

INTEGRATED BEEKEEPING AND HONEY PRODUCTION IN LITCHI ORCHARDS: FROM POLLINATION TO POLICY



Ipsita Samal • Jaipal Singh Choudhary • Vinod Kumar • Sunil Kumar • Ankit Kumar
Bhagya Vijayan • Sanjan Kumar Bharti • Amit Kumar • Bikash Das •



भा.कृ.अनु.प.-राष्ट्रीय लीची अनुसंधान केन्द्र
ICAR-National Research Centre on Litchi

मुशहरी प्रक्षेत्र, मुशहरी, मुजफ्फरपुर - 842 002 (बिहार)
Mushahari Farm, Mushahari, Muzaffarpur - 842002 (Bihar)





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Director, ICAR-National Research Centre on Litchi, Muzaffarpur (Bihar)

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Ipsita Samal, Jaipal Singh Choudhary, Vinod Kumar, Sunil Kumar, Ankit Kumar, Sanjan Kumar Bharti, Amit Kumar and Bikash Das

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Ipsita Samal

Jaipal Singh Choudhary

Vinod Kumar

Sunil Kumar

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Mushahari Farm, Mushahari, Muzaffarpur - 842002 (Bihar)



FOREWORD

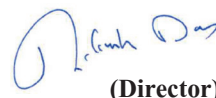


It gives me great pleasure to present this Technical Bulletin on “Integrated Beekeeping and Honey Production in Litchi Orchards: From Pollination to Policy”. The litchi ecosystem of India, particularly in the Indo-Gangetic plains, is globally recognized for its unique quality and flavor. Scientific beekeeping, when integrated with litchi cultivation, not only enhances pollination and fruit set but also provides farmers with additional income through the production of high-quality litchi honey.

In recent years, there has been a growing emphasis on sustainable horticultural practices, diversification of farm income, and ensuring the quality and traceability of agri-based products. Beekeeping aligns perfectly with these objectives. Managed colonies of *Apis mellifera* and native honey bees contribute significantly to improved yields, better fruit quality, and biodiversity conservation. At the same time, honey extracted from litchi orchards holds distinct characteristics that need to be safeguarded through adoption of recognized honey standards, quality assurance protocols, and authentication methods such as melissopalynology.

This bulletin provides practical guidance on seasonal apiary management in litchi orchards, strategies for maintaining colony health, and compliance with honey quality standards. It is designed to serve as a ready reference for farmers, extension workers, and entrepreneurs who wish to harness the dual benefits of pollination services and honey production.

I am confident that the knowledge compiled here will be of immense use to litchi growers, beekeepers, and stakeholders across the value chain. The effort of the scientific team at ICAR–National Research Centre on Litchi in preparing this bulletin is highly commendable. I hope it will encourage wider adoption of scientific beekeeping practices, improve the profitability of litchi-based farming systems, and contribute to the national mission of promoting apiculture for nutritional and livelihood security.



(Director)

ICAR–National Research Centre on Litchi

October, 2025
Muzaffarpur, Bihar



PREFACE



Beekeeping in litchi orchards represents a unique convergence of horticulture and apiculture, where pollination services and honey production complement each other to create economic, ecological, and nutritional value. Litchi, a high-value fruit crop of eastern India, particularly Bihar and Jharkhand, depends heavily on insect pollination for improved fruit set and quality. Integrating scientific beekeeping into litchi cultivation not only enhances orchard productivity but also opens avenues for premium litchi honey, supporting farmers' livelihoods and strengthening rural economies.

The technical bulletin “*Integrated Beekeeping and Honey Production in Litchi Orchards: From Pollination to Policy*” serves as a comprehensive guide for farmers, beekeepers, researchers, and policymakers. It covers key aspects from colony management and pollination optimisation to forage profiling, honey harvesting, and processing. The bulletin also addresses quality standards, export compliance, and concludes with policy recommendations to promote sustainable and profitable integration of beekeeping within litchi orchards.

Each section is designed to be practical and evidence-based, drawing from field experience, regional case studies, and recent research. The aim is to equip readers with both scientific insights and actionable practices that ensure stronger colonies, higher honey yields, and enhanced litchi fruit productivity. Special emphasis has been placed on ecosystem services, biodiversity conservation, and farmer–beekeeper partnerships, recognizing that sustainable beekeeping in litchi orchards contributes not only to agricultural profitability but also to environmental resilience.

We gratefully acknowledge the contributions of apiculture scientists, horticulturists, extension workers, and orchardists who shared their expertise and insights in preparing this bulletin. Their collaborative spirit has made it possible to integrate perspectives across disciplines and scales. It is our sincere hope that this resource will serve as a valuable reference for those committed to advancing integrated beekeeping, from the flowering orchards to the policy arena, and will inspire further innovations for sustainable apiculture in India and beyond.

(Ipsita Samal)

October, 2025
Muzaffarpur, Bihar

On behalf of all the authors



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CHAPTER 1

Strategic Site Selection and Timely Colony Management for Litchi Beekeeping

1.1. Introduction

Litchi orchards are a major beekeeping resource in India, providing mutual benefits to fruit growers and beekeepers. India ranks among the top litchi producers worldwide, with approximately 92,000 hectares under cultivation in states such as Bihar, Assam, Jharkhand, Odisha, Uttarakhand, and West Bengal. Bihar alone accounts for about 37% of India's litchi output, earning Muzaffarpur the nickname "Litchi City." Litchi trees are insect-pollinated (entomophilous) and self-sterile, requiring insect pollinators for optimal fruit set. Managed honey bees – particularly the introduced *Apis mellifera* (European honeybee) – play a crucial role in litchi pollination, significantly increasing yield and fruit quality. Beekeepers, in turn, produce a valued monofloral honey from the litchi blossom, known for its light amber hue, fragrant aroma, and market demand. This technical bulletin offers science-based guidance on managing *A. mellifera* colonies in litchi orchards, including site selection, seasonal management aligned with litchi flowering, colony preparation, pollination practices, honey harvesting and processing, quality standards, and the role of litchi nectar and pollen in colony health. The recommendations target agricultural extension officers and progressive beekeepers in India, emphasizing practical steps for success.

1.2. Site and Apiary Selection for Litchi Orchards

Choosing an appropriate apiary site is the first step in successful beekeeping in litchi orchards.

Location: Place hives as close to the litchi orchard as possible – ideally within or at the edge of the orchard – so bees have short foraging distances and conserve energy. A general guideline is to select an open, dry location that offers some partial shade, especially in hot afternoons. For example, hives can be kept under the light shade of orchard trees or an erected shade net; this protects colonies from direct midday sun while avoiding damp, fully shaded spots. The site should be well-drained (no waterlogging or high humidity around hives) and protected from strong winds and flooding.

Accessibility: Ensure the apiary is accessible by vehicle or foot for transporting hives (important for migratory beekeeping) and for regular management visits.

Hive stands: Place hives on stands about 30 cm above ground to keep them dry and reduce ant intrusion. Coat stand legs with oil or use water-moat bowls to prevent ants from climbing.

Water source: Provide a clean water source near the apiary, such as shallow containers with fresh water (with stones or floats for bees to land). This is essential in hot weather, as bees need water for cooling the hive and diluting honey. If no natural stream or pond is nearby, maintain an artificial water feeder throughout the season.

Distance from disturbance: The apiary should be in a quiet area away from human foot traffic or livestock tethering to minimize disturbances to the bees. It's also wise to avoid areas with excessive pesticide use – coordinating with the orchard owner to prevent pesticide spraying during bloom or to relocate/cover colonies if spraying is necessary. Good site selection sets the stage for healthy colonies that can forage optimally on litchi blossoms.

1.3. Seasonal Colony Management Aligned with Litchi Flowering

Managing *A. mellifera* colonies through the seasons is critical so that they reach peak strength during the litchi flowering period. Litchi in eastern/northern India generally blooms in spring (e.g. March in Bihar and adjoining areas). The goal



is to have strong, active colonies by this time, and then care for them after the bloom (Table 1.1).

Table 1.1. Seasonal Beekeeping Calendar for Litchi Orchards

Season / Months	Colony Condition & Floral Context	Recommended Beekeeping Practices
Winter (Dec–Jan)	Lean season; limited forage except mustard in some areas. Colonies may weaken in cold.	Protect hives from cold (insulation, sunny sheltered spots). Feed sugar syrup + pollen substitute if stores low. Unite weak colonies. Cluster management for <i>A. mellifera</i> . Ensure young queens + 5–6 frames of bees/brood. Check and treat for mites/diseases.
Pre-Flowering Early Spring (Feb)	Colonies preparing for litchi bloom; minor blooms (drumstick, pulses). Litchi at bud stage.	Start stimulative feeding (4–6 weeks before bloom). Inspect queen status. Combine weak colonies. Add wax foundation frames if expansion seen. Replace old combs. Aim for 8+ frame strength with ample sealed brood by early March.
During Litchi Bloom (Mar–Apr)	Main nectar flow; litchi bloom lasts ~3–4 weeks; strong colonies can yield 30–40 kg.	Deploy hives at ~5–10% bloom. Avoid disturbance. Add supers/empty combs to prevent overcrowding. Weekly quick checks for swarm cells; prevent swarming. Maintain ventilation. Use queen excluder below supers. Place hives in sunny morning spots, partial midday shade.
Post-Flowering (Apr–May)	Litchi flowers end; fruits develop. Next forage: sunflower, jamun, cucurbits.	Remove supers promptly for honey extraction. Prepare colonies for migration (sunflower fields, jamun in June). If stationary, monitor for dearth and feed if needed. Replace failing queens (requeening). During migration, move at night with screened entrances; extract honey beforehand to lighten hives.
Monsoon & Off-Season (Jun–Sep)	Major dearth; heavy rains, weak forage. Pests thrive in humidity.	Keep colonies dry and ventilated (rain covers, tilted lids). Provide 1:1 syrup or reserve honey frames. Feed pollen supplements. Control ants, wax moths, and brood infections. Unite weak colonies. Clear weeds/debris around the apiary.
Autumn Preparatory Phase (Oct–Nov)	Minor blooms (niger, cosmos, early mustard, coriander). Build colonies for winter.	Strengthen colonies: ensure ample stores (feed 2:1 syrup if needed). Treat mites in the fall. Utilise autumn crops (Niger, coriander, early mustard) to build strength. Prepare colonies for winter with young queens and strong populations. Ready colonies for next mustard → litchi cycle.

Throughout seasons, maintain colony inspections and good practices: keep colonies disease-free and well-queened, practice hygiene (clean bottom boards, remove old combs), and adjust management to weather (shade in summer, insulation in winter). This strategic year-round management aligns the colony's strongest population phase with the litchi bloom, maximizing both pollination and honey yield.



1.4. Colony Preparation and Stimulative Feeding before Litchi Bloom

Colony build-up before the litchi flowering is crucial. Stimulative feeding involves providing extra food (carbohydrates and proteins) to encourage the queen to lay eggs and the colony to raise more brood in anticipation of the honey flow. Approximately 4–6 weeks before expected bloom, start feeding colonies with a light sugar syrup (1:1 sugar: water ratio). Feed in small doses (e.g. 250–500 ml per colony every few days) to mimic a nectar flow – this continual influx of syrup prompts the bees to increase brood rearing rather than simply storing the syrup. Ensure feeders are clean and located inside the hive or at the entrance to prevent robbing. In addition to syrup, assess the colony's pollen stores: *A. mellifera* needs ample pollen/protein to raise brood. If natural pollen is insufficient in late winter, feed a pollen substitute or supplement. A commonly used recipe for pollen patty in India is a mix of defatted soy flour, yeast, skim milk powder, sugar, and honey – for example, one advisory suggests ~3 parts soy flour:1 part brewer's yeast:1 part skim milk powder combined with sugar and honey to form a patty. Such patties placed on top of brood frames can significantly improve brood development when outside pollen is scarce. Research from Bihar's agricultural university shows that colonies fed a supplemental diet (sugar syrup + vitamin + pollen substitute) during dearth produced more brood and even better quality queens compared to unfed colonies. This indicates the value of stimulative feeding in late winter to boost colony strength.

While feeding, also perform colony equalization: if some colonies are much stronger than others in brood, consider redistributing brood frames. Giving capped brood from very strong colonies to weaker ones (and swapping some empty combs or bees if needed) can even out populations so that all colonies reach decent strength by bloom. This ensures more colonies are viable for pollination service. Additionally, check queen status – replace any failing queen well ahead of bloom with a young queen, so that egg laying is at a maximum. Some progressive beekeepers rear queens in late autumn so that young queens are in place by late winter. Young queens typically lay more eggs, helping colonies build up faster.

About 1–2 weeks before litchi bloom, inspect each hive to ensure sufficient space is available for the impending nectar flow. If the brood chamber is packed with bees and brood, add a super or at least a few drawn combs so that incoming nectar can be stored without crowding out the brood nest. The colonies should be disease-free at this point – treat or discard any combs with symptoms of foulbrood, chalkbrood, etc., since disease can prevent a colony from capitalizing on the bloom. If the weather in pre-bloom is erratic (cold spells), use entrance reducers and insulation as needed, but remove them once bloom starts for full forager activity. Preventive swarm control is also part of preparation: providing space, possibly splitting the most populous colonies a couple of weeks pre-flow, and destroying queen cells can help avoid swarms just when bloom begins (swarming would drastically cut the foraging population). Overall, by intensive feeding and management in the weeks leading up to bloom, each *A. mellifera* colony can be “supercharged” – filled with 8–10 frames of bees and abundant brood – so that it will have a large cohort of foragers ready to collect litchi nectar and pollen at peak bloom. This preparation pays off in both improved pollination for the orchard and greater honey yields for the beekeeper.



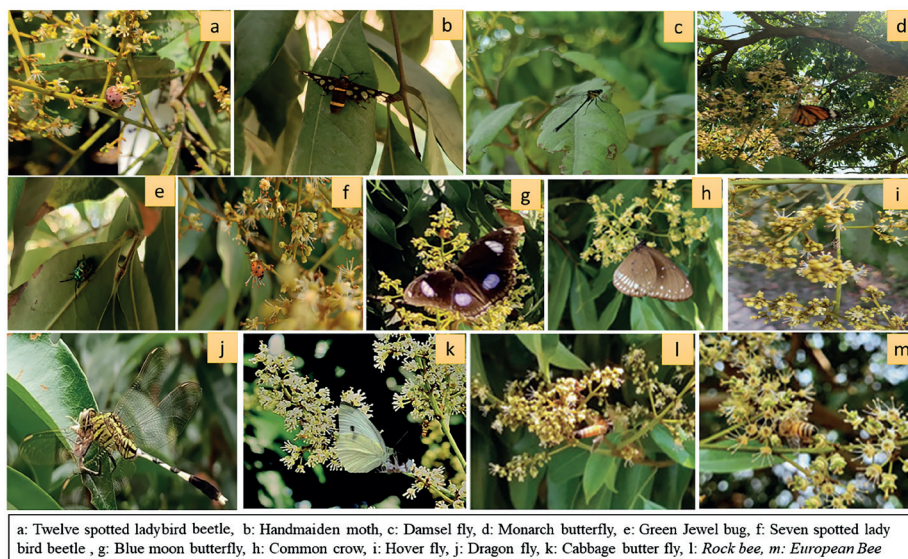


CHAPTER 2

From Flower to Fruit: Optimizing Pollination for Better Litchi Harvests

Reliable fruit set in litchi hinges on a tight synchrony between bloom phenology and pollinator activity. Even in well-managed orchards, growers often see strong flowering but uneven yields, a gap that typically reflects when and which flower visitors are actually moving pollen. This chapter uses field observations from the ICAR–National Research Centre on Litchi to turn that biological timing into practical management for better harvests, highlighted in Tables 2.1, 2.2, 2.3. and 2.4.

Figure 2.1. Diverse insect visitors and pollinators in litchi orchard



a: Twelve spotted ladybird beetle, b: Handmaiden moth, c: Damsel fly, d: Monarch butterfly, e: Green Jewel bug, f: Seven spotted lady bird beetle, g: Blue moon butterfly, h: Common crow, i: Hover fly, j: Dragon fly, k: Cabbage butterfly, l: Rock bee, m: European Bee

Table 2.1. Different insects were observed as the visitor/pollinators in litchi during the period of flowering

Order	Family	Taxon / Common name	Role in orchard
Lepidoptera	Nymphalidae	<i>Danaus plexippus</i> (Monarch)	Visitor
Lepidoptera	Nymphalidae	<i>Hypolimnys bolina</i> (Blue moon)	Visitor
Lepidoptera	Pieridae	<i>Pieris rapae</i> (Cabbage butterfly)	Visitor
Lepidoptera	Erebidae	<i>Syntomoides imaon</i> (Handmaiden moth)	Visitor
Coleoptera	Coccinellidae	<i>Coccinella septempunctata</i> (Sevenspotted ladybird)	Visitor
Coleoptera	Coccinellidae	<i>Coccinella novemnotata</i> (Ninespotted ladybird)	Visitor
Coleoptera	Coccinellidae	<i>Coleomegilla maculata</i> (Pinkspotted ladybird)	Visitor
Hemiptera	Scutelleridae	<i>Chrysocoris stollii</i> (Green jewel bug)	Visitor
Odonata	Libellulidae	Dragonflies	Visitor
Hymenoptera	Formicidae	<i>Camponotus compressus</i> (Ant)	Visitor
Hymenoptera	Apidae	<i>A. dorsata</i> (Rock bee)	Pollinator
Hymenoptera	Apidae	<i>A. mellifera</i> (Italian/Western honey bee)	Pollinator
Diptera	Syrphidae	<i>Eristalis</i> spp. (Hover flies)	Pollinator



Table 2.2. Bloom progression and *A. mellifera* response — key dates and peaks

Date (2025)	M1 (Male) flowers (mean $\pm$ SE)	Hm (Hermaphrodite) flowers (mean $\pm$ SE)	M2 (mean $\pm$ SE)	<i>A. mellifera</i> settling rate (mean $\pm$ SE)	Comment
15 th March, 2025	216.28 $\pm$ 0.76 (peak)	high	—	—	Male peak marks the onset of full bloom.
18 th March, 2025	—	rising	rising	high	Start of optimal pollination window.
19 th March, 2025	—	rising	high	high	The settling rate very high.
20 th March, 2025	—	rising	90.02 $\pm$ 4.66 (peak)	45.78 $\pm$ 1.74 (peak)	Peak bee activity aligned with M2 peak.
23 rd March, 2025	—	high	—	—	Hm nearpeak.
24 th March, 2025	—	high	—	—	Hm nearpeak.
25 th March, 2025	—	58.21 $\pm$ 1.91 (peak)	—	—	Hm peak~1 week after male peak.

Table 2.3. Overall correlations of settling rate with floral and environmental variables

Predictor	Strength	Association
M2 flowers	Strong	Positive
Hm (Hermaphrodite) flowers	Moderate–strong	Positive
M1 (Male) flowers	Weak	Positive
Wind gust	Moderate	Positive
Cloud cover	Moderate	Positive
Temperature	Weak–moderate	Positive
Wind speed	Weak	Positive
UV index	Negligible	Positive
Relative humidity	Negligible	Negative

Study site: ICAR–National Research Centre on Litchi (ICAR-NRCL). Flower morph codes: M1 = Male; Hm = Hermaphrodite; M2 =Male fertile flowers as defined in the above tables.

In the year 2025, a study conducted at ICAR-NRCL, the litchi canopy hosted a diverse insect guild. Many taxa were regular visitors but not primary pollinators, including butterflies and moths (e.g., *Danaus plexippus*, *Hypolimnas bolina*, *Pieris rapae*, *Syntomoides imaoon*), ladybird beetles (*Coccinella* spp., *Coleomegilla maculata*), jewel bugs (*Chrysocoris stollii*), dragonflies (Libellulidae), and ants (*Camponotus compressus*). Effective pollinators were led by honey bees, *A. mellifera* (Italian/Western honey bee) and *A. dorsata* (rock bee)—with syrphid hover flies (*Eristalis* spp.) contributing as well (Figure 2.1). Distinguishing incidental visitors from true pollinators is central to decisions about hive placement, landscape support, and pesticide timing.

Equally important is the sequence of flower phases. Litchi inflorescences presented male (M1), hermaphrodite (Hm), and a second male (M2) phase over days, not weeks. In 2025, M1 peaked on March 15 (216.28 $\pm$ 0.76), marking the onset of full bloom. The optimal pollination window opened by March 18–19 as Hm and M2 rose and honey-bee settling intensified. A clear joint peak occurred on March 20, when M2 reached 90.02 $\pm$ 4.66 and *A. mellifera* settling peaked at 45.78 $\pm$ 1.74—the strongest alignment of floral supply and bee foraging. Hm continued rising and peaked on March 25 (58.21 $\pm$ 1.91), roughly a week after the initial male peak. These dates illustrate the narrow windows in which management actions have an outsized impact.

Correlational patterns reinforce this timing. Bee settling was strongly and positively associated with M2 flowers, moderate–strong with Hm, and only weakly with M1—evidence that the second male wave and the functional hermaphrodite phase drive the bulk of effective visitation. Among weather covariates, wind gusts and cloud cover showed moderate positive associations with bee settling, while temperature was weak–moderate positive; mean wind speed was weak positive. UV index (negligible positive) and relative humidity (negligible negative) played minor roles during observation periods. Together, these signals point to a simple rule of thumb: prioritize pollination support around M2–Hm peaks and remain alert to microclimates that either enables or suppresses bee flight.

Building on these insights, this chapter highlighted flower phenology-based recommendations for placement of honeybee hives and thus, we aim to replace generic “more bees, more fruit” advice with a phase-aware pollination plan. The result is a practical pathway from flower biology to fruit set—so that, season by season, litchi orchards convert abundant blossoms into reliably higher yields.

2.1. Pollination Strategies and Impact on Litchi Fruit Set

Since *A. mellifera* are the dominant pollinators in litchi ecosystem, intentional use of *A. mellifera* for litchi pollination can dramatically improve fruit set and yields. Litchi flowers are attractive to many insects, but honey bees are among the most effective pollinators due to their sheer numbers and foraging behavior. To maximize pollination, introduce bee colonies at the correct time and density in the orchard. It is recommended to move hives into litchi orchards when about 10% of the tree’s flowers have opened. At this stage, enough bloom is present to attract the bees, but it’s early enough that the bulk of flowering (and pollination) is still ahead. If hives are brought too late (e.g. at full bloom), some early flowers may have missed optimal pollination; if brought too early (before bloom), the bees may drift to other plants or weaken due to lack of forage. Thus, timing at first bloom is important.

Hive density: For *A. mellifera*, a typical recommendation is on the order of 3–5 colonies per hectare of litchi orchard. The ICAR-NRCL in Bihar specifically found about 4 colonies/ha to be effective for litchi pollination, resulting in 25–30% higher yields compared to self-pollination without bees. Some experts even advise up to 10–15 colonies/ha for maximum fruiting in litchi, especially if the orchard is isolated from other pollinator sources. In practice, if litchi bloom is very abundant and colonies are strong, a moderate density (e.g. 4–5 hives/ha) often suffices because each *A. mellifera* colony can deploy tens of thousands of foragers. It’s beneficial to distribute hives in small clusters throughout the orchard rather than all in one corner. Place clusters of 5–10 hives every 200–300 m so that bees cover the orchard uniformly. This distribution also reduces competition among colonies and ensures even pollination. Position hive entrances facing away from busy areas (to avoid stings) and slightly towards the southeast if possible, so bees get morning sun. Also ensure the hives are stable and won’t tip over.

Pollination impact: The presence of *A. mellifera* can greatly increase litchi fruit set. Studies have shown that without insect pollinators, litchi trees set almost no fruit – inflorescences bagged to exclude insects yielded near-zero fruits (only 0–2 fruits per panicle). In contrast, open-pollinated litchi with honey bee colonies nearby can set many fruits per panicle. An experiment in Bihar demonstrated that litchi panicles accessible to *A. mellifera* had significantly higher fruit set, and those trees bore heavier fruits with better pulp recovery and sweetness (higher total soluble solids) than those without adequate bee visits. In one comparison, litchi fruit weight was around 20.5 g and sweetness 22.4°Brix under open pollination with *A. mellifera*, versus inferior quality in the absence of bees. Additionally, beekeeping authorities note that honey bee pollination improves not just fruit quantity but quality – fruits tend to be more uniform, larger, and have higher pulp content when adequately pollinated. The mechanism is that thorough pollination leads to more fertilized ovules and hence fuller arils (pulp) in litchi.

The hives must remain in or near the orchard throughout the flowering period. Research indicates fruit set decreases the farther the bee hives are from the litchi trees; in trials, moving hives even 500 m away resulted in reduced fruit set compared to hives placed directly under the trees. Thus, keeping colonies within the orchard (or immediately adjacent) during bloom maximizes the pollination benefit.



Bee behavior and fruiting: Honey bees begin foraging on litchi early in the day. Litchi flowers open in stages (male and female phases) and produce abundant nectar with a fragrant odor, attracting bees in large numbers. A single litchi inflorescence can receive numerous bee visits; for instance, surveys in South Asia have observed ~5 honeybee visits per panicle on average, making bees the most common flower visitor. This consistent foraging ensures pollen transfer between the functionally male and female flowers on different trees (since litchi is largely cross-incompatible). By facilitating this cross-pollination, bees can raise litchi fruit set by a significant margin. Extension data from India shows yield increases of roughly 25–30% in litchi due to bee pollination services. In some cases, fruit yields have even doubled when ample bees were present, especially in areas previously lacking wild pollinators.

Pollination management tips: During bloom, minimize pesticide use (pesticides should not be applied during full bloom as it could kill foraging bees). If pest control is needed in the orchard, it is recommended just before introducing bees, or only after removing the bees post-bloom. Also, provide a water source as mentioned so bees don't waste time searching for water. Avoid disturbing or relocating hives mid-bloom; stability helps the foragers establish foraging routes on litchi. Finally, once flowering is over and fruit set has occurred, remove the colonies before any spraying of insecticides in the orchard. As a best practice, when fruiting begins, have the farmer notify the beekeeper so hives can be taken out (or at least temporarily closed) prior to chemical sprays, thereby preventing bee poisoning. With these strategies, *A. mellifera* can be used as a powerful tool for improving litchi orchard productivity, while the beekeepers gain a honey crop – a classic win-win scenario.

Table 2.4 : summarized selected research findings from India and abroad on how honey bee (*A. mellifera*) pollination impacts litchi fruit set, yield, and fruit quality.

SL. No.	Study (Year, Location)	Pollination Scenario	Key Findings (Impact on Fruit Set, Yield, Quality)
1	Badiyala & Garg (1990, India)	4 <i>A. mellifera</i> hives/ha vs. bagged (no insects)	Fruit set was 2–3× higher in litchi inflorescences visited by honey bees compared to inflorescences where insects were excluded
2	Badiyala & Awasthi (1991, India)	Honey bee pollination vs. no pollinators	Litchi trees with honeybee colonies yielded ~38 kg of fruit per tree, versus only ~9.6 kg per tree without bee pollination – a nearly 4× increase in yield
3	Rai & Srivastav (2012, India)	<i>A. mellifera</i> introduced (caged with hive) vs. no-bee control	Significantly higher fruit set and yield with bees: ~4.5 fruits per panicle (at harvest) vs. essentially 0 in no-bee controls. Fruits were also heavier (~21.5 g average) and sweeter (TSS ~21.9 °Brix) under honey bee pollination
4	South Africa study (1990s)	Open (insect-pollinated) vs. bagged (no insects)	Almost no fruit developed without insects: 95% of bagged panicles set no fruit (average <1 fruit/panicle). In contrast, with open pollination ~92% of panicles set fruit, averaging 9 fruits per panicle (range 0–44)
5	Ali et al. (2023, Pakistan)	Free insect visits vs. insect exclusion	Insect-pollinated litchi produced larger and higher-quality fruits: fruit weight and size increased, pulp content was greater, and chemical quality improved (higher TSS and Vitamin C levels) compared to fruits from which pollinators were excluded

Each of these studies demonstrates that facilitating pollination (especially by honey bees) can dramatically improve litchi fruit set and yield, as well as enhance fruit size and quality. For instance, excluding insects often results in negligible fruit set, whereas introducing *A. mellifera* hives at bloom can increase fruit set by 2–3 times and boost yields by 25–300% depending on baseline conditions. Honey bee pollination not only increases the quantity of litchi fruits but also their quality – yielding heavier fruits with higher pulp recovery and sweetness (as reflected in total soluble solids). These findings underscore the vital role of managed pollination in optimizing litchi harvests.



CHAPTER 3

From Flower to Hive: Forage Impact and Pollen Profiling in Litchi Beekeeping

Litchi bloom is a high-value forage event for *A. mellifera*: flowers offer abundant (if dilute, ~5% sugar) nectar and plentiful pollen across dense canopies, letting strong colonies gain rapidly—often yielding ~30–40 kg honey per colony—and driving peak March pollen intake (Pusa, Bihar). This surge fuels brood rearing and population growth, so the immediate post-harvest window is ideal for splitting of bee colony and queen rearing, provided swarming is controlled and some honey remains in brood boxes. The resulting litchi honey—light golden to amber, fruity-floral, and typically slow to crystallize due to higher fructose—carries aroma “fingerprints” (linalool, its oxides, lilac aldehydes) that support authenticity and premium marketing; gentle handling (minimal heat, proper storage) preserves these volatiles. Economically and ecologically, bees lift litchi fruit set/yield and fit neatly into national migratory circuits, but the post-flow “brood boom” raises food demand and swarm risk, so managers should move promptly to the next flow (e.g., sunflower/jamun), supplement, or briefly curb brood (splits/queen caging) to prevent shortages. Melissopalynology-microscopic pollen identification in honey—then underpins labelling, QA, and management: $\geq 45\%$ of a single pollen type supports monofloral status, and field examples of 73–85% *Litchi chinensis* pollen (e.g., Malda) validate “Litchi Honey” claims while enabling traceability and adulteration checks (low counts or unexpected mixes flag issues). For stationary apiaries, a litchi-dominant pollen spectrum confirms bees worked the target crop; if non-litchi pollen is high, tweak hive numbers, placement, or harvest timing to isolate the litchi flow. Comparing samples across orchard blocks also reveals coverage—uniform litchi dominance suggests even pollination, while localized spikes in other pollen indicate gaps (late bloom, competing flora, suboptimal hive siting). In short: the litchi flow fuels colony growth and a premium monofloral crop; pollen analysis proves origin, supports pricing and branding, and functions as a practical pollination audit; after litchi, move, feed, or split so booming colonies don’t outgrow available forage.

Table 3.1: Summary of research studies on litchi pollination and its impact on fruit set, yield, and fruit quality

Study (Year, Location)	Pollination Treatments Compared	Key Findings (Fruit Set, Yield, Quality)
Pandey & Yadava (1970, India)	Open (insect-pollinated) vs bagged (no insects)	Near-zero fruit set without insect pollinators (<0.5%) versus up to ~11% fruit set with insect pollination. This demonstrated litchi’s strong reliance on insect cross-pollination for fruit set.
Badiyala & Garg (1990, India)	4 <i>A. mellifera</i> hives in orchard vs caged (no insects)	Honey bee pollination boosted litchi fruit set by roughly 2–3× compared to trees where insects were excluded. In other words, introducing managed honey bee colonies greatly increased fruiting.
ICAR-NRC Litchi (Bihar, India)	Recommended hive density (~4 <i>A. mellifera</i> colonies/ha) vs self-pollination	Field trials in Bihar showed about 25–30% higher yield in litchi orchards with honey bee pollination, compared to self-pollinated (no bees) control. Adequate honey bee density significantly improved fruit yield per hectare.



Study (Year, Location)	Pollination Treatments Compared	Key Findings (Fruit Set, Yield, Quality)
Mishra (2019, Bihar, India)	Open pollination (wild insects) vs managed honey bees vs pollination exclusion	Open pollination (with wild insects) or placement of <i>A. mellifera</i> hives led to much greater fruit set and yield than no-insect controls. Fruit set reached ~3.1% with open pollination vs only ~2.4% when insects were excluded. Likewise, yield was ~120.3 kg/tree under open-pollination, versus just ~92.1 kg/tree with no pollinators (managed-bee treatment was ~118.4 kg/tree, similar to open). These results confirm that keeping honey bee colonies in the orchard markedly increases litchi production.
Ali et al. (2023, Pakistan)	Open insect access vs self-pollination (insects excluded)	Insect pollination produced larger fruits (avg. ~21.2 g vs 17.5 g, with pulp ~13.7 g vs 11.4 g per fruit) and sweeter pulp (TSS ~26.6°Brix vs 17.7°Brix) compared to self-pollinated fruits. Litchi fruit quality (size, pulp content, sweetness) and total yield were all significantly improved when pollinators (honey bees and others) had free access to the flowers

3.1. Market Credibility, Traceability, and Floral Resource Management

Beyond pollination and honey labelling, melissopalynological analysis offers several practical benefits that enhance both the marketability of litchi honey and the management of floral resources in and around the orchard.

- **Authenticity and Market Credibility:** In an era where consumers are wary of fake or adulterated honey, having a pollen analysis profile for honey builds trust. For premium monofloral honeys like litchi honey, a verified pollen profile serves as a certificate of authenticity, confirming that the honey mainly comes from litchi nectar. This is especially valuable for branding and export. Buyers (and regulators) may require proof that “Litchi Honey” isn’t just a label – melissopalynology provides that proof in scientific terms. As noted, unifloral litchi honey commands a higher market value, being regarded as an exotic specialty, so producers who can demonstrate their product’s genuineness can secure better prices and access premium markets. Traceability is also crucial: the presence of minor pollen types can often identify the region’s flora. For example, litchi honey from northern India might regularly show traces of local wildflowers or trees. Honey samples from nearby areas tend to have similar pollen signatures, while those from distant regions will differ. Therefore, pollen analysis can sometimes determine a honey’s origin, aiding in marketing a “single-origin honey” and detecting mislabeling of geographic source.
- **Quality Control and Purity Testing:** Melissopalynology doubles as a quality control tool by revealing adulteration or poor-quality honey. Pure honey naturally contains many pollen grains (because bees inadvertently mix pollen into nectar and honey), whereas artificial syrup or ultra-filtered honey will have unusually few. For instance, genuine honey typically yields a sizable pellet of pollen after centrifugation, whereas adulterated or filtered honey might show a very low pollen count. Consistent pollen presence and diversity confirm a honey’s natural origin, while anomalies can trigger further testing. In India, where adulteration of honey with rice syrup or other sugars has been a concern, such tests help maintain credibility in the supply chain. Honey packers and processors can use melissopalynology to validate incoming honey batches (ensuring that a batch labelled “litchi honey” actually has the pollen profile of litchi honey), thereby protecting both consumers and honest beekeepers.
- **Honey Traceability and Certification:** With increasing interest in organic and regional products, some producers might leverage pollen analysis data to get certifications (such as Geographic Indications or other quality marks). A detailed pollen spectrum can be part of a honey’s dossier for certification, showing, for example, that “Bihar Litchi

Honey” consistently contains pollen from litchi and local flora, distinguishing it from honey produced in other areas. This kind of traceability is a value-add for storytelling and provenance – it connects the honey to the litchi orchards and the season in which it was made, which resonates with consumers.

- **Optimizing Floral Resource Management:** Perhaps one of the more strategic uses of melissopalynology is in guiding decisions about what plants to cultivate or encourage around the apiary for sustained honey production and bee health. A pollen analysis reveals which plants bees are utilizing for nectar and pollen throughout the season. For a stationary apiary in a litchi orchard, the litchi bloom is a major nectar flow in spring – but what about before and after? If the honey from after litchi season shows, say, significant pollen from mustard or niger (oilseed crops) or certain wild shrubs, that tells the beekeeper and orchard manager which other plants are important in the bees’ diet. In a study from Chhattisgarh, India, melissopalynological surveys identified multiple major bee forage plants (like *Brassica campestris* (mustard), *Guizotia abyssinica* (niger), *Litchi chinensis*, *Eucalyptus*, *Moringa*, etc.), and it was recommended that efforts be made to increase the cultivation of these plants locally to support robust beekeeping. In our litchi orchard context, this might mean planting or conserving auxiliary flora that blooms outside of litchi season, so the bees have nectar sources year-round. For example, if pollen analysis finds that after the litchi bloom the bees relied heavily on wild sage (Leucas) or clover in the vicinity, an orchard manager could decide to allow those plants to thrive as cover crops or along borders instead of clearing them, thereby providing food for the bees when litchi is not flowering.
- **Detection of Dearth Periods and Forage Gaps:** Conversely, pollen analysis can signal when bees are entering a dearth period (a time of scarce forage). If a honey sample shows a very high diversity of minor pollen types with no single dominant source, it can indicate that bees were scraping together nectar from many miscellaneous flowers – a sign that no major bloom was available at that time. For instance, summer or monsoon honey might contain 20–30 pollen types each at low percentages, reflecting scattered foraging. This information is useful management-wise: it suggests when supplemental feeding might be needed for stationary hives, or it can inform a decision to migrate the bees to another area for better forage. Beekeepers can track these patterns year to year. If litchi bloom is the big nectar flow in spring and the next major flow only comes in, say, winter (mustard or eucalyptus, etc.), there is a long mid-year gap. Knowing this, an orchard-based beekeeper might plant flowering crops like sunflowers or legumes in the interim, or temporarily move colonies after litchi harvest to areas with summer blooms. Melissopalynology provides the data to back such decisions, ensuring bee colonies remain healthy and productive by always having something to forage.

3.2. Stationary vs. Migratory Beekeeping: Benefits and Challenges in the Litchi Context

Finally, it’s useful to consider how mellisopalynology plays a role in stationary versus migratory beekeeping systems in litchi orchards, as each approach has its own advantages and challenges:

- **Stationary Beekeeping:** In a stationary system, bees live year-round at or near the litchi orchard. The obvious benefit is convenience and consistent pollination service – the bees are on site whenever the litchi flowers need them, and there’s no need to transport hives. From a mellisopalynological perspective, stationary hives will produce honey that reflects the entire tapestry of local flora over the seasons. During the litchi bloom, their honey can be harvested and verified as monofloral litchi honey. However, once the litchi flowering is over, those same bees must rely on whatever other blossoms are available nearby. If the surrounding environment has enough diversity (other fruit trees, wildflowers, crops, etc.), the bees will collect nectar from those, resulting in multi-floral honey later in the year (pollen analysis might show a mix of pollen types without a single dominant one). A challenge here is that stationary beekeepers often face seasonal dearth periods when little is blooming – for example, after litchi season, there might be months with scant forage. During such times, the honey yield drops and bees may require feeding. Pollen analysis of honey can



highlight this issue by showing many minor pollen sources (or very low pollen count) in those off-season honeys. Stationary beekeeping thus trades higher total honey yields for stability – the beekeeper might get only one big crop (litchi honey) and some minor honey flows, but in return the orchard is continuously pollinated and bees are less stressed by moving. Stationary litchi orchard beekeepers can use melissopalynology to monitor how self-sufficient their location is: if analyses show consistent nectar sources round the year, that's great; if not, it signals a need to either plant more forage or prepare to feed during gaps.

- **Migratory Beekeeping:** Migratory beekeepers move their colonies from one bloom to the next, often transporting hives over long distances to chase sequential flowering seasons. In India, a migratory beekeeper might bring hives to a litchi orchard for the Feb-March bloom, then move them to mustard fields, acacia forests, or other crop areas later. The big advantage here is increased honey production – the bees can tap multiple major nectar flows in one year, yielding several types of monofloral honey. In fact, migratory beekeeping is known to increase total honey yield and reduce the need to feed bees during dearth periods compared to stationary beekeeping, because the colonies are always kept where something is in bloom. From the melissopalynology angle, migratory beekeeping means one must carefully handle honey harvesting to preserve the identity of each floral source. After the litchi bloom, for instance, the beekeeper will typically extract the honey before moving the bees to the next location. This ensures that the litchi honey remains pure and monofloral, with its pollen profile showing >45% litchi and minimal influence from subsequent blooms. If they did not do this, the honey left in hives could get blended with the next nectar flow (e.g. sunflower or eucalyptus), and the pollen analysis would then show a mixed floral origin, spoiling its monofloral status. Thus, migratory beekeepers rely on melissopalynology as a quality check for each batch – it helps verify that the honey collected after each move is truly from the intended crop. An interesting consideration is that migratory colonies might carry over small amounts of pollen or nectar from the previous location. For example, bees moved into a litchi orchard might still have some residue of mustard honey in their combs; as they mix it, a trace of mustard pollen could appear in the first harvest of litchi honey. However, as long as litchi is predominant, the honey is still classified as litchi honey. The pollen analysis would catch any significant contamination, prompting better management (like ensuring supers are mostly empty before a new flow). In terms of challenges, migratory beekeeping involves transport logistics, possible stress on bees, and timing coordination with farmers. For litchi growers, hiring migratory beekeepers means negotiating hive placement each season, but it often brings a large number of hives into the orchard at bloom, achieving intensive pollination. The orchard's litchi honey crop then becomes a cooperative outcome – the beekeeper gets the honey, the farmer gets the pollination. Melissopalynology in this scenario is mostly the concern of the beekeeper or honey buyer, to certify the monofloral honey from that orchard. For the grower, as long as the fruit sets well, the exact pollen count in honey is less of a concern – though it still indirectly reflects how faithfully those migratory bees worked the litchi flowers.

Melissopalynology (pollen analysis of honey) strengthens both stationary and migratory beekeeping in litchi systems. For stationary hives, it shows how much bees used the local litchi bloom and what they foraged on between blooms—useful for confirming pollination, spotting forage gaps, and marketing small batches of traceable orchard honey. For migratory hives, it verifies the purity of each crop-specific honey (litchi, mustard, etc.) at different locations, supporting labels like “Muzaffarpur Litchi Honey” and meeting export standards. Trade-offs: stationary beekeeping offers simpler operations and consistent orchard pollination but can yield less; migratory beekeeping maximizes year-round honey flows but needs more effort and careful batch separation. In India, the choice depends on goals and resources, but in both models pollen analysis adds transparency, confirms floral origin, guides forage planning, and boosts marketability and trust. In short, melissopalynology is both a quality-assurance and management tool—linking honey credibly to blossoms and helping orchards reap better pollination.

At the ICAR–National Research Centre on Litchi (ICAR-NRCL), a field case study combined with melissopalynological analysis was conducted to examine the foraging dynamics of honey bees during and after the litchi flowering period. Although litchi (*Litchi chinensis* Sonn.) was observed to be the major nectar and pollen source attracting the highest bee visitation, observations revealed that honey bees also frequently visited several associated and alternative floral resources available within and around the orchards. These included *Maburea trinervis*, *Laurus nobilis*, *Dimocarpus longan*, *Leucaena retusa*, *Leucaena leucocephala*, and *Luffa aegyptiaca*, which were in bloom during or soon after the litchi flowering phase (Figure 3.1).

Recognising the importance of continuous floral availability to sustain colonies beyond the short litchi bloom, the study explored the potential of planting diverse seasonal flora to promote non-migratory beekeeping in litchi-growing regions. By establishing and monitoring these species, researchers evaluated bee foraging preferences and the sequence of floral use across seasons. The findings demonstrated that bees readily adapted to the supplemental floral resources, as depicted in Figure 3.2 showing the diverse plant species visited by honey bees during the litchi and post-litchi periods.

Figure 3.1. Alternative floral resources available within and around the orchards during litchi flowering season.

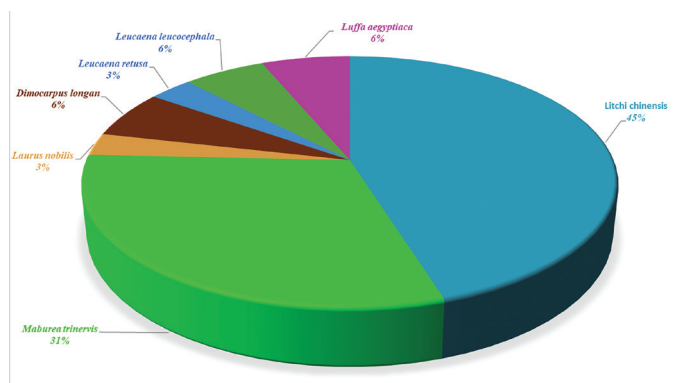


Figure 3.2. Different seasonal flora planted to enhance non-migratory beekeeping in litchi ecosystem





CHAPTER 4

Strategic Use of Floral Calendars in Litchi-Based Beekeeping Systems

A floral calendar underpins proactive colony management. It alerts beekeepers to periods of abundance and dearth in advance, so they can prepare their hives accordingly. During nectar-rich periods, colonies expand rapidly; the calendar lets beekeepers plan timely interventions (adding extra hive boxes/supers, preventing swarming, etc.) to accommodate this growth. Conversely, when the calendar shows an upcoming nectar dearth (e.g. the rainy off-season), beekeepers can take preventive steps like combining weak hives, reducing hive entrances, and providing supplemental feeding (sugar syrup or pollen substitute) to sustain the bees. In litchi-growing areas, for instance, monsoon months of July–August form a known dearth period when few major crops bloom; a floral calendar helps manage this by indicating when to curtail colony expansion and begin feeding before bees suffer. Proper scheduling of colony tasks (like requeening or brood control) is also guided by the bloom calendar – beekeepers avoid disturbing colonies during heavy flows (e.g. peak litchi bloom) and time these management tasks for the off-season. In essence, the calendar ensures that hive strength is optimized at the right moments and that colonies are neither starving nor swarming uncontrollably, leading to healthier bees year-round.

4.1. Migratory vs. Stationary Beekeeping Practices in Litchi Regions

Both migratory and stationary beekeepers rely on floral calendars, but they use them in distinct ways:

- **Migratory Beekeeping:** In litchi-rich regions like Bihar–Jharkhand, migratory apiculture is common to exploit sequential blooms. Beekeepers maintain mobile apiaries and move thousands of colonies along pre-planned routes following the floral calendar (Table 4.1). For example, a migratory beekeeper may start the season in winter mustard fields, then transport colonies to Muzaffarpur’s litchi orchards by March, then to summer flows like sunflower or forest blossoms, and finally back to autumn crops. The calendar is their guide to optimal timing: moving too early or late could mean missing a flow or arriving when blossoms are over. Migratory routes in Bihar have been refined such that “most beekeepers move honey bee colonies to litchi plantations from March to April and harvest monofloral (litchi) honey with good color and flavour”. After the litchi flow, the calendar might direct them to nearby forests where jamun (*Syzygium cumini*) and karanj (*Pongamia pinnata*) bloom in April–June, then perhaps to fields of Niger (oilseed crop) in autumn. By adhering to this schedule, migratory beekeepers keep their bees active and productive year-round, avoiding any prolonged forage gaps. The result is diverse honey harvests (litchi honey, mustard honey, etc.) and strong colonies maintained on continuous nectar flows.
- **Stationary Beekeeping:** Stationary beekeepers, who keep hives in one location (for instance, a beekeeper who maintains an apiary within or adjacent to a litchi orchard all year), use the floral calendar to supplement and plan around local bloom cycles. They benefit from the major local flows (notably the litchi bloom itself), but must manage bees through off-season periods when little is flowering. The calendar helps identify nearby alternative flora each month – e.g. mustard fields within the foraging radius in winter, or wild flowers in surrounding areas – that stationary bees can utilize. If the calendar shows a severe dearth coming (such as the rainy season), the stationary beekeeper can prepare by planting bee-friendly flora nearby, or by feeding and reducing colony size ahead of time. In Bihar’s litchi belt, stationary apiaries enjoy multiple floral sources in a 1–3 km radius across the year, thanks to a mix of crops and wild plants. However, no single location has abundant forage all year long. Thus, the floral calendar guides the stationary beekeeper’s interventions – when to harvest and when to conserve, when to expect pollen shortage, or when to stimulate the queen’s egg-laying.

Below is a month-by-month floral calendar for litchi-growing regions (such as Bihar and Jharkhand), highlighting litchi flowering and other significant bee flora, along with suggested beekeeping practices at each stage.

Table 4.1. Month-Wise Floral Calendar and Beekeeping Practices (Bihar–Jharkhand regions)

Major Floral Sources (Litchi)	Month	Other floral sources	Honey Flow Potential	Beekeeping Practices (Stationary & Migratory)
Litchi (vegetative stage)	January	Mustard, rapeseed, toria, early pulses	Strong flow	Place hives near mustard; monitor brood growth; harvest mustard honey end of month; ensure colonies have stores before February gap.
	February	Drumstick (Moringa), early pulses (Lathyrus/khesari), early fruit blossoms, Litchi (bud stage)	Moderate	Build-up phase: stimulate brood rearing with syrup/pollen feed; move colonies into litchi orchards by late Feb; equalize colony strength; control mites before bloom.
Major nectar flow of litchi	March	Litchi bloom (major nectar flow)	Very strong flow	Keep colonies at peak; add supers/frames; avoid disturbance; prevent swarming; harvest monofloral litchi honey late March; ensure strong pollination for fruit set.
	April	Post-litchi: sunflower, jamun, karanj, forest trees	Good flow	Relocate hives after litchi harvest to sunflower/forest sites; add supers; prevent robbing; treat for mites after extraction.
	May	Extended sunflower, jamun, cucurbits, sesame, safflower	Variable; moderate yields	Harvest sunflower honey; provide shade/water; manage ventilation in heat; reduce brood rearing slightly to prepare for monsoon dearth.
Litchi (fruiting stage, no nectar)	June	Jamun (late bloom), mahua, wild flora; Litchi (fruiting stage, no nectar), seasonal flowers	Short flow	Extract jamun honey in early June; ensure 5–10 kg reserves; rainproof hives; balance strong/weak colonies.
No litchi flowers	July	Scattered cucurbits, wild herbs, seasonal flowers	Dearth (no major flow)	Colony maintenance: feed sugar syrup/pollen patties; reduce entrances; control pests (wax moth/ants); ensure ventilation in humid weather.
	August	Sparse herbs, grasses, late monsoon crops (no litchi), seasonal flowers	Dearth continues	Support feeding; treat mites in low brood period; repair equipment; prepare colonies for autumn bloom.
	September	Post-monsoon sunflower, Niger (Guizotia), eucalyptus, wildflowers, seasonal flowers	Moderate flow	Stop feeding when bloom starts; expand brood frames; migrate hives to Niger/sunflower; final mite/disease treatments.
	October	Niger, sunflower (autumn), sesame, coriander (early), ber/acacia, seasonal flowers	Moderate multi-floral honey	Add supers if needed; harvest small multi-floral honey; ensure strong young queens; leave sufficient stores for winter.
Litchi (vegetative stage)	November	Mustard (early sowings), toria, coriander, vegetables; Litchi (vegetative stage)	Strong flow begins (mustard)	Migrate hives to <i>Brassica</i> areas by mid/late Nov; insulate hives at night; prep equipment for harvest.



Major Floral Sources (Litchi)	Month	Other floral sources	Honey Flow Potential	Beekeeping Practices (Stationary & Migratory)
Litchi (dormant/vegetative)	December	Mustard, rapeseed, eucalyptus, acacia; Litchi (dormant/vegetative)	Strong winter flow	Focus on mustard honey harvest; provide super space; extract promptly (granulation risk); protect hives from cold and condensation.

By following a month-wise floral calendar like the above, beekeepers in litchi-growing regions can skillfully navigate the year. The calendar serves as a planning tool that aligns beekeeping operations with nature's blooming schedule – ensuring that colonies are in the right place at the right time, whether for honey flows or crop pollination. In Bihar and Jharkhand, where diverse flora (from mustard to litchi to forest blooms) offer multiple opportunities, a floral calendar is indispensable for hive management, yield optimization, and agricultural synergy. It helps avoid dearth-period losses and maximizes honey production during nectar flows. Because litchi is a short-duration bloom crop concentrated between February and April, apiculturists in Bihar have developed a well-defined seasonal migration circuit (Table 4.2) to optimize colony utilization and honey yield. Colonies are moved successively across districts such as Muzaffarpur, Vaishali, Samastipur, Bhagalpur, and Sitamarhi, following the staggered flowering pattern of litchi varieties and the availability of post-litchi forage. To document these patterns, a case study was undertaken across major litchi-growing regions of Bihar, incorporating data from multiple beekeepers. The study recorded not only the migration routes and timing of colony movements but also the stocking densities, honey yields, and pollination benchmarks associated with litchi orchards (Tables 4.3 and 4.4). Further, since colony sustainability beyond the litchi bloom is critical to economic viability, the study identified key bridge forages available during the post-litchi period (April–July) and major Rabi-season floral sources (November–February) that maintain bee populations and enable continued honey flow (Tables 4.4 and 4.5). This information provides an integrated understanding of how migratory beekeeping aligns with litchi phenology and the broader floral calendar of Bihar. The results serve as a reference for optimizing pollination management, improving honey yield planning, and supporting regional strategies for sustainable apiculture in eastern India (Table 4.6).

Table 4.2. Seasonal Migration Circuit of beekeepers in Bihar

Window	Primary Regions	Key Floral sources	Objectives	Typical Actions/Notes
Mid Mar–Early Apr	Bihar litchi belt	Litchi (Lychee)	Anchor honey crop; pollination service	Arrive prebloom; equalize strength; add supers at 60–70% fill; avoid sprays during bloom; segregate monofloral litchi honey
Apr–Jul	Bihar (district specific)	Jamun, Sunflower, Lal ghash (pollen), Maize	Bridge flows to avoid dearth	Split apiary to chase staggered blooms; provide shade/water in heat; feed syrup if prolonged rain dearth
Jul–Oct	Western/Central	Bajra, Sesame, Pigeon pea, U.P. cucurbits & vegetables	Monsoon maintenance and buildup	Continuous trickle forage; low honey harvest priority; maintain colony health.
Jul–Nov	Eastern/Northern Rajasthan	Sesame, Bajra (early), Ber (Sep–Oct), Ajwain (Oct), wild herbs	Escape heavy rains; target specialty monoflorals	Time of ber bloom for honey; move partapiary to ajwain belts (short, aromatic flow)
Oct–Early Nov	M.P. stopover (Shivpuri–Gwalior belt)	Ajwain, wild flora	Rebuild stores; stimulate brood	Favour drier, cooler conditions; ready hives for winter flows

Window	Primary Regions	Key Floral sources	Objectives	Typical Actions/Notes
Nov–Feb	Rajasthan/M.P. → Bihar	Mustard/ Rapeseed, Berseem, Coriander; others	Peak rabi production; second major cash crop	Double mustard tactic: early western bloom (Nov–Dec) then Bihar peak (late Dec–Jan); add multiple supers; manage moisture in fog
Late Feb–Early Mar	Return staging → Bihar	Prespring maintenance	Prepare for litchi	Repair gear; prophylactic, varroa/ Nosema control; stimulative feeding; brood balancing to peak 7–10 days prebloom

Table 4.3. Stocking, Yields & Pollination Benchmarks

Flow / Crop	Suggested Stocking (colonies/ha)	Typical Yield per Colony	Pollination Benefit	Key Notes
Litchi	3–5 (up to 5–10 optimal)	Variable (major cash crop)	25–30% fruit set/ yield	Segregate monofloral litchi honey; avoid insecticides during bloom.
Jamun	Sitedependent	10–15 kg over bloom	–	Dark, strongflavored honey; good pollen.
Sunflower	4–6 (field edges)	30 kg/ Provide water/shade in heat	–	Provide water/shade in heat (May–Jun); two seasons possible in some areas
Maize	–	Honey: none	–	Pollen source for brood; use during dearth; rain may reduce foraging.
Mustard/ Rapeseed	4–8	25–40 kg/ season common	High pollination value	Backbone of rabi; add multiple supers; manage hive moisture.
Berseem	4–6 (where grown)	10–15 kg	–	Supplemental white clover type flow + pollen.
Coriander	4–6 (seed crop belts)	Short, variable	–	Distinctive amber honey; Feb harvest.
Ber (Sidr)	Sitespecific (arid scrub)	Variable; can be significant	–	Premium lightamber honey; time Sep–Oct bloom
Ajwain	Near specialty belts	Short, lucrative windows	–	Very aromatic honey; intense but brief Oct flow
*Yields depend on colony strength, weather, floral density, and management.				

Table 4.4. Post-Litchi Bridge Forage in Bihar (Apr–Jul)

Plant	Bloom Window	Forage Type	Surplus Honey Potential	Site Strategy
Jamun (<i>Syzygium cumini</i>)	May–Jun	Nectar + pollen	Moderate (10– 15 kg/hive)	Station near groves/ orchards; dark honey.
Sunflower (<i>Helianthus annuus</i>)	Mid May–Jun (also autumn)	Nectar + pollen	High (up to ~30 kg/ hive typical)	Ensure water + shade; watch storms/heat
Lal Ghash (<i>Euphorbia macrophylla</i>)	May–Jun	Pollen rich; minor nectar	Low	Sustains brood in scarce periods.



Plant	Bloom Window	Forage Type	Surplus Honey Potential	Site Strategy
Maize (<i>Zea mays</i>)	Jul–Aug (tasseling)	Pollen only	None	Protein for brood; supplement syrup if prolonged rains.

Table 4.5. Rabi Season Major Sources (Nov–Feb)

Crop	Bihar Bloom Peak	Other Regions (early/overlap)	Forage & Notes
Mustard/Rapeseed (<i>Brassica</i> spp.)	Late Dec– Jan	Rajasthan/M.P. often start Mid Nov	Long, reliable flow; multiple supers; 25–40 kg/ hive common
Berseem (<i>Trifolium alexandrinum</i>)	Dec–Jan (pockets)	U.P./Punjab pockets	White clover type honey; 10–15 kg/ hive where planted
Coriander (<i>Coriandrum sativum</i>)	Jan–Feb	Central India belts	Distinct amber honey; short follow-on after mustard.
Others (examples)	Dec–Feb	Regionspecific	Lathyrus (pollen), Eucalyptus (cool season nectar), onion seed crops (nectar; light amber).

Table 4.6. Hive Management Timeline (Operational)

Period	Core Tasks	Why It Matters
Prelitchi (Late Feb– Early Mar)	Equipment repairs; replace old comb; treat varroa/Nosema; stimulative feeding; brood balancing	Ensures strong, healthy foragers emerge just in time for litchi.
Litchi Bloom (Mid Mar–Early Apr)	Equalize strength; super at 60–70% fill; enforce nospray policy; extract promptly postbloom	Maximizes monofloral litchi honey and reduces swarming.
Apr–Jul Bridge	Split apiary to chase blooms; provide water/shade; emergency feeding in rain dearth	Maintains brood and avoids setbacks.
Monsoon (Jul– Sep)	Migrate to U.P/Rajasthan; prioritize health over harvest; monitor pests	Avoids Bihar’s rainy dearth; keeps colonies active.
Autumn (Sep– Nov)	Target ber and ajwain if available; rebuild stores	Specialty honeys and strength for.
Rabi (Nov–Feb)	Double mustard tactic; add supers; ventilate to reduce moisture; schedule extractions	Peak production; set colonies up for spring return.



CHAPTER 5

From Comb to Container : Effective Harvesting and Processing of Litchi Honey

5.1. Honey Harvesting Best Practices in Litchi Orchards

Harvesting litchi honey requires care to maintain quality and to protect the bee's future productivity.

Timing of harvest: The main honey flow from litchi occurs toward the end of the bloom, as bees will have been storing nectar throughout the flowering period. In practical terms, supers can begin to be harvested when most frames are at least ~75% capped with ripe honey. Capped cells indicate the nectar has been dehydrated to honey with <20% moisture, which is less prone to spoilage. It's best to wait until flowering is nearly complete (to avoid having to return supers that still have uncapped nectar) – typically a week or so after petal drop of the last flowers. Beekeepers in litchi areas often extract immediately after bloom to obtain pure litchi monofloral honey before bees mix in other floral sources. Choose a clear, warm day for harvesting when bees are actively foraging (many field bees will be out, making handling easier).

Equipment: Use only clean, food-grade equipment for honey handling. Honey extraction tools (knives, centrifuge/extractor, filters, storage containers) should be made of stainless steel or food-grade plastic. Avoid galvanized iron or ordinary metal containers, which can rust or contaminate honey; similarly, do not use second-hand jerrycans that held chemicals. Wash all equipment with hot water and dry before use, as honey readily absorbs odours and moisture.

Removing honey frames: To take honey-laden frames from the hive, one can gently smoke the hive (use minimal cool smoke to push bees off the super frames) and then remove frames one by one. Another method is to use a bee escape board a day in advance to clear bees from supers, or gently brush bees off each frame with a soft bee brush or feather. Avoid shaking frames vigorously as this can dislodge nectar or damage comb. Immediately place the frames in a closed bee-tight box or carton to prevent robbing by other bees.

Prevent robbing: This is critical – during honey harvest, the scent of exposed honey can trigger robbing frenzy in an apiary. To prevent this, cover colony entrances with grass or a screen while working, so returning foragers are confused and the colony goes into defensive mode. Also, never leave honey-filled frames or scrap comb out in the open; keep everything covered. It is recommended to do the actual extraction in a closed room or away from the apiary area to keep the madness of robbing under control.

Extraction process: Use a honey extractor (centrifuge) for spinning out the honey from combs – this preserves the drawn comb, which can be returned to the bees. Uncap the honeycomb cells with an uncapping knife or fork (a stainless steel knife dipped in hot water works if you don't have an official uncapping knife). Uncap over a tub to catch the capping and residual honey. Place frames in the extractor and spin at a moderate speed until the honey is flung out. Then reverse frames and spin again to extract both sides.

Straining and settling: Freshly extracted honey should be strained through a clean muslin cloth or nylon sieve to remove wax bits, bee parts, or other debris. Let the honey drip into a clean, dry food-grade bucket or settling tank. It's beneficial to allow honey to settle for a day or two in a covered tank; air bubbles and fine particles will rise to the top as foam/scum which can be skimmed off, yielding clearer honey.

During harvest, be mindful not to mix different honey flows if you want a premium monofloral litchi honey. For instance, if mustard honey (from earlier season) is still present in hives, keep that separate. In litchi areas, often mustard



(Brassica) blooms just before litchi; ideally, any mustard honey should be harvested in late January so that supers are mostly empty to collect litchi nectar. This ensures the honey you harvest post-litchi is primarily litchi honey. If some multi-floral blending has occurred, that is fine for general sale, but it might not qualify as pure litchi honey (which typically requires >45% pollen from litchi to be labelled monofloral).

Post-extraction hive care: After removing honey, return the supers and frames to the bees (if not migrating immediately) so they can clean up residual honey. An efficient way is to set the empty “wet” frames out near the apiary in an enclosed space or back on the hives (under supervision) for a day so bees lick them dry. Then store the dry drawn combs for future use. Avoid leaving wet frames outside unattended, as this invites robbing and can spread disease or pests. Also, never expose brood frames during harvesting – only honey supers should be extracted, leaving the brood box intact for the bee’s survival. Make sure each colony is left with some honey (at least 5–10 kg in the brood box, or feedback some of the harvest) if another dearth will follow the litchi flow, so the bees are not left hungry.

By adhering to these good practices – proper timing, clean equipment, careful handling, and preventing robbing – the harvested litchi honey will be high quality and the colonies will remain strong for future flows. Remember to label and record the source and date of each honey batch, as traceability is a good beekeeping practice especially when targeting premium markets.

5.2. Honey Processing: Filtration, Moisture Control, and Storage

After harvesting, the honey must be processed and stored properly to maintain its quality.

5.2.1. Filtration: Even after initial straining, fine particles and pollen may remain. Depending on the desired clarity and market, you may perform further filtration. For raw honey markets, minimal filtration (to retain pollen) is preferred, whereas for export or commercial bottling, finer filtration might be done to delay crystallisation and give a clear appearance. Use a fine mesh filter or muslin cloth; avoid excessive heating just to filter, as heat can degrade honey. It’s best to let honey settle at room temperature ~24–48 hours so that most impurities rise to the top, then filter or skim.

5.2.2. Moisture check: Honey’s moisture content is critical – too high and it can ferment, too low is rare (honey below 15% moisture may crystallize faster but is stable). Optimum moisture is around 17–20%. Litchi honey, when fully ripened by bees, usually falls in the 18–19% range in India’s climate (e.g. one report from a 2025 harvest in Bangladesh noted litchi honey at ~18.5–19.5% moisture). It is important to verify moisture using a refractometer. If the honey was harvested slightly unripe (moisture above 20%), steps should be taken to reduce it to prevent fermentation. Traditional methods include spreading the honey in a thin layer in a warming room (at ~40 °C with dehumidified air or a fan) to evaporate excess moisture, or mixing in dryer honey to balance it. Do not overheat the honey; keep temperatures as low as possible – prolonged heating over ~45 °C can raise Hydroxymethylfurfural (HMF) levels and destroy enzymes, lowering quality. FSSAI standards specifically warn that honey should not be heated or processed to the extent that its composition or quality is impaired.

5.2.3. Honey bottling and storage: Before storage or bottling, ensure the honey is clean and stable. This may involve a final fine filtration to remove any remaining specks. If the honey is to be sold as “Lychee Honey” (monofloral litchi), take care not to mix it with other honeys and consider getting a pollen analysis done to certify its floral source (monofloral honey in India should have $\geq 45\%$ pollen from the named source). Use only food-grade, dry containers for storage – commonly, beekeepers use white HDPE food-grade buckets with tight lids, or stainless steel drums for bulk storage. The containers must be absolutely dry because honey is hygroscopic (it absorbs moisture from the air, which could raise its water content). Fill containers to the top to minimize air space, and seal them. Label the containers with the date, type (litchi honey), and batch code if needed for traceability.

Store honey in a cool, dry place away from direct sunlight. Ambient room temperature (around 20–25 °C) is good for storage; avoid hot warehouses (quality can degrade faster) or refrigerators (which can cause granulation and



condensation on reopening). Protect the storage area from pests – ants are especially attracted to honey; keep containers tightly sealed and if necessary, place them on pallets with oil or water barriers for ant prevention. Honey should also be kept away from strong odors (paints, fuels, spices) as it can absorb odors over time. If large crystallization occurs (some honey crystallizes if its natural glucose content is high or if stored cool), the honey can be gently warmed (in a water bath not exceeding 40 °C) to re-liquefy before bottling. However, litchi honey is known to remain liquid for a long time due to its sugar composition (lychee honey often has a higher ratio of fructose, which makes it slower to crystallize).

Throughout processing, maintain hygiene – use clean ladles, avoid touching honey with bare hands, and keep everything covered. Indian regulatory guidelines emphasize cleanliness and food-safe handling at all stages to ensure honey remains unadulterated. By following these processing steps – proper filtration, moisture control, and careful storage – the end product will meet quality standards and have a longer shelf life, whether it's intended for local markets or high-value export.





CHAPTER 6

From Local to Global: Navigating Quality Standards and Export Compliance in Honey

India's Food Safety and Standards Authority (FSSAI) has defined specific quality standards for honey that beekeepers and processors must meet (Table 6.1).

Table 6.1. Specifications of Honey as per FSSAI

S. No.	Parameters	Limits
1	Specific gravity at 27°C, Min	1.35
2	Moisture percent by mass, Max	20
3(a)	Total reducing sugars (Honey not listed below), Min	65
3(b)	Total reducing sugars (Carviacallosa and Honeydew honey), Min	60
3(c)	Total reducing sugars (Blends of Honeydew with blossom honey), Min	45
4(a)	Sucrose (Honey not listed below), Max	5.0
4(b)	Sucrose (Carviacallosa and Honeydew honey), Max	10
5	Fructose to Glucose ratio (F/G Ratio)	0.95–1.50
6	Total Ash, Max	0.50
7(a)	Acidity as formic acid, Max	0.20
7(b)	Free Acidity (meq acid/1000 g), Max	50.0
8	Hydroxymethylfurfural (HMF), Max	80.0
9	Diastase activity (Schade units/g), Min	3
10(a)	Water insoluble matter (Honey not listed below), Max	0.10
10(b)	Water insoluble matter (Pressed honey), Max	0.5
11	C4 Sugar, Max	7.0
12	Pollen count and plant elements, Min	5000
13	2-Acetylfuran-3-Glucopyranoside (2-AFGP) - Rice Syrup Marker	Absent**
14	Foreign oligosaccharides (Max% Peak)	0.7
15	Proline, Min	180 mg/kg
16(a)	Electrical Conductivity (non-Honeydew), Max	0.8 mS/cm
16(b)	Electrical Conductivity (Honeydew), Min	0.8 mS/cm
17(a)	$\Delta\delta^{13}\text{C}$ Max (Maximum difference between all measured $\Delta\delta^{13}\text{C}$ values), per mil	± 2.1
17(b)	$\Delta\delta^{13}\text{C}$ Fru - Glu, (The difference in $^{13}\text{C}/^{12}\text{C}$ ratio between fructose and glucose) per mil	± 1.0
17(c)	$\Delta\delta^{13}\text{C}$ Protein - Honey, (The difference in $^{13}\text{C}/^{12}\text{C}$ ratio between honey and its associated protein extract) per mil	≥ -1.0

Broadly, honey is legally defined as the natural sweet substance from honey bees, with no additives or dilution; no sugar or other substances may be added to honey. Key FSSAI parameters for honey quality include:

- **Moisture content:** $\leq 20\%$ by weight. Low moisture indicates the honey is mature and not prone to fermentation. Good beekeeping practices (only harvesting capped honey) ensure this criterion is met.
- **Sugars:** Minimum total reducing sugars (mainly fructose + glucose) of 65% by weight for blossom honeys. This essentially measures that the honey has a high natural sugar content as expected. Sucrose (table sugar) content must be $\leq 5\%$ for most honeys, which helps detect adulteration or early harvesting (unripe honey can have higher sucrose). Litchi honey, being a floral honey, would be expected to easily exceed the 65% reducing sugar threshold and typically has low sucrose if properly ripened.
- **Acidity:** Free acidity not more than 50 milli-equivalents per 1000g (and formic acid content $\leq 0.2\%$). This ensures the honey is not fermented (fermentation increases acidity). Fresh litchi honey is usually well within limits, as long as moisture is controlled.
- **Ash (mineral content):** $\leq 0.5\%$ (which is normal for nectar honeys).
- **HMF (Hydroxymethylfurfural):** ≤ 80 mg/kg. HMF is a breakdown product that accumulates if honey is heated excessively or stored improperly. India's standard allows up to 80 mg/kg, taking into account the warmer tropical climate (which can naturally raise HMF over time). However, for premium quality and especially for export to markets like the EU, a stricter limit of 40 mg/kg is applied. Therefore, it's advisable to keep HMF as low as possible by avoiding high heat. Freshly extracted honey usually has HMF well below 15 mg/kg; values rise with heat and age.
- **Diastase (enzyme) activity:** ≥ 3 on the Schade scale. Diastase, an enzyme from bees, decreases if honey is heated. While FSSAI's minimum is 3 (somewhat low compared to the international Codex standard of 8), maintaining higher diastase activity is desirable to show the honey is unheated or minimally processed. Quick processing and low-temperature handling help preserve enzymes.
- **Insoluble matter:** $\leq 0.1\%$ (for filtered honey). This refers to bits of wax, debris, etc. Proper straining/filtration, as described, keeps insoluble matter low. If using "pressed honey" (from comb pressing), a slightly higher limit (0.5%) is allowed due to more particles.
- **Adulteration markers:** C4 sugar content $\leq 7\%$. This test detects cane sugar or corn syrup additions. Genuine honey from bees should have much lower C4 sugar. Ensuring no feeding of sugar syrup during the honey flow and not adding any sugars during processing will keep this in check. Additionally, FSSAI mandates a minimum pollen count of 5000 grains per gram to confirm the honey's authenticity (high filtration or ultrafiltration that removes pollen can be a red flag of adulteration). Litchi honey, being from a blossom source, will naturally contain litchi pollen; to meet export/monofloral claims, avoid over-filtering that could strip out pollen.
- **Pesticide and antibiotic residues:** While not enumerated in the basic honey standard table, Indian honey is expected to be free of harmful residues. If you use any mite control chemicals or antibiotics in the hives, ensure they are applied only per recommended guidelines (and never during a honey flow). For export, honey lots are tested for residues of antibiotics (e.g. chloramphenicol, streptomycin) and pesticides, and any detection can lead to rejection. It's best to follow organic or good beekeeping practices to keep honey pure – do not use prohibited substances, and if bees forage in pesticide-treated areas, be cautious. The National Bee Board's Good Beekeeping Practices advise persuading farmers to avoid or minimize pesticide use during bloom, use bee-friendly formulations, and notify beekeepers before spraying. Be prepared to temporarily cover or move colonies if a heavy spray is scheduled.

For export compliance, Indian honey must not only meet FSSAI but also the standards of the destination country. Many importing countries follow the Codex Alimentarius honey standard (which is similar to FSSAI but with HMF limit of



40 mg/kg in general, except some allowance for tropical honeys). The European Union requires honey to have HMF < 40 mg/kg (or <80 mg/kg if proven to be from tropical origin) and diastase ≥ 8 Schade units (if HMF is under 15, diastase can be lower). Additionally, EU and other markets demand that honey be free of added sugars – they will test isotope ratio (C3/C4 sugars) and pollen to verify authenticity. They also have zero tolerance for certain antibiotics. Therefore, if aiming for export-quality litchi honey, adhere to even stricter handling: keep honey raw (unblended, unheated), perhaps invest in residue testing of your batches, and maintain documentation (traceability of which apiary/orchard and date).

Labeling: Under FSSAI, if you sell packaged honey, you must label it correctly – monofloral litchi honey can be labeled as “Lychee Honey” provided it truly comes predominantly from litchi nectar. Include FSSAI license details if applicable and avoid any health claims that are not permitted.

Thus, by meeting the quality parameters – proper moisture, no adulteration, low HMF, adequate enzyme activity, and absence of contaminants – beekeepers can ensure their litchi honey is of high standard. Regularly referring to FSSAI’s latest standards (updated as of 2023) is good practice. Quality honey not only fetches a premium price but also builds consumer trust, which is vital for marketing litchi honey domestically and abroad.



CHAPTER 7

Bees, Litchi, and Beyond: Policy Implications for Honey, Farmers and Sustainability

Scientific beekeeping in litchi orchards has far-reaching policy implications at national, state, and local levels. The findings underscore the need for supportive policies that consider agricultural, environmental, economic, and social dimensions (Table 7.1 and 7.2).

Table 7.1: Policy Recommendations for Promoting Beekeeping in Litchi Orchards

Sl. No.	Policy Area	Implications / Recommendations
1	Scientific Beekeeping Promotion	Provide training, extension services, and subsidies for adoption of <i>A. mellifera</i> in litchi orchards.
2	Integration with Orchard Management	Recognize beekeeping as part of litchi orchard practices; incentivize managed colonies during flowering.
3	Honey Quality & Processing Standards	Establish honey standards (moisture, purity, floral origin); support processing units and GI branding.
4	Mellisopalynology Authentication	Require palynological testing for certification; strengthen measures against adulteration and mislabeling.
5	Pollination Services Recognition	Formalize and compensate beekeepers for pollination services as ecosystem contributors.
6	Research & Extension Support	Fund studies on bee health, litchi-bee interaction, and climate change; strengthen extension networks.
7	Environmental & Pesticide Regulation	Implement bee-safe pesticide guidelines; monitor orchard spraying to protect colonies.
8	Market Linkages & Rural Employment	Build litchi honey value chains, promote rural entrepreneurship, and support women's participation.

Key stakeholders – litchi farmers, beekeepers, policymakers, and honey exporters – all stand to benefit from well-crafted policies.

Below, we outline the multi-level policy measures and recommendations:

7.1. Strengthening National-Level Initiatives

At the National level, India has already recognized the importance of apiculture through programs like the “Sweet Revolution” – an initiative to promote beekeeping for quality honey production. The government’s National Beekeeping and Honey Mission (NBHM) was launched in 2018–19 to develop scientific beekeeping in a mission model. Building on these, the National policy should:

- **Integrate Pollination into Agricultural Policy:** Acknowledge honey bees as essential inputs for crop productivity. For cross-pollinated crops like litchi, planned pollination with honey bees dramatically improves fruit set, yield, and quality. Research in Bihar showed that placing *A. mellifera* hives in litchi orchards (5–10 colonies per hectare) significantly increased yields. Thus, National horticulture programs (e.g. Mission for Integrated Development of Horticulture) should include pollination management guidelines. Funding could be allocated for bee colony rentals or incentives to encourage farmers to host hives during litchi flowering. This aligns with India’s goal of doubling farmers’ incomes by improving crop productivity.



- **Enhance Quality Standards and Traceability:** The Food Safety Authority (FSSAI) has notified new standards to curb honey adulteration. Notably, monofloral honeys like litchi honey must contain $\geq 45\%$ pollen from that source. This requires robust melissopalynology (pollen analysis) capacity. Policy should operationalize honey testing labs and enforce these standards so that the “Litchi Honey” label truly reflects its botanical origin. Melissopalynology is a vital tool to detect adulteration and verify geographic origin, boosting consumer and export confidence. The government can support the National Bee Board in establishing regional honey quality labs and training personnel in pollen analysis. Additionally, traceability systems (perhaps through a digital honey trace program) can link honey back to its producer, assuring buyers of authenticity.
- **Promote the Sweet Revolution in Mission Mode:** Continued support to NBHM is crucial. NBHM focuses on training, capacity building, and infrastructure for beekeeping. Expanding NBHM funding will help scale up scientific beekeeping with modern technology (IoT hive monitoring, mobile apps, etc.) as suggested by NITI Aayog. This includes research on pollination and bee health, given that *A. mellifera* is an introduced species requiring management. By investing in technology and R&D, India can improve hive productivity, prevent colony losses, and produce export-grade honey. (India is already the sixth-largest honey exporter, with $\sim 59,500$ MT exported in 2019–20, so quality and scale improvements have high economic returns).

Table 7.2: Regulatory and Compliance Requirements for Honey Export from India

Pillar	What it covers	What you need to show/exporter actions
Legal basis	Export (Quality Control & Inspection) Act, 1963; Export Inspection Council (EIC) oversight	Process at EIC-approved facilities; comply with EIC Executive Instructions for honey (GHP/GMP/HACCP) and any destination-specific add-ons.
Food standards (composition & purity)	FSSAI Honey standard (Food Product Standards & Additives)	Meet FSSAI limits (e.g., moisture, HMF, sucrose, reducing sugars), no extraneous matter; aligns with Codex baseline. Keep test reports from NABL-accredited labs.
Adulteration & authenticity testing	National quality/label integrity	Demonstrate absence of added sugars/syrups; use multi-parameter panels (e.g., isotope ratios, NMR where buyer requires). Maintain botanical origin substantiation (melissopalynology when claimed monofloral).
Residue controls	EIC Residue Monitoring Plan (RMP) for honey	Participate in the current RMP cycle; keep results for antibiotics/pesticides/metals per plan. Non-compliance can suspend approval for sensitive markets (e.g., EU).
Traceability	Facility and lot traceability	Maintain lot-wise back-trace to beekeepers and apiary locations; retain harvest, transport, processing, and testing records. (APEDA/EIC emphasize traceability for market access.)
Labelling for export packs	Base pack labelling before destination tweaks	Product name “Honey”, net quantity, lot/batch, date coding, name/address of exporter/packer; apply destination-specific extras on top (see next table).

- **Pesticide Regulations for Pollinator Safety:** On the environmental front, national policy should ensure that agricultural chemicals are bee-friendly (Table 7.3). Honey bees are highly sensitive to certain insecticides like neonicotinoids. The government has acknowledged that the loss of bees would severely hit food production. In fact, moves were made to ban bee-toxic pesticides (e.g. imidacloprid) after they were prohibited abroad. Building on this, regulators should prohibit or strictly regulate pesticides harmful to pollinators, especially during bloom

periods. Encouraging Integrated Pest Management (IPM) in litchi orchards – such as using safer bio-pesticides and avoiding any spraying during flowering – is critical. A pollinator-safe certification could even be introduced for orchards, aligning with global trends to protect bees.

Table 7.3. Key International Regulatory Requirements for Honey Export from India

Market/Rule set	Scope	Key composition/ contaminants	Facility/listing & certificates	Labelling & claims	Extra notes for Indian exporters
Codex CXS 12-1981 (rev./ amend. 2019, 2022)	Global reference standard for honey	Defines moisture, HMF, sugars, electrical conductivity, etc.	—	Name of the food, floral source only if justified	Many buyers write Codex specs straight into contracts. Use as your spec baseline.
EU: Honey Directive 2001/110 (revised; origin rules updated 2024)	All honey marketed in the EU	EU composition/ definition must be met; strong focus on authenticity	Mandatory listing of exporting establishments in TRACES for apiculture products under Reg. (EU) 2023/2652 (from 29 Nov 2024)	Mandatory origin labelling; for blends, countries of origin must appear (phased in by 2026)	Work with EIC to ensure your plant is on the EU list; buyers often require NMR profiles and authenticity dossiers.
EU: Residues & antibiotics	Food safety contaminants	For most antibiotics, no MRL set for honey → effectively not permitted; enforce zero-tolerance via targeted methods	—	—	Tight supplier control and RMP evidence are critical; ensure veterinary drug non-use documentation from beekeepers. open-research-europe.
USA: FDA (FD&C Act), FSMA/ FSVP; Honey Labelling Guidance	All honey imported to the US	Must be safe and not adulterated; composition is assessed against “honey” understanding in FDA guidance	US importer must operate an FSVP: verify your hazards/ controls; foreign facility registration and prior notice apply	Follow FDA honey labelling guidance (common/usual name “Honey”; sweeteners trigger “Blend” or other descriptors)	Provide your US buyer with hazard analysis, supplier verification docs, and test reports to support their FSVP.



Market/Rule set	Scope	Key composition/contaminants	Facility/listing & certificates	Labelling & claims	Extra notes for Indian exporters
GCC (GSO 147:2008) & national regs (e.g., Saudi SFDA guide)	Honey trade in Gulf states	Composition largely harmonised with Codex/GSO; local residue and quality checks at entry	Some states require prior registration and conformity assessment; SFDA publishes import controls and documentation	Arabic labelling, country-specific date and shelf-life rules	Check buyer's notified body requirements; SFDA guide details import steps and documents.
UK (retained EU law)	Honey on the GB market	Mirrors EU composition rules post-Brexit	—	Origin and name rules similar to EU	Buyers often mirror EU authenticity expectations (NMR, pollen profiles).

7.2. State and Local Policy Actions in Litchi-Growing Regions

While national schemes provide a framework, state governments (especially where litchi is a major crop) play a key role in localization (Table 7.4). Bihar, for example, has emerged as a model with its proactive apiculture policies. Bihar is India's fourth-largest honey producer (contributing 12.3% of national output in 2023–24), largely thanks to monofloral honeys like litchi from Muzaffarpur, Vaishali, and Samastipur.

Table 7.4: Government Schemes Supporting Beekeeping and Litchi Orchard Integration in India

Sl. No.	Scheme / Initiative	Who Can Benefit	Main Supports (Training, Subsidy, Credit, etc.)	Impact on Beekeeping & Litchi Orchards	Reference
1	Madhukranti Scheme (National, under Atma Nirbhar Bharat)	Farmers adopting <i>A. mellifera</i> beekeeping	Training, bee box subsidies, branding of honey	More colonies available in litchi orchards → improved pollination and fruit quality	Madhukranti Portal
2	Bee Village Development Program (Punjab)	Rural farmers and cooperatives	Cluster formation, tech support, and marketing help	Stronger local bee presence increases cross-pollination in nearby litchi areas	Punjab State Horticulture Mission (2020)
3	Apiculture under MIDH (Himachal Pradesh)	Small/mountain farmers	Bee colonies supplied, training, and quality labs	Enhances pollination activity in hill litchi orchards	HP Horticulture Dept. Reports (2021–22)
4	Beekeeping Cluster Initiative (Bihar)	Farmers in Muzaffarpur & nearby districts	Bee clusters, credit linkages	Improves pollination efficiency in the Shahi litchi belt; reduces malformed fruits	Bihar Agriculture Dept. (2022)
5	Honey Mission (Tripura)	Tribal & rural farmers	Bee box distribution, training, and market access	Supports pollinator populations in litchi–agroforestry systems	Tripura Rural Livelihood Mission (2021)

Sl. No.	Scheme / Initiative	Who Can Benefit	Main Supports (Training, Subsidy, Credit, etc.)	Impact on Beekeeping & Litchi Orchards	Reference
6	National Beekeeping & Honey Mission (NBHM)	Farmers & FPOs nationwide	Colony multiplication, R&D, infra support, marketing	Increases managed pollinators during litchi bloom; boosts orchard income	MoA & FW, Govt. of India (2020)
7	PARAG Initiative (Jharkhand)	Agroforestry farmers	Bee-friendly agroforestry clusters, training, livelihood support	Creates sustainable pollinator habitats, including litchi orchards	Jharkhand Forest Dept. & JSLPS (2022)
8	Beekeeping & Honey Production Program (2023–24) (Bihar)	General, OBC, SC/ST farmers	75% subsidy (90% SC/ST) on bee equipment; 10–20 boxes per farmer + extractor	Strengthens nectar flow & pollination in litchi bloom season; diversifies income	Bihar Horticulture Dept. (2024)

State-level policy implications include:

- **Incentives and Subsidies:** Bihar’s Agriculture Department provides a 75% subsidy on bee boxes and equipment (90% for SC/ST beekeepers), drastically reducing startup costs. It also offers capital subsidies (15–25%) for honey processing units under the state’s Agriculture Investment Policy. These incentives have spurred a 20% increase in honey output over five years. Other litchi-growing states (e.g. West Bengal, Uttar Pradesh, Uttarakhand, Jharkhand) should consider similar subsidy models to encourage both small farmers and rural entrepreneurs to take up beekeeping. Prioritizing marginalized groups in subsidy schemes (as Bihar did for SC/ST) can ensure inclusive growth.
- **Regional Training and Extension:** Local agricultural universities and Krishi Vigyan Kendra (KVKs) in litchi belts should conduct regular training programs on scientific beekeeping and pollination. In Bihar, for instance, training at ICAR-NRCL enabled new beekeepers to start with just 20 boxes and later expand to hundreds of colonies. Such success stories highlight the value of hands-on training in hive management, queen rearing, disease control, and honey processing. State extension services should also educate litchi orchard owners on the yield benefits of bee pollination. Demonstrations can show that introducing *A. mellifera* hives can increase litchi fruit set and yields by over 100% in some cases. When farmers see that cross-pollination by bees leads to bigger, better fruit and almost no fruit set occurs on caged (bee-excluded) trees, they are more likely to collaborate with beekeepers.
- **Facilitating Beekeeper–Farmer Collaboration:** States can act as a bridge between orchard farmers and migratory beekeepers. Litchi blooms are brief (Feb–April, varying by region), and many migratory beekeepers transport hives across states to capitalize on this nectar flow. For example, beekeepers from Bihar and West Bengal often move to litchi orchards in Bihar’s Bhagalpur or West Bengal’s Malda after the mustard season. State agriculture departments (and district horticulture offices) could maintain a database of orchards needing pollination and beekeepers with available colonies, helping to coordinate placements. Simple measures like matchmaking platforms or local Pollination Service Centres would ensure optimal hive distribution (avoiding both shortages and overcrowding of hives in one spot). Policymakers should also sensitize rural communities so that outside beekeepers are welcomed and not seen with suspicion. Some states might even consider offering a small pollination stipend to farmers who host hives, given the mutual benefits (much like subsidies for bio-fertilizers or other inputs).



- **Local Processing and Branding Initiatives:** To maximize value, state policies can encourage processing clusters in litchi-producing areas. Setting up common facility centers with honey extractors, bottling and testing labs will help maintain quality and allow small producers to brand their product. Notably, Geographical Indication (GI) tagging is being explored for specialty honeys – for instance, “Litchi Honey” from Bihar’s Muzaffarpur belt has a GI application under examination. If granted, this would legally protect the name and ensure only authentic regional litchi honey is sold as such. State governments and cooperatives should actively pursue GI and other branding for unique honeys, as this can fetch premium prices in domestic and export markets. West Bengal’s Malda litchi honey, with 73–85% *Litchi chinensis* pollen content, is one such candidate for niche marketing. Local Honey Producer Companies (like the Kudhani FPC in Bihar) can drive these initiatives with government support.

7.3. Agricultural and Environmental Sustainability Measures

- One of the chapter’s key implications is that agricultural policy must work in harmony with environmental conservation – particularly pollinator conservation. Healthy bee populations are a cornerstone of sustainable litchi production. Policy measures in this realm include:
- **Pollinator-Friendly Orchard Management:** Authorities should develop guidelines for litchi orchard management that protect pollinators. This means avoiding pesticide use during flowering and using only bee-safe chemicals if needed. In the studied litchi orchards, farmers refrained from spraying any pesticides from bloom initiation to fruit set, specifically to safeguard pollinators. Such practices should be standard. The government can enforce this by making pollinator safety a condition for availing certain subsidies or certifications. Training programs should teach Integrated Pest Management where natural enemies and non-chemical controls are favored, reducing reliance on toxic agrochemicals.
- **Conservation of Native Pollinators:** While *A. mellifera* is emphasized for commercial pollination, India’s native bees (*A. cerana*, *A. dorsata*, *A. florea*, and stingless bees) also contribute to the ecosystem. Policies should protect wild bee nests (for instance, discouraging destruction of *A. dorsata* combs on trees) and encourage on-farm biodiversity. Planting buffer strips of flowering plants or maintaining some uncultivated patches with wildflowers can provide forage for both managed and wild pollinators beyond the litchi bloom period. This enhances overall pollinator diversity and resilience. Additionally, supporting community beekeeping of indigenous species (like *A. cerana* in village gardens, or meliponiculture of stingless bees) can empower farmers to have their own pollinators. These native bees can complement *A. mellifera*, especially in areas or seasons where *A. mellifera* is less active (e.g., *A. cerana* for smaller orchards or backyard litchi trees).
- **Climate Change Adaptation and Insurance:** Environmental changes (unseasonal rain, storms, drought) can impact both bees and litchi flowering. Policies should incorporate risk management for beekeepers. Currently, there are no insurance schemes to protect beekeepers from losses due to cyclones, floods or colony collapse. Establishing an insurance policy for bee colonies (perhaps under agricultural insurance or through the National Bee Board) would mitigate risks and encourage more people to take up beekeeping. Similarly, providing financial support for supplemental feeding during off-seasons can prevent colony starvation when climate extremes reduce natural forage. By treating beekeeping akin to other agricultural enterprises in risk coverage, we acknowledge its importance in the farming system.
- **Landscape-Level Planning:** State planning departments could consider floral calendars when promoting crops. For example, monoculture of non-nectar crops like maize has expanded (for ethanol production in Bihar), reducing bee forage and thereby honey yields. Encouraging a mosaic of crops – or sequential rotation (mustard,

then litchi, then karanj, etc.) – at the regional scale ensures bees have a continuous nectar flow and farmers get pollination for multiple crops. In regions like Assam, experts have called for planting more orchards and bee-friendly crops to support *A. mellifera* year-round. Policymakers can incentivize such land-use practices by, say, including flowering cover crops in subsidy programs or rewarding farmers who adopt diversified cropping beneficial to pollinators. This approach merges agricultural policy with ecological sustainability, ensuring mutual benefits: better crop yields and thriving pollinator populations.

7.4. Economic and Market Implications

- From an economic perspective, integrating beekeeping with litchi cultivation can unlock new income streams, but it requires market support policies:
- **Value Addition and Processing:** Raw honey production in litchi orchards can be augmented by value addition. Government programs should facilitate the establishment of honey processing units, quality testing labs, and packaging facilities in or near litchi-producing areas. This not only maintains honey quality (moisture reduction, filtration to remove impurities, etc.) but also helps producers fetch higher prices with properly branded, graded honey. As mentioned, Bihar gives capital subsidies for honey processing plants – similar measures could be expanded in other states to create local micro-enterprises. Supporting Farmer-Producer Organizations (FPOs) to collectively process and market honey will increase bargaining power for small beekeepers and farmers. Moreover, by-products like beeswax, propolis, pollen, and even bee venom have niche markets (cosmetics, pharma) and can significantly raise incomes. Policies can fund training on harvesting and processing these products safely.
- **Export Promotion and Standards Compliance:** India's honey exports are a significant foreign exchange earner, but maintaining international standards is crucial. Litchi honey, with its light color and floral aroma, is highly prized and could be a speciality export. Policymakers should ensure adherence to global residue limits (avoiding antibiotics or contaminants in honey) and facilitate international certifications (like organic, Fair Trade, etc. if applicable) for Indian honey. Strengthening the recently notified FSSAI standards – e.g. mandatory pollen count (min 5,000 count/gram) and limiting added sugars – will improve credibility abroad. The government might also negotiate to remove trade barriers by demonstrating our quality improvements. Traceability systems from hive to export can prevent fraudulent blending that sometimes led to import rejections in the past. Encouraging exporters to source directly from verified beekeeper cooperatives in litchi-growing regions could ensure purity and also give producers a better share of profits.
- **Geographical Indications and Branding:** As noted, pursuing GI tags for unique honeys can uplift rural economies. If “Bihar Litchi Honey” or “Muzaffarpur Litchi Honey” gains GI protection, it can not only command premium pricing but also require local value-add (since GI laws often mandate processing in the region of origin). This keeps more value in local communities. State and national governments should assist producer groups in the GI application process and in post-GI marketing. In parallel, domestic awareness campaigns (perhaps under the Honey Mission) can promote these unique honeys to Indian consumers – currently, India's per capita honey consumption is extremely low (0.02 kg/year). A rising local market for varietal honeys will make beekeeping more profitable and less dependent on exports.
- **Financial and Institutional Support:** Access to credit remains an issue as banks often hesitate to lend to beekeepers (many of whom are landless). Policies could designate beekeeping as a priority sector activity, enabling easier loans for purchasing bee boxes, vehicles for migration, etc. Micro-credit and self-help groups can be leveraged in villages to help women and landless labourers start small apiaries. Insurance, as discussed,



is another financial safety net that should be instituted. Additionally, simplifying the registration process for beekeepers and making it accessible (perhaps online or via local offices) would bring more beekeepers into formal networks. Registration can help in availing government schemes and also in tracking hive movement for disease control. Lastly, institutional support is needed to smooth the inter-state movement of bees: many beekeepers report harassment at state borders and en route while migrating their hives. A possible solution is issuing Bee Transport Permits or identity cards through the National Bee Board that all states recognize, thus treating bee migration as an essential agricultural activity. Such coordination between states (with central guidance) will reduce hurdles and encourage migratory pollination services to reach more litchi orchards nationwide.

7.5. Stakeholder-Specific Recommendations

- Farmers, beekeepers, policymakers, and exporters each have distinct roles in implementing these implications. Policies should be tailored to engage each stakeholder category:
- **Litchi Orchard Farmers:** They are the primary beneficiaries of improved pollination. Agricultural policy should encourage orchardists to integrate beekeeping into their farm management. This could involve training litchi growers in basic beekeeping or forming agreements with itinerant apiarists. Farmers should be made aware that introducing honey bee colonies can increase fruit set and yield significantly (studies showed *A. mellifera* pollination raised litchi fruit set by up to ~160% compared to open plots without nearby hives). Hence, farmers might consider hosting 5–10 colonies per hectare during bloom. Policymakers can support farmers by providing subsidised bee boxes if they wish to maintain their own hives, or by offering rent support if they invite commercial beekeepers. It's also in farmers' interest to adopt pollinator-friendly practices (no spraying during bloom, etc.), so extension agencies should work closely with them on this. Ultimately, seeing higher profits from both litchi yield and possibly a share of honey revenue will motivate farmers to champion these policies.
- **Beekeepers:** For professional beekeepers, especially those managing *A. mellifera* colonies, the policy implications focus on support and scientific capacity. They need training in modern beekeeping techniques, disease management, queen rearing, and handling of migratory logistics. Government training programs (through NBHM, Krishi Vigyan Kendra, etc.) should target skill development so beekeepers can maintain strong colonies ready for litchi flowering. Migratory beekeepers in particular require policy support: clear protocols for interstate movement, information on flowering timings in different states, and coordination to avoid overcrowding of too many apiaries in one area. The NBHM's efforts to train beekeepers in hive transportation and seasonal management should be intensified. Financial measures like low-interest loans for equipment (vehicles, syrup feeders, protective gear) and insurance will reduce their operational risks. By enabling beekeepers to run their operations smoothly and scientifically, policies ensure a steady supply of pollination services and quality honey. In return, beekeepers should adhere to quality standards (no adulteration, proper processing) and work cooperatively with farmers and authorities – for example, by registering their apiaries and sharing movement plans to aid coordination.
- **Policymakers and Extension Agencies:** Policymakers (at both central and state levels) need to take a holistic, cross-sector approach. Apiculture should not be seen in isolation but as a component of horticulture, agriculture, rural development, and the environment. This means ministries and departments must collaborate – e.g., Agriculture, Horticulture, Food Processing, Commerce (for exports), and Environment all have a stake. Creating inter-departmental task forces on pollinator promotion can help implement the various measures (from research to training to market development). Extension officers are the on-ground agents to implement policy: they should be adequately trained in pollination biology and apiculture so they can advise litchi farmers effectively.

Government should also use policy tools like public-private partnerships – for instance, working with agri-tech startups to develop apps that notify beekeepers of litchi flowering or with farmer cooperatives to set up honey collection centres. Monitoring and evaluation frameworks should be set: track how many orchards have adopted bee pollination, how honey yields are growing, and whether farmers' incomes are indeed rising. If certain policies (like subsidies or training programs) are not delivering expected results, policymakers should refine them continuously. In essence, policymakers must ensure an enabling environment — from simplifying regulations (e.g. easy beekeeper registration, hassle-free transport permits) to providing infrastructure and knowledge resources — so that the synergy between beekeeping and litchi horticulture can flourish.

- **Exporters and Honey Industry:** The commercial honey industry, including exporters, processors, and retailers, has a role in reinforcing these policy goals. They should invest in supply chain relationships with producers – for example, sourcing litchi honey directly from certified farmer-beekeeper groups in litchi zones to ensure authenticity. Exporters can assist producers in obtaining necessary quality certifications and follow international best practices (many importers now demand rigorous testing for purity and safety). The policy implication here is that the government can facilitate platforms for buyer-seller meets, help local cooperatives attend trade fairs, and perhaps implement a honey traceability system that industry players participate in. When exporters commit to fair prices for genuine monofloral litchi honey, it discourages adulteration at the source and encourages adherence to standards. Moreover, the industry should support R&D (via CSR or industry associations) in areas like melissopalynological mapping of different honeys, improved packaging to preserve aroma, etc. A vibrant, ethical honey industry will amplify the positive impacts of scientific beekeeping policies – by expanding market access, they make beekeeping more profitable, which in turn incentivizes farmers and rural youth to engage in it. The end result is a win-win: exporters get high-quality product to sell, and rural communities gain income.

Thus, the insights on *A. mellifera* in litchi orchards and melissopalynology point to a comprehensive policy approach. National policies should mainstream apiculture in agriculture and quality regulation, state policies should customize support for local conditions and crops like litchi, and multidimensional strategies should address economic, environmental, and social facets. By implementing these policy implications, India can enhance litchi fruit production, increase honey yields, and improve livelihoods – exemplifying how agricultural innovation coupled with supportive policy can drive sustainable growth. Litchi orchard beekeeping, therefore, is not just an agronomic practice but a pathway towards rural prosperity, nutritional security (via pollination), and ecological harmony, deserving concerted attention from all levels of policy making.





Glimpses of Trainings Conducted at ICAR NRCL



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“मधुमक्खी पालन के वैज्ञानिक दृष्टिकोण”

प्रायोजक: राष्ट्रीय मधुमक्खी बोर्ड (राष्ट्रीय मधुमक्खी पालन एवं शहद मिशन), नई दिल्ली
(03-09 नवम्बर, 2025)



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(29 अप्रैल-05 मई, 2025)



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(27 जनवरी, 2025-02 फरवरी, 2025)



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(21-27 जनवर, 2025)

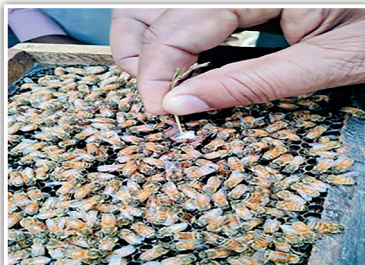


Glimpses of Trainings Conducted at ICAR NRCL





Hands on Training on Beekeeping and Honey Processing at ICAR NRCL





Visit of Dr M. L. Jat, Director General, ICAR & Secretary, DARE, ICAR at ICAR NRCL Beekeeping Unit



Online and Offline Beekeeping Training Sessions Conducted by Different Resource Persons at ICAR NRCL Beekeeping Unit

