



# Vision 2050



हर कदम, हर डगर  
किसानों का हमसफर  
भारतीय कृषि अनुसंधान परिषद

*Agri*search with a human touch



National Research Centre on Litchi  
Indian Council of Agricultural Research





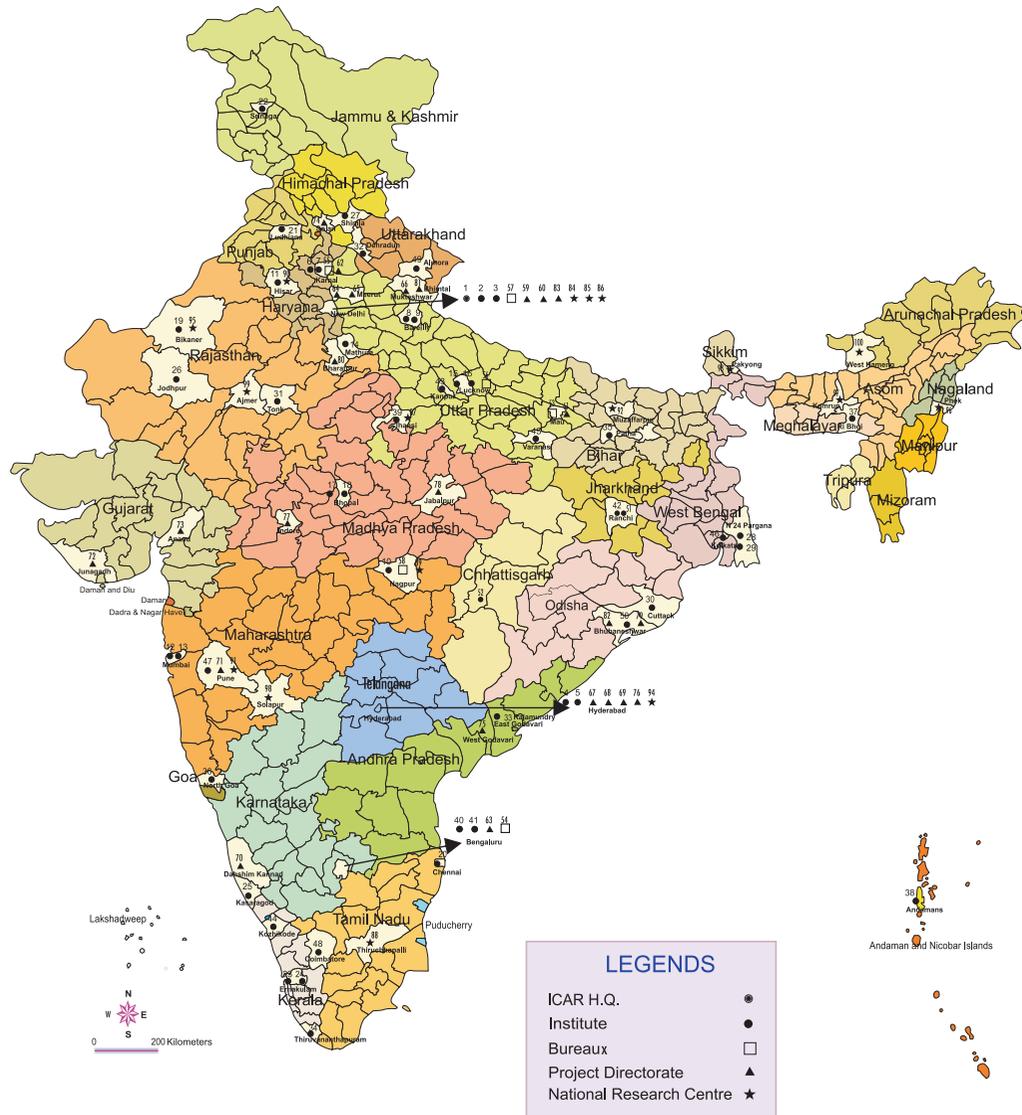
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Vision  
2050



National Research Centre on Litchi  
(Indian Council of Agricultural Research)  
Muzaffarpur (Bihar) 842 002

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## संदेश



भारतीय सभ्यता कृषि विकास की एक आधार रही है और आज भी हमारे देश में एक सुदृढ़ कृषि व्यवस्था मौजूद है जिसका राष्ट्रीय सकल घरेलू उत्पाद और रोजगार में प्रमुख योगदान है। ग्रामीण युवाओं का बड़े पैमाने पर, विशेष रूप से शहरी क्षेत्रों में प्रवास होने के बावजूद, देश की लगभग दो-तिहाई आबादी के लिए आजीविका के साधन के रूप में, प्रत्यक्ष या अप्रत्यक्ष, कृषि की भूमिका में कोई बदलाव होने की उम्मीद नहीं की जाती है। अतः खाद्य, पोषण, पर्यावरण, आजीविका सुरक्षा के लिए तथा समावेशी विकास हासिल करने के लिए कृषि क्षेत्र में स्थायी विकास बहुत जरूरी है।

पिछले 50 वर्षों के दौरान हमारे कृषि अनुसंधान द्वारा सृजित की गई प्रौद्योगिकियों से भारतीय कृषि में बदलाव आया है। तथापि, भौतिक रूप से (मृदा, जल, जलवायु), बायोलोजिकल रूप से (जैव विविधता, हॉस्ट-परजीवी संबंध), अनुसंधान एवं शिक्षा में बदलाव के चलते तथा सूचना, ज्ञान और नीति एवं निवेश (जो कृषि उत्पादन को प्रभावित करने वाले कारक हैं) आज भी एक चुनौती बने हुए हैं। उत्पादन के परिवेश में बदलाव हमेशा ही होते आए हैं, परन्तु जिस गति से यह हो रहे हैं, वह एक चिंता का विषय है जो उपयुक्त प्रौद्योगिकी विकल्पों के आधार पर कृषि प्रणाली को और अधिक मजबूत करने की मांग करते हैं।

पिछली प्रवृत्तियों से सबक लेते हुए हम निश्चित रूप से भावी बेहतर कृषि परिदृश्य की कल्पना कर सकते हैं, जिसके लिए हमें विभिन्न तकनीकों और आकलनों के मॉडलों का उपयोग करना होगा तथा भविष्य के लिए एक ब्लूप्रिंट तैयार करना होगा। इसमें कोई संदेह नहीं है कि विज्ञान, प्रौद्योगिकी, सूचना, ज्ञान-जानकारी, सक्षम मानव संसाधन और निवेशों का बढ़ता प्रयोग भावी वृद्धि और विकास के प्रमुख निर्धारक होंगे।

इस संदर्भ में, भारतीय कृषि अनुसंधान परिषद के संस्थानों के लिए विजन-2050 की रूपरेखा तैयार की गई है। यह आशा की जाती है कि वर्तमान और उभरते परिदृश्य का बेहतर रूप से क्रिया गया मूल्यांकन, मौजूदा नए अवसर और कृषि क्षेत्र की स्थायी वृद्धि और विकास के लिए आगामी दशकों हेतु प्रासंगिक अनुसंधान संबंधी मुद्दे तथा कार्यनीतिक फ्रेमवर्क काफी उपयोगी साबित होंगे।

*राम मोहन सिंह*

( राधा मोहन सिंह )

केन्द्रीय कृषि मंत्री, भारत सरकार



# Foreword

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Indian Council of Agricultural Research, since inception in the year 1929, is spearheading national programmes on agricultural research, higher education and frontline extension through a network of Research Institutes, Agricultural Universities, All India Coordinated Research Projects and Krishi Vigyan Kendras to develop and demonstrate new technologies, as also to develop competent human resource for strengthening agriculture in all its dimensions, in the country. The science and technology-led development in agriculture has resulted in manifold enhancement in productivity and production of different crops and commodities to match the pace of growth in food demand.

Agricultural production environment, being a dynamic entity, has kept evolving continuously. The present phase of changes being encountered by the agricultural sector, such as reducing availability of quality water, nutrient deficiency in soils, climate change, farm energy availability, loss of biodiversity, emergence of new pest and diseases, fragmentation of farms, rural-urban migration, coupled with new IPRs and trade regulations, are some of the new challenges.

These changes impacting agriculture call for a paradigm shift in our research approach. We have to harness the potential of modern science, encourage innovations in technology generation, and provide for an enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy, and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive. Our institutions of agricultural research and education must attain highest levels of excellence in development of technologies and competent human resource to effectively deal with the changing scenario.

Vision-2050 document of ICAR-National Research Centre on Litchi (NRCL), Muzaffarpur has been prepared, based on a comprehensive assessment of past and present trends in factors that impact agriculture, to visualise scenario 35 years hence, towards science-led sustainable development of agriculture.

We are hopeful that in the years ahead, Vision-2050 would prove to be valuable in guiding our efforts in agricultural R&D and also for the young scientists who would shoulder the responsibility to generate farm technologies in future for food, nutrition, livelihood and environmental security of the billion plus population of the country, for all times to come.



**(S. AYYAPPAN)**

Secretary, Department of Agricultural Research & Education (DARE)  
and Director-General, Indian Council of Agricultural Research (ICAR)  
Krishi Bhavan, Dr Rajendra Prasad Road,  
New Delhi 110 001

# Preface

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Litchi (*Litchi chinensis* Sonn.) is an important fruit crop commercially grown in some states with tremendous export potential and plays significant role in their economy. There has been ever-increasing demand for litchi in domestic and export market. Owing to specific climatic requirement, successful litchi cultivation has been restricted in certain areas but now with the development of improved cultivation technologies, it is spreading to many other parts of India.

Saturation of area in traditional belt, lack of post-harvest management facilities and marketing network for the highly perishable litchi fruit have been responsible for slow increase in area during past decades. Unstable market trend has resulted in low and declining litchi prices which has further lowered profits to farmers. India is the second largest producer of litchi and its productivity is higher as compared to China. The existing gap in productivity and potential yield needs to be addressed sincerely. In spite of its vast export potential, the quantity of exported litchi fruits is negligible. Therefore, there is a need for not only increasing the production but also the proportion of export of quality litchi fruit. Processing and value addition, and human resource development in the selected sectors will further boost the litchi industry. Attention on Research and Development for overall improvement in production and productivity of litchi in India has not been up to mark. The need for systematic research for identification of additional potential areas, development and refinement of technologies for enhancing productivity and quality alongwith post-harvest handling, processing and value addition, development of high temperature tolerant varieties, high yield and processing has long been felt and have been suitably focused in the earlier vision documents to be addressed during forthcoming years. With a view to emerging as a vibrant Centre/Institution in India and to sustain comparative advantage in the changing global scenario in production, processing, product development, and HRD in litchi, now a need has been felt to develop “Vision 2050” document for the centre to address such issues in forth coming years. It would aim at addressing issues related to production, productivity, food and nutritional security and institutional coordination to develop and sustain India as a prominent country in litchi production and trade.

I would like to place on record my grateful appreciation to all my colleagues presently working at ICAR-NRCL. The endless editing, corrections and suggestions we received from Dr. N. K. Krishna Kumar, Deputy Director General (Horticultural Science) are placed on record with gratitude. The untiring support we received from Dr. T. Janakiram, ADG (HS-I) for the successful preparation of this document is gratefully acknowledged.

Vishal Nath  
Director  
ICAR-NRC on Litchi  
Muzaffarpur

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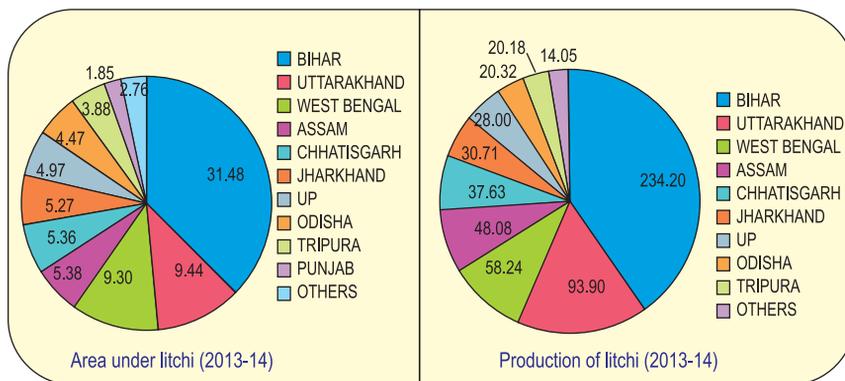
## Context

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Litchi is an evergreen subtropical fruit, known for its delicious, juicy aril and refreshing taste. Fruits are consumed fresh and processed into value added products. The pulp, canned aril, dried fruits, 'litchi nuts' are exported. The aril of dried litchi is eaten like raisins. Chinese use dried aril in their tea as a sweetener. Litchi fruits are also spiced or pickled, or made into sauce, preserves or wine. Litchi seeds are used as anodyne in neuralgic disorders and bronchitis.

The cultivation of Litchi is restricted to very few countries in the world, India being one among them. India and China account for 91 per cent of the world litchi production but it is mainly marketed locally. In India, 585,300 metric tonnes of litchi is produced annually from 84,170 ha. Litchi, being exacting in climatic requirement, is confined to a few states of India with 40 per cent of production in Bihar. In Bihar, litchi is the source of livelihood for millions of people as it provides both on-farm and off-farm employment. Small and marginal farmers get additional income from litchi plants in their homesteads. Thus, litchi cultivation is a major source of livelihood security for a large population, especially in the state of Bihar. Presently, it is grown in an area of 84,170 ha with a productivity 6.95 t/ha. Bihar occupies about 37.4% area and 40% production of litchi in India.

Litchi accounts for slightly more than one per cent of the total area under fruits in India but it has a definite economic significance in its growing areas. The harvesting period of litchi fruits is quite limited which extends from May to June in different parts of the country. Approximately 90 percent of the produce is utilized as fresh of which at least 25 percent goes to waste due to post-harvest losses. Usually, there is abundance of fresh litchi fruit in the market due to very short period of (45-60 days) fruit maturity and harvesting in its growing regions from Tripura to Himachal Pradesh. Only a meager quantity of litchi is exported though there is great demand and scope to increase the quantum of export; more so because the harvesting season is quite different in other parts of the world. The major litchi producing states in India are Bihar (Muzaffarpur, East Champaran, Samastipur, Vaisali, and Bhagalpur), Uttaranchal (Udhamsingh Nagar, Dehradun, Pithauragarh, Nainital, Haridwar), West Bengal (Murshidabad, 24-Paraganas), Assam (Kamrup, Sonitpur, Bongaigaon), Punjab (Gurdaspur, Pathankot,



**Fig. 1** Area (000 ha) and production (000 MT) in different states of India during 2013-14

Ropar, Hoshiarpur), Uttar Pradesh (Saharanpur, Muzaffarnagar, Meerut, Kushinagar), Jharkhand (Gumla, Ranchi, Lohardaga) and Tripura (East and Central).

The possibilities of production of litchi during December–January in the southern hemisphere do exist in few selected areas of southern India which can make its fruit available during off season. With increased market base, there is an ample opportunity for increasing the area under litchi in some other parts. The foothills of the Himalayas, i.e Terai belt, free from frost, offer good scope for plantation of litchi. Litchi can be cultivated up to an altitude of 1000 m above mean sea level. In these foothills, fruits mature late in the season. Extended area under different situations could be exploited for extended harvest. Based on the fruiting behaviour, quality development and area under cultivation, the litchi growing districts could be grouped to take full advantage of climatic variability. However, to increase production and productivity, concerted efforts would be required for technological support and development of infrastructure. Interestingly, the litchi in India matures early in comparison to other litchi-growing countries and offers better domestic and export markets. Accordingly, there is potential to bring additional 1, 00,000 ha area under litchi cultivation. However, to achieve targeted growth in production, strategic planning, including improved production systems and infrastructure for post-harvest management, is needed. Recently, it has been observed that litchi is performing well in some non-traditional areas of Southern India particularly in places above 800-900 m altitude. These include Kerala (Wynad, Iduki), Karnataka (Kodagu, Chikamangaloor), Tamil Nadu (Shevaroy Hills, Lower Pulneys and Gudalur), Andhra Pradesh (Vizag), Odisha (Raigarh), Chhatishgarh (Ambikapur), Maharashtra (Thane), and Gujarat. Litchi fruit maturity

in Kerala, Karnataka, and Tamil Nadu commences during December and shows the potential for off season production. In Maharashtra, Odisha, and Chhattisgarh, fruit matures during May-June and coincide with main season crop.

There is need for improving productivity and widening the genetic base. Concerted research efforts and effective linkages are needed in these areas. It is also essential to develop promising lines/hybrids, which have larger fruit, small/chicken-tongued seeds, tolerance to pericarp browning, fruit cracking and having various maturity groupings. Suitable agro-techniques particularly for source and sink management, micro-nutrients management, induction of off season flowering, post-harvest technology and effective marketing need due attention.

**Table 1** Commercial varieties

State-wise commercial varieties of litchi	
State	Commercial Varieties
Bihar	Shahi, Rose Scented, China, Kasba, Purbi, Early Bedana, Late Bedana
Uttar Pradesh	Rose Scented, Dehradun, Calcuttia
West Bengal	Bombay Green, Kalyani Selection
Punjab	Muzaffarpur, Dehradun, Seedless, Late Bedana

### Current Dimensions and Approaches

There is a sizeable increase in acreage and production of litchi in India. Cultivation of litchi has increased from nearly 72,000 ha in 2008-09 to 84,170 ha in 2013-14. In terms of production, however, it has increased from 4,23, 000 to 5,85,300 tons during the same period. The total production of litchi is concentrated mainly in Bihar, West Bengal, Assam and Jharkhand and to a smaller extent in Tripura, Punjab, Uttarakhand and Odisha. Bihar is the leading state in litchi production (2,34,200 tons), followed by West Bengal (93,900 tons) and Jharkhand (58,240 tons).

Export of litchi has increased from 161.5 tons in 2007-08 to 794.86 tons in 2012-13, but it is evident from Table2, that the quantum has gone up to 1546 tons in 2008-09 which shows very good potential for export. In recent years, domestic market for litchi has increased tremendously and good price has been realized in the distant south Indian market.

Export of litchi is mainly confined to SAARC countries, notably Bangladesh, Nepal, Maldives, and Bhutan, and the UAE. There is excellent potential for export of litchi to Gulf Cooperation Council

**Table 2** Export of litchi in the last six years

Years	Quantity (in tons)	Value (in Rs. Lakh)
2007-08	161.5	63.43
2008-09	1546.49	155.94
2009-10	545.38	88.92
2010-11	1186.1	135.86
2011-12	319.93	38.77
2012-13	794.86	118.13

countries at competitive prices compared to Thailand, as India produces excellent quality litchi fruits and it is nearer to Gulf countries when compared with export competitors like Thailand and China. The European Union also imports sizeable quantities of litchi. Litchi are available in India from 15th April (Tripura) onwards up to the third week of June (Gurdaspur, Punjab). Off-season litchi production (December – January) in India offers high potential from higher altitude (>1000 m) of Southern states.

The potential of export can be exploited by aggressive marketing and supplying better quality, borer pest free fruits having minimum pesticide residues, etc. Its cultivation in Tripura and Assam needs to be encouraged by establishing pack houses in a phased manner. In addition, markets for organic litchi need to be identified. Litchi-producing areas in Gurdaspur, Pathankot and Hoshiarpur districts of Punjab are near to Amritsar international airport. Export of litchi from this area can be enhanced by setting up modern pack house near the production zone.

Productivity of litchi continues to be low with a wide gap between potential and existing yield. The difference in yield between the best managed orchards and national productivity ranges between two to four times probably due to narrow genetic base, non-availability of superior cultivars, traditional production systems, poor technological support, incidence of insect pests, poor post-harvest management, shortage of genuine planting material, and long vegetative phase. The low female/male flower ratio, premature fruit drop and fruit cracking due to unscientific management of water and nutrient also add to low productivity and poor quality fruits. The litchi tree has luxuriant vegetative growth, which causes problems in harvesting due to increased tree height. Thus, canopy management to achieve the required plant architecture is essential. Lack of scientific information on critical stages for flower bud differentiation and requirements of water and nutrients also significantly reduces the yield. The litchi has a short shelf-life.

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Practices that can enhance post-harvest life of fruit would be useful to achieve more return.

Some of the Good agricultural practices (GAP) for cultivation of litchi are being followed by farmers like use of air-layered plants for orchard establishment, rejuvenation to make old litchi orchard productive, high-density planting, conservation of soil moisture with mulching, integrated nutrient management, maintenance of irrigation frequency and spray of zinc/boron chelates to avoid fruit cracking, integrated pest management against fruit borer and post harvest management through better packing methods along with value added products. Artificial flower induction in litchi is possible by application of potassium per chlorate ( $KClO_3$ ), Paclobutrazol and Prohexadion-Ca.

Technology for Controlled Atmosphere (CA) and Modified Atmosphere (MA) storage of litchi are being standardized at ICAR-NRCL and in due course of time it will be refined to extend shelf life of litchi and facilitate litchi export to Gulf countries through refrigerated containers and MA cartons. Residue analysis laboratory need to be set up near production centers. There is formidable loss of fruits due faulty method of harvesting, lack of storage facility, mismanagement and mishandling of produce, loss during transit and unsuitable and unscientific packaging.



## Challenges

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Worldwide litchi is considered as one of the most environmentally sensitive plants adapted to warm subtropics and elevated tropics having cool dry winters, warm wet and humid summers. High rainfall and humidity induce good vegetative growth. Dry autumn and winter are important to prevent vegetative growth essential for subsequent good flowering. The tree requires adequate moisture from rainfall or irrigation during fruit set and growth.

Over the period of time, a large number of ecotypes in various countries including India have been identified; however a cultivar having all the required characters in one has not been possible. Litchi plants are very good yielders and generally not affected by most serious biotic stress but abiotic stress, particularly that of climatic aberrations affect the fruit yield and quality. Numerous post-harvest diseases have their origins from pre-harvest management. Good field sanitation, pre-harvest disease management and discarding of fruit with symptoms of fruit piercing insects, cracks and sun-scorch are effective in minimizing losses. Disease causing organisms include *Aspergillus* spp., *Pestalotiopsis* spp., *Peronophytophthora* spp., sour rot caused by *Geotrichum candidum* and yeasty rots caused by *Botryodiplodia theobromae*, *Colletotrichum gleosporioides*, and *Rhizopus oryzae*.

Among production challenges, optimum shoot maturity for flowering and encouraging sufficient number of mature shoots in a litchi tree needs most focused attention. The number, opening time, duration of flowering and strength of female and functional male flowers coupled with pollinator are the main deciding factors for litchi yield, and need much critical attention. The hormonal status and balance of different phyto-hormones in the developing fruit and even in the flowering twig needs to be essentially looked into. The sink-source relationship, nutrients reserve in different plant parts is essential to determine the plant performance. Major and micro nutrients availability vis-a-vis sustainable supplementation through various inputs and means are the focused areas to be addressed. Optimization of orchard environment above the soil and sub-surface during the fruit development and maturity through advance tools and their standardization is also a major challenge for litchi. The symbiotic association of various beneficial micro-organisms in litchi production has to be first established and then quantified for

optimum performance. Rapid multiplications techniques, harnessing of rootstocks to encourage litchi in problem soil, round the year fruit availability are the some upcoming challenges in litchi.

Litchi is a non-climacteric fruit and therefore, critical stage of maturity, time of harvest and post-harvest handling are the major challenges to be addressed to reduce post-harvest losses. Despite processing of litchi into various products including canned fruit, purees and beverages, fresh fruit marketing is predominant, but limited by the high perishability of the fruit. The litchi pericarp is prone to enzymatic browning even during the first day of storage. After harvest, as the peel becomes fragile due to rapid water loss and micro-cracks, vis-a-vis the fruit develops off-flavours and physical injuries, often associated with fermentation by yeasts and moulds. Therefore, improved marketability requires better outlets, enhanced transportability through shelf-life extension and suitable packaging. Presently, sulphur dioxide fumigation is common practice, resulting into pale-yellow to pink pericarp colouring, but rising legal and consumer restrictions have increased the demand for alternatives. Other disorders of litchi are breakdown (softening, loss of turgidity) of pulp in senescent fruit after prolonged storage and over-maturity, post-harvest peel cracking etc which need focused attention. Responding to these concerns, scientists have been developing technological innovations to boost the relative profitability of litchi cultivation.

**Major bottlenecks of litchi production are:**

- Low productivity and proportion of quality fruits.
- Narrow genetic base and lack of natural biodiversity.
- Limited period of availability of fruits with high post harvest losses.
- Lack of quality planting materials along with scientific knowledge in rapid multiplication.
- Lack of complete scientific basis of shoot maturity and flowering.
- Lack of quantified role of microorganism in plant health and yield.
- Lack of standard canopy architecture and its management for different density.
- Unavailability of techniques to manage seed borer.
- Short shelf life and lack of information on proper storage environment.
- Very low level of processing, value addition and export of fresh and processed litchi.
- Insufficient product diversification and dissemination.
- Low level of institutional support, infrastructure and human resource development programme.

### Constraints in litchi development

- Short production season at a particular place.
- Absence of post-harvest infrastructure.
- Absence of an efficient and nationwide marketing system
- Unorganized production by individual farmers
- Unavailability of trained manpower and entrepreneurs.
- Climatic constraints (absence of sufficient chilling temperature during winter and hot winds and hailstorm during summer months), frost/ low temperature during winter

**Table 3** Challenges/constraints of litchi production

Major constraints	Factors governing constraints
Supply over demand	1) Limited overseas market (transport only possible by ship or air)
	2) Limited consuming population (eating pattern not known in non-traditional areas)
	3) Limited transportation capacity (no facility at railway station for proper handling and transport, faulty packaging boxes impaired quality of produce)
High cost , low profit	4) High labour cost (scarcity of labour,)
	5) Low yield (due to old and senile orchard)
	6) Low price of fruit (short period of availability, glut in the market)
Lack of infrastructures	7) Irrigation and fertilizer system (Flood irrigation, no testing of water and soil, Soils of northern Bihar in highly saline)
	8) Cold chain especially cold room (harvesting in day time, no proper cool chain is maintained from field to pack houses/transport)
	9) Processing facilities and consumer preferences (Indian prefers fresh fruit over processed one)
Lack of bank supporting system	10) For orchard management
	11) For post harvest management and processing
Safe environment and safe products	12) Pest and diseases (stem end borer, stink bug, thrips, scales, semi-looper, weevil, mite, downy mildew, anthracnose, fruit rot)
	13) Chemical residues (sulfur residue, pesticide residue in fruits)

Litchi production is currently limited to certain specific locations in few states in the country. Recently few other states have shown interest for promoting litchi cultivation. Their expansion could not be taken up firmly because of the constraints like specific climatic and soil requirements for commercial cultivation, non-availability of quality planting material at the site and poor technical knowhow. Inadequate institutional and infra-structural support also have been the weaknesses to harness the built-in opportunities in litchi. In this context, it was a humble yet strategic move to establish NRC for Litchi on 6th June,

2001 at Muzaffarpur, Bihar. The centre is mandated to provide leadership and coordinate R & D activities of litchi in the country. Presently, the centre has prioritized the areas of intervention and working vigorously towards achieving them. However, due to insufficient manpower and inadequate support at the grass root level, development and popularization of modern production technologies and promotion of litchi cultivation is a challenging task.



Canopy Management

# Operating Environment

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Worldwide litchi is distributed between 18° to 32° latitude in Northern and Southern hemispheres barring some exceptions particularly due to altitude and special climatic variations across the globe. If the soil and other biophysical parameters are suitable and required infrastructure support for production is made available, the new areas can be utilized for litchi production. But the socio-economic conditions, policies, etc, do play a crucial role as major operating environment for the crop and needs to be fine-tuned in a befitting manner.

In India, the entire Terai region in the foot hills of Himalayas starting from NEH region to Punjab, including Jammu and Kashmir, are suitable for litchi but the major expansion over the period of time has taken place in the Muzaffarpur region mainly because of larger land holding, proximity to transport facility and willingness of growers to grow litchi over large area as commercial crop which ultimately developed as major litchi hub of the country.

The spread of litchi to other countries in the past 400 years has been slow, due to the exacting climatic requirements and the short life of fruits and other obvious reasons related to crop husbandry. The main litchi producing countries are China, India, Taiwan, Madagascar, Thailand, South Africa, Australia, Mauritius and Reunion Island. There is also interest in the crop in Vietnam, and the USA. Thailand and Taiwan export litchi to Singapore and Hong Kong. Fruits are exported to Europe, mainly from South Africa, Mauritius and Reunion.

With a mission of harnessing science and technology by interfacing research, extension activities for enhanced productivity, quality production and diversified use of litchi for different stake holder the Centre has mandate to provide single window solution for all aspects of litchi and act as nodal institution for research and development and provide leadership at national level. The Centre has marched ahead and delineated its functions:

- To undertake basic, strategic and applied research for enhancing productivity, improved quality and utilization of litchi fruits.
- To act as repository of genetic resources and scientific information on litchi.

- To demonstrate improved technologies and impart training to stakeholders for upgrading their knowledge base.

The Centre has established a National Active Germplasm site of litchi and total of 52 germplasms including 20 superior clones have been planted for detailed characterization. The Centre has developed a comprehensive plan to identify and collect superior genotypes and clones available in the country by 2017.

Development of ideal litchi cultivars is the main focus of the centre for which precocious gene harnessing through natural cross pollination, provincial population, traditional breeding techniques and understanding the behavior of seedlessness including molecular characterization and barcoding of genotypes are priority areas of research during the coming years.

In the past, the Centre has developed quite good number of technologies and refined the package of practices. The technology developed for cropping sequence and crop combinations for inter spaces in young orchard to sustain the soil fertility and enhance income in initial years has been widely adopted and appreciated by growers. The protocol for rejuvenation of old senile litchi orchard developed by the centre has been adopted by the National Horticulture Mission (Bihar) for large scale conversion of unproductive orchards to productive ones. Further refinement of this technology is required for sustaining the productivity for longer period. Some positive indication for management of fruit borer and litchi mite, use of bio-fertilizers and mycorrhiza, conservation horticulture and canopy architecture management has been visualized which need further research intensification for providing total solution to litchi growers by 2050.

The post-harvest losses in litchi are 20-25% of production which needs to be reduced by adopting improved techniques at various stages of handling and transportation. The centre has come out with very good concept and preliminary protocol to extend the shelf life and availability period which needs further testing and commercialization in next few years. The product diversification and value addition, providing genuine and nucleus plant materials, technology back stopping and knowledge support for industries, developmental departments, entrepreneurs, etc are the areas of concern where the role of NRCL is inevitable. The headways made by the centre till now have been summarized to obtain insights in all areas during next 35-40 years.

## 1. Crop Improvement

- The centre has rich stock of plant genetic resources with collection

of fifty-two (52) accessions of litchi from Bihar, Jharkhand, West Bengal and Uttarakhand.

- Characterization (including molecular) and documentation of litchi cultivars and related species from different agro-climatic zones are in progress.
- The potential of Longan (a related species of litchi) is being evaluated under Muzaffarpur conditions. Almost 15% plants flower in the 3rd year of its planting and its fruit matures in August. However, the size of fruit and pulp content is not up to mark in the initial years.
- Twenty four (24) superior clones of litchi have been identified and are under evaluation for maturity, fruit size, seed size, color, flavour and aroma of the fruits.
- Eight hundred (800) seedlings of Shahi and China cultivars of litchi are under evaluation for precocity, maturity and fruit size.
- Eight varieties of litchi have been introduced from Spain under FAO project.

## 2. Crop Production

- Plantation of different litchi cultivars in 20.0 ha of land under different experiments along with 1.0 ha as mother block has been completed at research farm of the Centre.
- Package of practices for higher production of quality fruits by foliar application of Planofix @2.5ml/10 l of water or NAA 20 mg/l of water, one week after fruit set significantly checked the fruit drop.
- Spray of 4.0% KNO<sub>3</sub> delayed colour break by 5 days in litchi cv. Shahi.
- Three sprays of Borax @ 4.0 g/l of water during fruit development stage at 15 day interval maintaining moisture level in the soil has been standardized for checking fruit cracking and improving fruit quality improvement.
- Technique for tree canopy architecture management by pruning of non selective twigs every year after harvest and opening central portion to maximize solar energy utilization has been standardized & disseminated to the litchi growers.
- Application of GA<sub>3</sub> (50 to 75 ppm) during October showed early initiation of flower panicle and conversion of some vegetative flushes into mixed panicle.
- Inter space utilization protocol for young non-bearing litchi orchards in form of different models have been developed;
  - ♦ **Model 1:** Litchi based cropping system with banana showed

better potential for quality production for three consecutive years.

- ♦ **Model 2:** Okra-Gladiolus crop rotation was found to be the best in terms of net return and plant growth followed by Cowpea-Potato-Onion and Cowpea-French bean-Okra.
- Reiterative pruning methods and rebuilding canopy for rejuvenation of old senile orchards (>40 years) has been developed. Careful de-topping at 2-2.5 m height during August followed by thinning of unwanted shoots after six months and applying manures as per schedule resulted in enhanced production of quality fruits after three years.
- Riverbed soil + Vermi-compost (2:1) + fertilizers (DAP+MOP, 5g each) showed healthy and vigorous saplings growth.
- Off season plant propagation through air layering has been standardized to reduce the post nursery maintenance cost.

### 3. Crop Protection

- Major pests of litchi prevalent in the area have been identified, which include fruit borer, shoot borer, leaf miner, leaf roller, mite, bark eating caterpillar, leaf eating weevil, bug, along with some and minor pests like mealy bug, mealy scale, mango hopper, grass hopper and field crickets (young plants).
- Use of *Trichogramma chilonis* @ 50,000eggs/ha coupled with alternate application of Nimbecidine (0.5%), Cypermethrin (0.005%) and Nimbecidine (0.5%) and Cypermethrin (0.005%) with Nuvan were effective in minimizing the damage caused by fruit borer.
- Lower percentage (5.3%) of damaged fruits at harvest was recorded using pheromone trap + *Tricho. card* @50000eggs/ha and Kamdhenu Keet Niyatrak (ordinarily cow urine) sprays followed by pheromone trap + *Tricho. card* + Nimbecidine (0.5%) when sprayed at specified time.

### 4. Post Harvest Management and Value Addition

- The process of wine making from litchi fruit yielding 11.5% alcohol has been standardized in collaboration with CTCRI-RS, Bhubaneswar.
- Protocol for litchi wine and litchi nut has been developed, and is further being refined.
- Physico-chemical studies of litchi fruits during fruit development stage revealed that 19 °B TSS and red peel colour which appears during last week of May is the best time for harvesting in litchi.

- Effect of chemicals and PGR on fruit drop and cracking revealed that  $\text{KNO}_3$  (2.0 and 4.0%) and  $\text{CaNO}_3$  (1.0%) delayed the colour break stage by four days and increased the fruit retention by 18.0 and 26.0 per cent, respectively.
- Covering the canopy with 30% green or 50% white shade net has extended the harvesting period by almost 16 days due to reduced total heat units and intercepted scorched sunlight/burning symptoms.

### **HRD Activities**

- One national seminar was organized on “Production, processing and marketing and export of litchi for economic prosperity” 08-11<sup>th</sup> June, 2008.
- Two National Consultation meets during September, 2009 and 2010 and one Interface Meeting with State Officials during September, 2011 were organized.
- Twelve trainings in four district involving 800 progressive farmers, 250 Subject Matter Specialists and Kisan Salahkar, 50 Officers and 200 entrepreneurs was conducted.
- One scientist has been trained in USA for three months in field of Fermentation Technology.

## **OTHER ACHIEVEMENT**

### **Farm Mechanization**

- Irrigation networking for 20 ha and drip/sprinkler irrigation in four ha area.
- Litchi harvester cum pruner, power sprayer and mist chamber is being used.

### **Production of Seeds and Planting Material**

- 95,000 litchi gootee have been sold.
- 37.5 tons of potato seed tuber, 20 tons Zimikand, one ton each of turmeric and Colocacia have been produced.

### **Literature Published**

Two books, 6 folders, 3 manuals and 8 technical bulletins have been published from the centre.

### **Technology Commercialized**

1. Commercialization of litchi wine production technology.

2. Rejuvenation of old senile litchi orchards.
3. Integrated management of insect pests (fruit borers) of litchi
4. Litchi based cropping system

### **The Main Focused Researchable Areas of the Centre**

- Systematic collection, conservation, characterization and documentation of litchi germplasm for use in future breeding.
- Evolving high quality cultivars through selective breeding, genetic engineering and bio-informatics for domestic and export market.
- Undertake basic and strategic research to enhance productivity, processing qualities and value addition along with protected cultivation of litchi.
- Develop ‘Centre of excellence’ for litchi research and act as repository/data base on litchi.
- Act as centre for HRD and capacity building in modern technology on all aspects of litchi in public-private partnership or consultancy services provider mode.
- Establish linkages with National and International organizations working on Litchi.
- Set up a referral laboratory for fruit quality analysis and certification of new cultivar/products of litchi.

The objectives have been prioritized, and attempts have been made to focus the research on the basis of available resources. The major research has been focused through eleven research projects encompassing four theme areas i.e. Plant genetic resource management, crop production, crop protection, post harvest management and HRD. The centre has collected elite germplasm and developed few production technologies for the benefit of growers and further progress is expected with time. The centre has undertaken various capacity-building programmes with State Horticulture Mission, FAO, NHB and ATMA.

In last five years, one national seminar on “Production, processing and marketing and export of litchi for economic prosperity”, three National Consultation Meet and two workshops have been organized at the centre.

The scientists at the centre have written four books and 10 technical bulletins. The centre has developed protocol for commercialization of litchi wine preparation, Rejuvenation of old senile litchi orchards, integrated management of insect pests (fruit borers) of litchi and litchi based cropping system. The following infrastructure/processing unit have been set up in and around Muzaffarpur City, and they are taking

guidance from NRCL from time to time.

Sl. No.	Name of Unit	Location	Area of operation	Capacity	Activity
1	Litchika International	Bela, Muzaffarpur	Mushahari	500 Tons	Litchi Squash, Litchi Canning & Litchi Honey
2	Shyama Agro-industry	Ratwara, Muzaffarpur	Bandra block, Muraul block	200 Tons	Squash & Canning
3	Premier Food Products	Khabra Road, Muzaffarpur	Mushahari, saraiya, kanti	200 Tons	Squash & Canning
4	Thakur Litchi Industry	Bochahan, Muzaffarpur	Bochahan block	200 Tons	Squash & Canning
5	Radha Krishna Implex Pvt. Ltd. Muzaffarpur	Muzaffarpur	Muzaffarpur	500 Tons	Pasturised Litchi Juice



China litchi

## Opportunities

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**I**CAR-National Research Central on Litchi will have an important role in the transfer of production, protection and PHM technologies specially tailored for the need of farmers of the litchi-growing states. India can succeed in the competition only by increasing productivity and reducing cost of production of quality and export-oriented produce. The envisaged increased share of fresh as well as value added products of litchi in the export basket of fruits needs scientific packaging and processing facilities in the production catchment.

### **Impact Assessment of ICAR-NRCL**

The technologies developed by ICAR-NRC on Litchi in areas of production and protection brought about enormous benefits through increased production and productivity. Ray of hope in terms of identification of new areas may lead to area expansion in non-traditional areas. The production technologies have a bearing on the cost of production, fruit quality in terms of nutritive value and also export promotion. The research achievements made so far have necessitated further refinement of research work to plug the gap between the technology developed and the changing needs. They have also opened new avenues for further fine-tuning of research on basic aspects of shoot physiology, nutrient dynamics, microbial association, post-harvest physiology and so on.

Litchi crop is the least exploited for genetic improvement because of its narrow genetic base. The Centre has collected 52 germplasm/cultivars and maintained in the field gene bank but the hunt is on to collect more germplasm of litchi and allied species from indigenous and exotic sources for evaluation and further utilization in crop improvement programmes. The germplasm is being characterized using morphological and molecular markers. The clonal and seedling selection, hybridization and precocious gene mapping and utilization are the other areas where efforts are being made to have tangible results.

Standardization of agro-techniques with highest input use efficiency through constellations of different components in the form of integrated nutrient, water, weed and insect-pest and disease management has been aimed for quality production. Plant canopy architecture management helps to convert solar energy into chemical energy efficiently, leading to tree

longevity and flowering in exterior and interior branches and high quality fruit production has to be tendered. The technique for rejuvenation of old senile orchards has been standardized with farmers' participation and is being adopted by the farmers. The effect of plant growth regulators/chemicals on fruit set, fruit drop, seed abortion, extending harvesting period and quality of fruits is required to be standardized and the centre has made a significant progress in this direction. Individual tree netting with 30% green or 50% white agro-shade net or individual bunch bagging with cellophane bags or brown paper bag improved the ratio of export quality fruit and harvesting period.

Organic farming, litchi-based farming systems, HDO, and protected cultivation of litchi are also important areas of research. The horizontal and vertical expansion in the production of litchi can be achieved via increased productivity per unit area and expanding area under litchi cultivation in non-traditional yet potential locations in the country. These will increase total production and also ensure availability of fruits for a longer period, particularly during off season. Crop protection strategies evolved by the Centre are being adopted by the growers, but they still require refinement and standardization in an integrated management mode. Forecasting models for different major insect pests need to be evolved for residue free quality litchi production.

Proper harvesting in time frame, handling, packaging and storage methodologies are to be perfected for long distance transport and overseas markets to avoid post harvest losses and seasonal gluts in the market and for extending availability of fruits.

### **Input-output Assessment**

Use of rootstocks and grafting techniques needs to be perfected in Indian context. Research inputs on disease and pest have resulted in reducing the pre- and post-harvest losses. Research input of maturity standards, handling, storage, pericarp browning and packaging, pre-cooling with the future research need is required in the area of post harvest management. Retention of bright red colour during long storage needs concerted research efforts.

Post-harvest handling and management will require greater attention as litchi is highly perishable. Infrastructural support has to be provided to accommodate the fruits for their longevity and availability for a longer period in the market. Present trends of harvesting/grading/packaging would require greater emphasis by bringing about mechanization for complying strict sanitary and phyto-sanitary (SPS) measures to compete in the world market.

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We have to make this commodity remunerative to producers by promoting it through organized marketing, export and processing. At present the global share of our country in litchi is negligible, which is essentially to be increased, based on its strength in terms of quality. We need to pay attention on evolving/developing varieties suitable for processing, export or both. Export and processing of horticultural produce is growing at a slow pace of 15% and 10%, respectively, which requires to be raised to 25 and 30 %, respectively, by 2050. This would help minimize the post-harvest losses to a greater extent and increase the income and employment.

Still there lies vast scope in income and employment generation by way of establishing good nursery, mechanization in production, processing, packaging of fruits, transportation of fruits and value added products or litchi based blended products and their marketing at distant and different outlets.

Indian litchi is seldom utilized for processing and value addition, such as making litchi nuts (raisins), canned fruits/juices, and squash or other fruit drinks, jam, jelly and even wines. These products can reduce the post harvest losses and marketing problems on account of increased production. Therefore, for making the products internationally acceptable, identified techniques are to be perfected for each product and some new products should be developed which can have better domestic and export market.



# Goals and Targets

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In spite of shrinking land resources and declining interest of youth towards agriculture, the planned litchi plantation and production strategy in commercial mode at potential places having strategic locations, has bright future in ensuing decades. Accordingly, the goals and targets have been set to make litchi production more remunerative, sustainable and also an environmentally safe preposition.

## Goals

- Enhancing litchi production and productivity
- Reducing cost of litchi production and processing (pre and post harvest stage)
- Exploitation of marginal and degraded lands in traditional and non-traditional areas for commercial cultivation, maintaining the eco-system
- Integrating litchi in farming system approach including agro-forestry or social forestry.
- Technology assessment, release, refinement and transfer to beneficiaries.
- Post-harvest Technology for litchi fresh fruits and market intelligence.
- Human resource development
- Developing ICAR-NRCL as Center of Excellence for R & D on all aspects of litchi.

## Targets

- 1) To improve the competitiveness of domestically produced fruits for international markets
- 2) To adjust regional distribution of cultivar and improve the quality, unit yield and economic benefit based on the existing orchard area".
- 3) Rationalization of cultivar structure that extends the production season of litchi through selection, breeding and biotechnological methods to have high quality early litchi cultivars and extreme late season ones.
- 4) To clarify mechanisms of flower induction, fruit setting, cracking susceptibility and quality so as to formulate relevant technical strategies to ensure flower induction, improve fruit set and quality and to prevent fruit cracking.

- 5) Research programmes on the mechanisms and control of litchi browning, cultivation measures to improve litchi storability, breeding and selection for more storage-endurable cultivars, and technology for safer and longer storage and transportation of fruit have been strongly supported by all levels of researchers.
- 6) Integrate large scaled fruit production, post-harvest handling, marketing and export into a wholesale business.

### **Strategies to Achieve Targets**

- Germplasm collection, conservation, characterization, evaluation and documentation.
- Selection/improvement of cultivars through traditional and modern tools (biotechnology, bio-informatics, genetic engineering etc) for higher quality production and productivity.
- Litchi cultivation integrated with social and agro-forestry and farming system approach.
- Extending intensive for cultivation in non-traditional areas.
- Improved integrated management system for nutrients, water, pests and diseases and climate resilience.
- Sustainable and economical production/protection/management system through natural resource management.
- Development of models for forewarning against natural/biological disaster.
- Developing models for forecasting litchi production
- Mechanized farming system in litchi.
- Multiplication of quality certified planting materials for timely availability
- Litchi marketing research and infrastructure.
- Simple, low cost and high recovery technology for processing of litchi along with packaging.
- Linkages with litchi related national and international organizations through networking and collaboration.
- Creating and maintaining database on all aspects of litchi.



## Way Forward

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While the returns from litchi can be very lucrative, there are risks associated with its production and marketing. Many orchards are inherently low yielding due to the cultivar selected age of plant and/or the location of the planting. Even in an ideal location, there can be problems with flowering and fruit set. The crop is also susceptible to borers, cracking, sunburn etc. Harvesting and packing is very labour intensive, risk prone and costly. The fruits are susceptible to browning and rotting, and thus have a relatively short shelf-life when stored and transported by adopting existing technology. This creates problem in both the domestic and export markets, even for growers committed to grade their produce as per quality standards.

ICAR-National Research Centre on Litchi (ICAR-NRCL) is committed to harnessing science and technology for increasing productivity, enhancing input use efficiency, reducing pre and post-harvest losses, minimizing risk of climatic vagaries, improving quality of litchi through time-tested conventional as well as advanced techniques and empowered human resource associated with litchi production and trade.

Litchi improvement programmes aim at developing elite varieties and hybrids through conventional breeding and biotechnological tools. The centre will strive to establish pre-selection criteria for fast-tracking crop improvement programme in the endeavor to develop an ideal cultivar. Concerted efforts will be directed towards enriching the varietal pool through indigenous and exotic introductions. Modern breeding and biotechnology tools will be used for quick identification of markers and gene mining for traits of horticultural and agronomic importance including genes for precocity, stress resistance, aroma inheritance pattern, and seed abortion. Longan and Rambutan sp. can be used for development of new variety of litchi by intercrossing and hybrid vigour programme.

The centre will emphasize its efforts towards development of climate resilient production technologies for improved productivity of litchi. Canopy architecture, high density planting will be standardized for making best use of natural resources viz. light, water, soil strata and in built micro-climate. Stress physiology, off season flowering pattern and biochemical changes during fruit development and ripening of litchi fruits will be studied to develop better understanding for problem solving. Proteomics and metabolomics tools will be employed to develop

metabolite database, and deepen understanding and knowledge base to add to existing information. Such an effort will also include volatile and non-volatile profiling that offers wide potential for application in diverse fields including food, beverages, and pharmaceuticals. The centre will partner and collaborate with leading institutes and agencies, both nationally and internationally, towards meeting this objective.

The centre will strive to harness and devise biologically and environmentally safe strategies against pests and diseases afflicting litchi. Potent and eco-friendly pesticide/management practices will be developed to control borers and mites affecting litchi. Efforts will be made to derive useful products including secondary metabolites from litchi pericarp and seed. New technologies to be developed for the utilization of by-products like peel and seeds, which are biodegradable and to be ploughed back to the agricultural system, helps to generate lot of employment and income to the younger generation.

Post-harvest losses in litchi amount to a staggering 25 per cent. Sustained efforts will be made to develop integrated technology for packaging, transportation and storage by judicious use of low cost packaging/lining materials, reefer vans, MAP packaging and storage under air cooling system. Modern packaging systems and designs will be employed to develop packaging and distribution protocols by making use of intelligent/smart packaging. To this effect the centre will harness integration of packaging systems with high end technologies like sensors, time-temperature indicators, electronic nose, radio frequency identification, and wireless sensors network etc, to achieve extension of shelf-life and real-time product monitoring as a component of export protocol. In addition, the centre will strive to develop litchi-based functional foods. With growing complexity of human societies, it is only imperative to direct our efforts towards development of consumer-specific convenience foods that are not only health-beneficial but also competitive and cost-effective in the international market.

The centre will establish linkages and extend collaborative efforts with national and international agencies on strategic research needs. Advanced and communicative technology would be employed for dissemination of knowledge and technologies developed on litchi. Concerted efforts will be made to improve knowledge and skill of various stakeholders through world-class training, extension tools and consultancy. Risk analysis and disaster management, market intelligence will be employed to support litchi growers / farmers. The centre aims to develop its capability to act as knowledge resource centre for litchi related information on each and every aspect by 2050.



## Approaches

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The ICAR-National Research Centre on Litchi has formulated its research activities and strategies under wide perspective. It will function in close collaboration with national and international institutes working on litchi research and development. It will also seek help of state departments and NGOs for effective transfer of technology for the benefits of the farmers/growers and also try to develop entrepreneurship. It proposes research to extend the research activities for promoting litchi in non-traditional areas of the country through coordination among NARS partners.

To meet the growing demand, the centre has reoriented its programmes to enhance production (especially during off season), which can be achieved by expanding area under litchi cultivation in Karnataka, Kerala and Tamil Nadu etc. and other states of the country.

Due to its increasing demand, the area under litchi cultivation has increased manifold. However, there is need for improving productivity by adoption of suitable cultivars for various climatic conditions. It is also essential to develop promising lines/hybrids, which have larger fruit size, small/chicken-tongued seeds, and tolerance to pericarp splitting, and having various maturity groupings. Proposed initiative with respect to source-sink management, micro-nutrients, post-harvest technology and effective marketing will take care of quality litchi produce.

The following points require due consideration for improving litchi production with quality fruits:

- Widening of genetic base through creation of variability, conservation of germplasm, description of elite/ideal type and selecting superior activities.
- A systematic approach for litchi descriptor needs to be developed.
- Faster multiplication techniques for the production of quality planting material need due attention (exploitation of grafting and tissue culture techniques).
- The development of nutrition management to maintain tree health and encourage successful flowering, fruiting and quality in sustainable manner, requires attention.
- Monitoring of nutrition in litchi through leaf analysis and establishment of correlation between deficiency symptoms and micro-nutrient imbalances would be an approach for efficient fertilizer use.

- Through effective recycling of residues coupled with organic manure, it is possible to improve soil health (immense potential for organic production of litchi).
- Infrastructure for post-harvest management requires emphasis to reduce risk of pesticide residue.
- Starting of a network programme on litchi to boost the production and ensure livelihood security of the people.

Girdling (cincturing) can be used to control the timing of flushes so that they start when temperatures are ideal for flowering. Post-harvest handling and management will get greatest attention for this highly perishable commodity. While post-harvest losses account for at least 25% of the produce, the problem is further accentuated by glut of fresh fruits during harvesting season. Infrastructural support will be provided to accommodate the fruits for their longevity and availability for a longer period in the market. Present trends of harvesting/grading/packaging would require greater emphasis by bringing about mechanization with strict phyto-sanitary measures to compete with the world market. Growth retardants such as paclobutrazole, ethephon and daminozide are used to suppress or kill winter flush and induce flowering in next season.

A meager quantity of litchi fruits and its product is exported, and has lot of scope to increase the quantum of export, therefore an effort will be made to increase export to European/American country since the harvesting season is quite different in other parts of the world. Production of quality planting materials at cheaper rates will remain our utmost priority through different governmental and registered nurseries to make plants available in time to the farmers. Majority of litchi plantations have become very old and senile which would also require rejuvenation for quality fruit production. The expansion of the fresh litchi market will depend mainly on: (a) availability of high quality fruits in abundance, (b) availability for a longer period by lengthening of fruiting seasons, and (c) emergence of new supplier countries capable of transporting fruits by sea. Consequently, the supply of good quality litchi for fresh fruit markets round the year should receive a major development thrust.

Efforts will be made to transform ICAR-National Research Centre on Litchi to be farmer friendly addressing needs of the farmers with least resources support. The institute would strive hard to address all those vagaries of monsoon (drought or flood) which has negative impact on quality litchi production. The institute commits itself to the task of horticultural development through participatory means, imbining scientific spirit for changing global climatic conditions.



## Call for Urgent Action

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Community action must be raised for awareness as well as providing practical training on diversity conservation and good management practices of litchi. Most of the households may be taught about the techniques and multiple cropping to be adopted in pre-bearing litchi orchards, identify problems and demonstrate solutions about appropriate crops as alley cropping in litchi orchards. Villages may be ensured to grow their own planting materials and educate households to understand the benefits of a greater variety of litchi and adequate nutrition by litchi production.

Improving the home garden's litchi production, for better nutrition and generating extra income can boost nutritional security through litchi fruits using existing resources. Improving soil management with mycorrhiza, diversifying the food crops grown; intensifying land use and improving productivity of individual plants are the need of the hour. Exploration of possible ways to alter flushing and induce flowering in litchi can advance and stagger fruit availabilities. Development of a litchi integrated pest and disease management program based on low-toxicity chemicals and drive wide industry adoption can be boon for litchi production.

Production of litchi to be enhanced by 33% and also to increase the sale of Indian litchi in export markets is also included in our priority list. Litchi remain a 'special' fruit in the minds of consumers and that niche enables a premium price to be delivered, there is much potential for sales growth in the domestic market. Research reveals a high proportion of consumers (of non-Asian background) who are unfamiliar with or have not tried, can also enhance litchi demand. With adequate marketing effort (and at the same time addressing the retail quality issues) the industry should be able to capitalize on this market growth.

Considering the present constraints and opportunities the following actions may be undertaken immediately.

- Introduction/selection of high quality litchi varieties of early, mid and late maturity.
- Intensive training of the farmers and extension agent on the modern methods of litchi cultivation, management (i.e. High density orcharding with precise application of inputs).
- Production and distribution of quality planting materials.

- Development of complete protocol of post harvest management from harvest to wholesale mandis of distant market with inhibited pericarp browning.
- Technical advice for establishment of market infrastructure and information system.
- Setting up of Co-operative marketing units for marketing of fresh litchi produce.
- Establishment of processing units in litchi production zone.



## Road Map to Achieve Target

Goal	Approach	Target Year	Performance/Out Put
<ul style="list-style-type: none"> <li>Breeding for improved variety of Litchi &amp; Longan</li> <li>Improving Genetic base, dwarfing and hardy rootstocks identification.</li> </ul>	<ul style="list-style-type: none"> <li>Elite germplasm of litchi and longan will be collected from indigenous and exotic sources</li> <li>Gene mining for precocity, stress resistance, aroma inheritance, and seed abortion</li> </ul>	2050	<ul style="list-style-type: none"> <li>National repository of litchi and longan germplasm will be further improved</li> <li>Improved cultivars having higher yield and resistance to biotic and abiotic stresses</li> </ul>
<ul style="list-style-type: none"> <li>Improvement in productivity</li> </ul>	<ul style="list-style-type: none"> <li>Quality planting material production under off season.</li> <li>Canopy architecture and management, high density orcharding for efficient light interception and enhanced photosynthesis.</li> <li>Standardization of INM and organic production of litchi crop</li> </ul>	2045	<ul style="list-style-type: none"> <li>Number of plants multiplied using innovative techniques</li> <li>Improvement in production per plant per unit area with large sized, bright red colour fruits.</li> <li>Eco-friendly production of residue-free litchi</li> </ul>
<ul style="list-style-type: none"> <li>Inducement of flowering for out of season production</li> <li>Extension of fruit availability period</li> </ul>	<ul style="list-style-type: none"> <li>Establishment of shoot maturity, physiology with flowering and fruiting.</li> <li>Application of growth regulators/inhibitors</li> <li>Harness proteomic and metabolomics tools for metabolite profiling including volatiles and non-volatiles</li> </ul>	2025	<ul style="list-style-type: none"> <li>External source required for forced or natural flowering and basis of shoot maturity for flowering.</li> <li>Off season flowering and fruit availability</li> </ul>
<ul style="list-style-type: none"> <li>Abiotic Stress management</li> </ul>	<ul style="list-style-type: none"> <li>Climate resilient sustainable production technologies</li> <li>Standardization of pressurized irrigation and fertigation for litchi orchard.</li> <li>Root stock breeding for abiotic stress tolerance.</li> <li>Physiological adoption to abiotic stresses</li> </ul>	2040	<ul style="list-style-type: none"> <li>Regular fruiting without cracking and sunburn.</li> <li>Package and practices for litchi orchard under low and undulated land.</li> <li>More production of litchi fruits per unit amount of water and fertilizers used.</li> <li>Imparting dwarfness to litchi trees for mechanized horticulture (including mechanical harvesting).</li> <li>Physiological and biochemical investigation and adaptation mechanism in litchi towards drought, heat and salinity endurance under changed climatic conditions.</li> </ul>

<ul style="list-style-type: none"> <li>• Biotic Stress Management and development of bioagents</li> </ul>	<ul style="list-style-type: none"> <li>• Developing disease/ insect pest management models for the effective economical and socio-feasible strategy</li> </ul>	2045	<ul style="list-style-type: none"> <li>• Development of package and practices for the key pests of litchi and forecasting of outbreak of pests.</li> </ul>
<ul style="list-style-type: none"> <li>• Post harvest management &amp; value addition.</li> </ul>	<ul style="list-style-type: none"> <li>• Prevention of pericarp browning and extension of shelf life</li> <li>• Development of cold chain for transportation of produce.</li> <li>• MAP and active packaging of litchi for distant market</li> <li>• Smart/intelligent packaging using RFID-Wireless sensor network, electronic nose, biosensors etc, through strategic collaboration</li> <li>• Assessment of value added products and processing quality</li> </ul>	2040	<ul style="list-style-type: none"> <li>• Color retention at distant transport</li> <li>• Market specific smart packaging protocols</li> <li>• Fortified and functional products of litchi</li> <li>• Minimization of post-harvest losses</li> </ul>
<ul style="list-style-type: none"> <li>• Exploring non - traditional areas for expansion (South India &amp; North-East)</li> </ul>	<ul style="list-style-type: none"> <li>• Survey, collection and planting of litchi in non-traditional areas</li> </ul>	2050	<ul style="list-style-type: none"> <li>• Area of litchi expanded.</li> </ul>
<ul style="list-style-type: none"> <li>• Human resource development</li> </ul>	<ul style="list-style-type: none"> <li>• By developing capability and knowledge base to provide world-class training to the staff, farmers, farm-women and entrepreneurs.</li> <li>• Improve knowledge and skill of stakeholders</li> </ul>	2050	<ul style="list-style-type: none"> <li>• Better Human resource.</li> </ul>
<ul style="list-style-type: none"> <li>• Dissemination of technology</li> </ul>	<ul style="list-style-type: none"> <li>• Front line demonstrations litchi production systems.</li> </ul>	2050	<ul style="list-style-type: none"> <li>• Enhancement of area and production of litchi.</li> </ul>

