Cotton Cultivation Disease Insects and Disorder notes by Agriguru

1. Introduction

- Cotton is a crucial fiber and cash crop in India, significantly influencing the industrial and agricultural economy.
- Provides raw material (cotton fiber) to the textile industry.
- Direct livelihood for 6 million farmers; employment for 40-50 million people in trade and processing.
- Major cotton-growing states: Punjab, Haryana, Rajasthan (North Zone); Madhya Pradesh, Maharashtra, Gujarat (Central Zone); Andhra Pradesh, Telangana, Karnataka, Tamil Nadu (South Zone).
- Cotton cultivation is increasing in Orissa and small areas of Uttar Pradesh, West Bengal, and Tripura.

2. Cultivated Species

- Four cultivated species: Gossypium arboreum, G. herbaceum, G. hirsutum, and G. barbadense.
    - G. arboreum and G. herbaceum (diploid, 2n=26) - native to the Old World, known as Asiatic cottons.
    - G. hirsutum and G. barbadense (tetraploid, 2n=52) - referred to as New World Cottons.
    - G. hirsutum: American cotton or upland cotton.
    - G. barbadense: Egyptian cotton, Sea Island cotton, Peruvian Cotton, Tanguish Cotton, quality cotton.
- G. hirsutum contributes about 90% to global production.
- India uniquely grows all four species on a commercial scale.

3. Seed Rate & Spacing of Cotton

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- **G. hirsutum**:
  - Irrigated: Northern zone (20-22 kg/ha, 75x15 cm), Southern zone (10-15 kg/ha, 75x30 cm, 75x45 cm).
  - Rainfed: Northern & Central zones (18-20 kg/ha, 60x30 cm), Southern zone (18-20 kg/ha, 60x30 cm).
- **G. arboreum**:
  - Irrigated: Northern & Central zones (10-12 kg/ha, 60x30 cm).
- **G. herbaceum**:
  - Rainfed: Central zone (12-15 kg/ha, 45x30 cm), Southern zone (12-15 kg/ha, 60x30 cm).
- **G. barbadense**:
  - Irrigated: Southern zone (8-10 kg/ha, 90x30 cm; 12-15 kg/ha, 75x30 cm).
- **Hybrids**:
  - Irrigated: Southern zone (2-3 kg/ha, 45x60 cm, 90x60 cm, 45x30 cm); Central zone (2-3.5 kg/ha, 120x40 cm, 120x60 cm); Northern zone (3-3.5 kg/ha, 67.5x67.5 cm).
  - Rainfed: Central zone (3-3.5 kg/ha, 150x60 cm); Southern zone (2.5-3 kg/ha, 120x60 cm).
- **Bt Hybrids**:
  - Irrigated: 1.5 kg/ha (90x60 cm, 120x40 cm, 120x60 cm). Includes 150 gm of non-Bt seed. Spacing varies based on hybrid growth habit.

4. Climate & Soil Requirement

- Cotton is a semi-xerophyte, grown in tropical and subtropical regions.
- Minimum temperature for germination: 15°C.
- Optimal temperature for vegetative growth: 21-27°C.
- Can tolerate temperatures up to 43°C; temperatures below 21°C are detrimental.
- Warm days and cool nights with large diurnal variations during fruiting favor good boll and fiber development.

5. Crop Season

- **Sowing Time**:
  - Varies from April-May in northern India to monsoon-based in southern zones.
  - Kharif crop in major regions: Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, Karnataka.
  - Irrigated crop: March-May; rainfed crop: June-July with monsoon.
  - Tamil Nadu: irrigated and rainfed crop in September-October; southern districts extend sowing to November.
  - Karnataka and Andhra Pradesh: desi cotton in August-September.
  - Summer sowing in Tamil Nadu: February-March.
  - Rice fallows in Andhra Pradesh and Tamil Nadu: December to January.

6. Preparation of Land

- **North Zone**:
  - Limited time post-wheat harvest.
  - Pre-sowing irrigation after wheat harvest.
  - Tractor-drawn implements, leveling, and planking before ridge preparation for sowing.
- **Central and Southern Zones**:
  - Deep plowing recommended every 4 years to destroy perennial weeds.
  - Repeated harrowing before pre-monsoon rains.
  - Sowing on ridges and furrows for moisture conservation and weed management.

7. Method of Sowing

- **Sowing Techniques**:
  - Tractor or bullock-drawn seed drill or by dibbling.
  - Hand dibbling of seeds at recommended spacing in rainfed areas, particularly for hybrids.
  - Ensures proper plant stand, uniform geometry, and saves seeds.
  - Main system for sowing Bt. Hybrids.
  - Ridges across slopes for water conservation, reduced soil erosion, and improved yield.

8. Irrigation Scheduling

- **Water Requirements**:
  - 700-1,200 mm water depending on climate and crop period.
  - Low water requirement for first 60-70 days; highest during flowering and boll development.
  - Common irrigation methods: flood, furrow, alternate furrow.
  - Drip irrigation gaining popularity, especially for hybrids.
  - Irrigate at 50-70% soil moisture depletion.
  - Sandy loam soils (North): 3-5 irrigations.
  - Red sandy loam soils (Tamil Nadu): 4-13 light irrigations.

9. Inter Cultivation & Weed Control

- **Inter Cultivation**:
  - Regular inter-cultivation with blade harrow, three-tined hoe, or desi plough.
  - Hand hoeing for crops sown by broadcasting.
  - Benefits: weed control, better soil aeration, soil moisture conservation.
- **Weed Control**:
  - Weeds compete for nutrients, light, moisture.
  - Critical period: sowing to 70 days until canopy closure.
  - Yield reduction: 50-85% if unchecked.

- Recommended: Fluchloralin or pendimethalin @ 1 kg ai/ha with hand weeding and crosswise hoeing.
- Summer plowing to remove deep-rooted perennial weeds.

- **Thinning**:
  - Practice in Peninsular India and southern Gujarat for irrigated crops on ridges.
  - Ensures optimum plant population for high yield.
  - Retain vigorous seedlings; remove weak seedlings and off-types.

10. Fertilizer Doses and Methods of Application

- **Northern Cotton Zone**:
  - **Fertilizers**: N - 60-100 kg/ha. P and K dose as per soil test.
    - No P if previous wheat received recommended P.
    - 5.5 kg Zn/ha as $ZnSO_4$ once in two cotton-wheat cycles.
  - **Method**:
    - Half N at thinning and remaining at first flowering.
    - Half N at sowing in late-sown crop.
    - Foliar application of N if needed.
    - P to be drilled at sowing.
- **Central Cotton Zone**:
  - **Fertilizers**:
    - Varieties: N:P

      40:20:20, 50:25:25, 80:40:40.

        - Hybrids: N:P

          100:50:50, 160:80:80, 240:120:120.

    - **Method**:
        - N in three splits at sowing, squaring, and peak flowering stages.
        - P & K according to soil test.
        - Application of 2% urea or DAP at flowering and early boll development.
- **Southern Cotton Zone**:
    - **Fertilizers**:
        - Varieties: N:P

          40:20:20, 60:30:30, 90:45:45.

        - Hybrids: N:P

          100:50:50, 120:60:60, 150:60:60.

    - **Method**:
        - N at squaring and peak flowering.
        - P & K at sowing.
        - In Karnataka, entire NPK at planting (rainfed cotton).
        - Half N and entire P & K at planting, remaining N at flowering (irrigated cotton).
        - N in 4 splits in irrigated hybrid cotton.
- **Bio-fertilizer**:
    - Northern Zone: Seed treatment with azotobacter.
    - Southern Zone (Tamil Nadu): Seed and soil treatment with Azospirillum.

Cotton Cultivation in India

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Major Cotton Growing States

India is divided into three cotton-growing zones:

- **North Zone**:
  - Punjab
  - Haryana
  - Rajasthan
- **Central Zone**:
  - Madhya Pradesh
  - Maharashtra
  - Gujarat
- **South Zone**:
  - Andhra Pradesh
  - Telangana
  - Karnataka
  - Tamil Nadu

Other cotton-growing states include Orissa, Uttar Pradesh, West Bengal, and Tripura.

Cultivated Species

India is unique in cultivating all four major cotton species on a commercial scale:

- *Gossypium arboreum*
- *G. herbaceum*
- *G. hirsutum*

- *G. barbadense*

Climate and Soil Requirements

- **Climate**:
  - Tropical and subtropical conditions.
  - Minimum temperature for germination: 15°C.
  - Optimum temperature for vegetative growth: 21-27°C.
  - Can tolerate up to 43°C; temperatures below 21°C are harmful.
  - Warm days and cool nights with large diurnal variations during fruiting benefit boll and fiber development.
- **Soil**:
  - Grown on various soils: well-drained deep alluvial soils (north), black clayey soils (central), and black and mixed black and red soils (south).
  - Semi-tolerant to salinity and sensitive to waterlogging; prefers well-drained soils.

Crop Season

- **Sowing Season**:
  - Varies from April-May in northern India to monsoon-based timings in the south.
  - Major kharif crop in Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra, and parts of Andhra Pradesh and Karnataka.
  - Irrigated crop: March-May.

- Rainfed crop: June-July (monsoon).
- Tamil Nadu: irrigated and rainfed crop in September-October; rainfed crop in southern districts sown up to November.
- Desi cotton in Karnataka and Andhra Pradesh: August-September.
- Summer sowings in Tamil Nadu: February-March.
- Rice fallows in Andhra Pradesh and Tamil Nadu: December to January.

Land Preparation

- **North Zone**:
  - Limited time after wheat harvest.
  - Pre-sowing irrigation.
  - Use of tractor-drawn implements for land leveling and planking.
  - Ridge preparation for sowing.
- **Central and Southern Zones**:
  - Deep plowing every four years to destroy perennial weeds.
  - Repeated harrowing before pre-monsoon rains.
  - Sowing on ridges and furrows for moisture conservation and weed management.

Irrigation Scheduling

- **Water Requirements**:

- 700-1,200 mm depending on climate and crop period.
- Low water requirement for the first 60-70 days; highest during flowering and boll development.
- Common irrigation methods: flood, furrow, alternate furrow.
- Drip irrigation gaining popularity, especially for hybrids.
- Irrigate at 50-70% soil moisture depletion.
- Sandy loam soils (north): 3-5 irrigations.
- Red sandy loam soils (Tamil Nadu): 4-13 light irrigations.

Fertilizer Doses and Methods of Application

- **Northern Cotton Zone**:
  - **Fertilizers**:
    - N: 60-100 kg/ha.
    - P and K based on soil test.
    - No P if previous wheat received recommended P.
    - 5.5 kg Zn/ha as $ZnSO_4$ once in two cotton-wheat cycles.
  - **Application Method**:
    - Half N at thinning, remaining at first flowering.
    - Half N at sowing in late-sown crop.
    - Foliar application of N if needed.
    - P to be drilled at sowing.

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- **Central Cotton Zone**:
    - **Fertilizers**:
        - Varieties: N:P

40:20:20, 50:25:25, 80:40:40.

        - Hybrids: N:P

100:50:50, 160:80:80, 240:120:120.

    - **Application Method**:
        - N in three splits at sowing, squaring, and peak flowering.
        - P & K as per soil test.
        - 2% urea or DAP at flowering and early boll development.
- **Southern Cotton Zone**:
    - **Fertilizers**:
        - Varieties: N:P

40:20:20, 60:30:30, 90:45:45.

        - Hybrids: N:P

100:50:50, 120:60:60, 150:60:60.

    - **Application Method**:
        - N at squaring and peak flowering.
        - P & K at sowing.
        - Entire NPK at planting for rainfed cotton in Karnataka.

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  - Half N and entire P & K at planting, remaining N at flowering for irrigated cotton.
  - N in 4 splits for irrigated hybrid cotton.

- **Bio-fertilizers**:
  - Northern Zone: Seed treatment with azotobacter.
  - Southern Zone (Tamil Nadu): Seed and soil treatment with Azospirillum.

Pest Management Of Cotton in India

☐ Cotton Overview:

- Known as "White Gold".
- Key cash crop in tropical/sub-tropical regions.
- Provides over 65% of raw materials for the textile industry.
- India is the largest producer, followed by China, USA, and Brazil.

☐ Pest Complex:

- Includes insects, mites, pathogens, weeds, nematodes, rodents, and birds.
- Insect pests cause the highest economic losses.
- Cotton hosts 1326 species of insects; in India, 166 insect pests are recorded.

☐ Insect Pests:

- Bollworms, sucking pests, and mealybugs are economically important.
- Climatic changes alter pest scenarios.
- Emerging minor pests pose new threats.

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☐ Bt-Cotton:

- Commercial cultivation began in 2002 (central/south India) and 2005 (north India).
- Effective in managing bollworms.

☐ Disease Scenario:

- Historically: Fusarium wilt, root rot, seedling blight, anthracnose, grey mildew.
- With tetraploid upland cotton: Bacterial blight became prominent.
- Verticillium wilt in Tamil Nadu.
- Grey mildew, Alternaria blight, Myrothecium leaf spots prevalent.
- Cotton leaf curl virus major in north India.
- Climate change increases minor pests and diseases.
- Bt hybrids more susceptible to bacterial blight, Alternaria leaf spots.
- Emerging diseases: Tobacco Streak Virus, Corynespora cassicola.

☐ Pesticides:

- Chemical pesticides widely used but societal pressure to use biopesticides.
- Biopesticides seen as safer and eco-friendly.
- Proper field identification crucial for pest management decisions.

☐ Integrated Pest Management (IPM):

- Focus on sustainable, low-cost techniques.
- Reduces reliance on chemical pesticides.

- Guides symptom-based identification of diseases for management decisions.

Cotton Diseases in India: Overview and Distribution

1. **Overview of Cotton Diseases**:
   - Include seed-borne, soil-borne, foliar, and emerging diseases caused by bacterial, fungal, and viral pathogens.
2. **Economically Important Diseases**:
   - Bacterial blight and internal boll rots (Pantoea spp.) are widespread across all cotton-growing zones.
3. **Fungal Diseases**:
   - Alternaria leaf spot, Myrothecium leaf spot, root rot, and Fusarium wilt affect all zones.
   - Verticillium wilt is notable in the South zone.
   - Target leaf spot is prevalent.
   - Grey mildew is emerging in the Central and South zones.
   - Anthracnose and Helminthosporium leaf spot occur sporadically.
4. **Viral Diseases**:
   - Cotton leaf curl disease (CLCuD) is significant in the North zone.
   - Tobacco Streak Virus (TSV) is emerging in Andhra Pradesh, Tamil Nadu, and Maharashtra.
   - Cotton Blue Disease and Cotton leaf roll dwarf virus have limited occurrences.
   - Cotton virescence is specific to Western Africa.
5. **Regional Distribution**:
   - Diseases categorized by their prevalence across different cotton-growing zones:
     - **North Zone**: CLCuD
     - **South Zone**: Verticillium wilt, Leaf rust

- **Central & South Zones**: Grey mildew, Corynespora leaf spot, internal boll rot
- **All Zones**: Alternaria leaf spot, Myrothecium leaf spot, root rot, Fusarium wilt, bacterial blight, target leaf spot, outer boll rot

6. **Emerging Diseases**:
   - TSV and other viral diseases are gaining prominence in various states.
   - Changes in disease patterns influenced by climatic factors and cultivation practices.
7. **Management Strategies**:
   - Importance of accurate field identification for choosing appropriate management strategies.
   - Emphasis on integrated pest management (IPM) practices, including eco-friendly options like biopesticides.
   - Continued research and surveillance crucial for effective disease control and sustainable cotton production.

Cotton Leaf Curl Virus Disease (CLCuD)

- **Introduction and History**:
  - First reported in Nigeria on Gossypium species in 1912.
  - Spread to G. hirsutum in Nigeria and Sudan in the 1920s.
  - Emerged in Pakistan (1967) and India (1989, 1993).
  - Significant threat to cotton production in India's North zone.
- **Symptoms**:
  - Initial symptoms: Small and large vein thickening, leaf curling.
  - Dark green, thickened veins compared to healthy plants.

  - Enations (leaf-like structures) on affected leaves and bracts.
  - Stunted growth, reduced internodal length.
- **Spread and Vector**:
  - Spread by Bemisia tabaci (whitefly), which transmits the virus.
  - Symptoms visible as early as 30 days after sowing.
- **Impact**:
  - Economic losses due to yield reduction.
  - Yield loss ranges up to 72.1% depending on disease severity.
  - Significant reduction in fiber quality and plant vigor.
- **Management**:
  - Bt cotton hybrids and integrated pest management (IPM) strategies.
  - Control of whitefly populations crucial.
  - Research on resistant varieties ongoing.

5.2. Tobacco Streak Virus (TSV)

- **Overview**:
  - Belongs to the genus Ilarvirus, family Bromoviridae.
  - Wide host range including cotton and over 200 plant species globally.
- **Occurrence**:
  - Recorded in multiple countries; sporadic outbreaks in India.
  - Symptoms similar to physiological disorders and herbicide damage.
- **Symptoms**:
  - Chlorosis, bronzing, necrotic streaks on leaves, stems, and flowers.
  - Leaf curling, necrotic buds, and drying of young bolls under severe infection.

- **Spread and Vector**:
  - Transmitted by thrips (Thysanoptera: Thripidae) and through infected pollen.
  - Temperature-sensitive symptoms ranging from mild spots to severe necrosis.
- **Impact**:
  - Early infection can lead to significant yield loss.
  - Severe outbreaks cause premature plant death, reducing yield drastically.
- **Management**:
  - Monitoring and control of thrips populations.
  - Cultural practices to reduce viral spread.
  - Use of tolerant or resistant varieties where available.

□ Cotton Leaf Roll Dwarf Virus (CLRDV)

- **Causal Organism:** Positive-sense, single-stranded RNA virus, Genus Polerovirus, Family: Luteoviridae.
- **Transmission:** Aphid (Aphis gossypii) in a circulative-persistent manner.
- **Symptoms:** Stunting, leaf rolling, intense green foliage, vein yellowing, brittleness of leaves, reduced flower and boll size, sterility.
- **Impact:** Yield losses up to 80% reported in South America.

□ Cotton Leaf Crumple Virus (CLCrV)

- **Causal Organism:** Bipartite DNA genome begomovirus (Geminivirus), transmitted by whitefly (Bemisia tabaci).
- **Distribution:** Southwestern United States, Mexico, Guatemala.

- **Symptoms:** Stunted plants, leaf crumpling, downward leaf curling, interveinal hypertrophy, foliar mosaic.
- **Impact:** Severe outbreaks exacerbated by ratooning.

☐ Cotton Virescence - Phytoplasma

- **Causal Organism:** Phytoplasma associated with virescence, transmitted by brown leafhopper (Orosius cellulosus).
- **Symptoms:** Cessation of internode elongation, reduction in leaf size, witches' broom symptoms, dwarfing, resetting, abnormal floral parts.
- **Impact:** Significant losses in Western Africa, potential threat elsewhere.

☐ Root Rot

- **Causal Organisms:** Rhizoctonia bataticola, Macrophomina phaseolina, Rhizoctonia solani, Sclerotium delphinii.
- **Symptoms:** Lower stem discoloration, wilting, seedling rot, root discolored tips, circular patches in fields.
- **Impact:** Major cause of loss in many countries, prevalent in sandy, alluvial, and heavy clay soils.

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☐ Fusarium Wilt

- **Causal Organism:** Fusarium oxysporum f.sp vasinfectum.
- **Symptoms:** Wilting from top to bottom, yellowing, vascular discoloration, seed and soilborne.
- **Impact:** Diploid cotton (G. arboreum, G. herbaceum), loss from 5% to 40%.

☐ Verticillium Wilt

- **Causal Organism:** Verticillium dahliae.
- **Symptoms:** Wilting, interveinal chlorosis, necrosis, defoliation, vascular discoloration.
- **Impact:** Widespread, affects G. hirsutum, G. barbadense, G. herbaceum, G. arboreum.

☐ **Texas Wilt (Fusarium Wilt Race 4)**

- **Causal Organism:** Fusarium oxysporum f.sp vasinfectum race 4.
- **Symptoms:** Seedling damping-off, wilting, stem and root rot, vascular discoloration.
- **Impact:** Highly virulent, severe early-season damage, affects G. hirsutum, G. barbadense.

Bacterial Leaf Blight (Angular Leaf Spot, Black Arm)

- **Causal Organism:** Xanthomonas citri pv. malvacearum (Smith) Vauterin, Hoste, Kersters & Swings (Xcm).
- **Historical Context:** Significant disease pre-Bt era, decreased with resistant hybrids/varieties, but resurgence observed in central and south India.
- **Phases of the Disease:**
    1. **Seedling Phase:** Tiny round to elongate lesions on cotyledons, deep green and water-soaked, progressing to angular shapes.
    2. **Angular Leaf Spot Phase:** Angular, dark brown lesions on upper leaf surfaces, water-soaked appearance on underside, potential defoliation.

3. **Vein Blight Phase:** Water-soaked lesions on leaves and bracts, restricted by leaf veins, turning brown as they dry.
4. **Black Arm Phase:** Elongated grayish-black lesions on stems, leading to stem infections and potential plant death.
5. **Boll Rot Phase:** Small, round water-soaked spots on bolls, turning sunken and brown, often leading to extensive boll rot due to secondary infections.

- **Symptoms:**
  - Water-soaked lesions progressing to angular shapes on leaves, flower bracts, stems, and bolls.
  - Dark brown, angular necrotic spots, sometimes with a "shot-hole" appearance.
  - Systemic infections showing black streaks on main veins (Vein Blight).
  - Premature defoliation due to severe infections.
- **Observation Period:** From about 45 days after sowing to 105 days (DAS).
- **Impact:** Can cause significant yield losses and affect plant health throughout the growing season.

Bacterial Leaf Blight (Angular Leaf Spot, Black Arm)

- **Causal Organism:** Xanthomonas citri pv. malvacearum (Xcm).
  - **Variability:** Several races exist; Race-18 is particularly virulent.

- **Economic Impact:**
  - **Yield Loss:** Can lead to severe yield losses, up to 20%, depending on the variety and pathogen race.
  - **Research Findings:** Estimated potential yield loss up to 22% with a maximum disease index of 28.8% reported in areas like Dharwad, Guntur, Surat, and Akola (Monga et al., 2013).

This disease is characterized by its varied symptoms across different growth stages of cotton, impacting both foliage and reproductive structures, with potential severe economic consequences if not managed effectively.

Bronze Wilt (Copper Top, Red Wilt, Sudden Wilt, Phloem Wilt)

- **Biosecurity Threat:**
  - **Occurrences:** Reported in the Midsouth and Southeast USA during hot summers of 1995, 1996, and 1998.
  - **Characteristics:** Characterized by bronze or red discoloration and wilting of leaves.
  - **Affected Varieties:** Short-season varieties of Upland and Pima cotton.
- **Where to Observe/Look:**
  - **Stages:** Occurs at any stage, especially during boll development.
  - **Symptoms:** Look for symptoms like copper top, red wilt, sudden wilt, and phloem wilt on plant parts including leaves, flower bracts, bolls, branches, and

stems. Check for wilting despite healthy taproots and lower stems.

- **Symptoms Description:**
  - **Appearance:** Sporadic occurrence across fields, rapid wilting, collapse of youngest leaves, bronzing of leaves, reddening of stem, and fruit shed.
  - **Progression:** Symptoms worsen during fruit development, increasing severity as bolls mature.
  - **Spatial Pattern:** Typically isolated or random plants affected, distinguishing it from other diseases.
- **Causal Organism:**
  - **Uncertainty:** Exact cause not confirmed; both biotic and abiotic factors suspected.
  - **Reported Findings:** In Texas, USA, unique strain of Agrobacterium tumefaciens found in infected taproots.
  - **Environmental Factors:** High temperatures (>32°C for 2-3 weeks), high light intensity, high nitrogen fertilizer, deficiencies in phosphorus, sulfur, or potassium, and high soil pH (>7) conducive to disease.
  - **Impact of Conditions:** Drought followed by rain or irrigation can exacerbate symptoms.
- **Economic Loss:**
  - **Historical Losses:** Devastating losses in 1998 in upper Mississippi River Delta and Gulf Coast States.

- **Example:** Georgia reported cotton losses valued nearly at $25 million in 1998; Pima cotton varieties in Arizona and California also affected.

Bronze Wilt remains a significant challenge due to its sporadic nature and the complex interaction of environmental and possible pathogenic factors affecting cotton production.

Alternaria Leaf Spot or Blight

- **Biosecurity Threat:**
  - **Severity:** Considered minor but can become severe under specific conditions.
  - **Occurrences:** Widespread in India, affects all four cultivated species of cotton (G. hirsutum, G. barbadense, and interspecific hybrids).
- **Where to Observe/Look:**
  - **Stages:** Occurs predominantly during boll formation stages.
  - **Symptoms:** Look for dark brown to black spots with concentric rings on leaves, bracts, branches, and stems.
- **Symptoms Description:**
  - **Early Signs:** Starts with spots on cotyledons of seedlings, causing shedding.
  - **Leaf Symptoms:** Small dull, dark brown circular or irregular spots on upper leaf surface, with concentric rings.

  - **Progression:** Lesions expand, exhibiting concentric zonation, turning gray and dry with necrotic tissue falling out ("shot-holed" appearance).
  - **Impact:** Severe infections lead to blighted or burnt appearance of leaves, resulting in defoliation. Spots may also appear on petioles, stems, and bolls.

- **Causal Organism:**
  - **Pathogens:** Caused by Alternaria spp., including A. macrospora Zimm and A. alternata (Fr.) Keissler.
- **Economic Losses:**
  - **Yield Impact:** Typically not a problem if symptoms occur late in the season.
  - **Historical Data:** Yield loss estimated up to 26.6% during specific periods (2006-2008) in various regions like Rahuri, Guntur, and Dharwad.

Alternaria Leaf Spot or Blight is a recurring issue in cotton cultivation, exacerbated by potassium deficiency and drought conditions, leading to significant defoliation and sporadic economic losses in affected regions.

Cercospora Leaf Spot or Blight

- **Biosecurity Threat:**
  - **Severity:** Generally considered minor and sporadic.
  - **Occurrences:** Found in various cotton-growing regions of India but not reported as a serious threat to crops.
- **Where to Observe/Look:**

    - **Stages:** Occurs from vegetative to boll development stages.
    - **Symptoms:** Look for dull and dark brown circular or irregularly shaped spots with a grey center and dark brown to purple margins on leaves, bracts, branches, and stems.
- **Symptoms Description:**
    - **Early Signs:** Reddish spots on cotyledons of seedlings.
    - **Progression:** Lesions enlarge, turn white to light brown in the center, with concentric rings and distinct dark brown or blackish rims.
    - **Advanced Stage:** Spots dry with a grey center that cracks and may drop, giving a "target board" appearance. Large patches of leaves may wither and drop.
- **Causal Organism:**
    - **Pathogens:** Caused by Cercospora gossypina Cke., with its perfect state known as Mycosphaerella gossypina (Cke.) Atk.
- **Economic Losses:**
    - **Yield Impact:** Not considered a significant cause of yield loss.
    - **Differentiation:** Difficult to distinguish from other foliar diseases like Alternaria, Corynespora, and Myrothecium leaf spots without microscopic examination of spores.

Cercospora Leaf Spot or Blight, while not causing major economic losses, affects leaves and can lead to defoliation under favorable conditions, resembling other leaf spot diseases in appearance and distribution.

Corynespora Leaf Spot or Target Leaf Spot

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- **Biosecurity Threat:**
  - **Severity:** Considered an emerging disease on cotton and other crops in tropical and subtropical regions.
  - **Occurrences:** Widespread in cotton-growing regions of India and reported in several states. Can cause significant yield loss if occurring early in the season.
- **Where to Observe/Look:**
  - **Stages:** Symptoms appear as early as 60-70 days after sowing.
  - **Symptoms:** Look for dark brown to brick-red circular to irregular spots with concentric rings on leaves and bracts.
- **Symptoms Description:**
  - **Appearance:** Starts as small brown to brick-red circular spots, enlarging to about 2 cm in diameter with a target-like pattern.
  - **Progression:** Lesions may coalesce, leading to severe necrosis, premature senescence, and defoliation.
  - **Differentiation:** Unlike Stemphylium and Alternaria leaf spots, Corynespora spots are typically not bordered by a dark band. Defoliation starts at the bottom of the plant and progresses upwards.
- **Causal Organism:**
  - **Pathogen:** Caused by Corynespora cassiicola (Berk. & Curt.) Wei., a fungus widely distributed in the tropics and subtropics, diverse in host association.

- **Transmission:** Soil and partially seed-borne, overwinters in infected plant debris.

- **Economic Losses:**
  - **Impact:** Yield losses reported when disease occurs early in the season, causing significant defoliation.
  - **Incidence:** Reported with 30-40% incidence in certain regions of India and causing 5-40% yield losses in the southern United States.

Corynespora Leaf Spot or Target Leaf Spot poses a threat to cotton crops, especially during early stages of growth, leading to premature defoliation and potential yield losses if not managed effectively.

Myrothecium Leaf Spot

- **Biosecurity Threat:**
  - **Occurrence:** Found throughout India, especially severe in seasons with prolonged rainfall and humidity.
  - **Impact:** Causes significant damage, including defoliation and occasional boll damage, particularly in susceptible cotton cultivars.
- **Where to Observe/Look:**
  - **Symptoms:** Look for light brown to light ash-colored spots on leaves with dark brown/violet to reddish-brown margins.
  - **Fungal Fruit Bodies:** In favorable conditions, concentric rings of pinhead-sized black sporodochia may be visible on the spots.

- **Symptoms Description:**
  - **Appearance:** Small circular to oval spots, 2-10 mm in diameter, which can coalesce into larger patches.
  - **Advanced Symptoms:** Spots may develop a shot hole appearance, and infected leaves may fall off. Lint quality can be affected, becoming strained, yellow, or light brown.
  - **Severity:** Under severe conditions, stems and branches may also be affected, potentially leading to serious blight.
- **Causal Organism:**
  - **Pathogen:** Caused by Myrothecium roridum Tode, a fungus that infects a wide range of hosts and is seed-borne. Thrives in various soil types and conditions.
- **Economic Losses:**
  - **Impact:** Significant yield losses reported during peak infection years, such as 29.2% yield loss with a maximum disease index of 22.5% in Madhya Pradesh.
  - **Historical Incidence:** Noted outbreaks in Madhya Pradesh, where economic losses were estimated up to 37% intensity.

Myrothecium Leaf Spot is a notable disease affecting cotton, characterized by its distinctive symptoms and potential for causing economic losses, especially in regions prone to wet and humid conditions.

Colletotrichum Leaf Spot or Anthracnose

- **Biosecurity Threat:**
  - **Occurrence:** Initially prevalent in all cotton-producing zones, now occasionally observed in southern and central parts of India.
  - **Impact:** Primarily affects cotton at various growth stages, potentially causing significant damage during seedling and boll development stages.
- **Where to Observe/Look:**
  - **Symptoms:** Check for reddish-brown or dark-brown lesions just below the ground level on seedlings. On leaves, look for small circular, sunken reddish to brown spots, especially on margins or near tips. Cankers may appear on stems, initially small and reddish or brown with a depression, later turning black. On bolls, observe reddish-brown to purplish-brown spots with a depressed center.
- **Symptoms Description:**
  - **Seedling Stage:** Lesions appear below ground level, causing seedling collapse or yellowed leaves without collapse. Cotyledons may exhibit small necrotic spots.
  - **Leaf Stage:** Circular, sunken spots on leaves expand with a deep brown margin. Under severe infection, spots can lead to defoliation. Black acervuli (fungal fruiting bodies) may develop on lower leaf surfaces in humid conditions.
  - **Stem and Boll Stage:** Stem cankers appear as small reddish or brown spots that may later turn black. Boll symptoms include reddish-brown to purplish-brown

spots, which may turn black with a reddish margin. Infected bolls show compact, discolored lint covered with mucilaginous, pink spore masses in humid conditions.

- **Causal Organism:**
  - **Pathogens:** Colletotrichum gossypii Southw (perfect stage Glomerella gossypii), Colletotrichum capsici (Syd.) Butl. & Bisby.
  - **Characteristics:** Soil-borne fungi capable of infecting various plant parts from seedling to boll, thriving in humid conditions.
- **Economic Losses:**
  - **Impact:** Previously considered destructive in Tamil Nadu and Madhya Pradesh, but current losses are negligible. Occasional outbreaks noted in southern and central India.

Colletotrichum Leaf Spot, also known as anthracnose, poses sporadic threats to cotton production in India, primarily under humid conditions and affecting multiple stages of plant growth from seedling emergence to boll maturation.

Helminthosporium Leaf Spot

- **Biosecurity Threat:**
  - **Occurrence:** Occasional in many cotton-growing areas of India, particularly noted in the Dharwad region of Karnataka.
  - **Impact:** Considered a minor disease with minimal impact on yield.

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- **Where to Observe/Look:**
    - **Symptoms:** Look for numerous circular, light brown spots (0.5-2.5 mm in diameter) initially on lower leaves. Spots may later turn ashy in the center with a dark purple ring around them.
- **Symptoms Description:**
    - **Early Symptoms:** Small, circular light brown spots appear on lower leaves.
    - **Progression:** Spots may develop an ashy center with a dark purple ring. Tissue in the center of spots may drop out, leaving holes. Severe infections can lead to early defoliation.
    - **Boll Symptoms:** Rarely observed on bolls under natural conditions, but similar spots may develop on bracts.
- **Causal Organism:**
    - **Pathogen:** Helminthosporium gossypii Tucker.
    - **Hosts:** Infects all four cultivated species of Gossypium, including tree cotton.
    - **Survival:** Overwinters on diseased plant debris, particularly dead leaves during the off-season.
- **Economic Losses:**
    - **Impact:** Does not cause noticeable yield loss and is considered a minor disease in cotton cultivation.

Helminthosporium Leaf Spot, caused by Helminthosporium gossypii Tucker, is sporadically observed in cotton-growing

regions of India, primarily affecting lower leaves with small, light brown spots that may progress to ashy centers with dark purple rings. This disease typically results in minimal economic impact on cotton production.

Ascochyta Blight (Wet Weather Blight)

- **Biosecurity Threat:**
  - **Distribution:** Widely occurs in cotton-growing regions, especially during continuous rainy periods in Maharashtra, Gujarat, Tamil Nadu, and Karnataka.
  - **Impact:** Can cause serious seedling disease leading to potential loss of plant stand.
- **Where to Observe/Look:**
  - **Symptoms:** Look for lesions on cotyledons, leaves, stems, and bolls. Initial symptoms on lower leaves progressing upwards. Check for light brown to circular spots or shot holes with a narrow, dark border. Look for small black fruiting structures on older lesions.
- **Symptoms Description:**
  - **Early Stage:** Lesions appear as small, white to light brown circular spots (<2 mm in diameter) on cotyledons and leaves, which can coalesce into irregular necrotic spots. Dark borders may surround necrotic areas, sometimes giving a target-like appearance.
  - **Stem Symptoms:** Elongated canker spots with reddish-purple to black or ash gray colors observed on stems, potentially leading to death of affected parts.

    - **Boll Symptoms:** Rough, circular lesions may develop on bolls, sometimes leading to boll rot.
- **Causal Organism:**
    - **Pathogen:** Ascochyta gossypii Woron (perfect stage Phoma exigua).
    - **Hosts:** Wide host range, serving as a collateral host for the pathogen.
- **Economic Losses:**
    - **Impact:** Although widespread, actual yield loss is rarely reported. In favorable conditions, such as prolonged rains, it may affect plant stand. Light infections may allow plants to recover at later stages.

Ascochyta Blight, also known as Wet Weather Blight or Wet Weather Canker, is caused by Ascochyta gossypii Woron. It is prevalent in major cotton-growing regions and primarily affects young plants, causing circular lesions that can lead to significant plant stand reduction under prolonged wet conditions.

Ramularia Grey Mildew

Overview:

- **Names:** Grey mildew, areolate mildew, false mildew, white mildew, Dahiya (curd disease).
- **Distribution:** Found in cotton-growing regions of Madhya Pradesh, Bihar, Maharashtra, Karnataka, Andhra Pradesh, and Tamil Nadu in India.
- **Hosts:** Affected primarily Asiatic cotton (G. arboreum and G. herbaceum) historically, but also impacts many

hybrids/varieties of G. arboreum, G. herbaceum, and G. hirsutum.

- **Incidence:** Increased from 2008-2011 and remains a concern in central and southern zones of India.

Symptom Description:

- **Appearance:** Symptoms appear on leaves, starting from lower to middle canopy during vegetative to boll formation stages (60-120 days after sowing).
- **Spots:** Irregular, angular, pale, translucent spots (1-10 mm wide), restricted by major leaf veinlets (areolae), slightly chlorotic on upper leaf surface.
- **Fungal Growth:** Initially a frosty or mildew growth of conidiophores appears on undersurface, later spreading to upper leaf surface.
- **Progression:** Leaves may turn yellowish-brown, lesions can become necrotic resembling bacterial blight, leading to premature defoliation.
- **Other Locations:** Lesions also found on bracts subtending bolls and occasionally on cotyledons without sporulation unless in a moist chamber.

Identification Tips:

- **Differentiation:** Can be mistaken for bacterial leaf blight; look for dirty-white fungal growth (grey mildew) or water-soaked lesions (bacterial leaf blight).
- **Unique Feature:** White, powdery growth on underside of leaves distinguishes grey mildew from other common cotton diseases.

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Causal Organism:

- **Pathogen:** Ramularia areola Atk.
- **Survival:** Persists on infected dead leaves, perennial cotton, volunteer plants, and overlapping crops within the genus Gossypium.

Economic Impact:

- **Hybrid Susceptibility:** Majority of released Bt hybrids are moderately to highly susceptible.
- **Impact:** Yield losses estimated between 25.6% to 46.6% during 2009-2011 in affected regions like Dharwad, Guntur, and Nanded.

Ramularia Grey Mildew poses significant threats to cotton cultivation in India, affecting leaf health, plant productivity, and economic outcomes. Vigilant monitoring and early intervention strategies are crucial to mitigate its impact on cotton crops.

Phakospora Leaf Rust

Overview:

- **Causal Organism:** Phakospora gossypii (Arth.) Hirat. F.
- **Distribution:** Sporadic occurrence in cotton-growing regions of Tamil Nadu, Gujarat, Andhra Pradesh, and Karnataka, India.
- **Historical Impact:** Previously considered minor but reported yield depressions up to 24% in Coimbatore during 1963.

- **Current Status:** Increasing importance in southern India, affecting cotton crops late in the season, potentially aiding in defoliation before harvest.

Symptom Description:

- **Appearance:** Symptoms primarily on older leaves, progressing to younger ones, appearing during flowering to boll formation stages (120-180 days after sowing).
- **Rusty Spots:** Light to brown rusty spots develop on older leaves, leading to premature defoliation.
- **Uredial Sori:** Small pinkish-brown spots (1-3 mm) coalesce to form larger patches. Yellowish-brown uredia visible on both leaf surfaces.
- **Distribution:** Primary uredia deeply immersed on upper leaf surface, secondary uredia shallowly seated on lower leaf surface. Oval to circular shapes on pedicels and branches.
- **Spore Release:** Urediospores exposed upon epidermal rupture, favored by cooler temperatures.

Identification Tips:

- **Observation Areas:** Lower to middle leaves during flowering to boll formation stages. Look for rusty spots, premature defoliation, and yellowish-brown uredia on both leaf surfaces.

Causal Organism and Seasonality:

- **Pathogen:** Phakospora gossypii (Arth.) Hirat. F.
- **Seasonality:** Predominantly appears during the dry season in South India, notably from December to March.

Economic Impact:

- **Recent Losses:** Significant yield losses reported due to early appearance and severe incidences during the reproductive phase, particularly noted in northern Karnataka.
- **Estimated Losses:** Yield losses ranging from 21.7% to 34.05% in various hybrids/varieties in Andhra Pradesh and Karnataka during recent years.

Phakospora Leaf Rust poses a significant threat to cotton crops in India, impacting yield and necessitating careful monitoring and management strategies to minimize economic losses.

External Boll Rot

Overview:

- **Definition:** External boll rot refers to the decay of cotton bolls caused by a complex of fungal and bacterial pathogens, as well as saprophytic organisms.
- **Complex Nature:** Involves about 170 organisms, impacting cotton production and lint quality, categorized into three groups based on causal mechanisms.
- **Environmental Factors:** Triggered by factors like continuous cloudy weather, rain showers, warm temperatures, and high humidity, facilitating fungal and bacterial growth.

Symptom Description:

- **Appearance:** Initially manifests as small brown or black dots on bolls, which can expand to cover the entire surface.

- **Progression:** Infection extends to inner tissues, leading to seed and lint rotting.
- **External Signs:** Mycelial growth and fungal fruiting bodies visible on infected bolls, particularly under warm, humid conditions.
- **Impact:** Premature opening of infected bolls, affecting fiber quality. Bolls may fall prematurely or show pericarp rot while internal tissues remain unaffected.

Identification Tips:

- **Observation Areas:** Lower to middle bolls during boll formation stages (120-180 days after sowing). Look for discolored, water-soaked, or brown to black spots on bolls.
- **Visual Clues:** Presence of fungal growth and fruiting structures on boll surfaces indicates external boll rot.

Causal Organisms:

- **Pathogens and Saprophytes:** Includes a variety of fungal (e.g., Colletotrichum gossypii var. cephalosporioides, Fusarium sp., Ramularia areola, Lasiodiplodia theobromae) and bacterial species (e.g., Xanthomonas citri pv. malvacearum).
- **Examples:** Other pathogens involved are Phoma exigua, Phytophthora spp., Rhizoctonia spp., Aspergillus spp., among others.

External boll rot presents a significant challenge in cotton cultivation, influenced heavily by climatic conditions and insect damage, necessitating integrated pest management strategies for effective control.

Internal Boll Rot

Overview:

- **Definition:** Internal boll rot refers to the decay of cotton bolls caused by bacterial and fungal pathogens, often entering through wounds made by piercing-sucking insects like stink bugs.
- **Impact:** Significant economic losses, with reports of up to 10-15% yield loss in the USA and higher losses in regions like Xinjiang Province, China, and in Indian cotton fields.

Causal Organisms:

- **Bacteria:** Includes Pantoea agglomerans, Pantoea ananatis, Pantoea dispersa, Pantoea anthophila, Erwinia uredovora, and Xanthomonas citri pv. malvacearum.
- **Fungi:** Such as Nigrospora oryzae and Colletotrichum gossypii, among others.

Symptom Description:

- **Initial Signs:** No external symptoms visible; the boll may appear healthy on the outside.
- **Identification:** Symptoms only apparent when bolls are opened or cross-sectioned, revealing discolored locules (seed compartments) and seeds with brown, slimy lint.
- **Internal Damage:** Infected locules may exhibit rot, causing seeds to swell, discolor, and eventually rot. Headlocks, where entire locules are diseased, may also occur.

Environmental Triggers:

- **Conditions:** Continuous rain, cloudy weather, and high humidity during bud and boll development promote infection. Insect infestations during this period can exacerbate the problem.

Where to Observe/Look:

- **Observation Areas:** Start observing from any part of the cotton plant, particularly in the lower canopy where bolls develop.
- **Visual Inspection:** Cross-open bolls to inspect locules and seeds for signs of rot and discoloration. Check for slimy presence and abnormal coloration in seeds and lint.

Economic Impact:

- **Loss Estimates:** Internal boll rot can lead to productivity losses ranging from 20-30%, depending on geographic location, climate conditions, pathogen presence, and insect vector populations.

Internal boll rot underscores the importance of integrated pest management and timely monitoring during early boll development stages to mitigate potential losses in cotton production.

Physiological Disorders

Parawilt or Sudden Wilt Complex in Cotton

Overview:

- **Definition:** Parawilt or sudden wilt is a physiological disorder affecting cotton plants, primarily caused by disruptions in the soil-plant-atmosphere continuum,

particularly due to adverse environmental conditions like flooding or soil saturation.

- **Geographical Distribution:** Recorded across various cotton-growing states, particularly affecting newly released hybrids and varieties, causing significant damage in Central, South, and North cotton-growing zones.

Symptom Description:

- **Initial Signs:** Wilting begins from the top of the plant shortly after water stagnation occurs in the root zone.
- **Severity:** More pronounced in clayey soils due to slower drainage; however, sandy soils can also be affected if drainage is inadequate.
- **Progression:** Leaves wilt rapidly, often leading to complete defoliation within a few days, while bolls typically remain attached.
- **Impact on Yield:** If occurring near harvest, bolls may prematurely open but fail to ripen fully, resulting in reduced quantity and poor quality lint.

Environmental Triggers:

- **Causes:** Mainly triggered by factors such as sudden rain followed by water stagnation, high air temperatures, and intense sunshine.
- **Root Conditions:** Poor root development or shallow roots exacerbate the problem, particularly in soils with soil hardpan/compactness, low organic carbon, and under continuous cropping systems.

- **Metabolic Activity:** Rapidly growing plants during the grand growth stage exhibit higher metabolic activity, transpiration rates, stomatal conductance, and photosynthesis, which contribute to increased susceptibility to sudden wilting.

Where to Observe/Look:

- **Observation Areas:** Symptoms manifest in the plant canopy. Root examination may reveal healthy appearance without fungal growth.
- **Signs:** Monitor for rapid wilting progression from top to bottom of the plant within hours. Prompt treatment is crucial to prevent complete defoliation.

Causal Factors:

- **Primary Factors:** Soil saturation or waterlogging, rapid plant growth rates during critical growth stages, and environmental conditions promoting high stomatal conductance, transpiration, and photosynthesis.
- **Root Impact:** Oxygen deficiency due to waterlogged soil leads to root and root hair death, restricting water uptake and transport, further exacerbating wilt symptoms.

Management Considerations:

- **Prevention:** Implement drainage improvements, avoid excessive irrigation, and choose appropriate planting times to mitigate risk.
- **Early Detection:** Regularly monitor plant health and intervene promptly with appropriate treatments to minimize yield losses.

Parawilt or sudden wilt underscores the importance of soil management practices and timely monitoring to mitigate the impact of environmental stresses on cotton production.

Red Leaf or Leaf Reddening Complex in Cotton

Overview:

- **Common Names:** Also known as "lal patti" in India, and variously referred to as Bronze wilt, Copper top, Sudden wilt, and Phloem wilt in the U.S. and other countries.
- **Emergence:** A serious physiological disorder affecting cotton in several cotton-growing regions of the Indian subcontinent.

Symptom Description:

- **Appearance:** Reddening symptoms typically manifest during boll development and may intensify as bolls mature.
- **Initial Signs:** Fully expanded leaves exhibit raised areas between veins, with yellowing margins that transition into red pigmentation covering the entire leaf.
- **Progression:** Reddening may spread to other leaves and the stem, potentially leading to stunted plant growth and premature shedding of leaves and bolls.

Where to Observe/Look:

- **Observation Areas:** Symptoms are visible above ground level on leaves, stems, and bolls.
- **Monitoring:** Critically observe leaf reddening and its progression across the plant canopy and boll development stages.

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Causal Factors:

- **Abiotic Factors:** The exact cause remains unclear, but factors proposed include:
  - Nitrogen deficiency
  - Water stagnation and high soil moisture
  - Magnesium deficiency
  - Cloudy weather and low night temperatures
  - Environmental stressors like drought followed by rain or irrigation, high wind velocity, and intense solar radiation

Management Strategies:

- **Preventive Measures:**
  - Improve soil drainage and avoid waterlogging.
  - Implement balanced fertilization practices based on soil test reports to prevent deficiencies.
  - Adjust planting schedules to avoid periods of high environmental stress.
  - Use recommended Bt hybrids/varieties resistant or tolerant to CLCuD (Cotton Leaf Curl Disease).
- **Cultural Practices:**
  - Maintain field cleanliness to reduce weed hosts and pests like whiteflies.
  - Rotate crops to break disease cycles and improve soil health.

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- Incorporate organic matter and use bioagents like Trichoderma spp. and Pseudomonas fluorescence for disease management.
- Avoid saving and replanting seeds from infested fields without effective treatment.

- **Chemical Treatments:**
  - Apply seed treatments with fungicides or biopesticides to manage seed and soil-borne diseases.
  - Use micronutrient applications (e.g., zinc, magnesium, manganese, boron) as needed to supplement crop health.

Red leaf or leaf reddening complex underscores the importance of holistic management practices, including soil health improvement, balanced fertilization, and timely disease monitoring to mitigate its impact on cotton production. Regular field observation and adherence to recommended practices are crucial for effective disease management.

Zone	Disease/Stage	Management Practices
North Zone	**CLCuD**	- 3-5 foliar sprays of Salicylic acid (200 ppm), or buttermilk 5%, or Cow urine + Calcium nitrate (6.6% + 0.5%), or mustard oil (3.0%) at fortnightly intervals starting from 30 days after sowing.
	Early Season	- Spot application of Carbendazim @ 2.0 g/L of water or

		Trichoderma harzianum/viride @ 6 g/L in affected patches.
	Mid-Season	- Continued management with Carbendazim or Trichoderma for root rot/wilt.
	Late Season	- Fungicidal sprays for Alternaria & Cercospora leaf spots.
	Other Issues	- Sooty Mold: Flonicamid, propiconazole, mancozeb, COC.
		- Boll Rot: Copper oxychloride, Copper sulphate + Mancozeb.
		- Leaf Reddening: Foliar sprays of MgSO4, Urea, Zinc Sulphate, Boron, DAP.
Central Zone	**Rahuri, Maharashtra**	- Seed Treatment: Pseudomonas fluorescens, Soil Application of T. viride, Foliar sprays with Ergon, Taqat.
	Akola, Maharashtra	- Similar to Rahuri with additional fungal disease and ALS control.
	Nanded, Maharashtra	- Similar to Akola with specific emphasis on fungal disease and BLB control.
	Junagarh, Gujarat	- Seed Treatment with P. fluorescens or T. viride, specific fungicide and insecticide sprays.

	Surat, Gujarat	- Similar to Junagarh with tailored fungicide and insecticide applications.
South Zone	**Coimbatore, Tamil Nadu**	- Seed Treatment with Bacillus subtilis, Soil Application of T. viride, Foliar sprays with B. subtilis.
	Guntur, Andhra Pradesh	- Seed Treatment with P. fluorescens, Soil Application of T. viride, Foliar sprays with kresoxim methyl, COC.
	Dharwad, Karnataka	- Seed Treatment with P. fluorescens, Soil Application of T. viride, Foliar sprays with Ergon, Taqat, COC.

This table provides a concise overview of the disease management strategies recommended for each zone, focusing on specific diseases and growth stages of cotton cultivation.

Nutritional deficiencies and their managements

Nutrient	Deficiency Symptoms	Management Practices
Nitrogen	Uniform yellowing of leaves, more pronounced on older leaves; leaves become stiff and detach easily.	Top dressing with inorganic nitrogen fertilizer (e.g., Urea or DAP).
Phosphorus	Small, erect, dark green leaves; bronzy	Soil-applied fertilizers like Superphosphates or

	appearance on underside; restricted root growth.	monoammonium phosphate.
Potassium	Yellowing starts from leaf tips/margins, interveinal yellowing with necrotic spots; leaf curling.	Soil application of potassium fertilizers like muriate of potash or potassium sulphate.
Calcium	Chlorosis of young leaves along veins, bleaching of upper leaves, leaf tip curling (dieback).	Application of gypsum to correct soil pH.
Magnesium	Yellowing between veins of older leaves, green veins remain; necrosis; induced by high ammonium levels.	Foliar application of $MgSO_4$ to correct deficiency.
Sulfur	Yellowing similar to nitrogen deficiency, starts on younger leaves; narrow leaves with pale veins.	Application of sulfur (e.g., gypsum) or foliar spray of $MgSO_4$.
Iron	Interveinal chlorosis in young leaves, veins remain green; severe deficiency turns leaves white.	Soil application or foliar spray of $FeSO_4$ or iron chelate.

Zinc	Narrow, small leaves with green veins; dead spots; reduced shoot growth.	Incorporation of ZnO or $ZnSO_4$ in soil; foliar applications of $ZnSO_4$.
Boron	Irregular thickening of petioles, dark areas of tissue, floral abnormalities; "parrot beak" in severe cases.	Foliar boron applications; spray borox solution.
Manganese	Chlorosis followed by necrosis between veins; small leaves that abscise early.	Soil application of $MnSO_4$ or foliar spray to correct deficiency.
Molybdenum	General yellowing, interveinal chlorosis, marginal necrosis; rare in alkaline soils.	Spray micronutrient salt mixed with lime solution for quick recovery.
Copper	Chlorosis changing to necrosis, leaf rolling, wilting, twisting; affects young leaves.	Spray $CuSO_4$ or soil application to correct deficiency.
Chlorine	Pale green patches between veins, downward cupping of older leaves; necrosis at leaf margins.	Corrective sprays or soil treatments with appropriate chloride sources.

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This table provides a structured overview of each nutrient's deficiency symptoms and the recommended strategies for managing deficiencies in cotton plants.

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