Lentil (Lens culinaris) is an Old-World grain legume. Lentil is grown in Africa, Australia, Asia (Indian Subcontinent, Middle East, and West Asia), North America, North Africa, and Southern Europe. Two subspecies of lentil are cultivated in the world: macrosperma and microsperma. Macrosperma is found in the Mediterranean region and the New World (bigger seed size, 6–9 mm in diameter with yellow cotyledons) and microsperma (smaller seed size, 2–6 mm with red-orange cotyledons) is found on the Indian subcontinent and East Africa (Muehlbauer et al. 1985). Lentil is a major plant protein source that can provide moderate amounts of most essential amino acids and contains fair amounts of minerals, vitamins, and complex carbohydrates. This crop can fix atmospheric nitrogen and can sequester carbon, hence, can improve fertility and nutrient status of soil and further contribute to the sustainability of the agricultural production system. Legumes are a major part of agriculture in Nepal and are grown on about 11% of cultivated land, with lentil covering about 62% area of total legumes (Gharti et al. 2014). In Nepal, lentil is consumed locally and is also exported. Nepal exports lentil to Bangladesh, Singapore, Sri Lanka, Germany, Korea, UK, and Indonesia. In Nepal, lentil is a winter grain legume and commonly known as ‘masoor.’ Lentil is grown in agroclimatic zones of Terai, Inner Terai, and the mid-hills in Nepal. The occurrence of diseases and insect pests is a major constraint for lentil production and environmental conditions play an important role. Some diseases and insect pests are persistent and found in wide geographical areas. In Nepal, major diseases of lentil including fusarium wilt, stemphylium blight, botrytis gray mold, and rust can cause more than 80% of yield loss. Among insect pests, aphid, cutworm, and pod borer are major problems (Chen et al. 2011; Darai et al. 2017; Stevenson et al. 2007; Taylor et al. 2007).

WHAT IS IPM?

Integrated pest management (IPM), an environmentally-sound and economical approach to pest control, was developed in response to pesticide misuse in the 1960s. Pesticide misuse has led to pesticide resistance among prevailing pests, a resurgence of non-target pests, loss of biodiversity, and environmental and human health hazards.

WHAT ARE IPM PACKAGES?

The IPM Innovation Lab has developed and tested robust IPM packages, holistic suites of IPM recommendations and practices for the production of vegetables and other crops. Farmers who use IPM packages in planting, production, and throughout the supply chain see enhanced profitability in their crops. The recommended practices in IPM packages cover economically significant pest species over a wide range of cropping systems across the tropical world, resulting in benefits to human health and the environment.
Diseases
identification, descriptions, and images

Photos (From left):
- Botrytis gray mold
- Stemphylium blight
- Ascochyta Blight

CropPro

KnowPulse

DISEASES

Stemphylium blight
(*Stemphylium botryosum*)

It is a major problem in Asia and could cause more than 80% lentil crop loss. The host range of this disease is wide. It causes small, light-beige lesions that spread first on the upper canopy and then spread to the lower canopy. This causes leaf loss, and decreases plant biomass, seed size, yield, and germination rates. Several resistant and tolerant cultivars are available in Asia (such as Barimusur-4, -5, -6). A combination of intentional planting dates and resistant varieties is beneficial to manage this disease. Early sowing (mid-October) can significantly reduce this disease compared to when the crop is sown in December.

Ascochyta Blight
(*Ascochyta lentis*)

This disease attacks all aboveground plant parts at every growth stage. It causes severe lesions on leaves, petioles, stems, and pods. When severely infected, lesions girdle the stem and cause the death of all tissues above the lesion. It also causes shriveling, discoloration of seeds, and reduction in seed quality and yield. This disease is found in Asia, USA, Canada, and Australia.

Powdery mildew
(*Erysipheae polygoni*)

This disease causes small white spots on leaf surfaces, pods, and flowers. When heavily infested, leaves become chlorotic, curled, and necrotic before abscission. This causes a reduction in yield. Cool and dry weather is favorable for this disease and it is prevalent in Asia.

Botrytis gray mold
(*Botrytis cinerea*)

It affects aboveground plant parts including leaves, stem, flowers, pods, and seeds. The outbreak of this disease is reported in all growing regions. A series of cool, wet summers is ideal for its development. The first infection appears as dark green lesions on flowers, pods, or lower canopy, and then turns into pale, tan spots. Severely infected leaves wilt and fall and ultimately plants can die. Infected seeds are shriveled and discolored.

Fusarium Wilt
(*Fusarium oxysporum*)

This disease is found on almost all continents including the Americas, Africa, Europe, and Asia. It affects seedlings and reproductive stages. Wilting of top leaves, plant stunting, shrinking and curling of leaves, reduced root growth, and damaged tap root system are typical symptoms. In Asia, it is also reported at the seedling stage. Resistant and early maturing cultivars are available in several countries. Synergistic interaction between fusarium wilt and root-knot nematode (*Meloidogyne* spp.) has been observed in some lentil cultivars, hence the presence of nematodes in the field significantly increases wilt incidence. Damage done by nematodes facilitates the disease's infection on roots. Controlling one will help control the other. Seed treatment with *Trichoderma* spp. and *Pseudomonas fluorescens* can be used to reduce nematode incidence.

Collar rot
(*Sclerotium rolfsii*)

It causes yellowish brown discoloration, and rotting of infected regions. Dirty white-to-brown sclerotia are visible. This proceeds downward and causes root rot. Use of calcium fertilizers helps in reduction of this disease.

Downy mildew
(*Peronospora lentis*)

It infects all the aerial plant parts and causes curled, twisted leaves, and dwarfed tips. Cool and humid conditions are favorable. Infected plants remain stunted and form bushy apical growth. Resistant germplasm lines have been identified.
viruses, nematodes, insect pests

VIRUSES

Cucumber mosaic virus
It causes chlorosis, leaf malformation, and stunting in plants. Leaflets show a mild mosaic and reddening of leaf margins. This virus is transmitted by several aphid species.

Bean yellow mosaic virus
It causes malformation, motting, and stunting in plants. Infected leaves get twisted and curled. Flowering and pod formation are reduced and small seeds are produced by the infected plants. This is transmitted by several aphid species in a nonpersistent manner.

Pea seed-borne mosaic virus
It causes filiform leaves, indistinct mosaic patterns, motting, chlorosis, reddening, necrotic lesions, proliferations of stems, and abortion of pods. It is transmitted by several aphid species.

NEMATODES

Reniform Nematode
[Rotylenchulus sp. (Tylenchida: Hoplolaimidae)]
It causes patches of stunted chlorotic plants. Infected plants grow less vigorously.

Root-knot Nematode
[Meloidogyne spp. (Tylenchida: Heteroderidae)]
It has a wide host range and causes excessive branched and galled roots. It aids in Fusarium fungus entry into the roots.

INSECT PESTS

Aphids
[Aphis craccivora and Acrithosiphon pisum (Hemiptera: Aphididae)]
Aphids feed on several grain legumes. The action threshold is 1-2 aphids per leaf and 9-13 aphids per sweep. They suck the sap and colonize in large numbers and secrete powdery, sugary material. They cause sooty mold on the plants and also vector several viruses. Aphis craccivora is a vector of Alfalfa virus, Cucumber mosaic virus (CMV), and Lentil tobacco streak virus. Aphids usually infest lentil at the podding stage, but if they infest at an early stage, then control is necessary. Natural enemies recorded are predators including Coccinella septempunctata, C. transversalis, Cheiomenes sexmaculatus, Menochilus sexmaculatus, Brumus suturalis (all Coleoptera: Coccinellidae), chrysopids including Chrysoperla spp. (Neuroptera: Chrysopidae), and parasitoids including Trioxys indicus and Lipolexis scutellaris (Hymenoptera: Braconidae). Yellow sticky traps are useful to monitor aphids.

Green stink bug
[Nezara viridula (Hemiptera: Pentatomidae)]
Green stink bug is a polyphagous pest that sucks the sap from leaves, stems, and pods, and thus causes malformation and drying of plants. It causes heavy damage during the reproductive stage of the plant. Early planting, close spacing, and trap crops are used to manage this pest. The parasitoid Trissolcus basalis (Hymenoptera: Platygastridae) is known to attack eggs of stink bug.

Lygus spp. (Hemiptera: Miridae)
Lygus are a major pest in lentil production. Scouting is critical to spot the presence of lygus. Lygus bugs pierce tender leaves, stems, buds, petioles, and developing seeds. They cause serious damage to seeds and great economic damage due to chalky spot syndrome, which is characterized by pitted, crater-like depressions in the seed coat with or without a discolored chalky appearance. Economic thresholds have been established for lygus control. During bloom, one lygus bug for every three sweeps indicates action threshold.

Black cutworm
[Agrotis ipsilon (Lepidoptera: Noctuidae)]
Black cutworm is polyphagous and spread around the globe. The larvae feed on leaves, stems, and roots of lentil. The older larvae cut the plant above the root zone. Weeds in and around the crop are major oviposition sites. The sporadic nature of cutworm populations makes preventive treatments futile. One way to control cutworm is to broadcast a poison bait prepared with wheat bran, cotton, or groundnut cake, and moistened with water. Parasitoids, Bracon kitcheneri, Fileanta ruficanada, and Microgaster spp., are common in India. Natural enemies recorded include parasitoids Trichogramma spp. (Hymenoptera: Trichogrammatidae), Apanteles marginiventris, Microplitis sp. (Hymenoptera: Braconidae), Campeletis flavicincta, Hyposoter annulipes, and Ophion flavidus (Hymenoptera: Ichneumonidae), and tachinid flies (Diptera: Tachinidae), and predators Broscus punctatus (Coleoptera: Carabidae) and Liogryllus bimaculatus.
insect pests and other threats

Pod borer *Helicoverpa armigera* (Lepidoptera: Noctuidae)]

Pod borer is less of a problem in Asia compared to other parts of the world. The larvae cause damage to the leaves with young instars scraping the surface of leaflets and feeding on flowers, while older larvae feed on foliage and are more damaging to pods. The adults are active at night and lay hundreds of eggs individually on the underside of leaflets. The last instar drops to the soil to pupate. Natural enemies include *H. armigera*, Nucleopolyhedrosis Virus (HaNPV), *Trichogramma chilonis* (Hymenoptera: Trichogrammatidae), *Telenomus sp.* (Hymenoptera: Braconidae), Leaf weevil (*Sitona crinitus*, *Sitona macularius* (Coleoptera: Curculionidae)) and Thrips (*Frankliniella spp.* (Thysanoptera)) have been reported to have a higher larval population of *E. zinckenella*. The parasitoids *Bracon etiellae*, *Bracon pectoralis*, *Phanerotoma planifrons*, and *Pigeria piger* have been reported on larvae (Hymenoptera: Braconidae).

Bruchids [*Bruchus ervi*; *Bruchus lentis* (Coleoptera: Chrysomelidae)]

Bruchids are known storage grain pests; however, they do not reproduce in the storage. The adults feed on nectar and pollen and lay eggs on the young pods. Upon hatching, the larvae penetrate the pod and feed on developing seeds. Usually, single larvae feed on the single seed. Larvae eat and create a thin circular exit hole. After pupation, the emerging adult leaves the pod through this exit hole. Adults remain in the seeds or hibernate in protected places such as residual crop. Hot air and water treatment and drying are major cultural management methods.

OTHER IMPORTANT DISEASES, INSECT PESTS, AND NEMATODES

**Alternaria blight**

*Alternaria tenuis*

**Black streak root rot**

*(Thielaviopsis basicola)*

**Black root rot** *(Fusarium solani)*

**Sclerotinia stem rot** *(Sclerotinia sclerotiorum)*

**Dry root rot** *(Macrophomina phaseolina, Rhizoctonia bataticola)*

**Stored grain pests** *(Callosobruchus chinensis, Callosobruchus maculatus* (Coleoptera: Bruchidae))

**Leaf weevil** *(Sitona crinitus, Sitona macularius* (Coleoptera: Curculionidae))

**Bud weevil** *(Apion arrogans* (Coleoptera: Curculionidae))

**Thrips** *(Frankliniella spp.* (Thysanoptera))
CULTURAL MANAGEMENT

- Soil sanitation is necessary to manage soil-borne diseases and soil inhabiting insect pests.
- Organic soil amendments and mulching with oat or maize straw can be used.
- Sun drying or solar treatment (exposing to 70-80° C) of seeds and application of bentonite dust and hydrated lime to control bruchids.
- Crop rotation and a 2-3-year period without lentil production to reduce disease incidence.
- Crop rotation with lentil and maize can be beneficial.
- Changes in planting dates to avoid infection and infestation of some diseases and insect pests is recommended.
- Wide row spacing to reduce insect pest incidence.
- Weed management in the field to avoid alternate hosts for insect pests.
- Canopy management to manage microclimate to avoid diseases in lentil.
- Use of disease-free seeds.
- CIMMYT (The International Maize and Wheat Improvement Center) is developing and evaluating an ‘early warning system (EWS) for movement of agents – Stemphylium blight risk forecasting using Stempedia,’ a weather-based model.
- Sun drying for 3 hours for 3-4 consecutive days can manage seed-borne diseases.

MICROBIALS

- Several naturally available microbials are useful for managing diseases and insect pests of lentil without causing harm to humans, the environment, and natural enemies.

- Entomopathogenic fungus, Beauveria bassiana, Metarhizium anisopilae, Paecilomyces lilacinus to manage stink bug and lygus bugs.

- Soil/seed application of Trichoderma harzianum, T. viridae, Bacillus subtilis, Pencillium spp., and Gliocladium virens can be used to manage collar rot.

- Bacteria Pantoea agglomerans, Pseudomonas fluorescens, Penicillium griseofulvum, and the fungus Trichoderma spp. reduce severity of botrytis gray mold.

- Soil inhabiting fungus Paecilomyces lilacinus used with neem cake controls nematode infestation in the field.

- Seed treatment Trichoderma sp., Streptomyces pseudomonas, and Bacillus spp. to manage fusarium wilt/root rot of lentil.

- Most of the diseases are seed-borne, hence treating seeds can be a good option. If Trichoderma is used, then use of gum arabic can increase its efficacy.

- Seed treatment with Rhizobium sp. for root-nodule development is useful.

BIOPESTICIDES AND CHEMICAL PESTICIDES

Both foliar and seed treatments are used to protect lentil crops. Need-based pesticide application at the budding, flowering, and/or podding stage is helpful to manage diseases and insect pests.

Botanical pesticides:

- Foliar application of neem kernel extracts, neem oil, and pyrethrins are known to control the majority of insect pests without intense effect on the environment and grower’s health.

- Soil application of neem cake, castor cake, mustard cake, and cotton cake controls nematode infestation.

Chemical pesticides:

- Seed treatment and/or foliar application of metalaxyl, thiram, thiabendazole, chlorothalonil, metiram, carboxin, and mancozeb, captan, and carboxin to manage diseases, if needed.

- For insect pests, seed and foliar application of imidacloprid, carbaryl, chlorothalonil, and thiabendazole, if needed.

BIOLOGICAL MANAGEMENT

- Release of egg parasitoids, Trichogramma spp. and Telenomus remus, for control of cutworms and other caterpillar pests. The parasitoids, Trichogramma chilonis and Telenomus remus are produced by National Entomology Research Center at Khumaltar and National Maize Research Program at Rampur and others for control of fall armyworm.
USE OF TOLERANT AND RESISTANT VARIETIES

• Some high yielding lentil lines are reported to be resistant to multiple diseases including rust, ascochyta blight, and fusarium wilt.

• A resistant variety to both botrytis gray mold and ascochyta blight called ‘Nipper’ was released in Australia in 2006.

• Resistant cultivars are available (Bombay 18, Pant L 236, Pusa 10; available in India). In Nepal, use of resistant or moderately resistant varieties such as ILL 7164, ILL 7723, and Shital are recommended.

• Resistant cultivars (BARIMasur-4, -5, -6, -7) are available to manage Stemphylium blight and released in Bangladesh. Use of moderately resistant varieties such as Shikhar, Simal, Maheswor Bharati, Bari masuro 4, Bari masuro 3 for control of Stemphylium blight. Genotypes ILL 7715, ILL 8191, Arun, Simrik, ILL 4402, ILL 6467, ILL 8603, ILL 2780, and 39S-66L showed field tolerance to Stemphylium blight. ILL 9950, ILL 7537, ILL 9992, ILL 4402, ILL 2700-1, ILL 9881, ILL 6024, ILL 6025, CUMARA, AURUN, SHISHIR, ILL 9924, ILL 2712, X 94-S-38, RL-9, and RL-27 are moderately resistant to blight and are available in Nepal. Recently, RL-79, ILL 4605, KL-44, Khajura Masuro-3, and Black Masuro were screened for Stemphylium blight.

• PDR-14 and Amber cultivars are resistant to stem rot blight and are available in Nepal.

• Use of moderately resistant varieties such as Shikhar, Simal, Shital, Khajura 2, Sagun, and Maheswor Bharati, Khajura Masuro-1, Simal, Shital, ILL 1704, Baitadi 6A, PL 406, LNO136, LNO137, ILL 6025, F2003-49L, ILL 6821, Shikhar, ILL 8188, Mangal bazaar, ILL 3490, LNO136, ILL 6465, and Arun to manage fusarium wilt.

• Genotypes ILL 7164, ILL 7716, ILL 7986, and ILL 2526 are resistant to fusarium wilt/root rot complex.

• Genotypes ILL 9924, RL 83, ILL 10856, ILL 6458, and RL 67 are less susceptible to Aphis craccivora (Neupane et al. 2020).

• Cultivars LH 90-39, P 927, and P 202 are resistant, and LL 147 is tolerant, to Lima bean pod borer.

• Cultivars LH 90-39, P 927, and P 202 are resistant, and LL 147 is tolerant, to Lima bean pod borer.

FOR MORE INFORMATION

The Feed the Future Innovation Lab for Integrated Pest Management (IPM IL) develops sustainable and economical pest control methods to improve livelihoods for farmers worldwide. The program’s work is based in seven countries and is engaged with scientists, extension agents, students, and farmers in the tropical and subtropical world.

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