

Major Fungal Pathogens Infecting Carnation under Protected Cultivation System

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Introduction

Carnation (*Dianthus caryophyllus* L.) is one of the most leading and traditional cut flowers grown all over the globe including India. It has been used extensively by breeders for centuries and as a result, many cultivated hybrids exist. Carnation is a herbaceous plant belonging to the Caryophyllaceae family, native to the Mediterranean Region. Commercial production includes different cultivars of standard and mini types of carnation with a large variety of colours and combinations. Due to its excellent keeping quality, a wide range of forms, ability to resist long-distance transportation, and ability to rehydrate after continuous shipping, carnation is preferred by many growers to rose and chrysanthemum in several flower exporting countries. Modern cut flower varieties of carnation have been selected for flower size, petal number, stem length, and disease resistance. The flower is mostly grown in playhouses for commercial production. Under protected cultivation many pathogenic organisms' results in a reduction of quality and quantity of flowers. Many soil-borne fungi are known to infect carnation at different growth stages. Important fungal diseases of carnations include stem rot (*Sclerotinia sclerotiorum*), wilt (*Fusarium oxysporum* f.sp. *dianthi*), rust (*Uromyces dianthi*), *Phytophthora* Root Rot, *Pythium* Root Rot, *Rhizoctonia* root rot, fairy ring spot (*Cladosporium echinulatum*) and blossom blight (*Botrytis cinerea*). Among various diseases of carnation, *Fusarium* wilt caused by *Fusarium oxysporum* f. sp. *dianthi* is most prevalent and cause huge losses to the crop worldwide. Most of the fungi infecting carnation are soil-borne and their management becomes difficult under protected cultivation due to persistence in the soil. Researchers primarily focused on soil solarisation, sterilization and chemical methods for the management of these fungi. Recently many

bioactive molecules are tested against these pathogens for integrated control. More research is being focused on the development of eco-friendly methods for the control of these major fungal pathogens.

Major Fungal Diseases of Carnation

Disease	Causal Fungi
<i>Alternaria</i> Blight; <i>Alternaria</i> Flower Blight; <i>Alternaria</i> Petal Spot; <i>Alternaria</i> Leaf Spot	<i>Alternaria dianthi</i> , <i>Alternaria dianthicola</i>
<i>Botrytis</i> Blight; Gray Mold; Bud Rot; Blossom Blight	<i>Botrytis cinerea</i>
Downy Mildew	<i>Peronospora dianthi</i> ; <i>Peronospora dianthicola</i>
Rust	<i>Uromyces dianthi</i>
Fairy-Ring Leaf Spot	<i>Cladosporium echinulatum</i>
<i>Fusarium</i> Stem Rot; <i>Fusarium</i> Stub Dieback; <i>Fusarium</i> Basal Rot; <i>Fusarium</i> Branch Rot; <i>Fusarium</i> Cutting Rot; <i>Fusarium</i> Wilt	<i>Fusarium graminearum</i> , <i>Fusarium oxysporum</i> sp. <i>dianthi</i>
Powdery Mildew	<i>Erysiphe buhrii</i>
<i>Phytophthora</i> Root Rot, <i>Phytophthora</i> Foot Rot, <i>Phytophthora</i> Wilt, <i>Phytophthora</i> Collar Rot, <i>Phytophthora</i> Blight	<i>Phytophthora nicotianae</i> var <i>parasitica</i>
<i>Pythium</i> Root Rot	<i>Pythium aphanidermatum</i>
<i>Rhizoctonia</i> Cutting, Stem and Collar Rot	<i>Rhizoctonia solani</i>
<i>Sclerotium</i> Soil Line Rot; <i>Sclerotium</i> Stem Rot, Southern Blight	<i>Sclerotium rolfsii</i>
<i>Sclerotinia</i> Stem Rot; White Mold; <i>Sclerotinia</i> Flower Rot	<i>Sclerotinia sclerotiorum</i>
<i>Septoria</i> Leaf Spot; Carnation Leaf Spot; Common Yellow Leaf Spot	<i>Septoria dianthi</i>
<i>Verticillium</i> Wilt	<i>Verticillium cinerescens</i>

Alternaria Blight (Alternaria dianthi)

Symptoms/signs. Initial symptoms on leaves appear as circular or slightly oval leaf spots in the form of running parallel with the longitudinal axis of the leaf. Spots are generally purple to reddish-brown in the centre. Later the spots expand and adjacent spots tend to coalesce. Healthy tissues between the spots often turn yellow or yellowish-brown. In severe cases, the infection spreads at the stem joints resulting in blighting of the more distant parts of the plant and eventually killing the whole plant.

Botrytis Blight; Gray Mold; Bud Rot; Blossom Blight (Botrytis cinerea)

Symptoms/signs. Plants are generally attacked in the field or during transport or storage. Flowers may carry the fungus asymptotically during cutting and packaging, and symptoms develop later when the conditions are favourable. Symptoms appear as water-soaked spots on the edge of petals and sepals. As the disease progresses, the flower is covered by a fluffy, greyish-brown mass of mycelium, conidiophores, and conidia (signs) and eventually entire flowers are affected. Infected buds fail to open and may sometimes abort. Under conditions of high relative humidity, the pathogen may produce sporogenous sclerotial bodies.

***Alternaria blight******Botrytis Blight******Fairy-Ring Leaf Spot (Cladosporium echinulatum)***

Symptoms/signs. The fungus often affects the aerial organs of the plant, especially leaves and flowers. The infection on leaves begins as purple specks which later enlarge and have tan to grey centres enclosed by a purple border. On the petals, light-brown lesions are produced which limit cut flower marketability.

***Fusarium* Stem Rot; *Fusarium* Stub Dieback; *Fusarium* Basal Rot; *Fusarium* Branch Rot; *Fusarium* Cutting Rot (*Fusarium graminearum*)**

Symptoms/signs. The disease is divided into four phases (basal rot, basal stem rot, branch rot, and stub dieback) that affect different stages of production. Major losses occur due to basal cutting rot during propagation and basal stem rot of rooted cuttings shortly after planting. Basal stem rot and branch rots are observed before flowering. After flower harvest, damage occurs principally as a consequence of the dieback of stem stubs as the fungus grows down the stub into the main stem, reducing the number of flower shoots and plant productivity. The fungus can grow into the main stem and girdle it, causing the death of the plant.



Fairy-Ring Leaf Spot

***Fusarium* Stem Rot**

***Fusarium* Wilt (*Fusarium oxysporum*)**

Symptoms/signs. The pathogen infects the vascular system of affected plants, interfering in water and nutrient absorption. Externally, the infected plants appear chlorotic and show signs of wilting: lower leaves become yellow and dry, the stem often shrivels and turns greyish, and xylem tissues turn brown. Symptoms commonly appear on one side of the plant, causing it to curl. Eventually, the symptoms quickly spread to the other side of the plant, resulting in its death.

***Rhizoctonia* Cutting, Stem and Collar Rot (*Rhizoctonia solani*)**

Symptoms/signs. Cuttings under propagation are especially susceptible to this disease. The symptoms occur mainly in rooting trays of cuttings and in rooted cuttings planted on the ground (especially if they are placed too deeply). In this case, the pathogen could have colonized the soil or could enter the soil through the infected rooted cuttings. Infected cuttings suddenly die. The most characteristic symptom is the greyish-green colour and the

flaccid aspect of the foliage of affected plants. Leaves become yellow, and when pulling the plants, roots remain in the soil, and the stem base shows dark discoloration and soft rot. The symptom of stem rot at the soil line may be mistaken for *Phytophthora* stem rot.



Fusarium Wilt



Rhizoctonia Cutting, Stem and Collar Rot

***Phytophthora* Root Rot, *Phytophthora* Foot Rot, *Phytophthora* Wilt, *Phytophthora* Collar Rot, *Phytophthora* Blight (*Phytophthora nicotianae* var *parasitica*)**

Symptoms/signs. The symptoms occur in all growing stages of plants. *P. nicotianae* can invade the callus tissue of recently planted carnations causing a complete rot of the collar and first internodes and killing the plant. The symptom of infection by *Phytophthora* spp. is a rapid and complete wilting of the plants within 24–48 h. Leaves show a light greenish-grey discoloration; the tissues of the stem base have a brown, water-soaked appearance; and the roots rot.

***Pythium* Root Rot (*Pythium aphanidermatum*)**

Symptoms/signs. Different *Pythium* species produce rootlet rot and brownish-black, water-soaked lesions at or near the base of the cuttings growing in rooting benches. The infection spreads upward in the stems and downward into the roots, discolouring all tissues and rapidly spreading to neighbour plants. With high humidity, white mycelia (sign) can be observed on infected tissues. When infected cuttings have no visible symptoms, they carry the inoculum to the production site where symptoms are expressed. *Pythium*-infected plants in soil beds exhibit root rot, discolouration of stems and basal leaves and reduction in plant stem vigour and height (plants remain stunted) and of a number of flowers. Also, the pathogen can be

found in soil, its natural habitat through survival structures, and it can infect healthy transplanted cuttings.

Rust (*Uromyces dianthi*) Symptoms/signs. The first signs on leaves, stems, or flower buds are small, slightly raised blisters that eventually rupture, forming pustules filled with powdery reddish-brown urediospores. The pustules are surrounded by a yellow margin (symptom) and when infections are severe, entire leaves turn yellow and die. Stems may be girdled when several pustules develop around the shoot. The blackish-brown teliospores also form on stems, partially covered by the epidermis. Flower production and quality are decreased. Plants may be attacked at any stage of development.

***Sclerotinia* Stem Rot; White Mold; *Sclerotinia* Flower Rot (*Sclerotinia sclerotiorum*)**

Symptoms/signs. Symptoms are paleness of the whole plant as a consequence of rot at the base of the stem. If infection occurs through ascospores that reach the highest parts of the plant via air currents, symptoms are bleaching of portions of the stem and leaves emerging from the infected nodes and also of the buds. A sign of the disease is a cottony, white, dense mat of mycelial growth on the surface of the host and the adjacent soil surface. The mycelium develops dense white bodies which become black, irregular, and hard when mature. These bodies are the sclerotia, which can be produced outside or inside the stem.



Rust (*Uromyces dianthi*)

***Sclerotinia* Rot**

Management of Fungal Diseases

- Pasteurize/sterilize the soil before use.
- Use diseases-free stock/planting material.
- Grow carnations preferably on raised beds.



- Avoid sprinkler irrigation to the plants.
- Provide good ventilation and air circulation to avoid excess free water on leaves.
- **Alternaria blight:** Alternative sprays of the crop with chlorothalonil (0.2%), mancozeb (0.2%), zineb (0.2%) or difenoconazole (0.1%) at 8 days interval.
- Always give pre-plant dip to cutting in a fungicidal solution of carbendazim.
- Drench the soil with carbendazim (0.1%), thiophanate methyl (0.1%) or captan (0.3%).
- **Fusarium stem rot/wilt:** Drenching of soil with carbendazim (0.1%) is reported to significantly control the pathogen.
- **Rhizoctonia stem/collar rot:** Pre-plant soil application of pencycuron (0.2%) or flutolanil (0.1%) followed by spraying are reported to be effective.
- **Rust:** Apply sprays of zineb (0.2%), oxycaboxin (0.1%), triadimefon (0.1%), propiconazole (0.1%) or tubeconazole (0.1%) at suitable intervals.
- **Phythophthora blight and rot:** Dip cuttings before planting in copper oxychloride (0.3%), metalaxyl + mancozeb (0.2%) or metalaxyl M (0.2%).
- Applications of biocontrol agents, such as *Trichoderma*, *Streptomyces*, *Pseudomonas* and *Bacillus* spp., to soil are also reported effective.
- Grow disease-resistant varieties.