Scientific Progress, Emerging Challenges and Strategic Vision for the Indian Litchi Sector

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1. Introduction

Litchi (*Litchi chinensis* Sonn.) is one of the most distinctive fruit crops of the subtropical world, valued for its bright red pericarp, translucent pulp, characteristic aroma and rich nutritional properties. The fruit holds an important place in domestic markets and is increasingly gaining recognition in international trade due to its premium quality and consumer preference. Apart from its commercial importance, litchi also has cultural significance in many regions of India, particularly in eastern states where the fruit is associated with seasonal festivities and traditional cuisine. The crop originated in southern China where it has been cultivated for more than two millennia. It was introduced to India approximately three centuries ago and gradually became established in the eastern Indo-Gangetic plains. Today, the major litchi producing states include Bihar, West Bengal, Assam, Punjab, Jharkhand and Uttarakhand.

Recognizing the strategic importance of the crop, the Indian Council of Agricultural Research (ICAR) established the ICAR–National Research Centre on Litchi (NRCL) at Muzaffarpur, Bihar, located in the heart of the Shahi Litchi belt. The institute has a national mandate to conduct research on crop improvement, production technologies, post-harvest management, value addition and technology dissemination for sustainable growth of the litchi sector.

2. Global and National Status of Litchi

Litchi is cultivated across tropical and subtropical regions of Asia, Africa, Australia and the Americas. China is the largest producer in the world followed by India, Thailand, Vietnam and Bangladesh. Due to differences in climate between the Northern and Southern hemispheres, global litchi supply is available almost throughout the year. Asian countries supply fruits between March and June, while Southern Hemisphere countries such as South Africa, Madagascar, Australia and Brazil harvest litchi from November to February.

India benefits from a staggered harvesting pattern across states, which extends the domestic availability of fresh fruits. The harvesting season begins in Tripura during mid-April, followed by Assam, West Bengal and Odisha in early May. Peak production occurs in

Bihar, Jharkhand and Chhattisgarh from mid-May to mid-June, after which harvesting shifts to Uttar Pradesh, Uttarakhand, Punjab and Himachal Pradesh during June and early July. Limited off-season production is also observed in southern states such as Karnataka and Tamil Nadu during November–December.

Within India, Bihar remains the leading litchi producing state, contributing the largest share of area and production. Other important producing states include West Bengal, Punjab, Assam, Jharkhand and Chhattisgarh. The dominance of eastern and northern states reflects the favourable agro-climatic conditions prevailing in the eastern Indo-Gangetic plains.

3. Trends in Area, Production and Productivity

Over the past decade, the litchi sector has experienced structural changes. The area under litchi cultivation increased by nearly 19.8%, which is significantly higher than the overall growth observed in total fruit crops. However, the increase in production has been relatively modest, around 13%, indicating that yield improvements have not kept pace with area expansion. A major concern is the decline in productivity, which has decreased by about 5.4% during the same period. This trend contrasts with the substantial productivity gains recorded in other fruit crops in India. The results indicate that expansion of litchi cultivation has largely occurred through horizontal expansion rather than technological improvement.

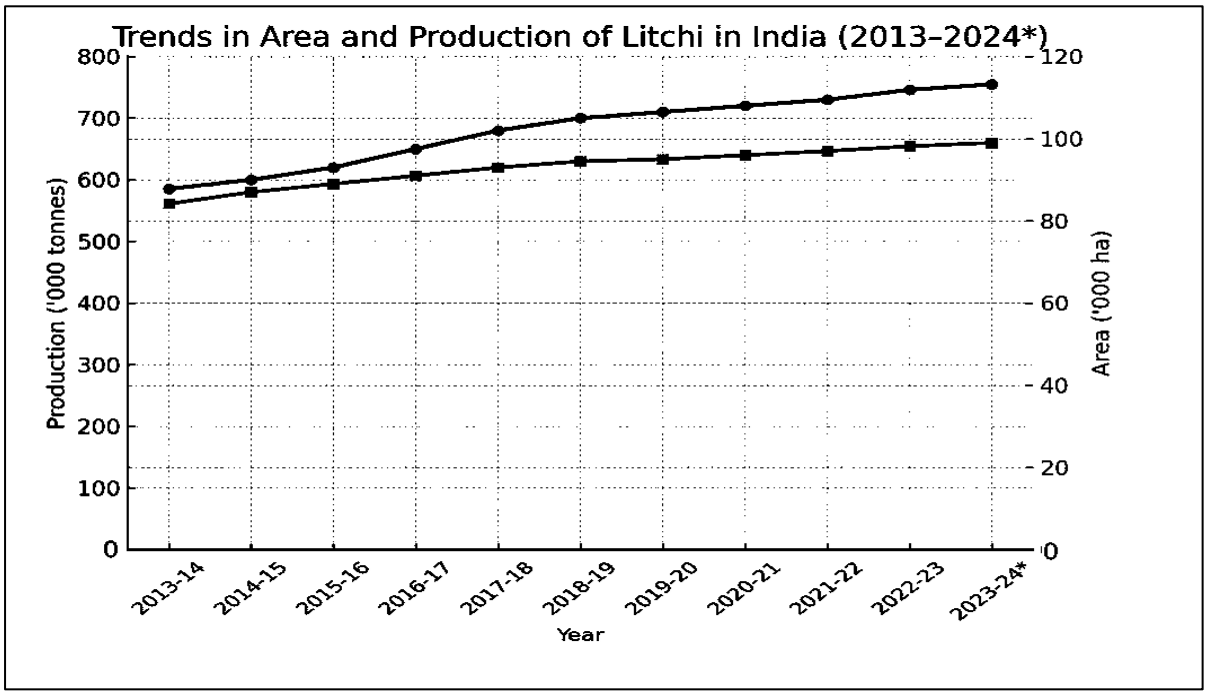

Fig 1. Trend in area, production and productivity during 2013-2024 * Estimate / interpolated figures; official published data for 2020–22

Table 1. Area, production and productivity during 2013-2024

Year	Area (ha)	Production (tonnes)	Productivity (t/ha)
2020	~95,000	~700,000	~7.37
2021	~96,500	~720,000	~7.46
2022	~97,500	~730,000	~7.49
2023	98,180	746,000	7.60

Further analysis reveals contrasting trends between traditional and non-traditional growing regions. Traditional litchi belts such as Bihar and West Bengal have experienced a decline in productivity, partly due to ageing orchards, climatic stress and management constraints. In contrast, several non-traditional regions have recorded improved productivity, suggesting that favourable climatic conditions and adoption of improved management practices may be contributing to better yields. These observations highlight the urgent need for rejuvenation of old orchards and adoption of improved production technologies in traditional litchi-growing areas.

4. Agro-climatic Suitability and Climate Challenges

Litchi cultivation is highly sensitive to climatic conditions, particularly winter temperature patterns that influence floral induction. Analysis of climatic parameters indicates that the number of winter days with minimum temperature below 12°C is a critical factor determining suitability for litchi cultivation. Regions receiving 60–100 cool days during winter are considered highly suitable for litchi production. In addition, moderate winter temperatures below 20°C, maximum temperatures between 28–38°C, and annual rainfall of 1200–2000 mm provide optimal conditions for litchi growth and fruit development. These climatic requirements explain why the eastern Indo-Gangetic plains and Himalayan foothill regions represent the most suitable zones for litchi cultivation in India.

However, recent climatic analysis reveals emerging risks. The number of cool winter days required for floral induction is gradually declining in major litchi growing regions such as Muzaffarpur, Pantnagar and Malda. At the same time, the occurrence of extremely high temperatures above 38°C during the fruit development stage is becoming more frequent. These changes can adversely affect flowering, fruit set and fruit quality, resulting in problems such as fruit cracking, sunburn and moisture stress. These trends highlight the growing influence of climate variability on litchi production and emphasize the need for climate-resilient management strategies and predictive phenology models.

5. Key Constraints in the Litchi Sector

The declining productivity and profitability of litchi orchards are the result of multiple interacting constraints. Structural and biological factors include large tree size, shortage of skilled labour for orchard management, limited post-harvest infrastructure and the inherently short shelf life of litchi fruits.

Climatic stresses also play a significant role. Rising winter temperatures during November–December can induce unwanted vegetative flushing, reducing flowering intensity. Similarly, high temperatures during April–May increase fruit cracking and scorching.

Emerging pest and disease problems further aggravate the situation. Increasing infestation of litchi stink bug, flower webber and other pests can cause significant yield losses. These challenges often lead to reduced investment in orchard management and lower farmer confidence, creating a negative cycle that ultimately affects productivity and profitability.

6. Technological Contributions of ICAR–NRCL

ICAR–NRCL has developed several technologies that have significantly improved litchi productivity and orchard management. One of the most impactful interventions is rejuvenation of old and senile orchards, which has been successfully implemented in more than 1000 hectares and has demonstrated a favourable benefit–cost ratio.

Canopy management technologies have also gained wide adoption, covering more than 2000 hectares, and have improved light penetration, fruit quality and yield stability. Other important innovations include single hedge row planting, girdling for improving bearing potential, and bunch bagging for protecting fruits from pests and environmental damage.

The institute has also developed NRCL Trichoderma, a biological soil health management technology that helps suppress soil-borne pathogens and improve root health. Integrated pest management packages targeting major pests and diseases have further strengthened sustainable production practices.

In addition to production technologies, the institute has developed promising varieties such as Gandaki Sampada, Gandaki Yogita and Gandaki Lalima, which possess desirable fruit quality and yield characteristics.

Due to its highly perishable nature, value addition plays a crucial role in improving the economic value of litchi. Several processed products have been developed from litchi fruits and by-products, including litchi in syrup, dehydrated litchi pulp, and litchi nut products.

7. Emerging Research Frontiers

The research landscape of litchi in India is evolving toward advanced, interdisciplinary approaches. Current cutting-edge research initiatives include Genome-Wide Association Studies (GWAS) for identification of trait-specific molecular markers and development of improved varieties. Efforts are also underway to standardize in vitro regeneration protocols, which will support advanced breeding approaches and genome editing.

Research on litchi phenology under climate change aims to develop predictive models for flowering and fruiting behaviour. In the field of plant protection, innovative strategies such as the use of entomopathogenic fungi, semiochemical-based pest monitoring, and metagenomics-based insect microflora management are being explored.

Additional research is focused on value addition from litchi waste, including extraction of nutraceutical compounds, and mapping the ecological footprint of litchi production systems to promote sustainability.

8. Collaborative Research and Scientific Output

ICAR–NRCL has strengthened its research capacity through collaborations with several ICAR institutes. Collaborative work with ICAR-NISA focuses on lac-based coatings for extending shelf life and utilization of litchi waste. Research with ICAR-RCER and ICAR-IIAB focuses on genomics and GWAS studies, while ICAR-NBAIR contributes to semiochemical-based pest management. Collaboration with ICAR-CISH addresses post-harvest technologies for improving shelf life.

The institute has also witnessed significant improvement in research output. The average number of research papers published per scientist in journals with NAAS rating above 6 increased from 0.35 during 2015–2020 to 1.47 during 2021–2025. Similarly, the average NAAS rating per publication increased from 5.72 to 7.80, reflecting improved scientific quality and impact.

9. Capacity Building and Farmer Outreach

Technology dissemination is an important component of the institute's mandate. The number of farmer training programmes conducted has increased steadily from 7 programmes in 2020–21 to 33 programmes in 2024–25. During the same period, the number of farmers trained increased from fewer than 200 participants to nearly 900 trainees annually. These initiatives have strengthened technology adoption, improved farmer knowledge and promoted sustainable orchard management practices across litchi-growing regions.

10. Growth Vision for the Litchi Sector

The long-term vision for the litchi sector aims to increase area, production and productivity while reducing losses across the value chain. At present, litchi occupies about 0.98 lakh hectares with a production of 7.64 lakh tonnes and productivity of 7.76 t/ha. By 2046–47, the vision targets expansion of area to 2.0 lakh hectares and production to 20 lakh tonnes, with productivity reaching 10 t/ha.

Pre-harvest losses are expected to decline from more than 30% to below 10%, while post-harvest losses are targeted to reduce from over 25% to less than 5% through improved harvesting, storage and cold chain technologies. Processing and value addition are expected to increase from less than 0.4% to more than 3%, while export value is projected to increase significantly.

The vision is guided by three major goals: improving the livelihoods of litchi stakeholders, increasing the availability of quality fruits in India, and strengthening the global presence of Indian litchi.

Year (FY)	Export Quantity (tonnes)	Notes
2018–19	~90	Earlier estimates of ~90–100 t of fresh litchi exported (primarily Nepal, UAE)
2019–20	~90	Similar scale, limited export due to perishability & lack of cold chain
2020–21	~88	Continued small-volume exports reported (~88 t)
2021–22	~108	Estimated on report of 108 t export & growth noted in literature
2022–23	~320	Bihar's airport export ramp-up; newspaper reports of ~320 t exported via air corridors (Patna & Darbhanga)
2023–24	639.53	Official APEDA figure for total litchi exported from India
2024–25	~830	From May–June 2025 export data showing ~829.7 t via air cargo from Bihar alone

Source: APEDA and National News

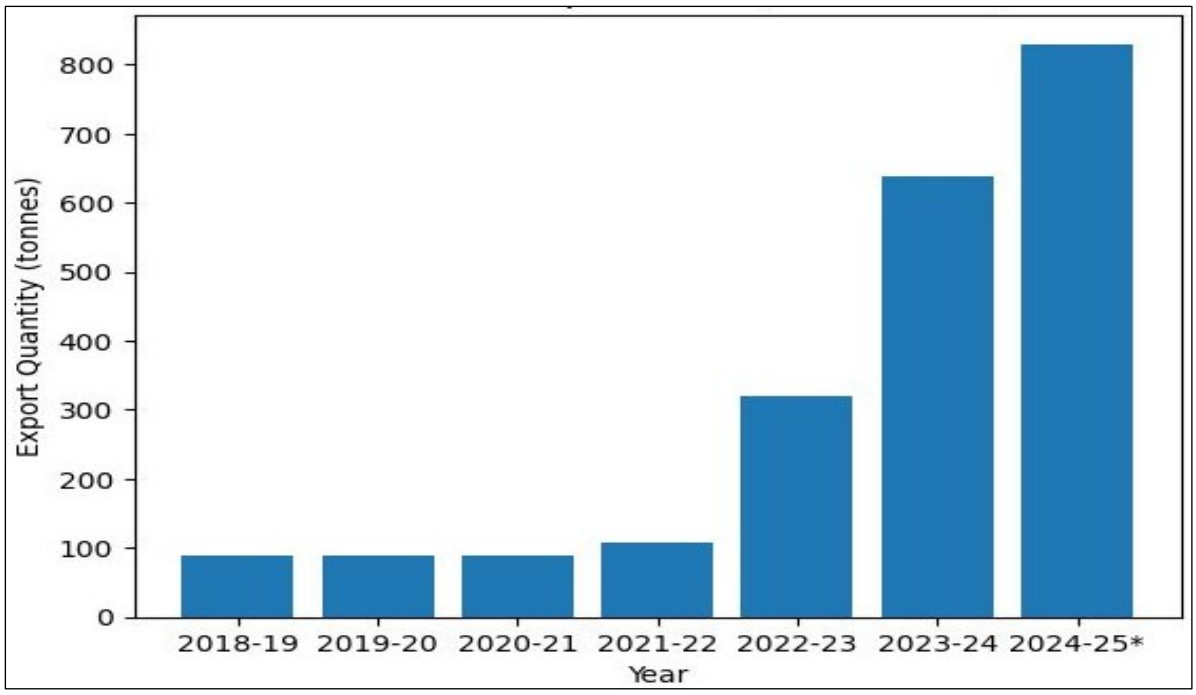

Fig 2. Litchi export trend in recent years in India

11. Strategic Targets for the Next Five Years (SFC)

The institute has outlined a comprehensive roadmap for the next five years in SFC focusing on crop improvement, production technologies, post-harvest management and socio-economic development. Key priorities include molecular fingerprinting of cultivars, identification of molecular markers, development of climate-resilient varieties, heat stress management technologies, resource conservation practices and phenology forecasting models. Post-harvest research will focus on dipping technologies for shelf-life improvement, novel packaging systems, export protocols and development of low-cost harvesters. In plant protection, emphasis will be placed on biological control using entomopathogenic fungi and semiochemical-based integrated pest management strategies. Socio-economic interventions will include expansion of litchi cultivation in non-traditional states, strengthening value chains through farmer producer companies, and mapping the ecological footprint of litchi production systems.

12. Conclusion

The Indian litchi sector is at a critical juncture where technological innovation, climate resilience and value-chain development must converge to ensure sustainable growth. While India remains one of the largest producers globally, productivity stagnation, climatic variability and post-harvest losses continue to pose major challenges. Through its research, technology development and capacity-building programmes, ICAR–NRCL has played a

pivotal role in strengthening the scientific foundation of the litchi sector. Continued investment in advanced breeding, precision horticulture, post-harvest technologies and market development will be essential to unlock the full potential of litchi cultivation in India. With coordinated efforts among research institutions, policymakers and farmers, the litchi sector can emerge as a dynamic contributor to horticultural growth and rural livelihoods in the coming decades.