

## AGRICULTURAL EXPERT KNOWLEDGE BASE

### Top 10 Oilseed Crops in India – Agronomic Reference for Expert LLM

This document summarises practical, India-focused agronomic knowledge for the top 10 oilseed crops. For each crop, it covers: importance and distribution, climate and weather needs, soil and fertility requirements, irrigation and water management, major pests and diseases, yield benchmarks (India vs global), and evidence-based strategies to improve yield when key parameters are sub-optimal. Values are indicative and should be adapted to local recommendations and soil test reports.

#### 1. RAPESEED-MUSTARD (INCLUDING INDIAN MUSTARD)

##### 1.1 Importance and Distribution

- One of the most important rabi oilseed crops in India.
- Major states: Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, Gujarat, West Bengal, Assam.
- Used for edible oil, condiments (mustard seed, sauce), and as a green manure crop.
- India is among the top producers globally, but average yields are lower than potential.

##### 1.2 Climate and Weather Requirements

- Season: Cool-season (rabi) crop; sown from October to November in North India.
- Temperature:
  - Optimum germination: 20–25 °C.
  - Vegetative growth: 18–25 °C.
  - Flowering and pod filling: 15–20 °C; very high temperatures and hot dry winds during flowering reduce pod set and seed weight.
- Rainfall:
  - Requires about 350–450 mm total rainfall in the season if rainfed; performs best under assured moisture or limited irrigation.
  - Highly sensitive to moisture stress at flowering and pod filling; terminal drought sharply reduces yield.
- Photoperiod: Long-day tendency; responds to day length and temperature for flowering.

##### 1.3 Soil Requirements and Soil Health Parameters

- Preferred soils:
  - Well-drained loam to clay-loam soils with good water holding capacity.
  - Avoid waterlogging; mustard is moderately sensitive to poor drainage and salinity.
- Ideal soil pH: 6.0–7.5; yield declines in strongly acidic (< 5.5) or alkaline (> 8.0) soils.
- Organic carbon: At least 0.5–0.75% for sustainable productivity; higher OC improves structure, microbial activity and nutrient availability.
- Key nutrients:
  - Nitrogen (N): High demand; supports vegetative growth and yield.
  - Phosphorus (P): Important for root growth and early vigour.
  - Potassium (K): Improves stress tolerance and oil content.
  - Sulphur (S): Very critical for oilseed crops; deficiency directly lowers oil content and yield.
  - Micronutrients: Boron (B) and Zinc (Zn) are often limiting on many Indian soils.
- Bulk density and water holding:
  - Ideal bulk density ~1.3–1.4 g/cm<sup>3</sup> for root growth; high compaction (> 1.6 g/cm<sup>3</sup>) restricts root depth.
  - Adequate water holding capacity helps bridge dry spells in critical stages.

##### 1.4 Sowing Time, Seed Rate and Plant Geometry

- Sowing window:
  - North-Western plains: Mid-October to early November.
  - Eastern India and Assam: Late October to mid-November.
- Seed rate:

- Indian mustard: About 4–6 kg/ha with line sowing.
- Toria and yellow sarson: Typically 8–10 kg/ha (smaller seed size).
- Spacing:
  - Common recommendation: 30–45 cm between rows and 10–15 cm between plants.
  - Wider spacing with higher fertility supports better branching and pod formation.

## 1.5 Nutrient and Fertilizer Management

(Exact doses must follow local soil test based recommendations; values below are indicative.)

- General NPK recommendation (irrigated mustard on medium soils):
  - Nitrogen: 80–120 kg N/ha (split between basal and topdressing).
  - Phosphorus: 40–60 kg P<sub>2</sub>O<sub>5</sub>/ha.
  - Potassium: 20–40 kg K<sub>2</sub>O/ha.
- Sulphur:
  - 20–40 kg S/ha often needed, especially on low S soils (e.g. using gypsum, elemental S or sulphur-bearing complex fertilizers).
- Micronutrients:
  - Zinc: 5–10 kg Zn/ha as basal in deficient soils or foliar sprays.
  - Boron: Very small doses (e.g. 1–2 kg B/ha equivalent) on known deficient soils.
- Organic sources:
  - 5–10 t/ha of well decomposed FYM or compost improves soil structure and moisture retention, especially in light textured soils.

## 1.6 Irrigation and Water Management

- Under limited irrigation:
  - Two to three critical irrigations are highly beneficial:
    - First at pre-flowering or bud stage.
    - Second at full flowering.
    - Third at pod filling (if water is available).
- Total water requirement: Roughly 190–400 mm depending on variety and environment.
- Avoid standing water; ensure quick drainage after heavy rainfall.

## 1.7 Major Pests and Diseases (High-Level View)

- Important pests:
  - Mustard aphid: Sucks sap, causing curling and stunted growth, and reduces seed filling.
  - Painted bug and sawfly in some regions.
- Important diseases:
  - Alternaria blight, white rust, downy mildew, powdery mildew.
- Management (conceptual):
  - Use tolerant / resistant varieties recommended locally.
  - Follow timely sowing to escape peak pest pressure.
  - Use seed treatment fungicides as per local guidelines.
  - Monitor fields and use integrated pest management (IPM): cultural control, need-based biological and chemical control following official recommendations and safety guidelines.

## 1.8 Yield Benchmarks and Improvement Opportunities

- Typical farmer yields in India: Around 1.0–1.5 t/ha on average, with higher yields (2.0–2.5 t/ha or more)
  - under well-managed irrigated conditions.
- Potential yields under best management and favourable weather can exceed 3 t/ha in experiments.
- Yield gap drivers:
  - Late sowing, poor seed quality, low N and S supply, moisture stress at flowering, pest and disease losses.
- Improvement strategies:
  - Timely sowing in optimal window.
  - Balanced fertilization including S and micronutrients based on soil test.
  - Two to three critical irrigations where possible.
  - Use of improved, high-yielding varieties suited to local climate.

- Adopting IPM, weed control, and residue recycling / organic inputs to enhance soil health.

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## 2. SOYBEAN

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### 2.1 Importance and Distribution

- Leading kharif oilseed crop in Central India.
- Major states: Madhya Pradesh, Maharashtra, Rajasthan, Karnataka; some area in Telangana and Chhattisgarh.
- Key source of edible oil and high-protein meal for livestock and poultry feed.
- India has large soybean area but yield lags behind major producers like the USA and Brazil.

### 2.2 Climate and Weather Requirements

- Season: Kharif crop; sown with onset of monsoon (June–July) and harvested in October–November.
- Temperature:
  - Optimum: 20–30 °C; sensitive to frost and high temperature stress during flowering and pod filling.
- Rainfall:
  - Requires about 500–700 mm of well-distributed rainfall; waterlogging during early growth causes root rot.
- Photoperiod: Many Indian varieties are sensitive to day length; sowing outside recommended window can cause poor flowering and podding.

### 2.3 Soil Requirements and Soil Health Parameters

- Preferred soils:
  - Deep, well-drained medium to heavy soils with good water holding capacity.
  - Avoid prolonged waterlogging; soybean is sensitive to stagnant water.
- Ideal soil pH:
  - 6.0–7.5 preferred; strong acidity and salinity reduce nodulation and yield.
- Organic carbon:
  - Higher OC supports nodulation, nitrogen fixation and better soil structure.
- Key nutrients:
  - Nitrogen: Soybean fixes N via Rhizobium, but starter N (15–20 kg/ha) may be beneficial on very poor soils.
  - Phosphorus: Crucial for root growth, nodulation and pod formation.
  - Potassium: Supports drought tolerance and seed quality.
  - Sulphur and micronutrients (Zn, Mo, Fe) important for oil and protein synthesis.
- Soil biological health:
  - Inoculation with effective Rhizobium strains enhances N fixation, especially in new soybean areas.

### 2.4 Sowing Time, Seed Rate and Geometry

- Sowing window:
  - With onset of monsoon – generally mid-June to early July depending on region.
- Seed rate:
  - Typically 60–75 kg/ha depending on seed size and row spacing.
- Spacing:
  - Commonly 30–45 cm rows with 5–10 cm between plants.
  - Closer spacing can help suppress weeds but needs good nutrient and moisture supply.

### 2.5 Nutrient and Fertilizer Management

- General NPK (indicative, follow local soil test recommendations):
  - Starter N ~20 kg/ha where needed.
  - Phosphorus: 40–60 kg P<sub>2</sub>O<sub>5</sub>/ha.
  - Potassium: 20–40 kg K<sub>2</sub>O/ha depending on soil K status.
- Sulphur:
  - Often 20–40 kg S/ha required; deficiency reduces oil content.
- Micronutrients:
  - Zinc and iron deficiencies are common on calcareous and high pH soils; foliar sprays or soil application

may be advised.

- Biofertilizers:

- Seed inoculation with Rhizobium and phosphate-solubilizing bacteria (PSB) improves nutrient supply.

- Organic matter:

- Incorporating crop residues and FYM improves soil structure and moisture retention.

## 2.6 Irrigation and Water Management

- Often grown as rainfed crop; supplemental irrigation where available greatly improves yield.

- Critical stages:

- Flowering and pod filling.

- Avoid:

- Waterlogging in early growth and at seedling stage, which predisposes plants to diseases like root rot.

## 2.7 Major Pests and Diseases (High-Level)

- Pests:

- Leaf-eating caterpillars, stem fly, girdle beetle.

- Diseases:

- Soybean rust, yellow mosaic virus, collar rot, root rot.

- Management:

- Use resistant/tolerant varieties.

- Treat seed with recommended fungicides/biocontrol agents.

- Follow crop rotation; avoid continuous soybean.

- Monitor field and use need-based IPM interventions as per official guidelines.

## 2.8 Yield Benchmarks and Improvement Strategies

- Typical yields in India: Around 1.0–1.5 t/ha, varying by region and year.

- Global benchmarks: 3.0–4.0 t/ha or higher in leading countries under intensive management.

- Key yield gap factors:

- Late sowing, poor drainage, inadequate P and S, ineffective nodulation, severe weed and disease pressure.

- Improvement levers:

- Timely sowing with good quality seed and Rhizobium inoculation.

- Balanced fertilization including S and micronutrients based on soil tests.

- Effective weed management in first 30–40 days.

- Drainage improvement and avoiding prolonged waterlogging.

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## 3. GROUNDNUT (PEANUT)

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### 3.1 Importance and Distribution

- Major kharif and summer oilseed crop; grown under both rainfed and irrigated conditions.

- Major states: Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Odisha.

- Important for edible oil, confectionery and fodder (haulms).

- India is among top producers, but productivity is constrained by drought, poor soils and management gaps.

### 3.2 Climate and Weather Requirements

- Season: Kharif (rainy), rabi and summer in some regions under irrigation.

- Temperature:

- Optimum: 25–30 °C; sensitive to frost and extreme heat during flowering.

- Rainfall:

- Requires about 500–700 mm in growing season; distribution is more important than total amount.

- Weather sensitivity:

- Drought at pegging and pod filling sharply reduces pod number and seed weight.

- Excess rainfall and waterlogging cause disease and poor pod development.

### 3.3 Soil Requirements and Soil Health

- Preferred soils:
  - Light-textured sandy loam to loam with good drainage; deep well-drained red and black soils also suitable.
  - Heavy clay or poorly drained soils cause poor pegging and pod formation.
- Ideal pH: About 6.0–7.5; salinity and alkalinity reduce yield.
- Bulk density and structure:
  - Moderate bulk density that allows easy peg penetration and pod expansion.
- Key nutrients:
  - Nitrogen, phosphorus, potassium and calcium are most important.
  - Calcium at pod zone (e.g. from gypsum) is critical for proper pod filling and seed quality.
  - Sulphur and boron also important for oil and seed quality.
- Organic matter:
  - FYM and compost improve soil structure and moisture holding, helping crop withstand dry spells.

### 3.4 Sowing and Plant Geometry

- Kharif sowing: With onset of monsoon.
- Summer sowing: January–March depending on region, under irrigation.
- Seed rate:
  - 100–150 kg/ha depending on pod size and variety.
- Spacing:
  - Commonly 30–45 cm between rows and 10–15 cm between plants.
  - Spreading vs. bunch types have different recommended spacing.

### 3.5 Nutrient Management

- General NPK (indicative):
  - Nitrogen: 15–25 kg N/ha as starter; much of the N is fixed by nodulating bacteria.
  - Phosphorus: 40–60 kg P<sub>2</sub>O<sub>5</sub>/ha.
  - Potassium: 30–40 kg K<sub>2</sub>O/ha on low to medium K soils.
- Calcium:
  - Application of gypsum in the pegging zone improves pod formation and reduces empty pods.
- Sulphur and micronutrients:
  - S, Zn and B on deficient soils improve yield and quality.
- Integrated nutrient management:
  - Combine inorganic fertilizers with FYM/compost and biofertilizers for better soil health.

### 3.6 Irrigation and Water Management

- As rainfed crop:
  - Ensure good land levelling and conservation furrows to store rainwater.
- Under irrigation:
  - Critical stages: flowering, pegging and pod development.
  - Avoid prolonged drought at these stages and prevent waterlogging.
- Mulching:
  - Organic mulches (e.g. crop residues) help conserve moisture and moderate soil temperature.

### 3.7 Major Pests and Diseases

- Pests:
  - Leaf miner, defoliators, sucking pests and soil-borne insects in some regions.
- Diseases:
  - Tikka (leaf spot), rust, stem rot, root rot and aflatoxin contamination in drought-stressed pods.
- Management:
  - Use resistant varieties and timely sowing.
  - Follow crop rotation to break disease cycles.
  - Maintain field sanitation; remove infected plants.
  - Use IPM-based fungicide and insecticide applications according to official guidelines.

### 3.8 Yield Benchmark and Improvement

- Typical Indian yields: 1.0–1.5 t/ha under rainfed conditions; 2.0–3.0 t/ha possible with irrigation and improved technology.
- Potential yields in research trials: Often exceed 3 t/ha.
- Main yield gap drivers:
  - Moisture stress, poor nutrient management, lack of calcium, pest and disease damage, poor quality seed.
- Improvement strategies:
  - Timely sowing, gypsum application in pegging zone, balanced fertilization including S and micronutrients.
  - Moisture conservation and supplemental irrigation during critical stages.
  - Use of improved varieties and good seed.

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## 4. SUNFLOWER

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### 4.1 Importance and Distribution

- Grown as an important oilseed crop in Karnataka, Andhra Pradesh/Telangana, Maharashtra and parts of North India.
- Short-duration, photo-insensitive crop suitable for multiple seasons (kharif, rabi and summer) under irrigation or conserved soil moisture.
- Produces high quality edible oil rich in polyunsaturated fatty acids.

### 4.2 Climate and Weather Requirements

- Temperature:
  - Optimum: 20–30 °C for germination and growth.
  - Very high temperatures combined with moisture stress around flowering reduce seed set.
- Rainfall:
  - Performs well with 400–600 mm of rainfall; responds well to irrigation in drier regions.
- Light:
  - Being day-neutral, it can be grown in various seasons; however, adequate sunlight is needed for good photosynthesis and head filling.

### 4.3 Soil Requirements

- Adaptable to a wide range of soils from sandy loam to clay loam, provided drainage is adequate.
- Ideal pH: 6.0–7.5; tolerates slightly alkaline soils but sensitive to severe salinity.
- Soil fertility:
  - Requires good levels of nitrogen, phosphorus and potassium.
  - Responsive to organic manures and integrated nutrient management.

### 4.4 Sowing and Plant Geometry

- Season:
  - Kharif: With monsoon onset.
  - Rabi/summer: Under irrigation after harvesting preceding crop.
- Seed rate:
  - Typically 8–10 kg/ha for hybrids.
- Spacing:
  - About 45–60 cm between rows and 20–30 cm between plants, depending on hybrid and fertility level.

### 4.5 Nutrient Management

- Indicative NPK:
  - Hybrids: Around 60 kg N, 60–90 kg P<sub>2</sub>O<sub>5</sub> and 40–60 kg K<sub>2</sub>O/ha, adjusted to soil tests and moisture regime.
- Organic sources:
  - 5–10 t/ha FYM or compost improves soil structure and water retention.
- Micronutrients:
  - Boron and zinc may be limiting on certain soils, affecting seed set and head filling.

#### 4.6 Irrigation and Water Management

- Critical stages for irrigation:
  - Flower bud initiation, flowering and grain filling.
- Waterlogging damages roots and increases disease incidence; ensure proper drainage.
- In rainfed areas, conservation furrows and mulching help improve moisture availability.

#### 4.7 Pests and Diseases

- Pests:
  - Head borer, capitulum weevils and sucking pests in some areas.
- Diseases:
  - Downy mildew, alternaria leaf spot, charcoal rot.
- Management:
  - Use recommended resistant hybrids.
  - Practice crop rotation and field sanitation.
  - Adopt need-based IPM following official recommendations.

#### 4.8 Yield Benchmarks and Improvement

- Typical Indian farmer yields: 0.8–1.2 t/ha.
- Potential yields: 2.0–2.5 t/ha or more with improved practices and adequate water and nutrients.
- Key constraints:
  - Soil moisture stress, unbalanced fertilization, pests and diseases.
- Improvement options:
  - Integrated nutrient and water management, choice of suitable hybrids, timely sowing, IPM and better soil conservation practices.

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### 5. SESAME (TIL)

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#### 5.1 Importance and Distribution

- One of the oldest oilseed crops, valued for high-quality oil and use in sweets and condiments.
- Grown across central, eastern and southern India.
- Major states: Uttar Pradesh, Madhya Pradesh, Rajasthan, Gujarat, Odisha, West Bengal, Tamil Nadu.

#### 5.2 Climate and Weather Requirements

- Warm-season crop; optimum temperature 25–35 °C.
- Moderately drought tolerant but sensitive to prolonged waterlogging.
- Often grown in kharif under rainfed conditions, and in some regions during summer or rabi with irrigation.

#### 5.3 Soil Requirements

- Performs well on well-drained loam and sandy loam soils.
- Tolerant to relatively poor, dry soils but yield is higher on fertile, moisture-retentive soils.
- Ideal pH: 5.5–7.5; sensitive to strong salinity.
- Soil health:
  - Needs adequate phosphorus, potassium and sulphur for high oil content.

#### 5.4 Sowing and Plant Geometry

- Season: Mainly kharif; some rabi/summer sesame under irrigation in South India.
- Seed rate: Around 3–5 kg/ha due to small seeds.
- Spacing: About 30–45 cm between rows and 10–15 cm between plants depending on variety and soil moisture.

#### 5.5 Nutrient Management

- Indicative NPK:
  - Nitrogen: 25–40 kg N/ha.

- Phosphorus: 25–40 kg P<sub>2</sub>O<sub>5</sub>/ha.
- Potassium: 20–30 kg K<sub>2</sub>O/ha on low to medium K soils.
- Sulphur:
  - 15–30 kg S/ha enhances oil content.
- Organic matter and green manuring improve moisture conservation and root growth.

## 5.6 Irrigation and Water Management

- Often grown as rainfed crop.
- Most critical stages: flowering and capsule development.
- Avoid waterlogging, especially in early growth stages.

## 5.7 Pests and Diseases

- Pests:
  - Leaf rollers, jassids, capsule borers in some areas.
- Diseases:
  - Phyllody, wilt, leaf spots.
- Management:
  - Use disease-tolerant varieties and healthy seed.
  - Practice crop rotation and timely sowing.
  - Follow IPM and need-based plant protection.

## 5.8 Yield Benchmarks and Improvement

- Typical yields: 0.4–0.8 t/ha under rainfed conditions.
- Potential yields: 1.2–1.5 t/ha or higher with improved varieties, better moisture and nutrient management.
- Improvement levers:
  - Timely sowing, weed control, balanced fertilization, soil moisture conservation, and use of improved varieties.

## 6. CASTOR

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### 6.1 Importance and Distribution

- Castor oil is used in industry, pharmaceuticals and as a lubricant.
- India is among the world's largest producers and exporters of castor oil.
- Major states: Gujarat, Rajasthan, Andhra Pradesh/Telangana.

### 6.2 Climate and Weather Requirements

- Warm-season crop with optimum temperatures 20–30 °C.
- Tolerant to drought but sensitive to waterlogging.
- Can be grown in kharif and rabi seasons in suitable regions.

### 6.3 Soil Requirements

- Grows in a range of soils from light sandy loams to deep black soils, provided they are well drained.
- Ideal pH: 6.0–8.0; moderately tolerant to salinity.
- Soil health:
  - Requires good supply of nitrogen, phosphorus and potassium, and benefits from organic matter.

### 6.4 Sowing and Plant Geometry

- Season:
  - Kharif sowing with onset of monsoon; rabi castor under irrigation in some regions.
- Seed rate:
  - 8–12 kg/ha depending on seed size and plant type.
- Spacing:
  - Wider spacing such as 90–120 cm between rows and 45–60 cm between plants due to large canopy.

## 6.5 Nutrient Management

- Indicative NPK:
  - Nitrogen: 60–90 kg N/ha.
  - Phosphorus: 40–60 kg P<sub>2</sub>O<sub>5</sub>/ha.
  - Potassium: 30–40 kg K<sub>2</sub>O/ha depending on soil test.
- Organic matter:
  - FYM application improves soil structure and water holding.
- Micronutrients like Zn and B may be important in deficient soils.

## 6.6 Irrigation and Water Management

- Often grown on conserved soil moisture as a rainfed crop in semi-arid regions.
- Under irrigation, critical stages include flowering and capsule development.
- Ensure good drainage; prolonged waterlogging increases root diseases.

## 6.7 Pests and Diseases

- Pests:
  - Capsule borer, semilooper, sucking pests.
- Diseases:
  - Wilt, root rot, grey mould.
- Management:
  - Use tolerant hybrids/varieties.
  - Follow crop rotation and field sanitation.
  - Adopt IPM with need-based plant protection as per recommendations.

## 6.8 Yield and Improvement

- Typical Indian farmer yields: 1.0–1.5 t/ha.
- Potential yields under improved practices: 2.5–3.0 t/ha or more.
- Improvement levers:
  - Improved hybrids, balanced fertilization, moisture conservation and IPM.

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## 7. SAFFLOWER

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### 7.1 Importance and Distribution

- Traditionally grown as a rabi oilseed in Maharashtra, Karnataka, Andhra Pradesh and parts of MP.
- Suited to low rainfall, residual moisture conditions.
- Oil used for cooking; also grown for ornamental flowers in some regions.

### 7.2 Climate and Weather Requirements

- Cool-season crop adapted to dryland rabi conditions.
- Tolerates drought and can grow on residual moisture, but severe terminal drought reduces yield.
- Sensitive to waterlogging.

### 7.3 Soil Requirements

- Performs reasonably well in deep, well-drained soils with moderate fertility.
- Often grown on black soils using stored moisture.
- Ideal pH: 6.0–8.0; tolerant to slightly alkaline conditions.

### 7.4 Sowing and Geometry

- Sown in October–November depending on region.
- Seed rate: Around 15–20 kg/ha.
- Spacing: About 45 cm between rows and 20 cm between plants.

## 7.5 Nutrient Management

- Indicative fertilizer:
  - Nitrogen: 40–60 kg N/ha.
  - Phosphorus: 20–40 kg P<sub>2</sub>O<sub>5</sub>/ha.
- Integrated nutrient management with FYM and crop residues improves soil organic matter and moisture storage.

## 7.6 Water Management

- Mostly grown on stored soil moisture; supplemental irrigation, if available, at flowering and grain filling greatly improves yield.
- Avoid waterlogging at all stages.

## 7.7 Pests and Diseases

- Pests: Aphids and other sucking pests on leaves and heads.
- Diseases: Leaf spots, rust in some areas.
- IPM approach and tolerant varieties are preferred.

## 7.8 Yield and Improvement

- Typical farmer yield: 0.6–1.0 t/ha.
- Potential with improved management: 1.5–2.0 t/ha.
- Improvement options:
  - Timely sowing, balanced N and P, residue and moisture management and IPM.

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## 8. NIGER

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### 8.1 Importance and Distribution

- Minor oilseed crop grown mainly in tribal and hilly regions.
- Major states: Odisha, Chhattisgarh, Madhya Pradesh, Jharkhand.
- Oil used for cooking and traditional uses; crop also supports biodiversity in marginal areas.

### 8.2 Climate and Weather Requirements

- Adapted to warm, humid and sub-humid climate.
- Often grown in kharif on marginal lands under rainfed conditions.
- Tolerant to some degree of drought and poor soils, but waterlogging is harmful.

### 8.3 Soil Requirements

- Performs reasonably well on light to medium-textured soils with good drainage.
- Can grow on low fertility soils but responds to moderate fertilization.
- Ideal pH: Around 5.5–7.0.

### 8.4 Sowing and Geometry

- Sown with onset of monsoon (June–July).
- Seed rate: 5–7 kg/ha.
- Spacing: 30–45 cm between rows and 10–15 cm between plants.

### 8.5 Nutrient and Water Management

- Nutrient requirements modest but crop responds to:
  - 20–30 kg N/ha and 20–30 kg P<sub>2</sub>O<sub>5</sub>/ha.
- Moisture conservation through mulching and contour farming important on sloping lands.
- Usually grown as a rainfed crop; irrigation rarely available on marginal lands.

### 8.6 Pests, Diseases and Yield

- Generally fewer serious pests and diseases compared to major oilseeds, but local issues may occur.

- Typical yields: 0.3–0.7 t/ha.
- Improvement:
  - Use of improved varieties, modest fertilization and better moisture conservation.

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## 9. LINSEED (FLAX)

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### 9.1 Importance and Distribution

- Grown as a rabi oilseed crop; seed used for linseed oil and industrial uses.
- Major states: Madhya Pradesh, Uttar Pradesh, Bihar, Chhattisgarh, Jharkhand.
- In some regions, also valued for fibre.

### 9.2 Climate and Weather Requirements

- Cool-season crop; prefers mild temperatures during growth.
- Sensitive to high temperature and drought during flowering and grain filling.
- Excess water and waterlogging are also harmful.

### 9.3 Soil Requirements

- Performs best on well-drained loam and clay-loam soils.
- Ideal pH: 6.0–7.5.
- Good soil fertility with adequate nitrogen and phosphorus is important for yield and oil content.

### 9.4 Sowing, Fertility and Water

- Sown in October–November.
- Seed rate: Around 25–30 kg/ha depending on variety and seed size.
- Spacing: About 30 cm between rows and 7–10 cm between plants.
- Fertility:
  - Nitrogen: ~40–60 kg N/ha.
  - Phosphorus: 30–40 kg P<sub>2</sub>O<sub>5</sub>/ha.
- Mostly grown on conserved soil moisture under rainfed conditions; one or two irrigations, if available,
  - at flowering and seed filling can boost yield.

### 9.5 Pests, Diseases and Yield

- Diseases: Rust, wilt and alternaria blight in some areas.
- Pests: Aphids, cutworms occasionally.
- Management:
  - Use resistant varieties and adopt IPM.
- Typical yields: 0.5–1.0 t/ha; can reach 1.5–2.0 t/ha under better management.

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## 10. COCONUT (AS A MAJOR OILSEED TREE CROP)

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### 10.1 Importance and Distribution

- Perennial tree crop providing copra and coconut oil.
- Major states: Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Odisha, West Bengal, Goa and coastal regions.
- Integral to livelihoods in coastal belts; intercropping improves system productivity.

### 10.2 Climate and Weather Requirements

- Tropical crop requiring warm, humid climate.
- Optimum temperature: 27–32 °C; sensitive to severe frost.
- Requires well-distributed rainfall of about 1500–2500 mm annually; can be grown with supplemental irrigation in drier tracts.

### 10.3 Soil and Water

- Grows in a wide range of soils: coastal sandy soils, alluvial soils, lateritic and red soils, provided drainage is adequate.
- Deep, well-drained soil with good water table is ideal.
- Soil pH: broadly tolerant from moderately acidic to slightly alkaline, provided other conditions are good.
- Nutrient demand is high due to perennial nature; requires regular manuring and fertilization.
- Irrigation:
  - Regular irrigation (basin, drip or micro-irrigation) is crucial in dry spells, especially in summer.

### 10.4 Nutrient Management

- Annual NPK requirements are substantial (exact doses depend on palm age and local recommendations).
- Integrated nutrient management with FYM, green manures, intercropping and mulching is central to long-term productivity.
- Micronutrients such as Zn, B, Mg and others may be limiting in some soils and should be corrected based on deficiency diagnosis.

### 10.5 Cropping System, Pests and Yield

- Often grown in mixed and intercropping systems with banana, spices, fodder grasses and pulses to improve total farm income.
- Major pests: Rhinoceros beetle, red palm weevil, eriophyid mite in some areas.
- Diseases: Bud rot, stem bleeding, root wilt (region specific).
- Yield:
  - Number of nuts per palm per year varies widely (e.g. 50–150 or more) depending on variety, climate and management.
  - Copra and oil yield per hectare is a function of palms per hectare, nut yield and kernel content.

### 10.6 Improvement Strategies

- Choose high-yielding, locally adapted varieties/hybrids.
- Maintain good soil moisture with mulching, basin irrigation or drip systems.
- Apply recommended manures and fertilizers annually.
- Adopt IPM against major pests and diseases.
- Use intercropping and multi-storey cropping to improve overall system productivity and resilience.

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## CONCLUSION

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These crop profiles summarise key agronomic parameters that strongly influence yield in India's major oilseed

crops. In an expert LLM system, these knowledge elements can be combined with:

- Site-specific soil test data (pH, EC, OC, NPK, micronutrients, bulk density, water holding capacity).
- Weather history and forecast (rainfall distribution, temperature extremes, dry spells).
- Remote sensing indicators (e.g. NDVI at early, mid and late growth stages).
- Historical yield performance at farmer, district, state, national and global levels.
- Management history (variety, seed rate, sowing date, irrigation, fertilizer, weed and pest control).

The LLM can then:

- Diagnose which domain (soil health, weather, agronomy, crop health) is most limiting.
- Suggest evidence-based improvements in each domain.
- Explain yield gaps relative to district, national and global benchmarks.
- Provide tailored, multilingual and farmer-friendly recommendations to support oilseed productivity and income enhancement.