

insect damage, and other causes. The number of primary and secondary branches developed on lentil plants depends mostly on cultivar, stand density, and environmental conditions.

Leaves (Fig. 2) of lentil plants are relatively small compared with those of other large-seeded food legumes and have been described as pinnate or imparipinnate and comprise as many as 14 leaflets that can vary in length from 1 to 3 cm. Each leaf is subtended by two small stipules and terminates in a tendril.

The flowers (Fig. 2) are borne singly or in multiples on peduncles that originate from the upper nodes of the plant. Each peduncle normally bears from one to three, and rarely four, flowers, but seven flowers per peduncle have been reported for plants grown in a glasshouse. The individual flower is complete and has a typical papilionaceous structure. Flowers are small (4–8 mm long) and white, pale purple, or purple blue. The flower has a calyx consisting of five equally elongated sepals that equal or exceed the length of the corolla of the unopened flower. The corolla has a standard, two wings, and two lower petals that lie internal to the wings and are united at their lower margin to form the keel. The stamens are diadelphous; nine are united and the upper vexillary stamen stands alone (Fig. 2). The ovary is flat and glabrous and normally contains one or two ovules that alternate along the margin. The ovary terminates in a short, curved style. The style is pilose on the inner side and usually develops at a right angle to the ovary and is flattened on the outer side. Flowers are nearly completely self-pollinating.

The pods are oblong, laterally compressed, and  $3.5\text{--}11 \times 6\text{--}20$  mm and usually contain one or two, but rarely three, seeds. Seeds are lens shaped and weigh  $2.0\text{--}8.0$  g per 100 seeds. The diameter of lentil seeds can range from 2 to 9 mm, and the seedcoat (testa) may be light tan, green or greenish red, gray, brown, or black. Purple and black mottling and speckling of seeds is also common in some cultivars and accessions. Seed size differs according to cultivar, and researchers frequently follow the classification of Barulina, who grouped lentils as “macrosperma” (those with large seeds that range from 4 to 9 mm in diameter) and “microsperma” (those with smaller seeds that range from 2 to 4 mm in diameter). The macrosperma types are common to the Mediterranean basin and the Western Hemisphere, while the microsperma types predominate throughout the Indian subcontinent and in parts of the Middle East.

The primary product of the lentil crop is the seed, which has high concentrations of protein ranging up to 26%. The vast majority of the crop in southern Asia is decorticated and split to make *dhal*, which is boiled, flavored with various spices, and consumed mostly as an addition to rice. Lentils can be used in main dishes, soups, side dishes, or salads.

### Selected References

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## Diseases and Insect Pests of Chickpea and Lentil

Diseases and insect pests are the major constraints in chickpea and lentil production worldwide. A disease is a product of complex interactions among the host (chickpea and lentil) plant, pathogen, and environment. At times, a vector (insect or nematode) may be involved or required for infection by viruses and phytoplasmas. Diseases are either infectious or noninfectious. Infectious diseases are caused by living pathogenic organisms such as bacteria, fungi, nematodes, phytoplasmas, protists, viruses, and parasitic plants. Noninfectious diseases are usually caused by nonliving (abiotic) agents such as physical or chemical factors, including extremes of temperature, herbicides, salinity, and nutrient deficiency or toxicity. Insect pests refer to insect species that are harmful to chickpea and lentil in the field or in storage, causing economic losses.

The severity and frequency of diseases and insect pests depend on environmental conditions. Some diseases and insect pests are persistent problems in chickpea and lentil production in wide geographical areas, such as Ascochyta blights, Fusarium wilts, and pod borers, while others are sporadic in occurrence or endemic in distribution in certain areas. Diseases and pests with limited distribution may still be economically important locally. Because of continuous changes in cultural practices, expansion of chickpea and lentil production into new areas, and climate change, some of the currently less important diseases and insect pests may become economically important. Also, new diseases and insect pests may emerge and become serious problems in chickpea and lentil production in the future.

Descriptions and illustrations are provided for individual diseases and insect pests of chickpea and lentil. However, because chickpea and lentil plants may encounter multiple diseases and insect pest problems concurrently, “typical” symptom descriptions and illustrations may be the exception rather than a rule. Therefore, diagnosticians need to be able to recognize complex symptoms of multiple infections different from simple textbook examples.

Fifty-four diseases and insect pests of chickpea and lentil are described in detail in this compendium. These include 19 fungal diseases, five nematode diseases, nine virus diseases (or complexes), four bacterial diseases, one phytoplasma disease, two parasitic weed problems, and 14 insect pests. Specific management practices are provided wherever available. Other diseases of local importance are presented in tabular form along with appropriate references. Most of the management practices are either only moderately effective or uneconomic when used alone. In addition, many of the diseases and insect pests do not occur alone. Therefore, integrated management practices and principles are discussed in considerable detail.

Each production region also has a unique set of important diseases, insect pests, and production practices. Therefore, no single management intervention is effective or practical for all chickpea or lentil crops. Some management practices are effective in certain production areas but are not followed in others because of local conditions. Use of synthetic pesticides (fungicides, insecticides, and nematicides) for reducing the extent of losses caused by diseases and insect pests in chickpea and lentil is on the rise. However, different countries have different regulations for using pesticides in chickpea and lentil production, and labels for pesticides vary accordingly. Consequently, it is very important to obtain current information on regulations governing safe and lawful use of pesticides for disease and pest management from local government agencies, farm advisors, or company representatives. Appropriate practices, regulations, and label directions must be followed carefully to achieve sustainable crop protection.

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