

# Opuntia

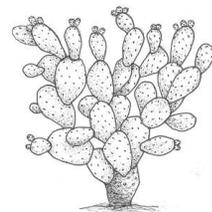
## *Opuntia ficus-indica* L., Cactaceae

### A drought- and saline-resilient crop of WaterMellon project

#### 01

#### History and origin

- Native to central Mexico, domesticated over 9,000 years ago, likely from *O. streptacantha* and *O. megacantha*.
- Spread globally via Spanish colonization for fruit, dye (derived from its pest cochineal mealybug), and scurvy prevention.
- Cultivated on over 100,000 ha globally, particularly in Mexico, Italy, Spain, Israel, Chile, Algeria, Tunisia, Morocco and Brazil.
- The primary diagnostic feature of *Opuntia ficus-indica* is the partial or complete absence of spines. Other key morphological traits include elongated cladodes, prominent areoles and pericarpels, as well as broader fruits exhibiting greater variability in color, seed size, and both the length and weight of the pulp.



#### 02

#### Morphological Characteristics



- **Lifespan:** 80 to 100 years under favorable conditions, 20 to 30 years for commercial cultivation.
- **Ploidy:** Cultivated varieties are typically octoploid ( $2n = 88$ ).
- **Growth:** Perennial cactus with tree-like growth, 3–7 m tall.
- **Stem:** Lignified, cylindrical stem, dark brown, green, or gray, up to 45 cm tall and 20 cm wide.
- **Cladodes (Pads):** Mostly elliptic, can be also obovate, bright green, with or without glochids.
- **Pericarpel:** Cylindrical to conic
- **Flowers:** Yellow to orange, 6–7 cm in diameter, with abundant stamens. Diurnal anthesis (day-opening), up to 10 per cladode. Usually located at the cladode's apical margin.
- **Fruits:** Oblong (5–10 cm), red/yellow/purple, with 40–60 areoles.
- **Seeds:** 5 mm in diameter, numerous per fruit, surrounded by mucilage.
- **Roots:** Shallow lateral roots dominate, up to 87% biomass within topsoil. Lateral spread reaches 1.8 m in one year. Roots account for 13% of total biomass. Root-to-cladode biomass ratio decreases under water stress.
- **Reproduction:** Sexually and asexually (vegetative propagation via cladodes).

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#### Soil and climate requirements

- **Soil:** Thrives in sandy-loam to loamy soils. Requires well-drained soils, highly susceptible to waterlogging. Although shallow-rooted, benefits from moderate soil depth (~40 cm or more).
- **pH Range:** Tolerates pH 5.5 to 8.5 (optimal: slightly acidic to neutral).
- **Climate:** 18–26 °C. Tolerates >40 °C in summer. Withstands brief frosts down to -3 °C. Grows from sea level up to 2,600 m a.s.l. Requires full sunlight; shade reduces fruit and cladode production.
- **Rainfall:** Best in semi-arid to arid climates, with minimum: 250–300 mm/year (can survive with <250 mm) and optimal: 350–600 mm/year.
- **Salinity:** Sensitive at seedling stage, mature plants tolerate moderate salinity.
- **CAM photosynthesis** (Crassulacean Acid Metabolism) gives high water-use efficiency. Survives 6–10 months of drought using stored water in cladodes.

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## Fertilization & Cultivation

- **Fertilization:** Requires nitrogen (N), phosphorus (P), and potassium (K).
  - High Nitrogen (>2.2% in cladodes) may reduce fruit quality and cause excessive vegetative growth.
  - Phosphorus and potassium significantly affect yield and fruit quality.
  - Moderate fertilization (e.g., 50–100 kg ha<sup>-1</sup> N and 50 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub>) increases productivity by 200–300 %.
  - Boron (B), calcium (Ca), magnesium (Mg), and iron (Fe) also enhance growth and yield.
  - Combining organic fertilizers (e.g., 100 t ha<sup>-1</sup> manure) with chemical inputs enhances yield.
  - **Planting:** Cladodes (pads) are planted directly in soil. Young cladodes require minimal irrigation (10 L per plant).
- **Density:** Dense, bushy planting enhances light interception by increasing canopy cover and reducing light loss to the soil surface.
- **Weed management:** Weed control is often achieved via organic mulch or inter-row tillage.
- **Harvesting:** Mostly manually, due to delicate nature of fruit and need to avoid damage. Mechanical harvesting techniques are applied experimentally in high-density plantations or for cladode biomass.



05

## Diseases & Pests

- **Insects:** *Cactoblastis cactorum*, *Dactylopius* spp., *Ceratitis capitata*.
- **Pathogens:** *Botrytis cinerea*, *Alternaria* spp., *Pectobacterium* spp.
- **High disease risk** in humid conditions or poor harvesting practices.

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## World production & Market Export and Import value

- **Global Production:** Mexico is the largest producer with 300,000–500,000 tons/year (44% of global production), covering 50,000–70,000 ha.
- **Other producers:**
  - **Italy:** 78,000–87,000 tons/year, 7000–8300 ha.
  - **South Africa:** ~15,000 tons/year, 1500 ha.
  - **Chile:** 934 ha.
  - **Peru:** ~5000 tons/year.
  - **Argentina:** 7500 tons/year
  - **USA:** 120 ha.
- **Economic Importance:**
  - In Mexico, average income: €1280/ha.
  - In Italy, higher at ~€1658.88/ha, due to quality, seasonal availability, and export value.
- **Top exporters:**
  - **Canada:** USD 317M
  - **USA:** USD 170M
  - **Chile:** USD 123M
  - **Peru:** USD 116M
  - **Mexico:** USD 107M
- **Top importers:**
  - **USA:** USD 706M
  - **Germany:** USD 298M
  - **Japan:** USD 160M
  - **UK:** USD 121M
  - **Canada:** USD 98M.



### Food Industry

- Fruits (prickly pears): eaten fresh, or processed into juices, jams, wines, marmalades, and syrups.
- Cladodes (nopalitos): consumed as vegetables in Mexico and Latin America, often fresh, cooked, or pickled.
- Used in bread, pasta, cookies, dairy products and meat preservation due to high fiber, antioxidants and mucilage content.
- Cladodes are used as livestock forage, especially in arid regions. With N fertilization, protein content can reach 9%, comparable to traditional fodder.



### Medicinal & Cosmetic Uses

- Rich in antioxidants (betalains, phenolics, vitamin C), amino acids and dietary fiber.
- Medicinal uses include anti-inflammatory, anti-ulcerogenic, hypoglycemic, hypolipidemic and wound healing properties.
- Used in cosmetic industry and as a supplement.



### Environmental & Industrial Uses

- Bioactive extracts for nutraceuticals.
- By-products like peels and seeds are valuable for biofuel, dye, or cosmetic industries.
- Cultivation helps in land rehabilitation and carbon sequestration, enhancing sustainability

*Opuntia ficus-indica is exceptionally well adapted to arid and semi-arid environments, capable of thriving on degraded soils and withstanding prolonged droughts-making it one of the few productive crops under such challenging conditions. Its global cultivation on extensive land areas, especially in drought-prone regions, highlights its critical role in sustainable agriculture, serving purposes from food and forage production to soil restoration and climate resilience.*



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