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Domestication and Adaptation of Temperate Fruit Crops in the Tropics: Opportunities for Indian Horticulture

*S. Aravinda Samy[1], Prashita Rao[2], D. Priyadharshini[1] and S. Sailakshmi[3]
[1]Department of Fruit Science, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India
[2]Div. of Fruit Science, ICAR–Indian Agricultural Research Institute, New Delhi, India
[3]Department of Fruit Science, Horticultural College and Research Institute for Women, Tamil Nadu Agricultural University, Tiruchirappalli, Tamil Nadu, India
*Corresponding Author's email: aravindfruits98@gmail.com

India has a wide range of climatic conditions, extending from tropical coastal plains to subtropical regions and temperate mountain ecosystems. Over time, each region has developed a characteristic portfolio of fruit crops suited to its temperature regime, rainfall pattern and seasonal conditions. However, these traditional boundaries are gradually becoming less rigid. Advances in crop improvement, rootstock development and orchard management have created opportunities to introduce selected temperate fruit crops into warmer environments. The present challenge is to identify suitable temperate fruit species and cultivars that can perform under the relatively mild winters and warm growing conditions of tropical and subtropical India. Such efforts should be based on crop physiology and systematic field evaluation rather than on isolated success stories.

Why diversification is important

In several fruit-growing regions, the large-scale cultivation of a single fruit crop, coupled with a short harvesting period, often leads to a market glut and a consequent decline in farm-gate prices. This is particularly evident in districts where a huge proportion of the cultivated area is devoted to the same fruit crop, resulting in the simultaneous arrival of large volumes of produce in the market. Limited storage, processing and organised marketing further increase the risk of distress sales. Introducing suitable alternative fruit crops, including selected temperate species, may help diversify farm income and extend the availability of fresh fruit across different seasons. Such diversification, however, must be guided by agro-climatic suitability, production economics and market demand.

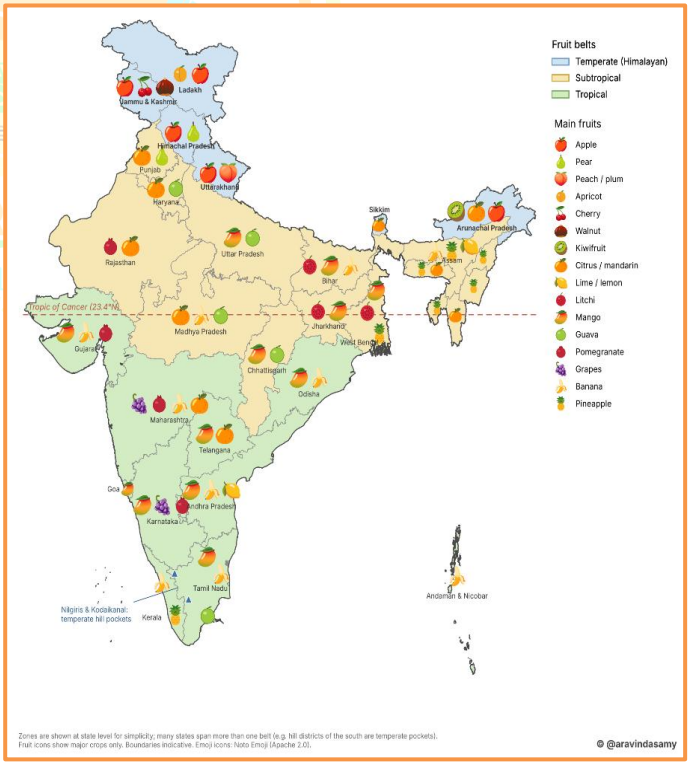

Figure 1. Major fruit-growing belts of India and the characteristic fruit crops of each region. The marked locations indicate temperate or high-altitude production pockets within southern India.

Domestication, introduction and acclimatization of temperate fruit crops

In the botanical and evolutionary sense, domestication refers to the long-term process through which plants are brought under cultivation and modified through selection. When an already cultivated temperate fruit crop is transferred to a tropical environment, the more precise terms are introduction, adaptation and acclimatisation. In breeding termed 'domestication in the tropics' is often used to describe this process of establishing and managing such crops under a new agro-climatic situation. Successful adaptation depends on the coordinated selection of a suitable genotype, rootstock and production system.

1. **The right genotype:** Many temperate fruit trees undergo winter dormancy. In apple, for example, buds generally require exposure to a certain amount of chilling before normal and uniform budbreak can occur. Chilling is commonly expressed as chill hours or chill units; a chill hour is often approximated as one hour at or below 7 °C, although different models are used. Conventional apple cultivars may require about 500–1,000 or more chill hours, which are rarely available in tropical plains. Therefore, low-chill cultivars capable of completing their rest requirement under relatively mild winters are essential for cultivation in warmer regions.
2. **The right rootstock:** Rootstocks influence tree vigour, anchorage, water and nutrient uptake, tolerance to soil constraints and, in some cases, the tree's response to environmental stress. For tropical cultivation, rootstocks should be selected after evaluating their performance under local soil, moisture and temperature conditions. A rootstock that performs well in a temperate region cannot automatically be assumed to be suitable for the tropics.
3. **The right orchard management:** Practices such as regulated defoliation, pruning, shoot bending, irrigation management and, where scientifically justified, dormancy-breaking treatments can help regulate budbreak and flowering. These practices may partly compensate for the absence of a distinct winter season, but they cannot overcome unsuitable temperatures during flowering, poor pollination conditions or other major environmental limitations.

Anna apple on MM111: an example of adaptation under tropical conditions

The genotype. Anna was developed by Abba Stein at Kibbutz Ein Shemer, Israel, from the cross Golden Delicious × Red Hadassiya and released in 1959. It is a low-chill apple cultivar, with a reported chilling requirement of approximately 200–300 hours, and has an early fruit-maturity period (Andersen *et al.*, 2022). For satisfactory fruit set, a compatible polliniser with overlapping flowering, such as Dorsett Golden or Ein Shemer, should be provided. Actual performance will depend on local climatic conditions and orchard management. The rootstock. MM111 is a Malling-Merton apple rootstock derived from Northern Spy × M.793. It is known for its comparatively vigorous growth, drought tolerance and resistance to woolly apple aphid (Lal *et al.*, 2025). These characteristics make it a candidate for evaluation in relatively warm and dry production environments. Reports have also indicated good graft compatibility or graft response when Anna is combined with MM111 (Ahmad and Khan, 2020). Nevertheless, local trials are necessary before recommending a particular rootstock on a commercial scale.

Evidence from Indonesia

Experience from Batu in East Java, located at approximately 8°S and 800–1,200 m above sea level, illustrates the importance of canopy and seasonal management. Growers remove leaves manually within two to four weeks after harvest, and a high proportion of buds has been reported to break within the following four weeks. Under suitable conditions, trees may produce nearly two crops in a year (Edwards and Notodimedjo, 1987). Staggering defoliation can also help distribute harvest over a longer period (Notodimedjo *et al.*, 1981). However, reports from lowland locations show that budbreak alone does not ensure a successful crop; high temperatures during flowering may prevent satisfactory fruit set (Edwards, 1987). Thus, suitable flowering temperature is as important as the management of dormancy.

Experience in India

Anna apple grafted on MM111 has been reported to flower and produce fruit in Anantapur in Andhra Pradesh and in selected locations of Karnataka and Tamil Nadu. The management schedule generally includes a post-harvest rest period, defoliation, a dormancy-breaking treatment where recommended, and carefully timed irrigation and fertigation. Provision of compatible pollinisers and pollinator activity is also important for fruit set. In Anantapur, where rainfall is low and summer temperatures can be very high, the reported production of low-chill apple demonstrates the potential of site-specific adaptation. The crop may also reach the market before the main Himalayan apple season. These observations should be supported by replicated, multi-year trials to establish yield stability and fruit quality.

Figure 2. Tropical apple in the orchard of Mr. Ramana Reddy, Anantapur, Andhra Pradesh

Other fruit crops with potential in warmer regions

Longan, a close relative of litchi, is widely cultivated in countries such as Thailand, Vietnam and China, but remains a relatively minor crop in India. ICAR–National Research Centre on Litchi, Muzaffarpur, has evaluated and distributed planting material since 2004 and has identified potential in Bihar, West Bengal and Jharkhand (Kumar *et al*., 2022). Reports from Kerala indicate that trees may commence bearing within approximately three years under favourable conditions. The reported retail price of ₹300–450 per kg suggests a possible premium-market opportunity (Onmanorama, 2026); however, local yield, quality and market studies are required before large-scale expansion. Litchi is traditionally cultivated in subtropical areas and the Himalayan foothills, with the main harvest generally occurring during May–June. In Kodagu, flowering during August–September and fruit maturity in December have been reported (Tripathi *et al.*, 2017). Production during this period may provide a seasonal market advantage. The performance of cultivars such as Shahi, China and Rose Scented should be assessed across suitable elevations, with particular attention to flowering temperature, fruit set and fruit quality (Nath *et al*., 2018).

Temperate and other high-value fruit crops under evaluation

Grape cultivation shows how crop management can shift production into different seasons in warmer regions. In Maharashtra and Karnataka, a double-pruning system separates vegetative growth from fruiting and gives a winter harvest. In the Cumbum valley of Theni district, Tamil Nadu, growers go further: staggered pruning of Muscat Hamburg (Panneer grape),

together with the valley's favourable climate, gives five crops in two years and fruit almost all year round. Similar approaches, built on suitable cultivars and site-specific management, are now being tried in other fruit crops.

Fruit crop	Home belt	Cultivars / genotypes reported	Locations in warmer India	Potential advantage
Apple	Temperate	Anna, Dorsett Golden, HRMN-99 on MM111	Andhra Pradesh, Karnataka, Tamil Nadu	Early-season fruit before the main Himalayan harvest
Peach	Temperate	Flordasun, Shan-e-Punjab, TropicBeauty	Punjab plains, southern hills	Early spring fruit
Pear	Temperate	Patharnakh (sand pear)	Punjab, Haryana, southern hills	Hardy, low-input crop
Plum	Temperate	Satluj Purple, Kala Amritsari	Punjab plains	Early-season premium
Strawberry	Temperate	Day-neutral cultivars (Winter Dawn, Sweet Charlie)	Maharashtra, Karnataka, Haryana plains	High-value crop with scope for off-season production
Avocado	Subtropical	Hass and local selections	Coorg, Wayanad, Nilgiris	Potential alternative to imported fruit
Longan	Subtropical	Double, White, Ruby, Ping Pong, Edor	Kerala, Bihar, West Bengal	Premium niche-market opportunity
Litchi	Subtropical	Shahi, China, Rose Scented	Coorg and southern hills	Potential for a December harvest and off-season market

Low-chill apple cultivars have been reported from Anantapur, Adilabad, Krishnagiri and Kodaikanal. Strawberry is cultivated in locations such as Mahabaleshwar, Lambasingi, Koraput and Munnar. Pear, peach, plum and southern highbush blueberry are being evaluated or cultivated in selected high-altitude areas of the Nilgiris and Kodaikanal. Avocado has gained importance in Coorg and Wayanad, while longan is reported from parts of Kerala, including Malappuram (Figure 3). These examples represent different levels of adaptation and commercial development; they should not be interpreted as evidence that all cultivars are suitable for all tropical locations.

Benefits of producing temperate fruits closer to consumers

For consumers. A substantial quantity of apples marketed in southern India is transported over long distances from Jammu and Kashmir and Himachal Pradesh, often following storage. Locally produced fruit from suitable locations such as Anantapur or Krishnagiri may reach nearby urban markets, including Bengaluru and Chennai, within a shorter period after harvest. This can improve access to fresh fruit, provided that post-harvest handling and quality standards are maintained.

For farmers. The introduction of suitable alternative fruit crops can help farmers diversify their farm enterprises, extend the harvesting season and reduce dependence on a single commodity. Production of such crops during the off-season offers an opportunity to obtain better market prices by meeting consumer demand when supplies from traditional growing regions are limited. Locally produced fruits can also reach nearby markets with reduced transportation costs, offering an advantage over produce transported from distant states. However, successful commercialization depends on identifying potential buyers and establishing reliable market linkages before expanding cultivation. Farmers should also consider the cost of planting material, orchard establishment, crop management, labour, yield consistency and post-harvest handling to ensure long-term economic viability.

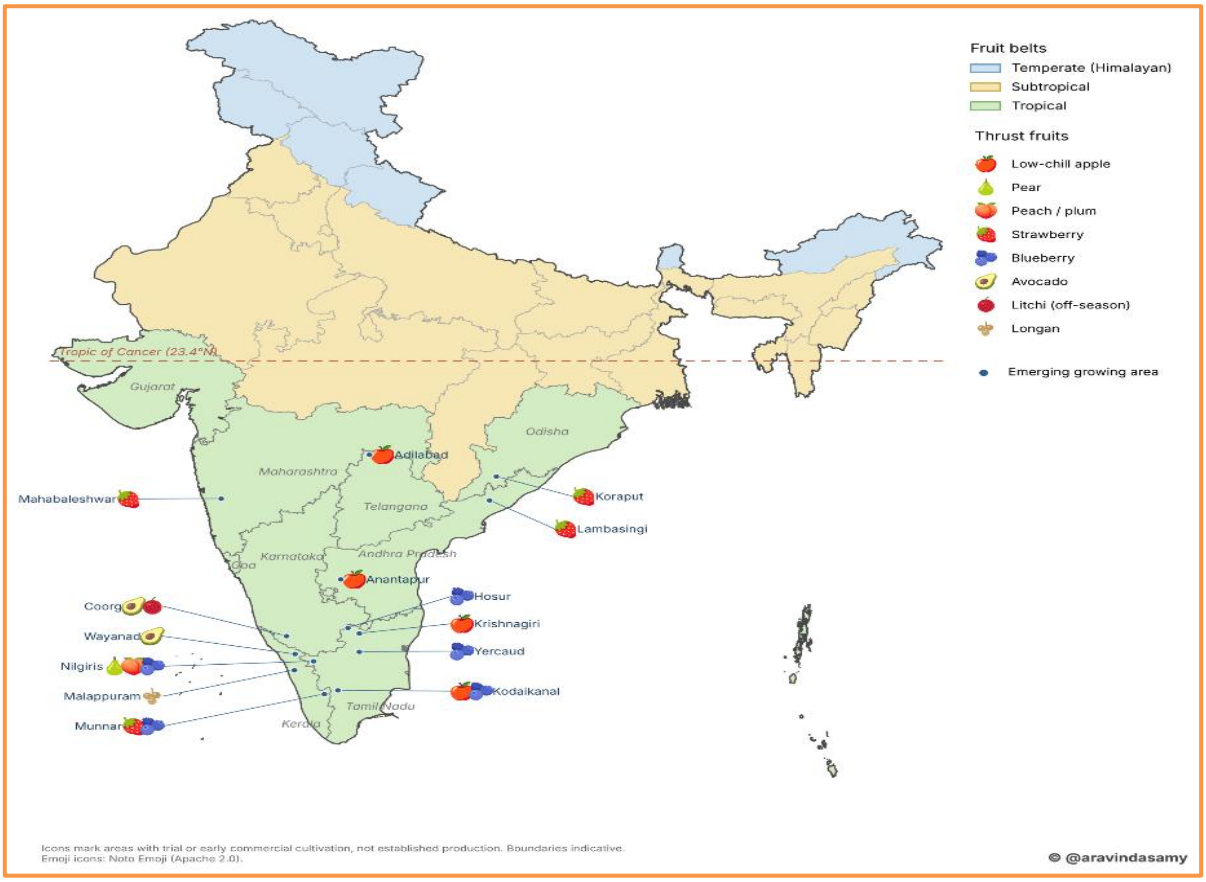

Figure 3. Important temperate and exotic fruit crops being cultivated or evaluated in tropical and subtropical regions of India

Important considerations for successful adaptation

- **Select the site based on crop physiology.** Temperature during budbreak, flowering, pollination and fruit development should be assessed carefully. In many warm locations, high temperature during flowering and fruit set may be a greater limitation than inadequate winter chilling.
- **Use authentic planting material.** Procure true-to-type, healthy and preferably certified plants from recognised nurseries or research institutions. The cultivar and rootstock combination should be clearly identified.
- **Begin with pilot trials.** Establish a small, replicated block and record phenology, flowering intensity, fruit set, yield, fruit quality and incidence of pests and diseases over several seasons.
- **Assess the market before expansion.** Premium fruit production requires appropriate grading, packaging, cold-chain or short-term storage facilities, and reliable links with retailers, institutional buyers or direct marketing channels.
- **Follow crop-specific plant protection recommendations.** The pest and disease complex may change when a crop is introduced into a new region. Use only locally recommended and legally registered plant-protection products, and maintain proper residue and pre-harvest interval records.

Conclusion

The cultivation of selected temperate fruit crops in tropical India is an emerging opportunity, but it requires a sound understanding of crop physiology and local agro-climatic conditions. Low-chill apple in parts of southern India, longan in Kerala and off-season litchi in the southern highlands demonstrate the possibilities of crop introduction and adaptation beyond traditional production belts. The next step is to move from individual success stories to systematic, replicated and multi-location evaluation. Research should focus on suitable genotypes, rootstock–scion combinations, flowering behaviour, pollination, fruit quality and

economic feasibility. Farmers should begin with small trials and expand only when consistent production and market demand have been established. With scientific planning and region-specific recommendations, the adaptation of temperate fruit crops can contribute to diversification and strengthen the fruit sector in tropical India.

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