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ALLIUM DISEASES: A GLOBAL PERSPECTIVE

Mini Review Article

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ABSTRACT

Allium crops were well known slightly perishable spicy vegetables. It is highly valued as anti drug, odor and flouring agents. The success of alliums global market is its inherent ability to be stored for long time. About 35-40% crop is lost due to damage caused by field and storage diseases. The fungal bulb rot imparts to about 15-30% losses during storage of different varieties. There are diverse fungal, oomycetes and bacterial pathogens like *Alternaria porri, Aspergillus niger, Botrytis allii, Colletotrichum circinans, Dikeya chrysanthemi, Erwinia carotovora, Fuarium oxysporum, Peronospora destructor, Phytophthora nicotianae, Pythium* spp., *Rhizopus stolonifer,* and some viral agents which attacks alliums during the field and post-harvest storage period. Amongst all *Alternaria porri* is the most virulent fungal pathogen in the field. The preventive approach of using fungicides to reduce the disease incidence is insufficient to provide safe for human consumption and may be hazardous for the human health due to residual impact issues. Therefore, it is mandatory to develop novel integrated strategies to reduce the crop losses by the potent application of newer molecules, bio agents and adotation of sanitation, crop rotation or in the form of combinations.

Introduction

Alliums, formerly classified with the Liliaceae (lilies and relatives), now have their own family, the Alliaceae. *Allium* species are monocotyledonous plants possessing long green leaves. The plants in this crop group are widely used for seasoning and cooking. The most familiar allium crops include bulb onion (*Allium cepa*), spring or salad onion (*A. cepa*), bunching onion (*A. fistulosum*), canada onion (*A. canadense*) garlic (*A. sativum*), leek (*A. porrum* = *A. ampeloprasum* var. *porrum*), elephant garlic (*A. ampeloprasum*), shallot (*A. cepa* var. *ascalonicum*), chives (*A. schoenoprasum*), Chinese chives (*A. tuberosum*), and Egyptian tree onion (*A. cepa* var. *aggregatum*). Allium plants are monocots and may have originated in Asia (Koike *et al*., 2007) there are over 600 species of Allium distributed Asia, Africa, Australia, America and Europe. In addition, for generations, over 20 other *Allium* species have been consumed by humans. They have been cultivated in India and China since very early times, and were highly esteemed in ancient Egypt, Lately, old and new alliums, both edible and ornamental, have started to become popular worldwide.

Significance of Onion and Garlic

Onion (*Allium cepa* L.) seeds have been found in Egyptian tombs built in 3200 B.C. and some authorities believe the onion may have been one of the first vegetables domesticated by humans. Allium plants possess several medicinal compounds with excellent anticancer, anti-inflammatory, anti-cholesterol and antioxidant activity. Today onions are important crop worldwide and China ranks first in total production of dry onion, followed by India, the United States, Turkey, Japan, Spain, Brazil, Iran and Poland, respectively. Onion, the principal *Allium*, ranks second in value after tomatoes on the list of cultivated vegetable crops worldwide (Kamenetsky and Fritsch, 2002). The word "onion" is derived from Latin and means "large pearl". The unique flavor and odor of onions and garlic have made them an excellent food

source. Garlic (*Allium sativum*) is commonly used as a flavoring for food, as a condiment, and for medicinal purposes. The milder-flavored elephant garlic (*Allium ampeloprasum*) is actually a leek that produces large cloves.

Diseases of Alliums at Global Status

Onion and other alliums production and quality are negatively affected by many foliar, bulb and root fungal pathogens (Schwartz and Mohan, 2004). There are only two reviews concerning the *Fusarium* basal rot and purple blotch diseases in onion (Aveling, 1998; Cramer, 2000), although there are a lot of research papers on onion diseases. It is affected by several bacteria, fungi, nematode, virus, phytoplasma and phanerogamic plant parasite. It has been estimated that more than 25% yield losses occur due to foliar diseases, especially *Stemphylium* blight (*S. vesicarium*) and purple blotch (*Alternaria porri*) (Cramer, 2000). Most of the major garlic diseases are soil borne, so proper site assessment and yearly rotations are crucial in maintaining a healthy garden of garlic. In addition to these diseases, garlic is also subject to damage by several genera of nematodes. reviews cover the detection of garlic viruses and the propagation of virus-free crops; bacterial diseases of the alliums, including descriptions of diseases that have become significant recently; and the important topic of forecasting and monitoring pests and diseases in connection with IPM methods of control.

Major Fungal Diseases of Alliums

Purple Blotch/ Brown Blotch/ Scald: *Alternaria porri*

Purple blotch is one of the major constraints in onion, garlic, shallots and leek cultivation. The causal organism, *Alternaria porri*, (Ellis) Cif (Phylum: Ascomycota; Subdivision: Pezizomycotina, Class: Dothediomycetes, Order: Pleosporales, Family: Pleosporaceae) is a polyphagus pathogen infecting crops like onion, garlic, shallot and other *Allium* spp. Shahanaz *et al.* (2007) reported losses about 50 to 100 per cent due to purple blotch disease. The yield losses of bulb and seed crop in India due to this disease under favorable conditions are 96 % (Gupta and Pathak, 1998). This disease distributed widely in Canada, India, South Africa, US, West Indies and Europe.

Symptoms: Symptoms begin as water-soaked lesions that usually have a white center with minute dots. Margin of lesions become brown to purple and the leaf turns yellow above and below the lesions. These are areas of fructifications of the fungus. As the disease progresses, lesions may girdle the leaf causing it to collapse and die. Similar symptoms occur on seed stalks and infected stalks can collapse resulting in shriveled seed development. Older leaves are more susceptible than younger leaves. When bulb infection occurs, it is normally through the neck. If the fungus invades the bulb, the infected area is initially bright yellow, but eventually turns a characteristic red wine color. Finally, bulbs become dry and papery.

Basal Rot/ Bulb Rot/ Root Rot/ Wilt: *Fusarium oxysporum* f. sp. *cepae*

Onion basal rot was first observed in Ohio, USA (Clinton, 1915). Basal rot is a common disease in onion growing regions worldwide, causing economically significant losses in both field and storage (Abawi and Lorbeer 1971). *Fusarium* basal rot caused by the pathogen *Fusarium oxysporum* f. sp. *cepae* which causes pre and post emergence damping off in seedlings, root rot in older plants, stem plate discoloration and basal rot of bulbs in the field and storage (Abawi and Lorbeer, 1972). *F. culmorum* is the causal agent of the same disease on garlic and leek. *Fusarium proliferatum* is reported to affect the bulbs of onion and garlic.The disease occurs in all stages of crop growth (Coskuntuna and Ozer, 2008).

Symptoms: Initially, above ground symptoms are chlorosis, curling and necrosis at the tip of leaf blades. With time, whole leaf blades show symptoms and eventually wither and dry. Infected roots are dark brownish, flattened, transparent and sometimes hollow. When affected bulbs are cut vertically, they show a watery, brown discoloration of the outermost layer of the stem plate, which may progress up through the storage leaves. White mycelium of the fungus may colonize the scale and, eventually, roots may rot. Infected plants can be pulled easily because of their decayed root. Infected bulbs may show no decay at harvest but may rot in storage.

Damping Off: *Pythium* spp., *Fusarium* spp., *Rhizoctonia solani*

Fusarium species - The fungus is mainly soil borne may cause both pre and post-emergence damping-off. Roots are invaded and eventually turn dark red or black as they decay. Seedlings are unthrifty and stunted, eventually turn yellow, wilt and die.

Pythium species - A water-soaked lesion develops on lower stems and a watery rot occurs on the roots. The roots may turn black as they decay. The fungus can also attack seeds and cause a watery decay. Older plants that are infected are stunted and yellowing and wilting of leaves may occur during severe infections.

Rhizoctonia solani - Seeds may rot before germinating and seedlings may decay before emergence. A brown rot develops on roots and lower stems at or below the soil line, and infected seedlings quickly wilt and collapse.

Downy Mildew: *Peronospora destructor*

The disease is caused by and reported from hilly track and plains particularly in high humid locations (Sharma, 2007). Since it has occurred and has often been destructive on various kinds of onions in recently all parts of the world. 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. It is a difficult disease to control with fungicides, and improved disease management strategies are a priority for research.

Symptoms: Initial symptom observed is the brownish-purple velvet-like sporulation of the pathogen on healthy matured leaves mostly under humid atmosphere. As the disease progresses lesions which are slightly paler than the normal leaf color, enlarge and may girdle the leaf. These lesions progress to a pale yellow followed by brown necrosis resulting in collapse of the leaf tissue. Infected seed stalks tend to remain pale yellow and, as with the foliage, are often invaded by other fungi, typically *Stemphylium* or *Alternaria* species. Field infections usually begin in small patches and progress rapidly throughout the field. Bulbs can be infected and may either rot in storage, or if planted, give rise to pale green foliage. The fungus can invade floral pats and thus infect a small proportion of the seed.

Blast: *Botrytis allii*, *B. byssoidea, B. squamosa, B. cepa*

Blast or Neck rot affects garlic, shallot, multiplier onion, and leek, but it is most important on bulb onion where losses can sometimes be greater than 50% .

Symptoms: Initially appear as a large number white speck with necrotic centres (2 mm in diameter) surrounded by a light green halo (1-1.5mm in width) which take an elliptical shape (Sharma, 2007). Under prolonged moist conditions, the fungus develops rapidly and causes blighting of leaves. The pathogen overwinters as sclerotia or mycelium on the crop debris. Sclerotia upon germination produce conidia and serve as source of primary inoculum.

Smut: *Urocystis cepulae*; *U. colchici*

Smut occurs in many onion growing areas and is occasionally important. It affects bulb and salad onion, leek, shallot, and chives (Koike *et al.*, 2007).

Symptoms: Infected seedlings often die within sixweeks of emergence. 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. Infected plants are stunted as infection progresses inward from leaf to leaf. 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.

Rust: *Puccinia allii* and its complex

Rust diseases of allium crops occur wherever these crops are grown and are important production factors that cause significant crop damage to onion, leek, garlic, and chives. However, the rust pathogen is comprised of genetically distinct sub-groups; therefore, rust in one part of the world may or may not be the same pathogen as rust elsewhere (Jennings *et al*., 1990).

Symptoms: The disease first appears as small, circular, white to tan lesions along leaf veins. Lesions develop into orange toured circular or elongate uredial pustules that are often surrounded by chlorosis. Chlorotic leaf spots may also occur without further symptom development. When disease pressure is severe, leaves turn yellow and die prematurely. Dark brown teliospores may form in the pustules later in the season.

Smudge: *Colletotrichum circinans*

It also produces black fungal growth on onion, leek, and shallot, so differentiating smut from smudge in the field may be difficult.

Symptoms: The disease occurs late in the season as the crop matures and continues to develop on bulbs in storage (Walker, 1921). The fruiting bodies of the fungus turn from dark green to black as they mature, and form concentric rings around the neck and on the surface of dry outer bulb scales. If the humidity is high, the disease may spread to the inner scales, causing small, yellow lesions. If the disease continues to develop, the bulb may shrivel and sprout prematurely. Under warm, wet conditions this fungus can cause damping-off and leaf spotting.

White Rot: ***Sclerotium cepivorum***

This is a major root rot disease of alliums, with onion and garlic being particularly affected (Entwistle, 1990). White rot can also be a common problem in garden settings. In some regions white rot is an increasing problem due to intense crop rotations and shortage of uninfested land.

Symptoms: This disease can be one of the most damaging on onions with the first symptoms including yellowing, wilting and dropping of the older leaves. As the fungus invades the root system and basal plate it causes a rot, which eventually results in the collapse of the foliage. A soft rot gradually develops in the bulb and a thick white mycelial growth develops on the base of the bulb. Numerous sclerotia form on the diseased tissues. This disease usually appears on groups of plants in the field that are often widely spaced. However, large groups of plants may die suddenly when the fungus is abundant in the soil and conditions are favorable for disease.

White Tip: ***Phytophthora porri***

White tip is one of the most important foliar diseases on leek. It has become more important in the UK with increasing leek production and loss of effective fungicides. The disease has been mainly reported from Europe, Canada, and Japan. *Phytophthora porri* affects various alliums, including bulb and green onion, and garlic. In Japan, losses of 70% or more can occur in onion crops (Koike *et al.*, 2007).

Symptoms: The tip of leaves becomes yellow and turns white. In severe attack, leaves turn backward. Water soaked area in the vicinity of the midrib may appear half way on the leaf or near the base. Lesions are readily colonized by secondary fungi and sooty molds, making diagnosis difficult in the field because of symptom similarities with other foliar problems such as *Cladosporium* leaf blotch, purple blotch, or frost damage. Badly affected leaves rot and plants may be stunted or even killed. The disease spreads rapidly in cool, wet weather. On onion and garlic, this pathogen causes water-soaked leaf blight and root rot symptoms.

Major Bacterial Diseases of Alliums

Bacterial Soft Rot: *Erwinia carotovora, Dickeya chrysanthemi, Pectobacterium carotovorum* subsp. *Carotovorum, Lactobacillus* spp.

Onion bulbs are susceptible to infection around harvest time when bulb rot bacteria can invade leaf tissue and enter the top of the bulbs via the neck if leaves and cut necks are wet. Bacterial soft rot attacks nearly every known fruit, fleshy tuber, root, and succulent bud or stem of most vegetable crops (Horst, 2013). Bacterial soft rot, is one of the most widespread and destructive storage diseases of onion. Soft rot generally starts in the field just before or during harvest. In 1995, *Dickeya chrysanthemi* caused severe economic losses to onions in New York. The soft-rot erwinias produce typical soft rot symptoms, mainly in the inner scales of the bulb onion.

Symptoms: Bacterial soft rot is mainly a problem on mature bulbs. Affected scales first appear water-soaked and pale yellow to light brown when infected by *Dickeya chrysanthemi* or bleached gray to white when infected with *Pectobacterium carotovorum* subsp. *carotovorum* or Initially oozing and may render complete rotting on the outer scales. As the soft rot progresses, invaded fleshy scales become soft and sticky with the interior of the bulb breaking-down. A watery, foul-smelling thick liquid can be squeezed from the neck of diseased bulbs.

Bacterial Blight of Leek: ***Pseudomonas syringae* pv. *porri***

In commercial orchards this bacterium affects primarily leek and has been reported from the USA,

England, France, and New Zealand. Onion, chives and garlic have developed bacterial blight when inoculated with this pathogen in experimental situations (Lelliott *et al*., 1952; Sansom *et al*., 1998).

Symptoms: Young leaves show water-soaked then yellow longitudinal lesions or stripes that later split and rot. The leaves can become curled and twisted as growth continues. On older leaves, the pathogen causes yellow spots around wounds. Flowering stalks are very susceptible and develop deep, water-soaked lesions that ooze a bacterial exudate. Older stalk lesions are sunken, first yellow, then finally brown in color. Leek transplants can develop the disease while growing in greenhouses. Leaves of transplants develop yellow, then brown, elongated lesions. Lesions usually involve the tips of the leaves.

Major Viral Diseases of Alliums

Onion Yellow Dwarf: *Onion yellow dwarf virus*

The Onion yellow dwarf virus infects plants from the genus Allium worldwide (Diekmann 1997). It is transmitted mechanically by aphids as a non-persistent virus. It is not transmitted via seeds (Brunt *et al*., 1996; Lot *et al*., 1998), but by vectors and vegetative propagation material. The host range of this virus is limited to the genus Allium; the infection is particularly prevalent in onions and shallots.

Symptoms: Infected leaves have symptoms ranging from yellow streaks to complete yellowing. Leaves tend to flatten, crinkle, twist and bend over (Shiboleth *et al*., 2001). Plants may be wilted and dwarfed and bulbs usually remain solid but do not reach their full size. In seed crops, plants produce smaller flower clusters and fewer florets.

Garlic Mosaic: *Garlic yellow streak virus, Leek yellow stripe virus, Garlic yellow stripe virus*.

Garlic mosaic is the common name of a virus disease that affects garlic. There are several viruses that infect garlic and cause this disease, and many of these pathogens are not yet fully identified or characterized (Chen et al., 2001).

Symptoms: Foliar symptoms can vary greatly, but mostly consist of mild to severe mosaics, streaking, striping, and chlorotic mottling. Symptoms are often most evident in the youngest leaves. The overall effect is generally smaller bulb size and yield reductions of up to 50%.

Diseases of Onion (*Allium cepa*)

1. Purple/ Brown Blotch: ***Alternaria porri, A. tennis, A. tenuissima***
2. Powdery Mildew: ***Oidiopsis taurica***, ***Leveillula taurica***
3. Basal Rot: ***Fusarium oxysporum* f. sp. *cepae***
4. Black Stalk Rot/ Tip Blight/ Seed Mold: ***Stemphylium botryosum***
5. Charcoal Rot: ***Macrophomina phaseoli***
6. Dry Rot: ***Diplodia natalensis***
7. Canker: ***Helminthosporium allii***
8. Neck Rot/ Gray Mold: ***Botrytis allii***; ***B. cinerea***
9. Brown Stain: ***Botrytis cinerea***
10. Blast: ***Botrytis allii***, ***B. byssoidea, B. squamosa, B. cepa***
11. *Botrytis* Leaf Blight: ***Botrytis squamosa***
12. Leaf blotch: ***Cladosporium allii-cepa***
13. Pink Root Rot: ***Pyrenochaeta terrestris***
14. *Phytophthora* Neck and Bulb: ***Phytophthora nicotianae***
15. Root Rot: ***Thielaviopsis basicola***
16. Smudge: ***Colletotrichum circinans***
17. Southern Blight: ***Sclerotium rolfsii***
18. Damping-Off: ***Pythium* spp., *Fusarium* spp., *Rhizoctonia solani***
19. Downy Mildew: ***Peronospora destructor***
20. Leaf Necrosis/ Seedling Death: ***Phytophthora nicotianae***
21. Leaf Spot: ***Heterosporium allii, Phyllosticta allii, Cercospora duddiae***
22. *Stemphylium* Leaf Blight: ***Stemphylium vesicarium***
23. Bulb Rot/Black Mold Rot: ***Aspergillus niger***
24. Yellow Mold Rot: ***Aspergillus alliaceus***
25. Blue Mold: ***Penicillium* spp**.
26. *Rhizopus* Rot: ***Rhizopus stolonifer***
27. Pink Rot: ***Phoma terrestris***
28. Soft Rot: ***Sclerotinia sclerotiorum***
29. Watery Soft: ***Fusarium proliferatum***
30. White Rot: ***Sclerotium cepivorum***
31. White Tip: ***Phytophthora porri***
32. *Sclerotium* Rot: ***Corticium rolfsii***

33.Rust: ***Puccinia asparagi*** (0, I, II, III), ***P. allii* (*P. porri*)** (II, III)
34.Smut: ***Urocystis cepulae***, ***U. colchici***
35.Twister: ***Colletotrichum gloeosporium***
36.Black Stalk Rot: ***Stemphylium botryosum***
37.Yeast Soft Rot: ***Kluyveromyces marxianus*var. *marxianus***
38.Bacterial Leaf Blight: ***Xanthomonas campestris, X. axonopodis, Pantoea ananatis***
39.*Xanthomonas* Leaf Blight: ***Xanthomonas axonopodis* pv. *allii***
40.Bacterial Rot/Slippery Skin: ***Pseudomonas gladioli* pv. *alliicola, P. cepacia***
41.Seedling Blight: ***Pseudomonas siccatum***
42.Scale Rot/ Internal Bulb Decay: ***Enterobacter cloacae***
43.Sour Skin: ***Pseudomonas cepacia***
44.Bacterial Soft Rot: ***Erwinia carotovora, Dickeya chrysanthemi, Pectobacterium carotovorum* sub sp. *Carotovorum, Lactobacillus* spp.**
45.Bacterial Leaf Streak and Bulb Rot: ***Pseudomonas viridiflava***
46.Bacterial Yellows: ***Spiroplasma citri***
47.Center/Bulb Rot: ***Panatoea ananatis***
48.Leaf Blight: ***Pantoea agglomerans***
49.Dwarfing: ***Onion yellow dwarf virus***
50.Scape Blight: ***Impatiens necrotic spot virus, Iris yellow spot virus***
51.Phytoplasma: **Aster yellows, California aster yellows, Clover proliferation**
52.Dodder: ***Cuscuta* spp**.

Diseases of Vidalia Sweet Onion (*Allium*)

1. Downy Mildew: ***Peronospora destructor***
2. Bulb Rot: ***Botrytis tulipae***

Diseases of Garlic (*Allium sativum*) See Onion.

1. Neck Rot/Bulb Rot: ***Botrytis allii, Fusarium oxysporum***
2. Internal Bulb Rot: ***Macrophomina phaseolina***
3. *Stemphylium* Leaf Blight: ***Stemphylium vesicarium***
4. Black Mold Blemish: ***Aspergillus alliaceous, A. niger, A. repens, A. sclerotiorum***
5. Shrivelled Bulb Rot: ***Rhizopus oryzae***
6. White Rot: ***Sclerotium cepivorum***
7. *Botrytis* Rot: ***Botrytis porri***
8. *Penicillium* Decay: ***Penicillium hirsutum***
9. Rust: ***Puccinia allii***
10. Powdery Mildew: ***Oidiopsis* spp.**
11. Dwarfing: **Onion yellow dwarf virus, Leak yellow stripe virus, Garlic common latent virus**
12. Mosaic/Stripe: **Garlic yellow streak virus, Leek yellow stripe virus, Garlic yellow stripe virus, Leak yellow strip virus, Iris yellow spot virus**, **Irish yellow spot virus, Japanese garlic virus** (Virus A, B and D), **Garlic common latent virus.**

Diseases of Chives (*Allium schoenoprasum*)

1. Leaf Blight: ***Botrytis byssoidea***
2. Downy Mildew: ***Peronospora destructor***
3. Rust: ***Puccinia porri***(II, III)
4. Smut: ***Urocystis cepulae***
5. Pink Rot: ***Phoma terrestris***

Diseases of Leek/Shallot (*Allium porrum, Allium ascalonicum*) See Onion.

1. White Tip of Leek: ***Phytophthora porri***
2. Southern Blight: ***Sclerotium rolfsii***
3. Purple Blotch: ***Alternaria porri***
4. Downy Mildew: ***Peronospora destructor***
5. Bulb and Basal Rot: ***Fusarium culmorum***
6. *Fusarium* Foot Rot: ***Fusarium oxysporum***
7. *Verticillium* Wilt: ***Verticillium dahliae***
8. Neck Rot/ Gray Mold: ***Botrytis allii***
9. *Botrytis* leaf spot: ***Botrytis cinerea***
10. Leaf blotch: ***Cladosporium allii-cepa***
11. Smudge: ***Colletotrichum circinans***
12. Leaf Blight: ***Stemphylium botryosum***
13. Rust: ***Puccinia porri***
14. *Pleospora* Rot: *Pleospora herbarum*
15. Pink Root Rot: ***Pyrenochaeta terrestris,Fusarium solani***
16. White Rot: ***Sclerotium cepivorum***
17. Smut: ***Urocystis cepulae***
18. Bacterial Blight: ***Pseudomonas syringae* pv. *porri***
19. Wilt: ***Tomato Spotted Wilt Virus***
20. Yellows: ***Iris yellow spot virus, Aster yellows, Shallot latent mosaic virus***
21. Stripe: ***Leek yellow stripe virus***

22.Dwarf: ***Onion yellow dwarf virus, Shallot latent virus, Shallot virus X***

Integrated Management Approaches

The integrated management of Allium crop diseases utilizes many principles of plant diseases control. Resistance lines to most seed, soil, and airborne diseases presently are not available in commercial cultivars. Crop rotation, soil solarization, biological amendments and the use of new generation fungicides in seed treatments, furrow treatments, seedling dips and sprays are procedures extensively used, especially for onions and garlic. Crop rotation is mainly used to reduce the inoculum level of many pathogens persist in soil. Soil fumigants control *Fusarium, Pythium, Rhizoctonia, Sclerotinia* and nematode diseases. Soil treatment with garlic oils, flooding, alternate wetting and drying and dipping transplant onions in fungicide solutions have been utilized to control white rot. Seed treatments with fungicides control seedborne *Botrytis* neck rot, smut, smudge, root rot, stalk rot, basal rot and damping-off diseases. Seed furrow treatments with fungicides control *Fusarium*, *Pythium*, damping off and onion smut. Fungicide sprays control *Botrytis* and *Stemphylium* leaf blights, *Botrytis* flower blight, *Alternaria* purple blotch and downy mildew. Antibiotic and copper based sprays may reduce the incidence of bacterial diseases and bulb decays. Undercutting, wind rowing, and/or heating in storage to dry the inside tissues of onion bulb necks prevents *Botrytis* neck rot. Onion yellow dwarf virus is controlled by roguing volunteer onions. Thermotherapy is the most efficient method for elimination of garlic viral infections (Conci and Nome, 1991). In Alliums, garlic can be affected by over 20 different viruses. Antisera are used to detect such viruses in garlic and other allium crops. Infected garlic is destroyed or heat treated under controlled condition to rid the propagative material of the virus. Certain onion cultivars resistant to pink root, *Fusarium* basal rot and *Botrytis* brown stain have been reported. If possible, work in clean fields prior to working in fields where infections or infestations have been found. Additionally, as with any crop, it is important to plant clean healthy seed. For most of the mentioned diseases (basal rot, white rot, downy mildew and nematode infestation), once the pathogen is established in a field, rotation away from *Allium* spp. for several years is an essential management tool.

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