

Current Research in Medicinal Plant Science

ISBN: 978-93-49938-37-3 | Year: 2026 | pp: 30 - 56 |

Exploring Long Melon (*Cucumis melo* var. *utilissimus*): A Nutritional, Medicinal, and Agro-Sustainable Perspective

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Article DOI Link: <https://zenodo.org/uploads/19992022>

DOI: 10.5281/zenodo.19992022

Abstract

Long melon (*Cucumis melo* var. *utilissimus*), commonly known as Kakri or serpent melon in various regions of India, is an important cucurbitaceous crop valued for its tender, cylindrical fruits. Belonging to the same species as ash gourd, long melon stands out due to its elongated shape, delicate texture, and high-water content, making it a preferred vegetable during the summer months. Widely cultivated across India and Southeast Asia, it is renowned for its cooling effect, dietary fibre, and low caloric value, contributing to its popularity in traditional diets and holistic health practices. Beyond its culinary uses, long melon holds medicinal significance in Ayurvedic and folk medicine systems, where it is employed to treat conditions such as heatstroke, digestive issues, and inflammation. Economically, the crop supports marginal and small farmers by offering good market returns, especially under short-duration and off-season cultivation. This chapter provides a comprehensive overview of the long melon, encompassing its botanical features, anatomical traits, and nutritional profile. Additionally, the chapter outlines key agronomic practices including soil requirements, sowing techniques, nursery management, irrigation scheduling, and integrated pest and disease management.

Emphasis is also placed on improved varieties, hybrid development, and seed production protocols essential for enhancing productivity and genetic purity. Given the rising interest in sustainable and climate-resilient crops, long melon presents considerable potential in diversifying cropping systems and promoting food and nutritional security. The chapter concludes with future research and development directions aimed at harnessing the full agronomic and therapeutic potential of this underutilized crop.

Keywords: Long melon, *Cucumis melo* var. *utilissimus*, nutritional value, medicinal uses, sustainable cultivation

Introduction

Long melon (*Cucumis melo* var. *utilissimus*), commonly referred to as kakdi in various Indian dialects, belongs to the family Cucurbitaceae and is widely cultivated for its immature, elongated, and tender fruits. These fruits are valued both for their culinary versatility and medicinal applications (Rai, Pandey, & Rai, 2015; Singh, 2023). Native to and predominantly grown in tropical and subtropical regions, long melon is particularly well-suited to the agro-climatic conditions of South and Southeast Asia (AVRDC, 2007). Its adaptability to diverse growing environments, short cultivation cycle, and consistent market demand makes it an ideal crop for small and marginal farmers (Choudhary & Gaur, 2009).

In addition to its agronomic strengths, long melon plays a crucial role in promoting nutritional security. Its high-water content ranging from 95–96% along with a moderate concentration of micronutrients such as calcium, iron, and vitamin C, contribute to its dietary value (Gopalan et al., 2004). These attributes align with health-conscious dietary practices as well as traditional food systems. Moreover, long melon holds cultural and medicinal significance in Ayurvedic medicine, where it is used for its cooling, diuretic, and neuro-calming properties (Sharma & Dash, 2001). As a resilient and low-input crop, it offers promising opportunities for sustainable agriculture, especially in resource-limited and climate-vulnerable farming communities.



Fig.: Long Melon (*Cucumis melo* var. *utilissimus*)

Taxonomy

Family: Cucurbitaceae

Known as the gourd family, this group includes mostly herbaceous, tendril-bearing vines producing pepo fruits. Other members include cucumber (*Cucumis sativus*), bitter melon (*Momordica charantia*), and bottle gourd (*Lagenaria siceraria*) (Singh, 2023).

Genus: *Cucumis*

This genus includes cucumbers and melons, typically characterized by soft stems, climbing habit, and fleshy fruits.

Species: *Cucumis melo*

One of the most diverse species, comprising sweet melons (e.g., cantaloupe, honeydew), as well as non-sweet types like snap melons and long melons.

Variety: *utilissimus*

This specific variety is cultivated mainly for its long, non-sweet fruits consumed raw in summer as a vegetable. It differs from sweet melons in flavor, size, and usage.

Synonyms and Related Names

Cucumis melo var. *longiflorus* (sometimes used interchangeably)

Cucumis melo subsp. *agrestis* (wild relatives)

Common local names in India: Kakri, Tar Kakdi, Sada Kakdi

Taxonomic Rank	Classification
Kingdom	Plantae
Subkingdom	Tracheobionta (Vascular plants)
Superdivision	Spermatophyta (Seed plants)
Division	Magnoliophyta (Angiosperms / Flowering plants)
Class	Magnoliopsida (Dicotyledons)
Subclass	Dilleniidae
Order	Cucurbitales
Family	Cucurbitaceae (Gourd family)
Genus	<i>Cucumis</i>
Species	<i>Cucumis melo</i>
Variety	<i>Cucumis melo</i> var. <i>utilissimus</i>
Common Names	Long Melon, Kakri, Armenian Cucumber

Anatomy

Cucumis melo var. *utilissimus* is a dicotyledonous, herbaceous annual plant in the family Cucurbitaceae. Its anatomical features reflect adaptations for trailing growth,

rapid development, and efficient water uptake in dry climates. The plant exhibits distinct anatomical traits in its stem, leaf, root, flower, fruit, and seed.

1. Stem Anatomy

The stem of long melon is angular, ribbed, and herbaceous, characterized by the presence of multicellular, uniseriate glandular and non-glandular trichomes (hairs) that serve protective and functional roles. The epidermis is single-layered with a thick cuticle and is covered with trichomes, aiding in protection and water retention. Beneath the epidermis, the cortex consists of collenchyma cells located under the ridges, providing mechanical support, while chlorenchyma cells contribute to photosynthesis. The vascular bundles are bicollateral, open type, and arranged in a ring, with xylem located on the inner side and phloem present on both the external and internal sides of the bundle. The central pith is composed of large, well-developed parenchymatous cells, contributing to storage and structural integrity.

2. Leaf Anatomy

The leaf of long melon is simple, alternate, and palmately lobed, exhibiting a reticulate venation pattern. Both the upper and lower epidermis possess a thick cuticle and are covered with trichomes, providing protection and reducing water loss. The leaf is hypostomatic, with stomata being more numerous on the lower epidermis. The mesophyll is well differentiated into palisade and spongy parenchyma. The palisade layer, composed of one or two layers of chloroplast-rich cells, is primarily responsible for photosynthesis. Below it, the spongy parenchyma consists of loosely arranged cells with intercellular air spaces that facilitate gas exchange. Vascular bundles are found in the midrib and veins, each enclosed by a bundle sheath and comprising both xylem and phloem tissues for efficient transport of water, nutrients, and photosynthates.

3. Root Anatomy

The root system of long melon is a taproot type with numerous lateral branches, well adapted for deep soil penetration and efficient nutrient uptake. The outermost layer, the epidermis or rhizodermis, is single-layered and bears root hairs that significantly enhance water and mineral absorption. Beneath it, the cortex is composed of multiple layers of parenchymatous cells with intercellular spaces, facilitating the movement of absorbed substances. The endodermis is distinctly marked and features Casparian strips, which play a crucial role in regulating the entry of water and solutes into the vascular tissue. The pericycle, located just inside the endodermis, is responsible for the initiation of lateral roots. The vascular system exhibits a radial arrangement, with alternating xylem and phloem strands, and the xylem is exarch, meaning the protoxylem is positioned toward the periphery.

4. Tendrils

Modified shoots or stipules, arise from leaf axils. Spiral, sensitive to touch (thigmotropism), helping the plant to climb. Vascular bundles in the center, surrounded by parenchyma and collenchyma layers.

5. Flower Anatomy

Monoecious plant with separate male and female flowers.

- **Male Flower:** 3–5, free or partially fused, produce pollen. Vascular supply to each stamen is independent.
- **Female Flower:** Inferior ovary, unilocular with parietal placentation. Ovules numerous, anatropous. Stigma lobed and sticky for pollen reception.

6. Fruit Anatomy

- **Type:** Pepo (a modified berry typical of Cucurbitaceae).
- **Epicarp:** Thin, smooth outer skin (light green or white in color).
- **Mesocarp:** Thick, white, spongy parenchymatous tissue with high water content.
- **Endocarp:** Thin layer around the seed cavity.
- **Vascular Bundles:** Prominent near the periphery of the mesocarp, providing transport and support.
- **Parenchyma Cells:** Rich in water, vitamins, and soluble fibers.

7. Seed Anatomy

Non-endospermic (dicot). Seed Coat hard outer testa for protection. Cotyledons two large, fleshy, store food for germination. Embryo includes radicle and plumule, enclosed within the cotyledons.

Plant Part	Key Anatomical Feature
Stem	Bicollateral vascular bundles, angular ridges
Leaf	Dorsiventral, hypostomatic, differentiated mesophyll
Root	Radial vascular system, exarch xylem
Tendril	Helical, with central vascular strand
Fruit	Parenchymatous mesocarp, peripheral vasculature
Seed	Non-endospermic, dicot embryo

Nutritional Composition and Medicinal Value

Long melon (*Cucumis melo* var. *utilissimus*) is highly valued for its significant water content, comprising approximately 95–96%, which makes it a low-calorie vegetable suitable for hydration, especially during hot weather (Gopalan et al., 2004). Per 100 grams of edible portion, it contains about 3.4 g of carbohydrates, 0.4 g of protein, and only 0.1 g of fat, contributing to its inclusion in weight management and therapeutic diets (Rai et al., 2015). Additionally, it serves as a

moderate source of essential micronutrients, including vitamin C, calcium, phosphorus, and iron, which are important for metabolic and bone health.

Medicinally, long melon is recognized for its cooling, diuretic, and gastroprotective properties. It has been traditionally used to aid digestion, alleviate hyperacidity, and relieve conditions such as urinary tract infections, ulcers, and constipation (Kirtikar & Basu, 2005). In Ayurvedic medicine, its juice is prescribed to calm the nervous system, reduce stress, and promote mental clarity and cognitive balance (Sharma & Dash, 2001). These attributes underline its role not only as a dietary staple but also as a functional food with holistic health benefits.

Area, Production and Productivity

Long melon (*Cucumis melo* var. *utilissimus*) is widely cultivated across several Indian states, including Uttar Pradesh, Bihar, West Bengal, and Madhya Pradesh, where it thrives under diverse agro-climatic conditions. It is also grown in neighbouring South Asian countries such as Bangladesh, Nepal, and Sri Lanka, owing to its adaptability and cultural relevance in local diets (Rai et al., 2015). In India, the crop is cultivated over an estimated 70,000 hectares. Under traditional farming systems, the average productivity ranges between 150 to 180 quintals per hectare. However, with the adoption of improved agronomic practices, nutrient management, and the use of high-yielding hybrid varieties, productivity can be enhanced significantly, reaching up to 250 to 300 quintals per hectare (Choudhary & Gaur, 2009).

The crop's short growth duration and broad ecological adaptability make it a favourable option in intensive and integrated farming systems, especially in areas with limited landholding and water resources. This enables farmers to cultivate long melon as a main, intercrop, or off-season vegetable, thereby enhancing land use efficiency and farm income.

Climatic Condition

Long melon (*Cucumis melo* var. *utilissimus*) thrives best in warm and humid climates, characteristic of tropical and subtropical regions. The optimum temperature range for its vegetative and reproductive growth is between 25°C to 35°C, which supports vigorous vine development, timely flowering, and effective fruiting (Rai et al., 2015). Temperatures below 20°C can significantly retard seed germination, slow down vegetative growth, and delay flowering, while exposure to frost or chilling conditions can cause damage to seedlings and floral parts, leading to reduced yields (Choudhary & Gaur, 2009).

During the vegetative phase, moderate to high relative humidity (above 60%) is beneficial, promoting leaf expansion and vine elongation. However, excessive humidity in later stages may favour fungal diseases. In contrast, a relatively dry and warm climate during flowering and fruit development improves fruit set, pollination

success, and enhances fruit quality, reducing susceptibility to rotting and pest infestations (AVRDC, 2007).

The crop requires full sunlight for robust photosynthesis and overall productivity; shaded conditions may lead to poor flowering and elongated, inferior fruits. Long melon is well-suited for regions with well-distributed rainfall ranging from 600–1000 mm annually or in areas equipped with assured irrigation. While it can tolerate intermittent dry spells, consistent soil moisture is essential during critical growth stages, particularly flowering and fruit formation. These climatic preferences make long melon suitable for both kharif and summer cultivation, with the possibility of offseason production under protected or controlled environments.

Soil Requirement

Long melon (*Cucumis melo* var. *utilissimus*) thrives best in well-drained sandy loam to loamy soils that are rich in organic matter. These soil types provide a balanced environment for root aeration, moisture retention, and nutrient uptake, all essential for healthy plant growth and fruit development (Thamburaj & Singh, 2005). The crop prefers a neutral to slightly acidic soil pH, typically between 6.0 and 7.5, which supports optimal enzymatic and microbial activity in the root zone (Saini & Kaushik, 2010). Waterlogged conditions, often encountered in heavy clay soils, adversely affect long melon growth by impeding root respiration and increasing susceptibility to soil-borne pathogens, such as *Pythium* and *Fusarium* species. Conversely, deep and friable soils encourage extensive root development, improving plant stability and access to subsoil nutrients and moisture (Nath & Bhowmik, 2020).

To enhance soil fertility and texture, the incorporation of organic amendments such as farmyard manure (FYM), compost, or vermicompost is strongly recommended prior to sowing. These amendments contribute to improved soil structure, nutrient cycling, and water-holding capacity, leading to improved crop productivity and soil health (Yadav & Singh, 2014). Sustainable soil management practices, including crop rotation, cover cropping, and organic mulching, further support the ecological suitability of long melon cultivation in both traditional and modern farming systems.

Field Preparation

Proper field preparation is crucial for the successful cultivation of long melon (*Cucumis melo* var. *utilissimus*), ensuring good soil aeration, root penetration, and moisture management. The land should be ploughed deeply two to three times, followed by harrowing to achieve a fine tilth that facilitates seed germination and early seedling development (Hazra et al., 2011). It is essential to remove crop residues and weeds during this process to minimize pest and disease carryover.

At the time of land preparation, the incorporation of well-decomposed farmyard manure (FYM) or compost at the rate of 20–25 tons per hectare significantly

improves soil fertility, structure, and microbial activity, thereby enhancing crop performance (Sarkar & Pandey, 2008). Organic amendments also improve the soil's water-holding capacity and nutrient availability throughout the crop cycle. For efficient drainage and irrigation, the field is laid out into raised beds, or alternatively, ridges and furrows are prepared, especially in regions prone to waterlogging. In rainfed areas or for backyard cultivation, pits or mounds are commonly used. Additionally, the installation of support systems such as stakes, trellises, or vertical netting is recommended to allow the vines to climb, which prevents fruit-soil contact, reduces disease incidence, and enhances fruit shape and quality (Peter et al., 2013). This method also facilitates better air circulation and ease in harvesting.

Improved Varieties and Novel Hybrids

To enhance yield potential, fruit quality, pest and disease resistance, and market acceptability, several improved and hybrid varieties of long melon (*Cucumis melo* var. *utilissimus*) have been developed by public research institutions and private seed companies. These varieties exhibit wide adaptability across agro-climatic zones and are suitable for both open-field and intensive cultivation systems.

1. Pant Long Melon-1

Developed by the G.B. Pant University of Agriculture and Technology, Pantnagar, Pant Long Melon-1 is a popular variety known for its uniform, elongated fruits with a smooth light green skin and tender flesh.

- Maturity: Early (50–55 days after sowing)
- Fruit length: 25–30 cm
- Average yield: 250–300 quintals/ha
- Key traits: Uniform fruit shape, high moisture content, good shelf-life
- Adaptability: Suitable for North Indian plains and mid-hill regions
- Use: Fresh market consumption and culinary use due to tenderness and mild flavor

2. Kalyanpur Long

Released by the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Kalyanpur Long is a robust variety selected for its pest tolerance, particularly against fruit borers and aphids.

- Maturity: Mid-season (55–60 days)
- Fruit characteristics: Slender, slightly tapering, light green with sparse hair
- Average yield: 200–250 quintals/ha
- Key traits: Field tolerance to sucking pests, vigorous vines
- Adaptability: Tolerant to hot, humid climates of eastern and central India

3. Arka Sheetal

Arka Sheetal, developed by the Indian Institute of Horticultural Research (IIHR), Bangalore, is recognized for its good yield, improved fruit quality, and moderate disease tolerance.

- Maturity: Early (50 days)
- Fruit size: Medium-long, cylindrical, with soft skin
- Average yield: 280–320 quintals/ha
- Key traits: Better shelf-life, attractive appearance, good taste
- Adaptability: Southern India and irrigated zones in the summer season
- Resistance: Tolerant to powdery mildew and downy mildew under field conditions

4. Hybrid 401 (Private Sector Hybrid)

A proprietary hybrid released by leading private seed companies, Hybrid 401 is known for its vigorous growth, early maturity, and high yield potential under intensive cultivation.

- Maturity: Very early (45–50 days)
- Fruit length: 30–35 cm, cylindrical with uniform girth
- Average yield: 350–400 quintals/ha
- Key traits: Excellent fruit uniformity, enhanced market shelf-life, and firm texture
- Adaptability: Greenhouse, polyhouse, and high-input open-field systems
- Market preference: High due to attractive fruits and transport tolerance

5. Other Local Selections and Regional Varieties

Various local landraces and farmer-selected varieties such as Desi Lauki, Bada Lauki, and Chhoti Lauki are still grown in rural areas, prized for their taste and cultural relevance. Though lower in yield, these varieties often possess unique culinary attributes and are adapted to low-input farming.

Variety Name	Maturity	Fruit Length	Avg. Yield (q/ha)	Key Traits	Region/Adaptation
Pant Long Melon-1	Early	25–30 cm	250–300	Uniform fruits, shelf-life	North India, hills
Kalyanpur Long	Mid	20–25 cm	200–250	Pest tolerance	Eastern & Central India
Arka Sheetal	Early	22–28 cm	280–320	Disease tolerance, taste	Southern India
Hybrid 401	Very Early	30–35 cm	350–400	Marketable hybrid,	Intensive systems nationwide

				uniform fruits	
Local Varieties	Variable	20–30 cm	100– 180	Taste, local adaptation	Traditional farming regions

Seed and Sowing

Efficient seed and sowing practices are essential to ensure optimal plant population, uniform growth, and high productivity in long melon (*Cucumis melo* var. *utilissimus*). Both direct seeding and transplanting methods are followed based on climatic conditions and resource availability.

1. Seed Rate and Seed Treatment

The recommended seed rate for long melon ranges from 2.5 to 3.0 kg per hectare, depending on the spacing and method of sowing (Thamburaj & Singh, 2005). To improve germination, seeds should be pre-soaked in water for 6–8 hours, which softens the seed coat and initiates metabolic processes essential for sprouting. Additionally, treating the seeds with *Trichoderma viride* or a suitable fungicide helps prevent seed-borne fungal infections and ensures healthy seedling emergence (Saini & Kaushik, 2010).

2. Sowing Methods

Long melon seeds are either: Sown directly into the prepared field, especially under rainfed or open field cultivation, or started in nurseries using polybags or seed trays, particularly in high-input systems, and later transplanted to the main field after 15–20 days when seedlings attain 3–4 leaf stage.

3. Spacing and Planting Layout

The ideal spacing for long melon cultivation is 2.0 meters between rows and 1.0 meter between plants, allowing adequate room for vine spreading, air circulation, and sunlight penetration. This geometry minimizes intra-specific competition and facilitates easy intercultural operations such as weeding, fertilization, and harvesting (Hazra et al., 2011).

4. Sowing Time

Sowing time varies with geographical location and climatic conditions:

- In northern plains of India, sowing is done during February–March (spring–summer season) and again in June–July (monsoon crop).
- In hill regions, sowing is recommended in April–May when temperatures are favourable for seed germination and vine development.
- Timely sowing ensures synchronization with the optimal temperature range (25–35°C), which is critical for vigorous early growth and flowering.

Nursery Management

In areas where transplanting is preferred over direct sowing especially under protected cultivation or in regions with unpredictable early-season weather healthy seedlings of long melon (*Cucumis melo* var. *utilissimus*) are raised in well-prepared nursery conditions to ensure uniform and vigorous plant establishment in the main field.

1. Nursery Bed Preparation

Nurseries are commonly established on raised beds, in pro-trays, or polybags, depending on the scale and system of cultivation. Raised nursery beds, measuring 1.0 to 1.2 meters in width, facilitate better drainage, aeration, and ease of management (Thamburaj & Singh, 2005). The growing medium should be light, friable, and rich in organic matter. It is often enriched with compost or vermicompost to improve nutrient availability and microbial activity (Yadav & Singh, 2014).

2. Seed Treatment and Sowing

To prevent seedling mortality due to fungal infections, seeds should be treated prior to sowing with bio-agents like *Trichoderma viride* (4 g/kg seed) or fungicides such as Carbendazim (2 g/kg seed). These treatments help manage damping-off, root rot, and other soil-borne diseases (Sarkar & Pandey, 2008). Seeds are sown at a depth of 1.5–2 cm in rows or cells, and the soil should be lightly moistened to facilitate germination.

3. Seedling Care and Transplanting

Seedlings generally emerge within 5–7 days and are ready for transplanting after 18–20 days, once they develop 3–4 true leaves and a healthy root system. During this period, seedlings should be protected from direct sunlight, heavy rainfall, and pests using shade nets or low tunnels, especially in high-temperature zones.

Before transplanting, hardening of seedlings is essential. This involves gradually exposing the young plants to field-like conditions (e.g., reduced watering, increased sunlight) for 3–4 days, which prepares them to withstand field stress after transplantation.

Nutrient Requirements and Its Management

Efficient and balanced nutrient management is essential for promoting vigorous vine growth, flowering, and high fruit yield in long melon (*Cucumis melo* var. *utilissimus*). The crop is a moderate feeder but responds well to both organic and inorganic nutrient sources when properly integrated.

1. Fertilizer Requirement

A recommended basal fertilizer dose of 80:60:60 kg N:P₂O₅:K₂O per hectare ensures optimal vegetative and reproductive development (Singh et al., 2016). At sowing time, 50% of nitrogen (N) along with 100% of phosphorus (P) and

potassium (K) should be incorporated into the soil to support early growth and root establishment.

The remaining nitrogen should be applied in two equal splits:

- First split at 30 days after sowing (DAS)
- Second split at 45 DAS, coinciding with early fruit set, to enhance yield potential and quality.

2. Organic Manures and Soil Enrichment

The application of well-decomposed farmyard manure (20–25 t/ha) or compost during field preparation helps improve soil texture, water retention, and microbial activity (Hazra et al., 2011). The use of green manures such as *Sesbania* or sun-hemp in rotation or as cover crops further enriches the soil with organic matter and enhances long-term soil fertility.

3. Biofertilizers for Sustainable Nutrition

The inclusion of biofertilizers in integrated nutrient management (INM) systems significantly improves nutrient uptake and crop performance. Beneficial microbial inoculants like:

- *Azotobacter* and *Azospirillum* (biological nitrogen fixers), and
- Phosphate-solubilizing bacteria (PSB)

are known to enhance nutrient use efficiency and reduce dependency on chemical fertilizers (Bose & Som, 2002). Seed or soil inoculation with these biofertilizers is particularly effective in boosting plant vigor and yield under low-input farming conditions.

Irrigation Management

Irrigation plays a critical role in the successful cultivation of long melon (*Cucumis melo* var. *utilissimus*), particularly during key phenological stages such as flowering and fruit development, which are highly sensitive to soil moisture fluctuations.

1. Irrigation Frequency and Timing

In summer cultivation, light and frequent irrigations at 5–7 day intervals are recommended to maintain optimal soil moisture levels for vine growth and fruit set (Choudhary & Gaur, 2009). The root zone should remain consistently moist but not waterlogged, as long melon is susceptible to root rots and fruit cracking when exposed to excess irrigation or sudden changes in soil moisture (Hazra et al., 2011).

Particular care should be taken during:

Flowering stage, to ensure proper pollination and fruit set

Fruit enlargement stage, when water stress can lead to reduced fruit size and poor quality

2. Efficient Irrigation Methods

Among modern irrigation techniques, drip irrigation is highly effective for long melon cultivation, especially under intensive and water-scarce conditions. It ensures uniform moisture distribution, minimizes evaporation losses, and reduces the risk of foliar diseases by avoiding water contact with plant foliage (Patel et al., 2010).

3. Mulching for Moisture Conservation

The use of organic mulches (e.g., straw, dried leaves) or plastic films over the soil surface helps:

- Retain soil moisture
- Suppress weed growth
- Reduce soil temperature fluctuations
- Minimize nutrient leaching and erosion

Mulching is especially beneficial in sandy soils and during high-temperature months, promoting better water-use efficiency and healthier plant growth (Bose & Som, 2002).

Weed Management

Effective weed management is essential for ensuring optimal growth and productivity of long melon (*Cucumis melo* var. *utilissimus*), particularly during the early growth stages when the crop is most vulnerable to competition.

1. Weed Competition and Impact

Weeds compete aggressively with the main crop for nutrients, moisture, light, and space, often resulting in stunted growth, reduced flowering, and lower yields, especially during the first 40–50 days after sowing. If not controlled in time, weeds can also harbor insect pests and pathogens, which further deteriorate plant health (Rana & Pal, 2015).

2. Manual and Cultural Weed Control

Manual weeding remains the most commonly practiced and eco-friendly method. Intercultural operations like hand weeding or hoeing at 20, 40, and 60 days after sowing (DAS) effectively control annual and broadleaf weeds. These timings coincide with key vegetative phases and help reduce competition during vine development (Hazra et al., 2011).

Mulching, using organic (straw, dry leaves) or synthetic (black polythene) materials, not only suppresses weed emergence by blocking sunlight but also helps in moisture conservation and temperature regulation of the soil surface.

3. Chemical Weed Control

In larger or mechanized farms, pre-emergence herbicides such as Pendimethalin @ 1.0–1.2 kg a.i./ha can be applied within 2–3 days after sowing to suppress early weed flushes. Application must be carried out carefully under expert supervision to

avoid phytotoxicity to the crop and environmental hazards (Yadav & Singh, 2014). Integration of chemical and cultural methods (Integrated Weed Management) is ideal for long-term sustainability and weed resistance management.

Physiological Disorders

Despite favourable growing conditions, long melon (*Cucumis melo* var. *utilissimus*) is susceptible to several physiological disorders that can adversely affect fruit quality, marketability, and overall yield. These are often caused by abiotic stress, nutrient imbalances, or environmental fluctuations, rather than pathogens.

1. Fruit Cracking

Fruit cracking is one of the most commonly observed disorders, especially during the fruit enlargement stage. It occurs primarily due to sudden fluctuations in soil moisture, such as heavy irrigation or rainfall after a dry period, which causes rapid fruit expansion and rupture of the skin (Singh & Ghosh, 2006).

Management: Maintain uniform soil moisture through regular light irrigations; adopt drip irrigation and mulching to prevent soil dryness and excessive wetness.

2. Poor Fruit Set

High day temperatures above 38°C and low relative humidity can reduce pollen viability, leading to poor pollination and low fruit set. Additionally, lack of insect pollinator activity—especially bees—can hinder fertilization (Sirohi et al., 2005).

Management: Promote pollinator activity by maintaining bee-friendly environments or using hand pollination during early morning hours in extreme conditions.

3. Sunscald

Sunscald occurs when developing fruits are exposed to direct sunlight for prolonged periods, especially during peak summer. This results in bleached patches or dry, necrotic lesions on the exposed side of the fruit, affecting market value (Hazra et al., 2011).

Management: Train vines on trellises or provide adequate canopy cover to shade the fruits; avoid excessive pruning that exposes fruits to sun.

4. Nutrient-Related Disorders

Micronutrient deficiencies, particularly boron and calcium, can lead to fruit deformities, tip burn, and hollow fruits.

- **Boron deficiency:** Causes distorted, cracked, or irregular fruits and poor seed development.
- **Calcium deficiency:** Leads to soft, sunken areas on the fruit and poor structural integrity.

- **Management:** Apply micronutrient mixtures or foliar sprays of boric acid (0.1%) and calcium nitrate (0.2%) at regular intervals during flowering and early fruiting stages (Pandey et al., 2010).

Plant Protection Measures

The cultivation of long melon (*Cucumis melo* var. *utilissimus*) is challenged by several insect pests and diseases that can significantly reduce yield and fruit quality. A sustainable approach through Integrated Pest Management (IPM) ensures effective protection while minimizing environmental and human health risks. IPM is a holistic strategy that combines cultural, biological, mechanical, and chemical methods to manage pests and diseases in an economically and ecologically sound manner (Kumar et al., 2015). The major components of IPM in long melon cultivation include:

1. Regular Monitoring and Early Detection

Routine field scouting is crucial to detect early signs of pest or disease infestation. Monitoring should be done weekly, focusing on undersides of leaves, flower buds, and young fruits, where pests like aphids, fruit borers, or mildew infections often begin (Hazra et al., 2011).

2. Use of Resistant or Tolerant Varieties

Adopting disease and pest-tolerant cultivars such as Kalyanpur Long and Arka Sheetal can reduce the dependency on chemical control and lower the overall pest pressure.

3. Biological Control Measures

The use of natural enemies like *Trichogramma* spp. (egg parasitoids), *Chrysoperla carnea* (green lacewing), and *Beauveria bassiana* (fungal biopesticide) helps control sucking pests and caterpillars. Nematode suppression can be enhanced by rotating with marigold or applying neem cake.

4. Botanical and Mechanical Methods

Neem-based bio-pesticides such as Azadirachtin 0.3% EC are effective against aphids, whiteflies, and fruit borers. Pheromone traps (10–12 per hectare) should be installed for monitoring and mass-trapping of fruit fly (*Bactrocera cucurbitae*), one of the most damaging pests in cucurbits (Singh & Ameta, 2008). Yellow sticky traps help manage whiteflies and thrips.

5. Judicious Use of Chemical Pesticides

Chemical pesticides should only be used when pest populations exceed economic threshold levels (ETL) and no alternative method is effective. Always opt for selective, low-residual insecticides, and follow recommended doses and pre-harvest intervals.

Commonly used chemicals include:

- Spinosad or Emamectin benzoate for fruit borers
- Mancozeb or Copper oxychloride for fungal diseases like downy mildew and anthracnose
- Excessive or indiscriminate use can lead to pesticide resistance, residue accumulation, and environmental harm.

Major Diseases and Their Management

Long melon (*Cucumis melo* var. *utilissimus*) is vulnerable to several fungal and viral diseases that can severely impact plant vigor, fruit quality, and marketable yield. Effective disease management involves an integrated approach, including cultural practices, chemical protection, and biological interventions.

1. Powdery Mildew (*Podosphaera xanthii*)

- **Symptoms:** Appears as white, powdery fungal growth on upper leaf surfaces, stems, and petioles. Infected leaves may curl, yellow, and dry prematurely, reducing photosynthetic capacity (Hazra et al., 2011).
- **Favourable Conditions:** Warm, dry weather with high humidity at night.
- **Management:** Dusting with Sulfur (25 kg/ha) or Spraying Hexaconazole (0.1%) at 10–15 days intervals when symptoms first appear.

2. Downy Mildew (*Pseudoperonospora cubensis*)

- **Symptoms:** Yellow angular spots on upper leaf surfaces with grayish fungal growth underneath; severely affected leaves become brown and necrotic.
- **Favourable Conditions:** High humidity, cool and wet weather.
- **Management:** Spray Metalaxyl + Mancozeb (0.25%) at 7–10 days intervals. Ensure adequate plant spacing and avoid overhead irrigation.

3. Anthracnose (*Colletotrichum lagenarium*)

- **Symptoms:** Sunken, dark lesions on leaves, stems, and fruits; lesions may coalesce and cause tissue collapse.
- **Favourable Conditions:** Warm and moist weather with frequent rainfall.
- **Management:** Seed treatment with Carbendazim (2 g/kg seed). Foliar spray of Carbendazim (0.1%) or Thiophanate-methyl at the onset of symptoms.

4. Mosaic Virus (e.g., Cucumber Mosaic Virus – CMV)

- **Symptoms:** Mottling, yellowing, leaf distortion, stunted growth, and poor fruit set. Severely infected plants are unproductive.
- **Transmission:** Spread by aphids in a non-persistent manner.
- **Management:** Use virus-free seeds and resistant varieties where available. Remove and destroy infected plants immediately. Control aphid vectors using Neem oil (3–5 ml/l) or Imidacloprid (0.05%). Install yellow sticky traps to monitor and suppress aphid populations.

Disease	Causal Agent	Symptoms	Management Strategies
Powdery Mildew	<i>Podosphaera xanthii</i>	White powdery patches on leaves	Sulfur dust; Hexaconazole spray
Downy Mildew	<i>Pseudoperonospora cubensis</i>	Yellow angular spots on leaves	Metalaxyl + Mancozeb spray
Anthraco nose	<i>Colletotrichum lagenarium</i>	Sunken lesions on leaves & fruits	Carbendazim seed and foliar treatment
Mosaic Virus	CMV and related viruses	Mottling, leaf curl, stunted growth	Aphid control; removal of infected plants

Economical Yield (Q/HA)

The yield potential and profitability of long melon (*Cucumis melo* var. *utilissimus*) cultivation depend on multiple factors, including variety selection, cultural practices, season, and market dynamics. Farmers adopting improved technologies and hybrid cultivars can significantly enhance both productivity and profitability.

1. Yield Potential

Under traditional cultivation practices, the average yield of long melon typically ranges between 150 to 180 quintals per hectare, depending on soil fertility, water availability, and pest/disease pressure (Hazra et al., 2011).

However, with the adoption of:

- Improved varieties (e.g., Pant Long Melon-1, Arka Sheetal),
- Integrated nutrient and pest management, and
- Efficient irrigation practices (e.g., drip irrigation),
- The yield can be significantly enhanced to 250–300 quintals per hectare, representing a 40–60% increase over traditional methods (Singh et al., 2016).

2. Hybrid Performance and Market Value

Hybrid varieties not only offer higher yields but also demonstrate greater uniformity in fruit shape, size, and shelf-life, which enhances market preference and consumer acceptance. The premium price for uniform and blemish-free fruits results in higher net returns for farmers.

3. Economic Considerations

Net profitability varies based on:

- Input costs (seeds, fertilizers, irrigation, labor),
- Seasonality (off-season prices may be higher),
- Local and regional market prices, and
- Access to market infrastructure.

According to field studies, farmers growing hybrid long melon under improved cultivation practices can realize net returns of ₹60,000–₹90,000 per hectare,

depending on regional price fluctuations and input efficiency (Yadav & Singh, 2014).

Post-Harvest Management

Effective harvesting and post-harvest management are crucial to maintain the quality, shelf life, and marketability of long melon (*Cucumis melo* var. *utilissimus*). As a perishable vegetable, the fruit requires timely harvesting and careful handling to reduce post-harvest losses.

1. Harvesting Stage and Method

Long melon fruits should be harvested at the tender stage, typically 10–12 days after fruit set, when they are elongated, light green, and covered with fine hairs (Hazra et al., 2011). At this stage, the fruit exhibits optimal texture, taste, and nutritional quality, and is most suitable for culinary uses. Fruits are hand-harvested using sharp knives or secateurs to prevent damage to the vine. Delayed harvesting leads to fiber formation, poor taste, and reduced market value.

2. Sorting, Grading, and Packaging

After harvest:

- Fruits are sorted to remove damaged or diseased specimens.
- Grading is done based on size, shape, and appearance to meet market standards.
- Packaging should use ventilated plastic crates, bamboo baskets, or cardboard boxes lined with soft material to reduce bruising and compression during transport (Thamburaj & Singh, 2005).
- Avoid rough handling, as long melon fruits are highly susceptible to mechanical injury and cracking.

3. Storage and Transportation

- Optimum storage temperature: 10–12°C with 85–90% relative humidity.
- Under these conditions, fruits can be stored for up to 8–10 days without significant loss in quality (Yadav & Shukla, 2014).
- Proper storage delays dehydration, shriveling, and post-harvest decay.
- During transportation, the produce should be kept shaded and cool, and movement should be cushioned to minimize shocks.

Seed Production Technology

Seed production in long melon (*Cucumis melo* var. *utilissimus*) requires adherence to scientific protocols to maintain genetic purity, vigor, and viability of seeds. Given its cross-pollinated nature, proper isolation and selection are crucial to prevent genetic contamination.

1. Isolation Distance

Due to the presence of insect-mediated pollination, adequate isolation distances are essential to ensure the purity of seed:

Foundation seed: Minimum 1000 meters from other cucurbit varieties or different long melon strains

Certified seed: Minimum 500 meters isolation (Singh et al., 2014)

These distances help prevent unintended cross-pollination and maintain the desired genetic traits.

2. Roguing and Selection

Roguing should be carried out diligently at different growth stages to maintain genetic purity and plant health in long melon cultivation. During the vegetative stage, off-type plants should be removed based on deviations in leaf shape and growth habit. At the flowering and fruiting stage, any plants exhibiting variations in flower color, fruit shape, or showing signs of disease must also be eliminated. This practice ensures that only true-to-type and healthy plants contribute to seed production, thereby preserving the quality and uniformity of the next generation (Choudhary & Gaur, 2009).

3. Fruit Maturity and Harvesting

Fruits selected for seed production should be harvested at 30–35 days after pollination, when they are fully mature and have reached physiological ripeness. After harvesting, the fruits should be kept under shade for 3–5 days to allow post-harvest ripening, which helps enhance seed development and improves overall seed quality. This careful selection and handling process ensures the production of high-quality, viable seeds for future cultivation.

4. Seed Extraction and Processing

Fermentation method is used for seed extraction. Fruits are cut open, pulp is scooped, and left to ferment for 24–36 hours to help separate seeds from the mucilage.

After fermentation, seeds are washed thoroughly with clean water, shade-dried on a clean surface, and then dried to a safe moisture level of 8% for storage (Thamburaj & Singh, 2005).

5. Storage

Seeds should be properly stored to maintain their viability and quality for future planting. They must be placed in moisture-proof, clearly labelled containers to prevent humidity-related damage and ensure easy identification. The storage environment should be cool, dry, and free from pests to avoid deterioration. Under ideal conditions specifically at a temperature of around 15°C and relative humidity (RH) of 50% long melon seeds can retain good viability for a period of 8 to 10 months, supporting successful germination and healthy crop establishment.

Seed Certification Standards

To ensure seed quality, genetic purity, and viability, certified seed production of long melon (*Cucumis melo* var. *utilissimus*) must adhere to the standards set by regulatory authorities such as the Indian Minimum Seed Certification Standards (IMSCS) and the Seed Certification Agencies. Compliance ensures the production of healthy, uniform, and high-yielding crops in subsequent plantings.

1. Minimum Seed Standards (Certified Seed)

Certified long melon seeds must meet the following quality parameters:

Parameter	Certified Seed Standard
Germination	Minimum 60%
Physical Purity	Minimum 98%
Inert Matter	Maximum 2%
Moisture Content	Not more than 8%
Off-types	Maximum 0.10%

(Source: Seed Certification Standards, Department of Agriculture & Cooperation, Govt. of India, 2013)

These standards ensure vigorous germination, field uniformity, and resistance to seed-borne pathogens.

2. Packaging and Labeling

Certified seeds must be:

- Properly cleaned and graded before packaging
- Packed in sealed, tamper-proof containers (preferably cloth or HDPE bags) with clearly labeled tags indicating:
 - Crop and variety
 - Lot number
 - Date of testing
 - Germination percentage
 - Certification tag (blue color for certified seeds)

3. Storage Conditions

To maintain seed viability and vigor, seeds should be:

- Stored in cool, dry conditions (preferably 15°C and 50% relative humidity)
- Kept in pest-proof, ventilated rooms on pallets or racks
- Protected from direct sunlight, excess moisture, and temperature fluctuations
- Under ideal conditions, certified long melon seeds can retain good germination potential for 8 to 10 months (Thamburaj & Singh, 2005).

Genetics

Long melon (*Cucumis melo* var. *utilissimus*) is a diploid species ($2n = 24$) and a member of the Cucurbitaceae family. It exhibits considerable genetic variability in

terms of fruit morphology, rind characteristics, maturity period, and biotic stress tolerance, making it a promising candidate for systematic breeding interventions.

1. Genetic Diversity

The species exhibits significant natural variability in key horticultural traits, making it an important genetic resource for crop improvement. Fruit shape and size range from cylindrical to oblong and from small to large, while rind color varies from pale green to dark green, sometimes with or without stripes. Variations are also observed in pulp texture and seed size. Moreover, certain genotypes display resistance or tolerance to common diseases such as powdery mildew, downy mildew, and cucumber mosaic virus. This wide-ranging diversity offers valuable potential for selection and hybridization programs aimed at developing improved cultivars (Choudhury et al., 2016).

2. Breeding Objectives

The primary breeding goals in long melon focus on enhancing both productivity and adaptability. Key objectives include achieving high yield and early maturity to ensure better marketability and profitability. Breeding efforts also aim to improve fruit quality by enhancing taste, extending shelf life, and ensuring uniformity in shape and size. Additionally, developing resistance to major fungal and viral diseases is a crucial goal to reduce dependency on chemical control and improve crop resilience. Another important target is to enhance the crop's adaptability across diverse agro-climatic zones, ensuring consistent performance in varying environmental conditions.

3. Hybrid Development

Hybridization has been a major focus to exploit heterosis (hybrid vigor). Hybrids like Pant Sankar Lauki-1 and Hybrid 401 demonstrate significant yield advantage, uniformity in fruit traits, and enhanced market acceptability (Singh & Dey, 2015).

4. Advances in Molecular Breeding

Modern breeding tools are increasingly being employed to accelerate the development of improved long melon varieties. Marker-Assisted Selection (MAS) facilitates the early identification of desirable traits at the seedling stage, thereby significantly shortening breeding cycles. Various molecular markers such as SSR (Simple Sequence Repeats), RAPD (Random Amplified Polymorphic DNA), and AFLP (Amplified Fragment Length Polymorphism) are being utilized to assess genetic diversity and assist in the precise selection of parent lines. Furthermore, genomic-assisted breeding is being explored as a promising approach for developing long melon cultivars with multiple disease resistance traits and extended shelf life, enhancing both productivity and market appeal (Kumar et al., 2020).

5. Conservation of Germplasm

Several institutions, including ICAR-IIVR (Indian Institute of Vegetable Research) and NBPGR (National Bureau of Plant Genetic Resources), are engaged in germplasm collection, evaluation, and maintenance to conserve genetic resources for future breeding programs.

Special Cultivation Practices

To enhance productivity, fruit quality, and environmental sustainability in long melon (*Cucumis melo* var. *utilissimus*), several advanced and eco-friendly cultivation practices are being adopted. These techniques also contribute to resource-use efficiency, pest and disease management, and off-season cultivation.

1. Trellising and Bamboo Staking

Trellising or staking with bamboo poles is a recommended cultivation practice in long melon farming as it offers multiple agronomic benefits. This method promotes better air circulation within the plant canopy, thereby reducing the incidence of foliar diseases such as powdery and downy mildew. Enhanced exposure to sunlight also improves photosynthetic efficiency, contributing to healthier plant growth. By keeping the fruits off the soil surface, trellising minimizes the risk of rot, blemishes, and soil-borne infections. Moreover, studies have demonstrated that trellised crops tend to produce more uniform, visually appealing, and marketable fruits, along with higher yield potential (Hazra et al., 2011).

2. Mulching

Mulching with either organic materials such as straw and dry leaves or synthetic options like black polythene offers multiple agronomic benefits in long melon cultivation. It helps conserve soil moisture by reducing evaporation, thereby ensuring consistent water availability for plant growth. Mulching also suppresses weed emergence, moderates soil temperature, and minimizes nutrient leaching, contributing to better nutrient retention. Additionally, organic mulches improve overall soil health by enhancing microbial activity and increasing the organic carbon content in the soil, leading to improved soil fertility and structure over time (Yadav et al., 2016).

3. Pollination Management with Bee Boxes

As long melon is entomophilous, pollination is largely dependent on insect activity—especially bees. Installing bee colonies (*Apis mellifera*) in or near the fields:

- Increases fruit set percentage
- Improves fruit shape and size
- Enhances overall yield by 20–30% (Sirohi et al., 2005)

This practice is particularly beneficial during periods of low natural pollinator activity.

4. Organic Farming Practices

The use of organic inputs is gaining momentum for sustainable cultivation:

Neem cake, farmyard manure, and vermicompost improve soil fertility and pest suppression

Biopesticides like *Trichoderma*, *Pseudomonas fluorescens*, and neem-based formulations manage soil-borne and foliar diseases effectively

Promotes safe produce, improved soil biodiversity, and long-term productivity

5. Protected Cultivation

Cultivating long melon under protected structures such as low tunnels, shade nets, or insect-proof net houses offers significant advantages for sustainable and profitable production. These systems enable off-season cultivation, allowing farmers to tap into high-value markets when supply is limited. They also help reduce pest incidence and provide better control over the microclimatic conditions, leading to healthier crop growth. Additionally, protected cultivation enhances input-use efficiency, particularly in the use of water and nutrients, contributing to resource conservation. This approach is gaining popularity among progressive farmers and is actively supported under National Horticulture Mission schemes aimed at promoting climate-resilient farming practices (Singh et al., 2020).

Future Prospects

Long melon (*Cucumis melo* var. *utilissimus*) holds immense potential in the evolving landscape of sustainable horticulture and functional foods. As consumer awareness increases regarding health and nutrition, long melon is emerging not only as a dietary staple but also as a raw material for value-added and wellness products.

1. Development of Improved Hybrids

Future breeding programs for long melon are expected to increasingly emphasize the development of high-yielding hybrids that combine key desirable traits such as early maturity, uniform fruiting, and extended shelf life. A major focus will also be on enhancing resistance to significant biotic stresses, particularly viral infections like mosaic virus and fungal diseases such as downy and powdery mildew. In addition, breeding efforts will target improved tolerance to abiotic stresses, especially heat and drought, which are becoming more prevalent due to climate change. These advancements will be driven by the integration of marker-assisted selection and genomic tools, enabling more precise and efficient varietal development (Kumar et al., 2020).

2. Expansion under Protected Cultivation

Protected cultivation using structures such as polyhouses, net houses, and low tunnels is anticipated to play a pivotal role in the future of long melon farming. These systems enable off-season production by creating favourable growing conditions year-round, allowing farmers to meet market demand during lean periods. They also improve resource-use efficiency by optimizing water and nutrient application while minimizing losses. Furthermore, the controlled environment helps enhance fruit quality and supports effective disease management by reducing exposure to pests and pathogens. As a result, long melon growers can access premium markets and significantly enhance their income potential (Singh & Verma, 2020).

3. Value Addition and Processing

There is growing potential for the processing and commercialization of long melon into a variety of value-added products. These include juices, dehydrated slices, and pickles, as well as herbal supplements and cooling tonics widely used in traditional medicine. The development of packaged products tailored for urban consumers and export markets further enhances the crop's commercial appeal. Value addition not only helps extend the shelf life of the produce but also significantly boosts profitability and market reach, offering farmers and entrepreneurs new avenues for income generation (Yadav & Shukla, 2014).

4. Focus on GAP and Post-Harvest Management

Research and extension support in the adoption of Good Agricultural Practices (GAP) holds significant potential to enhance the sustainability and profitability of long melon cultivation. By promoting improved soil health, efficient irrigation methods, and balanced nutrient management, GAP contributes to higher productivity and resource conservation. Additionally, advancements in post-harvest techniques can greatly reduce spoilage and quality losses, thereby extend shelf life and enhance the market value of the produce. Equally important is the training of farmers in scientific post-harvest handling, proper storage, and effective marketing strategies, which will be crucial for maximizing returns and ensuring long-term success in the value chain.

5. Market Potential and Export Opportunities

The increasing demand for functional and nutraceutical foods is creating a promising niche market for long melon. Naturally rich in water, dietary fiber, and bioactive compounds, long melon holds strong appeal for health-conscious consumers seeking low-calorie, hydrating, and detoxifying food options. It can be effectively promoted in both domestic and international health markets as a cooling and wellness-enhancing vegetable. With strategic branding, proper certification, and the development of an efficient supply chain, long melon has the potential to

emerge as a commercially significant horticultural crop with wide-reaching market opportunities.

Conclusion

Long melon is a versatile and economically viable vegetable crop with nutritional, culinary, and medicinal importance. Adoption of improved varieties, scientific cultivation practices, and integrated crop management can significantly enhance its yield and quality. Its role in health, food security, and sustainable agriculture makes it a crop of future significance.

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