

Boosting India's citrus industry: ICAR-CCRI introduced elite exotic varieties from the USA

The ICAR-CCRI, Nagpur, has introduced 16 elite exotic citrus varieties from the USDA's National Clonal Germplasm Repository for Citrus and Dates, Riverside, California. These include six sweet oranges (*Bahianinha*, Frost, Lima, Midnight, Olympic Gold, and Salustiana), three mandarins (Pixie, Shasta Gold, and Tahoe Gold), Australian finger lime (*Microcitrus australasica*), a pummelo hybrid (Cocktail), tangor (King), tangelo (Minneola), and three rootstocks (Flying Dragon, C-35, and Troyer). Known for superior yield, premium quality, and extended harvesting windows, these varieties address challenges in India's citrus industry such as low productivity, limited varietal diversity, and subpar fruit quality. Performance trials across diverse agro-climatic zones are underway, with anticipated outcomes including higher yields, enhanced profitability, and improved global competitiveness for India's citrus sector.

CITRUS (*Citrus* spp.) is one of the most important perennial fruit crops globally, with India ranking as the third-largest producer after China and Brazil. Contributing approximately 9% of global citrus production, India cultivates citrus across 10.86 lakh ha, yielding 142.62 lakh tonnes annually (NHB, 2022). The key citrus species grown in India include mandarin (*Citrus reticulata*), sweet orange (*Citrus sinensis*), and acid lime (*Citrus aurantifolia*). Mandarin cultivation is concentrated in regions such as Maharashtra and Madhya Pradesh (Nagpur mandarin); Punjab, Haryana, and Rajasthan (*Kinnow* mandarin); South Karnataka (Coorg mandarin); West Bengal (Darjeeling mandarin); and Northeast India (*Khasi* mandarin and its ecotypes). Sweet orange, predominantly cultivated in Maharashtra, Andhra Pradesh, Karnataka, Punjab, and Rajasthan, is dominated by the Mosambi and Sathgudi varieties. Despite their widespread cultivation, these varieties face significant limitations that restrict their commercial potential, global market access, and processing value.

Key challenges faced by the Indian citrus industry

- **Productivity and profitability issues:** Low productivity, declining yields, emerging pests and diseases, climate change impacts, and high export duties (e.g. by Bangladesh) present major hurdles for citrus growers.
- **Limited varietal diversity:** The scarcity of high-quality citrus scion and rootstock varieties limits opportunities for diversification and expansion.
- **Quality constraints:** Predominant varieties such as Mosambi and Nagpur Mandarin have poor colour,

low total soluble solids (TSS), high seed content, and bitterness, which reduce their commercial appeal.

- **Narrow export market:** Indian citrus exports are largely restricted to neighbouring countries such as Bangladesh, Nepal, Bhutan, and the UAE. In contrast, premium markets in Europe and the US prefer superior Valencia and Navel oranges, tangerines, and other high-grade varieties. India also imports significant quantities of citrus from South Africa, Egypt, Australia, and Spain.
- **Processing industry limitations:** Most sweet oranges and mandarins in India are sold as fresh produce, with only C-grade fruits being processed. This limits opportunities for value-addition and profitability.
- **Lack of international varieties:** The absence of globally dominant citrus cultivars in India reduces the country's competitiveness in international markets.
- **Harvesting window constraints:** The lack of early- and late-maturing varieties results in market saturation during peak seasons, thereby lowering profitability.

To address these challenges, the ICAR-Central Citrus Research Institute (ICAR-CCRI, Nagpur), has successfully imported 16 elite citrus varieties, including three rootstocks, from the USDA's National Clonal Germplasm Repository for Citrus and Dates (NCGRCD), Riverside, California, USA. This initiative aims to strengthen India's citrus sector by introducing varieties with superior yield potential, premium fruit quality, extended harvesting windows, and enhanced resistance to pests and diseases.

The imported collection comprises six sweet oranges (*Bahianinha*, Frost, Lima, Midnight, Olympic Gold, and Salustiana), three mandarins (Pixie, Shasta Gold,

and Tahoe Gold), Australian finger lime (*Microcitrus australasica*), pummelo hybrid (Cocktail), tangor (King), tangelo (Minneola), and three rootstocks (Flying Dragon, C-35, and Troyer). Details of these varieties are presented in table below.

Widely established in global markets, these cultivars are expected to substantially improve fruit quality, expand export opportunities, and boost the citrus processing industry in India. For example, the Tahoe Gold mandarin features a deep orange rind, rich flavour, and low seed count, while the sweet orange is celebrated for its exceptional quality and high productivity. The Australian finger lime, known for its tolerance to citrus greening disease and drought, offers valuable potential for future

breeding programmes. Additionally, rootstocks such as Flying Dragon, with its dwarfing trait, open the possibility for high-density planting of Nagpur Mandarin and Mosambi.

Significance of plant introduction

Plant introduction has historically played a pivotal role in crop improvement, enriching and diversifying agricultural and horticultural systems. The introduction of new crops has broadened India's fruit basket, adding species that were previously absent from cultivation. Targeted germplasm introduction, carried out in accordance with international agreements, has strengthened national crop improvement programmes by

Detail characteristics of imported exotic citrus varieties

Citrus spp.	Variety	Exotic Collection No.	Trait
Mandarin (<i>Citrus reticulata</i> Blanco)	Pixie	EC1231606	Fruit seedless, orange coloured, good tree storage with late maturity.
	Tahoe Gold	EC1231608	Large fruit size, deep orange rind colour, rich fruit flavour and low seed count, 48% juice content, 13.5% to 15.5% brix.
	Shasta Gold	EC1231607	Large fruit size, attractive deep-orange rind colour, rich fruit flavor and absence of seeds. Fruit is juicy (49%), 13% to 15% brix.
Sweet orange (<i>Citrus sinensis</i> L. Osbeck)	Olympic Gold	EC1231602	Belongs to Navel orange group, exceptional fruit quality, yellow colour rind, good yield.
	Frost	EC1231599	Belongs to Valencia orange group, exceptionally vigorous and productive, currently the most popular in California USA.
	<i>Bahianinha</i>	EC1231597	Belongs to Navel orange group, suitable for export market, better adapted to hot and tropical climates, excellent fruit quality.
	Midnight	EC1231601	Belongs to Valencia orange group, seedless, excellent size (mainly 70-85 mm), good round shape, fruit of excellent quality and medium-late maturity.
	Lima	EC1231600	Belongs to Acidless orange group, prominent variety in Brazil, highly sweet, early in maturity, popular among children.
	Salustiana	EC1231603	Prominent variety in Spain, early in maturity, seedless with good peel colour.
Tangelo (<i>Citrus</i> × <i>tangelo</i>)	Minneola	EC1231605	Tangelo, popular in Florida, attractive colour, and excellent flavor and low seed content.
Finger lime (<i>Microcitrus australasica</i>)	Australian finger lime	EC1231609	Tolerant to citrus greening disease and drought.
Tangor (<i>Citrus nobilis</i> Lour.)	King	EC1231604	Suitable for very hot climatic conditions. Deep orange flesh, maturity is late to very late.
Pummelo hybrid (<i>Citrus maxima</i> hybrid)	Cocktail	EC1231598	Thin, smooth, yellow rind. The flesh is seedy, yellow-orange in colour, and exceptionally juicy.
Rootstock spp.	Flying Dragon	EC1232138	True dwarfing rootstock.
	C-35 citrange	EC1232140	Commercial citrus rootstock in most citrus growing countries, produces excellent quality fruits.
	Carrizo citrange	EC1232139	Commercial citrus rootstock in most citrus growing countries, produces excellent quality fruits.

enabling climate adaptation and trait-specific breeding.

Several crops such as kinnow, kiwi, apple, and prickly pear were systematically introduced and have since evolved into major horticultural commodities in India. Likewise, germplasm imports facilitated the successful establishment of soybean and sunflower as important field crops.

The regulated exchange of germplasm adheres to national biosafety and quarantine guidelines, ensuring the protection of agricultural biosecurity. In India, the Director of ICAR-NBPGR, New Delhi, is the authorised authority for issuing import permits for germplasm, transgenic, or genetically modified crops intended for research purposes. ICAR-NBPGR also manages the receipt of imported material, quarantine inspection, clearance, and distribution to researchers across the country. This rigorous process safeguards against biosecurity risks while enabling the safe and efficient introduction of new germplasm, thereby fostering innovation, productivity, and sustainability in Indian agriculture.

National Clonal Germplasm Repository for Citrus and Dates

The National Clonal Germplasm Repository for Citrus and Dates (NCGRCD) is a USDA-ARS facility dedicated to preserving and managing genetic resources for citrus, dates, and related species. Located in Riverside, California, its mission is to safeguard genetic diversity, reduce vulnerability to pests and diseases, and provide pathogen-free germplasm for global research and breeding programmes. The repository maintains a diverse collection of over 1,000 citrus and 200 date palm accessions, employing advanced techniques such as cryopreservation and micropropagation to ensure long-term conservation. It collaborates with international stakeholders to enhance genetic characterisation, disease resistance, and sustainable agricultural practices. By distributing germplasm to qualified researchers worldwide, the NCGRCD supports global efforts in crop improvement and food security. This facility plays a vital role in advancing citrus and date palm research, ensuring the availability of resilient



A) Dr Robert Krueger and Dr K L Manjunath of USDA showcasing citrus biodiversity to Dr Dilip Ghosh at National Clonal Germplasm Repository for Citrus and Dates, Riverside, California, USA, and B) Dr Dilip Ghosh inspecting imported budwoods of exotic citrus varieties at ICAR-CCRI, Nagpur

and high-quality genetic resources for future generations.

Procedure for germplasm import: The import of seeds or planting materials into India is governed by the Plant Quarantine (Regulation of Import into India) Order, 2003. The procedure varies depending on whether the import is for commercial purposes in bulk quantities or for research purposes in small quantities. For commercial imports, applications must be submitted to the Directorate of Plant Protection, Quarantine, and Storage (DPPQS) in Faridabad. However, for research purposes, the Director of ICAR-NBPGR, New Delhi, is authorised to issue import permits for germplasm, including transgenic crops. ICAR-NBPGR also oversees the receipt of imported materials from customs authorities, conducts quarantine inspections, and ensures clearance before distributing the materials to researchers across the country.

Steps for Importing Germplasm

Registration: The importer must first register on the official ICAR-NBPGR portal: <http://exchange.nbpgr.ernet.in/register.aspx>.

- **Application submission:** After registration, the applicant submits an application proforma (PQ 08) to the Director, ICAR-NBPGR, New Delhi, along with the prescribed fee and required supporting documents.
- **Verification and permit issuance:** The application is verified by ICAR-NBPGR. If approved, an Import Permit (PQ 09) is issued in triplicate. Two copies are sent to the indenter or supplier, along with a set of import instructions.
- **Export and arrival in India:** The approved material is exported from the country of origin to New Delhi Airport. Upon arrival, the consignment is cleared through customs, the foreign post office, or courier services, and registered with the Division of Plant Quarantine (DPQ), ICAR-NBPGR.
- **Quarantine examination and release:** The DPQ conducts a thorough quarantine examination of the imported material. If it is free from quarantine pests and diseases, it is transferred to the Germplasm Exchange & Policy Unit (GEPU), where Exotic Collection (EC) numbers are assigned. The importer is then notified to pay handling charges and quarantine fees. After payment confirmation, the material is officially released to the indenter.

As per the existing procedure for the import of germplasm for research or experimental purposes, the Government of India mandates two essential requirements. Firstly, an import permit must be obtained before importing any material into India. Secondly, a Phytosanitary Certificate issued by the country of origin is required, in accordance with the Plant Quarantine (Regulation of Import into India) Order, 2003 (PQ Order 2003). Both documents must accompany every consignment of seeds or planting materials imported for research purposes. This structured procedure ensures compliance with national and international quarantine regulations, safeguarding Indian agriculture from potential biosecurity threats.



Dr Himanshu Pathak, Hon'ble former DG, ICAR visited post-entry quarantine facility of imported citrus germplasm at ICAR-CCRI, Nagpur

Phytosanitary certification

The introduction of new genetic material carries inherent risks, including the potential entry of exotic pests and diseases that can severely impact agriculture. In the past, the arrival of such threats has caused significant crop losses and economic damage. To mitigate these risks, a stringent quarantine examination is conducted to ensure that imported samples or materials for research are free from harmful organisms. Specifically, for the import of citrus germplasm, a phytosanitary certificate with an additional declaration is required. This must certify that the material is free from specified pathogens, insect pests, and nematodes listed under the quarantine regulations:

- *Deuterophoma tracheiphila*
- *Spiroplasma citri*
- *Xanthomonas campestris* pv. *Aurantifolii*
- *Capillo* and *Satsuma* dwarf virus
- *Elsinoe australis* and *Sphaceloma fawcettii* var. *scabiosa*
- *Radopholus citrophilus*
- *Chrysomphalus aonidum*
- *Eriophyes sheldoni*
- *Phyllocoptruta oleivora*

Future plan of work at ICAR-CCRI, Nagpur

- The recently imported exotic citrus varieties have been propagated on Rough lemon rootstock and are currently housed in the post-entry quarantine facility at ICAR-CCRI, Nagpur, for a period of one year.
- Imported scion varieties will be tested in different agro-climatic zones across India on various rootstocks, including Rough lemon, Alemow, C-35, and Carrizo.
- Exotic scion varieties will be top-worked on matured citrus trees to reduce juvenility and get early fruiting.
- Their performance will be evaluated based on key

traits such as fruit yield, quality, nutritional value, consumer preference, and resistance to diseases and pests.

Expected outcomes: The introduction of these exotic citrus varieties is expected to bring transformative changes to India's citrus sector:

- **Enhanced fruit quality and yield:** The new varieties offer superior traits such as high juice recovery, optimal TSS-to-acidity ratio, and extended shelf-life, making them ideal for fresh consumption and processing.
- **Extended harvesting period:** Varieties like Pixie mandarin (late maturity) and Lima sweet orange (early maturity) will extend the harvesting window, providing growers with greater flexibility.
- **Climate resilience:** Varieties like Australian finger lime and King tangor are expected to perform well under challenging climatic conditions, offering resilience against heatwaves and drought.
- **Market expansion:** The superior quality of these varieties is likely to boost India's citrus exports to European and American markets.
- **Economic benefits:** By adopting high-yielding, disease-resistant varieties, Indian citrus growers can expect increased profitability and long-term sustainability.

CONCLUSION

The strategic introduction and propagation of exotic citrus varieties at ICAR-CCRI, Nagpur, represents a significant step towards strengthening India's citrus industry. By leveraging international collaborations and advanced breeding programmes, this initiative addresses the immediate challenges faced by Indian citrus growers while positioning India as a key player in the global citrus market. Evaluating these varieties across diverse agro-climatic zones and on different rootstocks will help identify high-performing cultivars that combine superior yield, quality, nutritional value, and resistance to pests and diseases. As these varieties undergo multi-location trials across the country, the future of India's citrus sector looks promising, with higher yields, improved fruit quality, and enhanced climate resilience for sustainable growth. This comprehensive approach is expected to boost productivity, profitability, and global competitiveness, while supporting long-term sustainable horticultural development.

For further interaction, please contact:

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