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*Review*

# Management of major diseases and insect pests of onion and garlic: A comprehensive review

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**Onion (*Allium cepa* L.) and garlic (*Allium sativum* L.) are the most important commercial crops grown all over the world and consumed in various forms. In India, onion and garlic have been under cultivation for the last 5000 years. It is generally used as vegetables, spices or as medicines. India ranks second to China in area and production in both onion and garlic, but ranks 102nd for onion and 74th for garlic in terms of productivity. These crops are generally grown throughout the country especially in the states of Maharashtra, Uttar Pradesh, Orissa, Gujarat, Madhya Pradesh, Haryana, Punjab, Rajasthan, Uttaranchal, Jammu and Kashmir, Bihar, Andhra Pradesh and Karnataka. The onion and garlic crop is attacked by many diseases and insect pests at different crop growth stages which causes considerable losses in yield. Apart from reduction in crop yield, the disease and insect pests also poses harmful effects during harvesting, post harvesting, processing and marketing stages, which lower the quality and export potential of the crops that significantly causes the economic loss. The diseases and insect pests alter the cropping pattern and also affect the local and export markets. The consistent use of chemicals to control the plant diseases and insect pests not only poses a serious threat to the environment and mankind but also slowly build up resistance in the pathogens and insect pests. Most of the new generation pesticides are systemic in their mode of action which may leads to certain level of toxicity in the plant system and thus resulting health hazards. Further, it disturbs the microbial diversity which is an important part of the ecosystem. All these factors have led to new dimension in research for biological control and integrated approach for the management of plant diseases and insect pests. Important diseases and insect pests affecting the onion and garlic crops along with their management are briefly summarized in the present manuscript.**

**Key words:** Onion (*Allium cepa* L.), garlic (*Allium sativum* L.), *Trichoderma viride*, bulbs.

## INTRODUCTION

Onion (*Allium cepa* L.) and garlic (*Allium sativum* L.) is one of the most important commercial vegetable crops grown in India and being used as vegetables, spices or as medicines. The genus *Allium* also contains a number

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**Table 1.** Major diseases and insect pests.

| **Name of disease** | **Damping-off** |
|---|---|
| Causative agent | *Pythium* sp<br>*Phytophthora* sp<br>*Rhizoctonia solani* (Kuhn)<br>*Fusarium* sp |
| Area and distribution | Damping off is an important disease of onion during nursery stage which causes about 60 to 75% damage to the crop. The disease is more prevalent during *kharif* (rainy) season and causes delayed seedling emergence in addition to root and basal rots. High soil moisture and moderate temperature along with high humidity especially in the rainy season leads to the development of the disease. |
| Symptomatology | Two types of symptoms are observed which are as follows:<br>Pre-emergence damping-off: The pre-emergence damping off results in seed and seedling rot before these emerge out of the soil.<br>Post-emergence damping-off: The pathogen attacks the collar region of seedlings on the surface of soil. The collar portion rots and ultimately the seedlings collapse and die. |
| Management strategies | i. Healthy seeds should be selected for sowing.<br>ii. Continuous raising of nursery in the same plot should be avoided.<br>iii. Application of safer fungicides in soil at the time of nursery raising can substantially reduce the crop damage.<br>iv. Soil solarization by spreading 250 gauge polythene sheet over the bed for 30 days before sowing and application of bio-control agent.<br>v. The seed should be treated with Thiram or captan at 2 g/kg of seed before sowing.<br>vi. The top soil of nursery should be treated with Thiram or captan at 5 g/$m^2$ area of the soil and nursery should be drenched with the same chemical at 2 g/litre of water at fortnight interval.<br>vii. *Trichoderma viride* in soil *at* 4 to 5 kg/ha is also found effective to control damping-off to considerable extent |
| | |
| **Name of disease** | **Purple blotch** |
| Causative agent | *Alternaria porri* (Ellis) Cif. |
| Area and distribution | It is an important disease of onion and garlic prevalent in all the onion and garlic growing areas in the world. Hot and humid climate with temperature ranging from 21 to 30°C and relative humidity (80 to 90%) favors the development of the disease. It is more common in *kharif* season. The intensity of disease varies from season to season, variety to variety and region to region. |
| Symptomatology | The fungal spores germinate on onion leaves and produce a small, water-soaked spot that turns brown. The elliptical lesion enlarges, becomes zonate (target spot) and purplish. The margin may be reddish to purple and surrounded by a yellow zone. During moist weather, the surface of the lesion may be covered by brown to black masses of fungal spores.<br>Lesions may merge or become so numerous that they kill the leaf. Leaves become yellow then brown and wilt 2 to 4 weeks after initial infection. Lesions may form on seed stalks and floral parts of seed onions and affect seed development. Diseased tissue turns brown to black and dries out in the field or more commonly in storage.<br>Purple blotch first appears as small, whitish sunken lesions. Almost immediately, the spots turn brown, enlarge, and become zoned, somewhat sunken, and more or less purplish. The lesions occur on the leaves, flower stalks, and floral parts of seed onions. The lesion borders are reddish and surrounded by a yellow “halo.” If conditions are favorable for disease development, the lesions quickly girdle the leaves and seed stems. Affected leaves and stems may turn yellow, die back, collapse, and die within several weeks after the first lesions appear. In moist weather, diseased tissues are covered with a dense, dark purplish black mold composed of large numbers of microscopic, dark multi-celled spores (conidia). The conidia are carried to other onion leaves by air currents, splashing rains, tools and so on. When the spores land on susceptible onion tissue they germinate in a film of water, and the germ tubes penetrate the stomata or penetrate directly through the epidermis. Early symptoms can appear within 1 to 4 days after penetration has occurred. A new generation of conidia may be produced every 5 days in warm, moist weather.<br>Infection, reproduction and spread of the disease may follow in rapid succession as long as |

**Table 1.** Contd.

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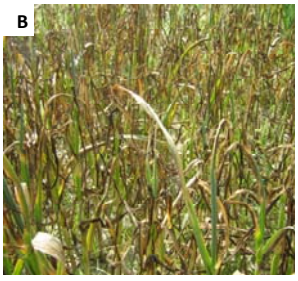
|---|---|
| | favorable conditions persist. Free moisture, in the form of rain, persistent fog, or dew, is required for infection and spore production. Mycelial growth of the fungus occurs over a temperature range of 6° to 34°C (optimum 25° to 27°C) at a relative humidity of 90 percent. Onion bulbs become infected at harvest or later in storage through the neck or through wounds in the fleshy bulb scales. The rot is first semi watery and a deep yellow but gradually turns a wine-red, finally becoming dark brown to black. |
| Management strategies | Cultural methods include long rotations with non related crop and good drainage brings down the incidence of the disease.<br>i. Lowering the density of transplanted crops causes reduced infection.<br>ii. Avoid excess doses of nitrogenous fertilizers.<br>iii. Use of resistant/tolerant varieties.<br>iv. Frequent and judicious application of fungicides reduces the incidence of purple blotch |
| Figures/captions |   <br>**Figure 1.** (a) Onion and (b) Garlic crop affected with purple blotch disease. |
| **Name of disease** | **Stemphylium blight** |
| Causative agent | *Stemphylium vesicarium* (Wall.) Simmons |
| Area and distribution | It infects herbaceous plants such as onion, garlic, asparagus, lucerne, tomato and soybean and trees also, that is, pear, mango etc. The fungus produced significant damage alone and in a complex with *Alternaria porri*. In some fields, foliage losses of 80 to 90% have been recorded. |
| Symptomatology | The symptoms that develop on each host are quite different. Initial symptoms appear on the leaves as brown spots, often surrounded by a purple halo. In garlic and onion, infection usually remains restricted to the leaves and does not extend to the bulb scales. Symptoms on pear are visible from blossom to ripening and are characterized by necrotic spots on the leaves and young stems, and brown spots surrounded by a red-purple halo on the fruits. Lesions on fruits are mainly located at the blossom end. Infections progress internally through the fruit causing its maceration. On garlic, two types of leaf lesions can be observed such as small white spots and progressing purple spots (with sunken tissues). These lesions may be found simultaneously and are associated with large, necrotic areas progressing along the leaf. If the infection is severe, necrosis is observed in all aerial plant organs and the plant desiccates. On onion, initial infections on the leaves produce small, light-yellow to brown, water-soaked lesions. As the lesions expand, they coalesce, causing extensive blight of the leaves. The centre of the lesions turn brown and finally black as the fungus sporulates. |
| Management strategies | i. Reduced plant density and good field drainage significantly reduced the disease incidence.<br>ii. Avoid excess doses of nitrogenous fertilizers.<br>iii. Use of resistant/tolerant varieties.<br>iv. Judicious application of fungicides reduces the incidence of disease. |
| Figures/captions |   <br>**Figure 2.** (a) Onion and (b) garlic crop affected with stemphylium blight disease. |

**Table 1.** Contd.

| **Name of disease** | **Downy Mildew** |
|---|---|
| Causative agent | *Peronospora destructor* |
| Area and distribution | Downy mildew is a destructive and widely distributed disease of bulb crops. Due to this disease, considerable losses of bulbs and seed production of onion crops have been reported. The pathogen and disease was first described by Berkley in 1841. |
| Symptomatology | Downy mildew caused by *P. destructor* may cause local infections on onion leaves or be systemic and infect the entire plant. Additional hosts of the fungus include Egyptian onion, the potato or multiplier onion, Welsh or Spanish onion, chives, garlic, leek, shallot, and possibly other species of *Allium*. Red onions have resistance to some extent. The disease is reported from northern hilly track and plains particularly in high humid locations. The disease is worst in damp conditions and late planting of the crop, application of higher doses of fertilizers and numerous irrigation increased disease severity. Symptoms appear on the surface of leaves or flower stalk as violet growth of fungus, which later becomes pale greenish yellow and finally the leaves or seed stalks collapse. |
| Management strategies | i. Onion bulbs used for seed crop should be exposed to sun for 12 days to destroy the fungus.<br>ii. Avoid application of higher doses of fertilizers and frequent irrigation.<br>iii. Timely sowing of bulbs also reduces the severity of the disease.<br>iv. Foliar spraying of Zineb (0.2%), Karathane (0.1%) or Tridemorph (0.1%) also gives good control of the disease. |
| | |
| **Name of disease** | **Basal Rot/Bottom rot** |
| Causative agent | *Fusarium oxysporum f. sp. cepae* W. C. Snyder and H. N. Hansen |
| Area and distribution | It is present in most parts of the world wherein onions are being grown. There can be up to 90% loss of seedlings (Barnoczkine, 1986), yields of susceptible cultivars can be halved, and there can be a 30% loss in store. Seed yield is also reduced (Davis and Reddy, 1932). The disease causes serious losses in garlic also. The disease incidence is more in the area where onion and garlic crop is grown continuously. A moderate temperature of 22 to 28°C favours disease development. |
| Symptomatology | An initial symptom of the disease is yellowing of leaves and stunted growth of plant and later on, the leaves dry from tip downwards. In early stage of infection, the roots of the plants become pink in colour and rotting take place later. In advanced stage, the bulb starts decaying from lower ends and ultimately whole plant die. Disease also appears during storage when the temperature (35 to 40°C) and relative humidity (70%) are high in the month of July to August. |
| Management strategies | i. Since the pathogen is soil borne, it is difficult to control disease. Mixed cropping and crop rotation reduce the incidence of disease.<br>ii. Soil solarization by spreading polythene sheet of 250 gauges in summer season for 30 days reduces the infectious propagules, which in turn reduces the disease.<br>iii. Seed treatment with Thiram (2 g/kg of seed) and soil application of Carbendazim, Thiophanate Methyl (Topsin-M) or Benomyl at 0.1% is effective in the controlling the disease.<br>iv. Seedling dip in Carbendazim (0.1%) or with antagonist *viz. Pseudomonas cepacia* and *Trichoderma viride* significantly reduces the basal rot in onion crop.<br>v. Application of *Trichoderma* spp along with arbuscular mycorrhizal fungi (AMF) at the time of transplanting of the crop. |
| Figures/captions |  <br>**Figure 3.** Garlic bulbs are affected with *Fusarium* basal rot. |

**Table 1.** Contd.

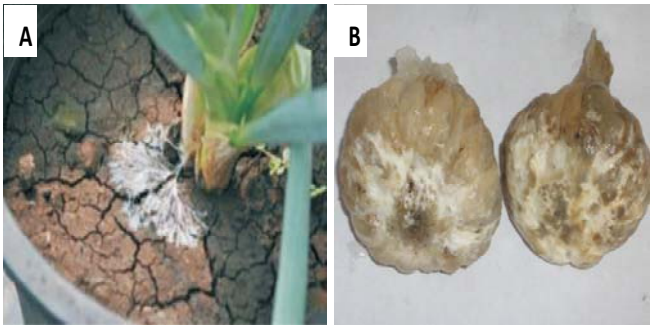
| **Name of disease** | **White rot** |
|---|---|
| Causative agent | *Sclerotium cepivorum* Berk |
| Area and distribution | White rot is first reported in onion in the UK (Berkeley, 1841) and in garlic in Italy (Walker, 1924). The disease is now present in many areas of the world where *allium* crops are cultivated and environmental conditions are favorable to the pathogen (Walker, 1924; Asthana, 1947; Adams, 1971). |
| Symptomatology | The initial symptom of the disease is yellowing and dieback of leaf tips. Scales stem plate and roots get destroyed. The bulbs become soft and water soaked. White fluffy or cottony growths of mycelium with abundant black sclerotia resembling mustard grain are seen on the infected bulbs. |
| Management strategies | i. Seed treatment with Thiram (2 g/kg of seed) and soil application of Carbendazim, Thiophanate Methyl (Topsin-M) or Benomyl at 0.1% is effective in the controlling the disease.<br>ii. Seedling dip in Carbendazim (0.1%) or with antagonist viz. *Pseudomonas cepacia,* and *Trichoderma viride* significantly reduces the basal rot in onion crop.<br>iii. Application of *Trichoderma* spp along with arbuscular mycorrhizal fungi (AMF) at the time of transplanting of the crop. |
| Figures/captions |  <br>**Figure 4.** (a) Onion plant (b) garlic bulb affected with white rot. |
| **Name of disease** | **Onion smut** |
| Causative agent | *Urocystis cepulae* Frost |
| Area and distribution | This disease is first reported from United States in 1850 and is probably present in most *Allium* growing areas. The smut fungus survives as spores in the soil for many years. |
| Symptomatology | The disease occurs in areas where temperature remains below 30°C. Since the fungus remains in soil, disease appears on the cotyledon of the young plant soon after it emerges. Smut appears as elongated dark, slightly thickened areas near the base of seedlings. The black lesions appear near the base of the scales on planting. The affected leaves bend downwards abnormally. On older plants, numerous raised blisters occur near the base of the leaves. The lesions on plant at all stages often expose a black powdery mass of spores. |
| Management strategies | i. Crop rotation with other vegetable crops reduces the incidence of the disease.<br>ii. Treating the seeds with Captan or Thiram at 2.5 g/kg of seed before sowing controls the disease.<br>iii. Seed bed treatment with Methyl Bromide (1 kg/25 $m^2$) is effective in controlling the disease. |
| **Name of disease** | **Black mold** |
| Causative agent | *Aspergillus niger* |
| Area and distribution | Black mold is the most important post-harvest disease under hot climates. In India, it is very common wherever onion and garlic is stored (Gupta and Srivastava, 1992). |
| Symptomatology | The disease is common in onion and garlic stored in hot climates where the temperature ranges between 30 to 45°C. It is characterized by the black powdery mass of spores that appear on the exterior of the scales. The black spore masses are also seen on inner scales. It reduces the market value of the bulbs. |
| Management strategies | i. For effective control of disease, bulb should be left for drying in the field for two days. These bulbs should be further dried in shade for 10-15 days before storage.<br>ii. Care should be taken to avoid injury to the bulbs during post harvest handling.<br>iii. The crops should be sprayed with Carbendazim (0.2%) 10-15 days before harvesting. |

**Table 1.** Contd.

| **Name of disease** | **Anthracnose/Twister /Seven curl disease** |
|---|---|
| Causative agent | *Colletotrichum gloeosporiodes* |
| Area and distribution | Onion twister disease, anthracnose or seven curl disease is reported to be widespread throughout the world but more usual in the tropics and subtropics. It is a facultative parasite wide host range. |
| Symptomatology | The symptoms appear initially on the leaves as water soaked pale yellow spots, which spreads lengthwise covering entire leaf blade. The affected leaves shrivel and droop down. |
| Management strategies | i. Since the pathogen survives on crop debris, sanitation and destruction of infected crop debris helps in reducing the disease.<br>ii. Use of Mancozeb (0.25%), Carbendazim (0.1%) or Thiophanate Methyl (0.1%) as foliar spray is effective against the disease.<br>iii. Application of bio-control agents like *Trichoderma viride* to the soil reduces the disease inoculum. |
| | |
| **Name of disease** | **Pink root rot** |
| Causative agent | *Phoma terrestris* |
| Area and distribution | Disease is first reported in Texas in 1917 but had been important for at least last 20 years (Hansen, 1929). In India, it was reported by Mishra et al. (2012). The disease is present in areas with high soil temperatures, and mainly affects onion and garlic. Pink root often occurs in association with *Fusarium* basal rot. In these circumstances, it may be difficult to determine the relative importance of each disease. |
| Symptomatology | Pink root rot commonly occurs on onion roots of under matured plants in poorly drained areas. The typical symptoms are light pink to yellowish brown discoloration on roots that becomes dark pink and then eventually purple colour in advanced stages of the disease. Diseased roots eventually shrivel, become brittle and die. Below ground, symptoms are pink to deep carmine root leading to necrosis and a reduction in total root mass (Figure 1). The conidium is hyaline and single celled and upon germination it produces hyphae that penetrates young roots and grows through the cortical tissues. The fungus produces minute, black almost globose fruiting bodies (pycnidia) in the epidermal and cortical cells with size of 3.9-5.8 x 2-2.3 µm. |
| Management strategies | i. Long rotations of 3 to 6 years with crops not susceptible to the pathogen will reduce but not eliminate the occurrence of disease.<br>ii. Some onion cultivars possess resistance to the pathogen and should be planted in fields with a history of pink root.<br>iii. Fumigation with chloropicrin is effective but costly.<br>iv. Soil solarization during the nursery raising. |
| | |
| **Name of disease** | **Neck rot** |
| Causative agent | *Botrytis allii* |
| Area and distribution | Neck rot of onion, garlic and shallot is one of the major bulbs destroying diseases which are caused by *Botrytis allii, B. squamosa and B. cinerea*. The fungus usually infects mature plants through the neck tissues or through wounds in the bulbs. |
| Symptomatology | Symptoms are first seen as a softening of the tissues around the neck of the bulb, or more rarely, at a wound. A definite margin separates diseased and healthy tissues. Infected tissues become sunken, soft and appear brownish to grayish in color, as if they had been cooked. These symptoms progress gradually to the base of the bulb. In a humid atmosphere, a grey felt like mold later forms on the rotting scales. Often, the outer scales of the bulb need to be removed before the mold can be seen. Hard, irregularly shaped kernel-like bodies, sclerotia, may form between scales, especially at the neck region. White at first, these turn black with age; they vary from $^1/_8$ to $^1/_4$ inch in size. The neck area becomes sunken and dried out; the entire bulb may become mummified. Secondary invasion by soft rot bacteria causes a watery rot. |
| Management strategies | i. The most common point of infection is through the exposed succulent tissue when plants are topped before they have dried sufficiently. A combination of several of the following cultural procedures should reduce losses.<br>ii. Plant varieties that mature properly so neck tissues are dry before storage. Generally colored varieties are more resistant than white varieties. |

**Table 1.** Contd.

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| | iii. Do not apply nitrogen fertilizer after mid-July and be sure that slow release nitrogen fertilizers are not applied too late in the season.<br>iv. As harvest time approaches discontinue irrigation to allow tops to dry down.<br>v. Allow tops to mature well before harvest.<br>vi. Undercut and windrow onions until inside neck tissues are dry before topping and storing.<br>Do not store improperly cured bulbs. |
| | |
| **Name of disease** | **Sour skin** |
| Causative agent | *Pseudomonas cepacia* (Burkholder) Palleroni and Holmes |
| Area and distribution | It is first described in 1950, has been reported from onion-growing areas all over the world. Losses often appear in stored onions, but infection usually begins in the field. The disease can be serious in individual fields, with yield losses of 5–50%. Sour skin is primarily a disease of onions, but other *Allium* species are reported to be hosts. |
| Symptomatology | Primary symptoms on onions include a slimy (but initially firm), pale yellow to light brown decay and breakdown of one or a few inner bulb scales. Adjacent outer scales and the center of the bulb may remain firm. Externally, bulbs appear sound, but the neck region maysoften after leaves have collapsed. In advanced stages, healthy scales can slip off during handling. Young leaves some times die back, starting at the tips. Bacterial cells are rods that measure 1.6-3.2 × 0.8-1.0 µm; they occur singly or in pairs; and they are motile by means of tufts of polar flagella. Most strains produce non-fluorescent, yellowish or greenish pigments, but the pigments may be of a variety of colors. *P. cepacia* is an obligate aerobic bacterium. The optimum growth temperature is 30–35°C. No growth occurs at 4°C, and most strains grow at 41°C. Denitrification is negative while nitrate is reduced to nitrite. It is oxidase positive and arginine dihydrolase negative and can liquefy gelatin. |
| Management strategies | i. Control measures include proper maturing of the crop and quick drying after topping and harvest.<br>ii. Since contaminated irrigation water has been implicated in the spread of the pathogen, the use of recycled or irrigation runoff water should be avoided.<br>iii. The method of irrigation has a substantial impact on the incidence of sour skin. Season-long overhead irrigation provides a favorable environment for infection by *P. cepacia*, whereas furrow irrigation results in almost complete absence of the disease. In experimental plots, the final four or five sprinkler irrigations were accompanied by increases in sour skin of 150–300%.<br>iv. Where sour skin is a potential problem, changing from sprinkler to furrow irrigation, at least from bulbing to the end of the season, is advisable where feasible. |
| | |
| **Name of disease** | **Bulb canker/Skin blotch** |
| Causative agent | *Embellisia allii* (Campan.) E. G. Simmons |
| Area and distribution | It is a major problem of onion and garlic during storage. |
| Symptomatology | The initial symptom of the disease was grayish spots on the outer scales of the bulb, later becoming enlarged and covering the entire bulb with a dark, blackish colour (Figure 1a, b).<br>Colonies on PDA were effuse, grey to brown to black, with diameters averaging 30 mm after five days at 22°C. Microscopic observations revealed chlamydospores (Figure 2A), dark brown to black, forming abundantly on the host, variable in shape and size, up to 100 to 120 µm long and 3 to 5 µm wide. Conidia (Figure 2B) were generally smooth, obovoid or ellipsoidal, rounded at the ends, 20-50 x 7-10 µm, mid- to dark-brown to black, with generally two to five (maximum six) thick, very dark transverse septa, and occasionally one or two oblique or longitudinal septa |
| Management strategies | i. Proper curing and drying is essential before storage.<br>ii. Fungicide applications during the season and especially prior to harvest may reduce the incidence of neck rot. However, fungicide applications cannot overcome improper cultural or storage practices.<br>iii. Cure onions with forced, heated air at 80-95 F (27-35°C) for a few days at the beginning of the storage period.<br>iv. As harvest time approaches discontinue irrigation to allow tops to dry down. |

**Table 1.** Contd.

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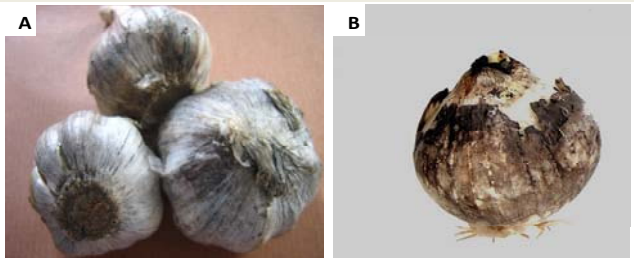
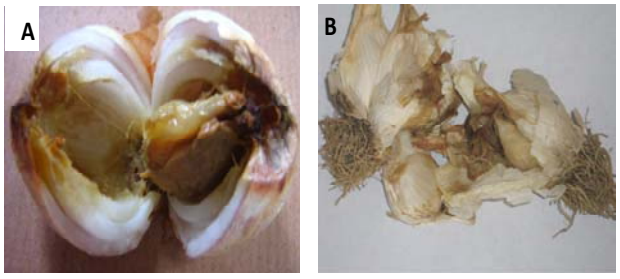
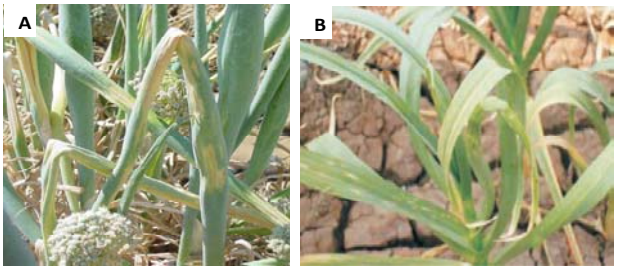
| Figures/captions |   **Figure 5.** (a) Garlic (b) Onion bulbs affected with bulb canker. |
| **Name of disease** | **Bacterial Brown Rot** |
| Causative agent | *Pseudomonas aeruginosa* |
| Area and distribution | It is caused by bacterium *Pseudomonas aeruginosa* |
| Symptomatology | It is very serious disease of onions in storage. The infection occurs through the wounds. The rot begins at the neck of the bulbs which later gives foul smell through the neck when squeezed. |
| Management strategies | i. Proper curing and rapid drying of the bulbs after harvesting is essential for controlling the disease.<br>ii. Affected bulbs should be discarded before storage.<br>iii. If rains occur during maturity, spraying of Streptocycline (0.02%) is recommended. |
| Figures /captions |   **Figure 6.** (a) onion (b) garlic bulbs affected with bacterial rot. |
| **Name of disease** | **Iris yellow spot virus (IYSV)** |
| Causative agent | Virus |
| Area and distribution | IYSV previously reported in Netherland, Israel and Brazil. First reported in US in Idaho in 1991, now it is worldwide. It is caused by *Gemini* virus. |
| Symptomatology | Plants infected with IYSV will have characteristic yellow- to straw-colored lesions. Lesions may be more or less round with or without a necrotic center or may be diamond shaped (Figure 1). Lesions will appear on both the seed stalk and the leaves. Seed stalks may swell at the point of infection. Late in the season, infected seed stalks and leaves will lodge (fall over). |
| Management strategies | i. Removal and destruction of the diseased plants checks the spread of the disease. Healthy bulbs should be used for seed production.<br>ii. Spraying of Decis (0.1%), Malathion (0.1%) or Metasystox (0.1%) to control the vectors checks further spread of the disease. |
| Figures/captions |   **Figure 7.** (a) onion (b) garlic plants affected with IYSV. |

**Table 1.** Contd.

| **Name of disease** | **Onion Yellow Dwarf Virus (OYDV)** |
|---|---|
| Causative agent | Virus |
| Area and distribution | This is a viral disease caused by onion yellow dwarf virus. It can be transmitted either mechanically or by insect vectors. Onion yellow dwarf virus, a member of the genus poty virus in the family potyviridae, is a filamentous virus containing a single, positive sense genome RNA. OYDV is transmitted by Aphids in a non-persistent manner. |
| Symptomatology | The symptoms of the disease are severe stunting of the plants, dwarfing and twisting of the flower stalk. The affected leaves and stems change their normal green colour to various shades of yellow and leaves tend to flatten and crinkle and as a result bend over. |
| Management strategies | i. Removal and destruction of the diseased plants checks the spread of the disease.<br>ii. Healthy bulbs should be used for seed production.<br>iii. Spraying of Decis (0.1%), Malathion (0.1%) or Metasystox (0.1%) to control the vectors checks further spread of the disease. |
| **Name of disease** | **Root-knot nematode** |
| Causative agent | *Meloidogyne* spp |
| Area and distribution | Root-knot nematodes are major pathogens of vegetable crops throughout the world, impacting both the quantity and quality of marketable yields. In addition, root-knot nematodes interact with other plant pathogens, resulting in increased damage caused by other diseases. In case of bulb crops, the weight of bulb onions may be reduced by as much as 50 to 70% in heavily infested fields at an infestation level of 20 eggs/cc soil. Recently Mishra et al. (2010) first time reported occurrence of *Meloidogyne graminicola* on onion from India. |
| Symptomatology | Affected crops show stunted growth, yellowing of the leaves, smaller bulbs, delayed maturity, wilting of the plants despite adequate soil water content. Severely infected seedlings produce few roots and usually die rapidly. Heavy infection of older plants causes the plants to wilt unexpectedly and die off early. Swelling or galls, develop on the roots of infected plants, as the result of nematode-induced expansion of root cells. All the root-knot galls damage the vascular tissues of roots and thus interfere with the normal movement of water and nutrients through the plant. They also increase the susceptibility of the root system to invasion by disease causing fungi and bacteria. |
| Management strategies | i. Grow seedlings in nematode free soil and test of soil for nematodes before planting in fields.<br>ii. Use of crop rotation. Do not plant susceptible crops repeatedly in some areas.<br>iii. Summer fallowing, in which all vegetation is kept off the infested area, is a cheap and effective way to reduce nematode numbers. This will not stop nematode eggs from hatching but without food plants, the young worms will die.<br>iv. Practice of soil solarization. Solarization involves covering raised and moist beds with clear plastic for 2 to 4 months during the hottest months of the year. The increased soil temperature helps to kill many soil borne pests and pathogens including root-knot nematode. Nematodes in these moist beds will hatch out from eggs, move around for roots and will die of starvation.<br>v. Organic amendment. Beneficial microorganisms are in high numbers in soil amended with different organic matters. Some beneficial fungi and bacteria are parasites of nematode eggs and also prey on nematodes. The parasitized eggs do not hatch and thus populations are reduced. Organic amendments enhance biological suppression of parasitic nematodes in soil |
| Figures /captions |  <br>**Figure 8.** Onion bulb affected with root knot nematode. |
| **Name of insect/pests** | **Thrips** |
| Causative agent | *Thrips tabaci* |
| Area and distribution | i. Thrips are spread worldwide.<br>ii. These are important pests of onions, garlic, and several other crops in most parts of the world. |

**Table 1.** Contd.

| | |
|---|---|
| | iii. Thrips can colonize crops from sea level up to 2000 m above sea level. |
| | iv. They can be a problem in several other crops such as chilli, capsicum, cabbage, cotton, celery, tomato, beans, cucumber and pineapple. |
| | v. Thrips can be found in almost any cultivated and weedy plants. |
| Symptomatology | A reliable treatment threshold has not been developed; however, a threshold of 30 thrips per plant during mid-season has been considered. For small onion producers, the recommended economic threshold is 20% of plants infested with thrips. The threshold is three thrips per green leaf. The cumulative thrips-days are 500 to 600 (that is, 50 to 60 thrips for 10 days). |
| Management strategies | i. Colour-sensitive mulch: aluminium-coated mulch repels pest by 33 to 68%.<br>ii. Intercropping with maize and carrot may also reduce thrips population.<br>iii. Lack of adequate soil calcium may invite higher population of thrips.<br>iv. High nitrate levels invite thrips.<br>v. Irrigation of onions is very important to control thrips.<br>vi. Use sprinkler irrigation to simulate rainfall and control thrips.<br>v. If onion plants encounter water stress, damage by thrips may be magnified because the plants lose large amounts of water from the damaged tissue.<br>vi. It is very important that onion seedlings are clean of thrips before transplantation.<br>vii. Spraying of Deltamethrin at 1 ml/L gives best performance.<br>viii. Fipronil at 1 ml/L of water and spionsad at1 ml/L of water offer best control of this pest.<br>ix. At high temperature, profenophos at 2 ml/L gives good control.<br>x. Alternately use chemical groups.<br>xi. Spinosad is a recently discovered insecticide, derived from the fermentation of actinomycetes bacteria, commonly found in soil.<br>xii. The National Organic Board has recommended that Spinosad be allowed in organic production. |
| Figures /captions |  |
| | **Figure 9.** Onion plant showing infestation of thrips. |
| **Name of insect/pests** | **Onion maggot** |
| Causative agent | *Delia antique* Meigen<br>*D. Platura* |
| Area and distribution | i. Maggot is an onion pest and does not generally cause economic damage to garlic.<br>ii. Onion maggot can cause losses from 20 to 90% in temperate regions. |
| Symptomatology | i. Onion maggot adults are one-fourth of an inch, gray brown, bristly, humpbacked flies.<br>ii. Eggs are white and elongated with characteristic surface ridging and hexagonal pattern.<br>iii. The one-third of an inch maggots are legless, cylindrical, tapering at the head, and creamy white. They pupate with in a chestnut brown puparia.<br>iv. These flies lay eggs in small batches on the soil surface near the base of seedlings.<br>Female mates only once, but males are capable of repeated mating. Maggots prefer soils heavy in organic matter where they can survive and move to seeds. |
| Management strategies | i. Avoid planting in soils that are high in undecomposed matter.<br>ii. Avoid planting where crop rotations are not followed.<br>iii. Employ biological control.<br>iv. No promising natural enemies exist, which can be successfully employed for control of this pest at field level.<br>v. Only braconid, *Aphaereta pallipes*, *Staphylinid,* and *Aleochara bilineata* have significantly increased the mortality of onion maggot, but the performance in field is poor.<br>vi. Ground beetle is an onion maggot predator, and establishing grassy refuse stripes in an onion crop enhances beetle population and reduces maggot population. |

of other species variously referred to as onions and cultivated for food, such as the Japanese bunching onion (*Allium fistulosum*), Egyptian onion (*Allium proliferum*) and Canada onion (*Allium canadense*). There are over 600 species of *Allium*, distributed throughout Europe, North America, Northern Africa and Asia. The bulb of onion consists of swollen bases of green foliage leaves and fleshy scales. These bulb crops are rich in minerals like phosphorous, calcium and carbohydrate. It also contains proteins and Vitamin C.

## CHEMICAL COMPOUNDS OF ONION AND GARLIC

The pungency in onion and garlic is due to allyl-propyldisulphide and alinase. Onions contain chemical compounds with potential anti-inflammatory, anticholesterol, anticancer and antioxidant properties, such as quercetin (Slimestad et al., 2007). It has also been reported that garlic extract inhibited vascular calcification in human patients with high blood cholesterol (Durak et al., 2004). The known vasodilative effect of garlic is possibly caused by catabolism of garlic-derived polysulfides to hydrogen sulfide in red blood cells (RBCs), a reaction that is dependent on reduced thiols in or on the RBC membrane. Hydrogen sulfide is an endogenous cardioprotective vascular cell-signaling molecule. The fungicidal and insecticidal properties of onion and garlic are also well identified. *In vitro* studies have revealed that onion and garlic possesses antibacterial, antiviral and antifungal activity.

## CULTIVATION OF ONION AND GARLIC

In India, onion and garlic have been under cultivation for the last 5000 years. As per FAO (FAOSTAT, 2010), onion is grown in 0.8 million hectares with production of 8.2 million tones and productivity of 101.6 q/ha whereas, garlic is grown in 0.015 million hectares with production of 0.65 million tones and productivity of 43.2 q/ha in India. Maharashtra is the leading state in onion production followed by Uttar Pradesh and Orissa whereas Madhya Pradesh is the major garlic producing state, followed by Gujarat and Uttar Pradesh (Anonymous, 2010). India ranks second to China in area and production in both onion and garlic, but ranks 102$^{nd}$ for onion and 74$^{th}$ for garlic in terms of productivity (FAOSTAT, 2010).

## PRODUCTION OF ONION AND GARLIC

Production and productivity not only depends upon area and cultural practices but also on genotypes, environment, several diseases and insect pests that affect the crop during entire cropping period. There are a number of pathogens and insect pests that attack onionsand garlic plants throughout their developmental stages and significantly reduce the crop yield. The present manuscript deals with management of major bacterial, fungal, viral and nematode diseases and insect pests of onion and garlic with an emphasis for which effective diseases and insect pests management systems have been put into practice. Brief descriptions of the symptoms are included to assist in identification of the specific diseases and insect pests (Table 1).

## Conflict of interests

The authors have not declared any conflict of interests.

### REFERENCES

Anonymous (2010). National Horticultural and Research Development Foundation (NHRDF) Database. Available at http://www.nhrdf.com/contentPage.asp?sub_section_code=115

Asthana RP (1947). Studies on Sclerotium-forming fungi I. Sclerotium cepivorum Berk. and S. tuliparum Klebahn. Part 2. Symptoms, mode of infection and host range. Proc. Indian Acad. Sci. Section B 26:108-116.

Barnoczkine S (1986). Possibilities to control Fusarium on onion. Zoldsegtermesztesi Kutato Intezet Bulletinje 19:33.

Davis GN, Reddy CS (1932). A seedling blight stage of onion bulb rot. Phytopathology 22:8.

Durak I, Kavutcu M, Aytaç B (2004). Effects of garlic extract consumption on blood lipid and oxidant/antioxidant parameters in humans with high blood cholesterol. J. Nutr. Biochem. 15(6):373-377. http://dx.doi.org/10.1016/j.jnutbio.2004.01.005

FAOSTAT (2010). Available at: http://faostat.fao.org/faostat/ collections http://dx.doi.org/10.1016/j.jnutbio.2004.01.005

Hansen HN (1929). Etiology of the pink root disease of onion. Phytopathology 19:691.

Mishra RK, Singh S, Pandey S, Sharma P, Gupta RP (2010). First report of root knot nematode Meloidogyne graminicola on onion in India. Int. J. Nematol. 20(2):236-237.

Slimestad R, Fossen T Vågen IM (2007). Onions: A source of unique dietary flavonoids. J Agric. Food Chem. 55(25):10067-10080. http://dx.doi.org/10.1021/jf0712503

Walker JC (1924). White rot of Allium in Europe and America. Phytopathology 14:315-323.