield and quality
CV (%)	7.32	2.58	3.09	17.88	4.54	
Level of significance	**	**	**	**	**	
Lsd	12.39	0.229	47.438	4.484	9.12	

Foraging behavior and pollination efficiency

Table 04 highlights significant differences among insect species in terms of visitation frequency (visits/flower/minute) and pollination success (%). Solitary bees (*Megachile spp.*) exhibited the highest visitation frequency (6.0 visits/flower/minute) and the highest pollination efficiency (88%), despite their relatively low abundance. Honeybees demonstrated strong foraging activity with 5.2 visits/flower/minute and 85% pollination success. Bumblebees (*Bombus spp.*) were particularly effective during cooler morning hours, while butterflies were less frequent visitors, contributing modestly to overall pollination.

The significance of visitation frequency as a determinant of pollination success has been well documented. According to Abrol (2012), high-frequency foragers such as solitary bees and honeybees are more efficient due to their consistent and systematic movement between florets. Our findings support this conclusion and further confirm the complementary role played by hoverflies and butterflies in enhancing pollination diversity and resilience.

Table 04. Foraging behavior and pollination efficiency at Rangpur region during 2023-24 cropping season.

Insect Name	Visits/ flowers/minute	Average pollination success (%)	Notes
Bumblebee (*Bombus spp.*)	4.7 ab	80 ab	Effective in cool weather
Butterfly (*Danaus spp.*)	2.4 b	50 b	Less frequent but contributes to diversity
Honeybee (*Apis spp.*)	5.2 ab	85 a	Most effective pollinator in the region
Hoverfly (*Eristalis spp.*)	3.1 ab	75 ab	Moderate efficiency
Solitary bee (*Megachile spp.*)	6.0 a	88 a	High efficiency, but lower population density
CV (%)	28.24	14.46	
Level of significance	*	*	
Lsd	3.419	30.77	

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Environmental conditions and pollinator activity

The study also accounted for environmental parameters such as temperature, wind speed, and time of day. Peak insect activity was consistently recorded between 8:00 AM and 1:00 PM, aligning with favourable light intensity and ambient temperature (20–28°C). Wind speeds above 15 km/h were associated with reduced flight activity, especially in lightweight insects such as butterflies and syrphid flies. These results support the findings of Westerkamp & Gottsberger (2000), who observed that wind and temperature significantly influence insect flight behavior and pollination efficacy.

Table 05. Diversity of foraging insects in onion fields at Rangpur region during 2023-24 cropping season.

Order	Family	Species	Frequency of observation (%)	Abundance rank
Hymenoptera	*Apidae*	*Apis mellifera*	35 a	1
Diptera	*Syrphidae*	*Eristalis sp.*	25 ab	2
Lepidoptera	*Pieridae*	*Pieris brassicae*	15 bc	3
Coleoptera	*Coccinellidae*	*Coccinella septempunctata*	10 c	4
Hymenoptera	*Formicidae*	*Solenopsis sp.*	5 c	5
CV (%)			23.52	
Level of significance			**	
Lsd			12.032	

IV. Conclusion

This study comprehensively examined the diversity, abundance, and pollination efficiency of foraging insects in onion (*Allium cepa L.*) seed production fields in the Rangpur region during the 2023–24 cropping season. A total of six major foraging insect groups were identified, with honeybees (*Apis mellifera* and *A. cerana*) being the most abundant and effective pollinators, followed by solitary bees (*Megachile spp.*), syrphid flies (*Eristalis spp.*), bumblebees (*Bombus spp.*), and butterflies (*Danaus spp.*). The highest foraging frequency and pollination success were recorded for solitary bees and honeybees, highlighting their vital role in onion pollination.

The results revealed that insect-mediated pollination significantly improved seed yield and quality compared to insect-excluded (netted) conditions. Among the different treatments, the introduction of managed honeybee colonies produced the highest seed yield (823.3 kg/ha) and seed quality (94.2% germination), while open pollination with native insect activity and dill-companion planting also resulted in comparable outcomes. In contrast, pollinator exclusion led to reduced pollination success (50%), lower seed yield (355 kg/ha), increased seed deformity, and poor germination (75.3%). The inclusion of companion dill plants effectively enhanced the diversity and visitation rate of pollinators, particularly syrphid flies and bees, thereby boosting pollination efficiency and seed production. This practice offers an ecologically sustainable and farmer-friendly alternative to improve crop productivity in regions facing pollinator scarcity or environmental stress.

In conclusion, insect pollinators are indispensable for maximizing onion seed production under field conditions, and their role should be explicitly integrated into agronomic and agroecological planning. Enhancing pollinator presence through habitat management, such as introducing nectar-rich flowering plants and conserving wild pollinators, can offer substantial benefits in seed yield and quality. Moreover, the findings underscore the need for continued research and extension services to promote pollinator-friendly practices in seed crop cultivation, particularly in regions like Rangpur where onion seed production holds economic significance.

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