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Knowledge gain and adoption of improved beekeeping practices among beekeepers trained under ARYA

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ABSTRACT

Beekeeping is an important allied agricultural enterprise with potential to generate employment, supplement farm income and support rural youth entrepreneurship. The Attracting and Retaining Youth in Agriculture (ARYA) programme of the Indian Council of Agricultural Research promotes skill development and enterprise establishment among rural youth through Krishi Vigyan Kendras (KVKs). The present study assessed the change in knowledge and adoption of improved beekeeping practices among rural youth trained under ARYA. The study was conducted in six selected KVKs of Uttar Pradesh, namely Ghazipur-I, Deoria, Pratapgarh, Basti, Muzzafarnagar-I and Gorakhpur-I. A total of 200 rural youth who had participated in beekeeping enterprise training were selected as respondents. Knowledge was assessed through structured objective questions, while adoption was measured on a three-point continuum of always, sometimes and never, scored as 2, 1 and 0, respectively. The findings showed substantial improvement in knowledge across all 15 assessed areas, with gains ranging from 44.0 to 56.0 percentage points. The highest gain was observed for honey harvesting and extraction (56.0 percentage points), followed by honey processing, grading and storage (53.0 percentage points). Adoption was comparatively higher for use of protective clothing and equipment (83.8%), selection of suitable apiary sites (81.0%) and maintenance of hygiene (79.8%). Lower adoption was observed for record keeping (60.0%), hygienic processing and storage of honey (66.0%), and pest and disease management (69.5%). The findings indicate that practical training and follow-up mentoring can improve technical knowledge, but additional support is required for enterprise management, post-harvest handling, pest and disease management, record keeping and market linkages. Strengthening these components through need-based KVK interventions may contribute to the sustainability and profitability of ARYA-supported beekeeping enterprises.

Keywords: ARYA, Beekeeping, Apiculture, Knowledge gain, Adoption, Rural youth

Introduction

Agriculture and allied activities continue to provide important livelihood opportunities for the rural population of India. However, declining farm profitability, fragmentation of landholdings, limited employment opportunities and migration of rural youth have created a need for promoting diversified and remunerative agricultural enterprises. In this context, entrepreneurship development among rural youth has emerged as an important strategy for creating employment, generating additional income and strengthening rural livelihoods. The Attracting and Retaining Youth in Agriculture (ARYA) project of the Indian Council of Agricultural Research (ICAR) was initiated with the objective of attracting rural youth towards agriculture and allied sectors through skill development, entrepreneurship promotion and establishment of income-generating enterprises. ICAR reports that ARYA is implemented through Krishi Vigyan Kendras (KVKs) and focuses on developing technical skills and entrepreneurial capacities among rural youth. Beekeeping is one of the enterprises promoted under the ARYA programme.

Beekeeping, or apiculture, is a suitable enterprise for rural youth because it can be undertaken with relatively limited land requirements and can be integrated with crop production and other farming activities. Thus, beekeeping has both direct economic value through production and sale of bee products and indirect agricultural value through pollination. The availability of diverse natural and cultivated flowering vegetation in India provides a strong resource base for the development of this enterprise. According to the Agricultural and Processed Food Products Export Development Authority (APEDA), around 500 flowering plant species, including wild and cultivated plants, serve as major or minor sources of nectar and pollen for honey bees.

The importance of beekeeping as an income-generating enterprise is also reflected in the growing production of honey in the country. India's total honey production was approximately 152 thousand metric tonnes during 2024-25. The major honey-producing states include Uttar Pradesh, West Bengal, Punjab, Bihar and Rajasthan. Uttar Pradesh contributed approximately 16.74 per cent of India's honey production, followed by West Bengal (15.85%), Punjab (13.91%), Bihar (12.35%) and Rajasthan (8.84%). These figures indicate the

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considerable importance of Uttar Pradesh in India's beekeeping and honey-production sector (APEDA, 2026) [1].

Uttar Pradesh possesses considerable potential for beekeeping because of its extensive agricultural area and availability of diverse seasonal floral resources. Mustard/rapeseed, eucalyptus, litchi, sunflower and multiflora vegetation provide important nectar and pollen sources in different periods of the year. Such floral diversity supports colony development and provides opportunities for honey production under both stationary and migratory beekeeping systems. The availability of these resources, combined with a large rural population and agricultural base, provides favourable conditions for promoting beekeeping as an enterprise for rural youth (Ghosh *et al.*, 2025) [2].

Successful establishment of a beekeeping enterprise, however, depends not only on the availability of bee colonies and equipment but also on the technical knowledge and managerial skills of the entrepreneur (Singh *et al.*, 2019) [3]. A beekeeper needs knowledge of honey bee species, bee biology and behaviour, bee flora, selection of apiary sites, colony selection and management, seasonal management, pest and disease management, queen rearing, use of beekeeping equipment, honey harvesting, processing, storage, value addition, economics and marketing. Previous studies have reported knowledge gaps among beekeepers in several of these areas. Kumar *et al.* (2020) [4] reported deficiencies in knowledge related to bee biology, bee enemies, disease management and bee breeding among beekeepers, highlighting the importance of systematic extension education and technical training.

In this context, assessment of the knowledge and adoption of improved beekeeping practices among ARYA-associated youth is important for evaluating the effectiveness of capacity-building interventions and identifying areas requiring further technical support. A systematic assessment can help determine whether training and practical demonstrations have improved knowledge and whether this knowledge is reflected in the adoption of recommended practices. It can also help identify gaps in post-harvest management, record keeping, pest and disease management, value addition and marketing that may influence the sustainability and profitability of beekeeping enterprises.

In view of the increasing importance of honey production and the substantial contribution of Uttar Pradesh to India's honey sector, assessment of beekeepers' knowledge and adoption of improved practices is important for strengthening the enterprise. Understanding the areas in which knowledge has improved and identifying practices with relatively lower adoption can help extension agencies, Krishi Vigyan Kendras and other supporting institutions design need-based training and follow-up interventions. Therefore, the present study was undertaken to assess the change in knowledge and adoption of selected improved beekeeping practices among the respondents, with particular emphasis on major technical and enterprise-management aspects of beekeeping.

Methodology

The study was conducted in the selected Krishi Vigyan Kendra viz., Ghazipur-I, Deoria, Pratapgarh, Basti, Muzzafarnagar-I and Gorakhpur-I, where the ARYA project was operational and beekeeping was promoted as an enterprise through training programme. These KVKs were purposively selected based on the implementation of ARYA activities and availability of mushroom related training for rural youth.

A total of 6 KVKs were selected for the study and 200 rural youth who had participated in beekeeping enterprise training under ARYA were selected as respondents. Data were collected through a structured interview schedule covering socio-economic characteristics, knowledge, and adoption of beekeeping practices. Knowledge was assessed using objective questions analyzed by frequency and percentage method, while for adoption respondents answers were recorded on three-point continuum, with the values of 2, 1 and 0 for always, sometimes and never respectively. Based on the mean and standard deviation of their scores in various adoption elements and total adoption and the respondents were divided into three adoption categories: low, medium and high.

Result and discussion

Table 1. Distribution of respondents based on change in level of knowledge ($n = 200$)

Sl. No.	Knowledge criteria	Pre-knowldgen (%)	Post-knowldgen (%)	Change in level of knowledge
1	General information about beekeeping	76 (38.0)	166 (83.0)	+45.0
2	Identification of honey bee species	68 (34.0)	158 (79.0)	+45.0
3	Bee flora and selection of apiary site	63 (31.5)	151 (75.5)	+44.0
4	Colony organization and bee behaviour	59 (29.5)	157 (78.5)	+49.0
5	Selection and management of colonies	55 (27.5)	149 (74.5)	+47.0
6	Seasonal management of colonies	51 (25.5)	145 (72.5)	+47.0
7	Management of bee enemies and pests	47 (23.5)	142 (71.0)	+47.5
8	Management of bee diseases	42 (21.0)	139 (69.5)	+48.5
9	Queen rearing and colony multiplication	38 (19.0)	132 (66.0)	+47.0
10	Use of bee boxes and equipment	71 (35.5)	169 (84.5)	+49.0
11	Honey harvesting and extraction	52 (26.0)	164 (82.0)	+56.0
12	Honey processing, grading and storage	45 (22.5)	151 (75.5)	+53.0
13	Value addition and other bee products	34 (17.0)	136 (68.0)	+51.0
14	Economics and profitability of beekeeping	39 (19.5)	141 (70.5)	+51.0
15	Marketing and market linkages	31 (15.5)	129 (64.5)	+49.0

Table 1 presents the change in knowledge of respondents regarding different aspects of beekeeping before and after participation in the ARYA training programme. The findings indicate a substantial improvement in knowledge across all the assessed areas.

The knowledge regarding general information about beekeeping increased from 38.0 per cent before training to 83.0 per cent after training, recording a gain of 45.0 percentage points. The considerable im-

provement indicates that the training programme strengthened the respondents' basic understanding of apiculture, its importance and its operational aspects. This finding is supported by Singh *et al.* (2019) [5], who reported a remarkable increase in the knowledge of trainees after participation in beekeeping training programmes. The similarity suggests that structured training can effectively strengthen founda-

tional knowledge required for initiating and managing a beekeeping enterprise.

Knowledge regarding identification of honey bee species increased from 34.0 per cent to 79.0 per cent, resulting in a gain of 45.0 percentage points. The improvement may be attributed to exposure to bee colonies, practical demonstrations and repeated discussion of species characteristics during training. Kumar *et al.* (2020) [6] reported that beekeepers possessed varying levels of knowledge about improved apiculture practices and emphasized the importance of technical knowledge for scientific beekeeping. The present result therefore indicates that practical exposure during training may have improved the ability of respondents to recognize important honey bee species.

Knowledge of bee flora and selection of an appropriate apiary site increased from 31.5 per cent before training to 75.5 per cent after training, showing a gain of 44.0 percentage points. The result reflects improved understanding of the importance of floral resources and suitable environmental conditions for successful colony establishment. Panchani *et al.* (2022) [7] reported that good beekeeping practices included appropriate site conditions and availability of floral resources. Thus, the observed increase may be considered an important outcome of practical orientation towards apiary-site selection.

The knowledge level concerning colony organization and bee behaviour increased from 29.5 per cent to 78.5 per cent, with a gain of 49.0 percentage points. The improvement indicates that respondents acquired a better understanding of colony structure and the behavioural characteristics of honey bees. Kumar *et al.* (2020) [4] identified bee biology as one of the areas in which knowledge gaps existed among beekeepers. The present improvement is therefore important because adequate understanding of bee biology and behaviour provides the basis for scientific colony management.

Knowledge concerning selection and management of colonies increased from 27.5 per cent to 74.5 per cent, recording a gain of 47.0 percentage points. The increase suggests that respondents became more familiar with the characteristics of healthy colonies and the practices required for maintaining colony strength. Kumari and Singh (2012) [8] reported a significant impact of beekeeping training on the adoption of beekeeping technology among trained rural women. Their finding supports the role of systematic training in converting technical information into practical beekeeping skills.

Knowledge of seasonal management of colonies increased from 25.5 per cent to 72.5 per cent, resulting in a gain of 47.0 percentage points. Seasonal management requires modification of colony-management practices according to temperature, floral availability and colony condition. The improvement observed in the present study indicates better understanding of these requirements after training. Panchani *et al.* (2022) [7] included seasonal management among the important components of good beekeeping practices, supporting the relevance of this area in technical training.

The knowledge regarding management of bee enemies and pests increased from 23.5 per cent to 71.0 per cent, with a gain of 47.5 percentage points. The relatively low pre-training level indicates that pest management was initially an important knowledge gap. Kumar *et al.* (2020) [4] similarly reported inadequate knowledge concerning bee enemies among beekeepers in Jammu Province. The substantial post-training increase therefore suggests that focused technical instruction can improve awareness of pest-related problems and their management.

Knowledge regarding management of bee diseases increased from 21.0 per cent to 69.5 per cent, recording a gain of 48.5 percentage points. The result indicates substantial improvement in respondents' awareness of disease identification and management. Kumar *et al.* (2020) [4] reported significant knowledge gaps in disease management among beekeepers, highlighting the importance of extension education in this area. The present finding demonstrates that disease-

management components included in the training programme contributed to strengthening technical knowledge.

Knowledge concerning queen rearing and colony multiplication increased from 19.0 per cent before training to 66.0 per cent after training, resulting in a gain of 47.0 percentage points. Although the improvement was considerable, the post-training knowledge level remained comparatively moderate. This may be because queen rearing and colony multiplication involve relatively advanced technical skills and require repeated practical exposure.

Knowledge regarding the use of bee boxes and equipment increased from 35.5 per cent to 84.5 per cent, showing a gain of 49.0 percentage points. The relatively high post-training score may be attributed to the demonstrative nature of equipment-related learning, where participants can directly observe and practice the use of hives and associated implements. Singh *et al.* (2019) [5] reported substantial knowledge gains among trainees across different aspects of beekeeping following organized training programmes, which supports the effectiveness of practical instruction.

The largest gain in knowledge was observed for honey harvesting and extraction, increasing from 26.0 per cent before training to 82.0 per cent after training, representing an improvement of 56.0 percentage points. The high gain may be associated with the practical nature of harvesting and extraction operations, which can be demonstrated and practiced comparatively easily during training. The finding is consistent with the broader evidence of Singh *et al.* (2019) [5], who observed remarkable knowledge improvement following beekeeping training. This result highlights the value of practical demonstrations in strengthening knowledge of operational activities.

Knowledge of honey processing, grading and storage increased from 22.5 per cent to 75.5 per cent, giving a gain of 53.0 percentage points. The marked improvement indicates greater awareness of post-harvest handling and quality-maintenance practices. Anu *et al.* (2025) [9] reported inadequate processing facilities and training-related limitations as important constraints in beekeeping enterprises. The present finding suggests that although training can substantially improve knowledge of post-harvest practices, continued support and appropriate facilities may be required to translate this knowledge into consistent adoption.

Knowledge of value addition and other bee products increased from 17.0 per cent to 68.0 per cent, showing a gain of 51.0 percentage points. The low initial score indicates comparatively limited exposure to enterprise diversification beyond honey production. Kumar *et al.* (2020) [4] also identified production of other bee products as an area in which beekeepers had knowledge deficiencies. The improvement in the present study therefore indicates that training broadened respondents' understanding of the possibilities for diversification and value addition in apiculture.

Knowledge regarding economics and profitability of beekeeping increased from 19.5 per cent to 70.5 per cent, recording a gain of 51.0 percentage points. The result indicates that respondents developed greater awareness of the economic dimensions of beekeeping, including the importance of costs, returns and enterprise viability. Singh *et al.* (2016) [10] reported financial and investment-related constraints among beekeepers adopting apiculture as an enterprise. Hence, strengthening economic knowledge through training is relevant for supporting informed enterprise management.

Knowledge concerning marketing and market linkages increased from 15.5 per cent to 64.5 per cent, representing a gain of 49.0 percentage points. Despite the substantial improvement, the post-training score remained the lowest among the knowledge components, indicating that marketing may require additional mentoring and institutional support. Singh *et al.* (2016) [10] reported low honey prices and difficulties associated with marketing as important constraints to beekeeping adoption. Therefore, the relatively lower post-training knowledge in the present study highlights the need to strengthen market-oriented training and follow-up support.

Table 2. Distribution of respondents based on adoption level in beekeeping enterprises ($n = 200$)

Sl. No.	Adoption statement	Always (2) (%)	Sometimes (1) (%)	Never (0) (%)	Adoption %
1	Regularly inspect bee colonies for colony strength, queen status and brood development.	126 (63.0)	56 (28.0)	18 (9.0)	77.0
2	Provide adequate and clean water near the apiary when required.	108 (54.0)	68 (34.0)	24 (12.0)	71.0
3	Select a suitable location with sufficient bee flora and protection from hazards.	138 (69.0)	48 (24.0)	14 (7.0)	81.0
4	Follow recommended seasonal management practices for maintaining healthy colonies.	112 (56.0)	67 (33.5)	21 (10.5)	72.8
5	Monitor colonies regularly for common pests and diseases and take appropriate measures.	104 (52.0)	70 (35.0)	26 (13.0)	69.5
6	Use appropriate protective clothing and equipment while handling bee colonies.	146 (73.0)	43 (21.5)	11 (5.5)	83.8
7	Maintain cleanliness and hygiene of bee boxes, tools and apiary equipment.	132 (66.0)	55 (27.5)	13 (6.5)	79.8
8	Harvest mature honey using recommended methods without unnecessarily disturbing colonies.	118 (59.0)	62 (31.0)	20 (10.0)	74.5
9	Filter, process and store harvested honey under suitable hygienic conditions.	96 (48.0)	72 (36.0)	32 (16.0)	66.0
10	Maintain records of colony performance, honey production, expenditure and income.	82 (41.0)	76 (38.0)	42 (21.0)	60.0

Table 2 presents the adoption of selected improved beekeeping practices among the respondents. The adoption scores varied from 60.0 to 83.8 per cent, indicating differences in the extent to which individual practices were incorporated into routine enterprise management.

Regular inspection of bee colonies for colony strength, queen status and brood development recorded an adoption score of 77.0 per cent. A majority of the respondents (63.0%) reported that they always followed this practice, indicating comparatively regular monitoring of colonies. Regular inspection is essential for identifying changes in colony condition at an early stage. Mishra *et al.* (2020) [11] reported that knowledge and extension-related characteristics were associated with adoption of improved apiculture practices, supporting the importance of continued technical guidance for routine colony management.

The adoption level for providing adequate and clean water near the apiary was 71.0 per cent. More than half of the respondents (54.0%) always followed the practice, whereas 12.0 per cent reported non-adoption. The variation may be associated with differences in access to natural water sources and awareness of the need for supplemental water.

Selection of a suitable location with sufficient bee flora and protection from hazards recorded an adoption level of 81.0 per cent. The relatively high adoption indicates that respondents were generally able to apply knowledge related to site selection. Panchani *et al.* (2022) [7] reported widespread adoption of several good beekeeping practice parameters among beekeepers, including practices related to maintaining appropriate conditions for colonies. The present finding suggests that site-selection recommendations may be comparatively easy to incorporate into routine practice.

Recommended seasonal management practices recorded an adoption level of 72.8 per cent. More than half of the respondents (56.0%) reported always following these practices, while 10.5 per cent reported non-adoption. The finding indicates reasonable application of seasonal management knowledge, although some respondents may require additional follow-up support. Singh *et al.* (2019) [5] demonstrated that organized training substantially improved knowledge of beekeeping practices, which can facilitate subsequent application of season-specific recommendations.

Monitoring colonies for common pests and diseases and taking appropriate measures recorded an adoption level of 69.5 per cent. The comparatively lower adoption may be related to the technical difficulty involved in early diagnosis and selection of appropriate control mea-

sures. Kumar *et al.* (2020) [4] identified bee enemies and disease management among the areas where beekeepers had substantial knowledge gaps. The present result therefore emphasizes the need for repeated practical demonstrations and diagnostic guidance.

The use of appropriate protective clothing and equipment recorded the highest adoption level of 83.8 per cent, with 73.0 per cent of respondents reporting regular adoption. The high adoption may be associated with the immediate personal-safety benefit of protective equipment during colony inspection and handling. Singh *et al.* (2016) [10] reported fear of bee stings as a socio-psychological constraint associated with beekeeping adoption. The high use of protective equipment in the present study may therefore reflect increased awareness of safety during beekeeping operations.

Maintenance of cleanliness and hygiene of bee boxes, tools and apiary equipment recorded an adoption level of 79.8 per cent. The relatively high level suggests that hygiene practices were commonly incorporated into routine management. Good hygiene is important for maintaining colony health and ensuring safer handling of bee products. Panchani *et al.* (2022) [7] reported widespread adoption of several good beekeeping practices, providing support for the relatively favourable adoption observed for routine hygiene in the present study. Harvesting mature honey using recommended methods recorded an adoption level of 74.5 per cent. A majority of respondents (59.0%) reported always following the practice, indicating that harvesting-related recommendations were reasonably well incorporated into enterprise operations. Singh *et al.* (2019) [5] demonstrated that beekeeping training was effective in improving trainees' knowledge across different technical areas. The present result suggests that practical learning may also facilitate application of harvesting procedures.

Filtering, processing and storing harvested honey under suitable hygienic conditions recorded an adoption level of 66.0 per cent, making it one of the comparatively less-adopted practices. Sixteen per cent of respondents reported non-adoption. The lower adoption may be related to the additional requirements of processing facilities, equipment and quality-control procedures. Anu *et al.* (2025) [9] identified lack of processing facilities as an important constraint in beekeeping, supporting the interpretation that infrastructural limitations can affect post-harvest adoption.

Maintenance of records relating to colony performance, honey production, expenditure and income recorded the lowest adoption level of 60.0 per cent. Only 41.0 per cent of respondents reported always maintaining such records, whereas 21.0 per cent reported non-adop-

tion. This indicates that enterprise-management documentation was less consistently practiced than field-level technical activities. Singh *et al.* (2016) [10] reported financial and investment-related constraints as important barriers in beekeeping enterprises, highlighting the importance of strengthening business-management capabilities along with production skills.

Overall, the findings demonstrate that ARYA-oriented training was associated with substantial improvement in knowledge across all fifteen assessed areas. Knowledge gains ranged from 44.0 to 56.0 percentage points, with the largest increase observed in honey harvesting and extraction. Adoption was comparatively higher for protective equipment, apiary-site selection and hygiene, whereas record keeping, hygienic processing and storage, and pest and disease management showed relatively lower adoption. The results indicate that technical training should be complemented with repeated practical demonstrations, follow-up mentoring, enterprise-management guidance, post-harvest support and market-oriented interventions to strengthen the sustained application of improved beekeeping practices.

Conclusion

The study demonstrates substantial improvement in respondents' knowledge across all assessed areas of beekeeping, with gains of 44.0-56.0%. The results particularly highlight strong improvement in honey harvesting and extraction, post-harvest handling, value addition and enterprise economics. Adoption was relatively higher for protective equipment, apiary-site selection and hygiene, whereas record keeping, post-harvest handling, and pest and disease management showed comparatively lower adoption. The findings support the importance of practical, need-based extension interventions combined with follow-up mentoring. Future programmes should give additional attention to enterprise record keeping, marketing, post-harvest quality management, pest and disease diagnosis, and advanced colony-management skills.

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