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Prevalence and Management of Major Diseases of Garlic is it Global Level: A Review

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ABSTRACT

The garlic (*Allium sativum* L.) is family amaryllidaceae, perennial plant are the most important commercial crop grown all over world and consumed in various forms. These crops are generally grown throughout the country especially China, India, Bangaldesh, Egypt, south Korea, Russian Federation, Ukraine, Spain, Uzbekistan and Myanmar in India is the major growing of the states of Maharashtra, Uttar Pradesh, Orissa, Gujarat, Madhya Pradesh, Haryana, Punjab, Rajasthan, Uttaranchal, Jammu and Kashmir, Bihar, Andhra Pradesh and Karnataka. Garlic contains at least 33 sulfur compounds, several enzymes and the minerals germanium, calcium, copper, iron, potassium, magnesium, selenium and zinc; vitamins A, B1 and C, fiber and water and also contains amino acids lysine, histidine, arginine, aspartic acid threonine, glutamine, proline, glycine, alanine, cysteine, valine, methionine, isoleucine, leucine, tryptophan and phenylalanine garlic extract is effective against bacteria, fungi, parasites, lower blood pressure, blood cholesterol and blood sugar, prevent blood clotting, protect the liver and contains antitumor properties in humans garlic extracts have exhibited activity against. The garlic crop is cultivated in several countries and susceptible to number of diseases at various stages of plant growth. From different parts of the world, downy mildew, rust, purple blotch; Stemphylium blight, basal rot, have been observed leading to substantial. Apart from reduction in crop yield, the disease 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 of qualitative and quantative. The diseases alter the cropping pattern and also affect the local and export markets. The consistent use of chemicals to control the plant diseases not only poses a serious threat to the environment and mankind but also slowly build up resistance in the pathogens.

Key words: Garlic, Pink rot, Purple blotch, *Stemphyllum* spp., White rot.

The garlic (*Allium sativum* L.) is useful to mitigate the effect of medicinal and culinary properties throughout the world. Biochemical constituents including thiosulfinates, thiosulfonates, allicin, ajonen that make the crop very precious in human health care system. Effective antimicrobial properties of garlic have been well accepted. The crop has exhibited a potential therapeutic medicinal value with antifungal, antibacterial, antiviral, anti helmantic, antiseptic and anti-inflammatory properties. The most recent classification scheme of garlic is class Liliopsida, subclass Liliidae, superorder Lilianae, order Amaryllidales, family Amaryllidaceae subfamily Allioideae, tribe Allieae and genus Allium which is mainly based on the sequences of nuclear ribosomal DNA (Reuter *et al*., 1996).

Garlic is a herbaceous annual bulbous plant in the family Amaryllidaceae grown for its pungent, edible bulb. The garlic plant can either have a short, woody central stem (Hard neck) or a softer pseudo-stem made of overlapping leaf sheaths (soft neck). India ranks second with 2.0 lakh ha area and production with 10.58 lakh tons at global level, However, productivity remains low with 5.05 t/ha as compared with Egypt (25.28 t/ha) and China (23.60 t/ha). Long day and Short day type of garlic are cultivated in India. In Madhya Pradesh short day type varieties are grown. Long day type of garlic is confined to hills of India, especially in Jammu and Kashmir, Himachal Pardesh and Uttrakhand region. Worldwide, garlic was grown over 14.22 lakh hectares and had a total production of 237.70 lakh tons and an average productivity of 16.71 t/ha (Source: FAOSTAT, 2013). Among 140 countries where garlic is grown, China is world leader in production (80.92%), followed by India (4.45%). Per hectare productivity of garlic is the highest in Egypt (24.36 t/ha).

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The garlic crop is cultivated in several countries and susceptible to number of diseases at various stages of plant growth (Walker, 1952). From different parts of the world, downy mildew, rust, purple blotch; Stemphylium blight, basal rot, have been observed leading to substantial losses (Ahmad and Karimullah, 1998; Apaza and Matos, 2000; Schwartz and Mohan, 1995; Evarts and Lacy, 1990).

Investigation on various aspects of Purple blotch (*Alternaria porri*) (Dhiman *et al*., 1986; Quadri *et al*., 1982);

Stemphylium blight (Thind *et al*., 1985; Singh *et al.,* 1977), basal rot (*Fusarium oxysporum*) (Mathur and Sankhala, 1963) Rust (*Puccinia porri*) (Sandhu and Kang, 1988); garlic mosaic virus (Ahlawat, 1974), downy mildew (Singh *et al*., 1987) are reported from India. Management approaches for purple blotch; Stemphylium blight, basal rot, rusts; garlic mosaic virus, downy mildew has been worked out in various agro ecological zones of India (Shrivastava *et al*., 1992; Anonymous, 2013).

Various diseases have been reported on garlic bulbs in particular are affected by association of number of fungal pathogens both in fields and storages. The bulbs due to handling, cultivation practices and ill storage are infected severely by number of fungal pathogens. The bulbs are significantly damaged and destroyed resulting in bulb rot and bulb necrosis (Rai and Agarwal, 1976; Georgieva and Kotev 1977).

Global distribution fungal disease

Disease	Causal organism	Distribution
Basal rot	*Fusarium oxysporum f.* sp.*cepae*	Worldwide
Black mold	*Aspergillus niger*	Worldwide
Black stalk rot	*Stemphylium botryosum*	Worldwide
Blue mold	*Penicillium* species	Worldwide
Botrytis brown stain	*Botrytis cinerea*	North America and Europe
Botrytis leaf blight	*Botrytis squamosal*	North America and Europe
Damping-off	*Fusarium* species, *Pythium* spp., *Rhizoctonia solani*	Worldwide
Downy mildew	*Peronospora destructor*	Worldwide in temperate and cool growing regions
Leaf blotch	*Cladosporium allii*	British Isles and Canada
Neck tot	*Botrytis allii*	Worldwide
Phytophthora neck, bulb rot	*Phytophthora nicotianae*	Brazil and Taiwan
Pink toot	*Phoma terrestris*	Worldwide
Powdery mildew	*Leveillula taurica*	Brazil, Israel, Italy, Turkey and USA
Purple blotch	*Alternaria porri*	Worldwide
Rust	*Puccinia allii*	Worldwide
Smut	*Urocystis colchici*	Worldwide
Stemphylium blight	*Stemphylium vesicarium*	India and USA
White rot	*Sclerotium cepivorum*	Worldwide
White tip	*Phytophthora porri*	Worldwide

Virus diseases

Disease	Causal organism	Distribution	Reference
Garlic common latent carlavirus	GCLV	South America, Central America, India, China	Delecolle and Lot (1981), Raichen 1991)
Garlic dwarf reovirus	GDV	Southern France	Lot, INRA, Montfavet
Leek yellow stripe potyvirus	LYSV	Europe, South America, Australia, New Zealand	Walkey *et al.* (1987)
Mite-borne filamentous viruses	MbFV	Cosmopolitan	Kanyuka *et al. (*1992), Yamashita *et al. (*1996)
Onion yellow dwarf potyvirus	OYDV	Cosmopolitan	Bos (1976), Louie and Lorbeer (1996)
Shallot latent carlavirus	SLV	Asia , Europe, Mexico	Bos (1982), van Dijk (1993)
Shallot yellow stripe potyvirus	SYSV	Asia	van Dijk (1993), Barg *et al.* (1997)
Cucumber mosaic cucumovirus	CMV	Yugoslavia	Stefanac (1980)
Lettuce necrotic yellows rhabdovirus	LNYV	Australia	Sward (1990)
turnip mosaic potyvirus	TMV	SlovenialsraeI	Gera *et al.* (1997)
Garlic mosaic virus	GMV	South America, Central America, India, China	

Bacterial diseases

Disease	Causal organism	Distribution
Bacterial flower stalk and leaf necrosis	*Erwinia herbicola*	North America and Europe
Bacterial internal brown rot	*Pseudomonas aeruginosa*	Worldwide
Bacterial soft rot	*Pectobacterium carotovorum*	Worldwide in temperate and cool growing regions
Center rot	*Pantoea ananatis, Erwinia ananatis*	British Isles and Canada
Sour skin	*Pseudomonas cepacia*	Worldwide
Xanthomonas leaf blight	*Xanthomonas axonopodis* pv. *allii*	Asia and Europe, Mexico
Center rot	*Pantoea ananatis*	Worldwide

Nematode diseases

Disease	Causal organism	Distribution
Lesion nematode	*Pratylenchus penetrans*	Worldwide in temperate and cool growing regions
Needle nematode	*Longidorus africanus*	Worldwide
Root-knot nematode	*Meloidogyne hapla*	India and USA
Stem and bulb nematode (Bloat)	*Dictaylanchus* sp	Worldwide
Sting nematode	*Belonolaimus longicaudatus*	Worldwide
Stubby-root nematode	*Paratrichodorus allius*	South America, Central America, India, China

In India

Garlic was grown on Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, Assam, Punjab, Maharashtra on various aspects of Purple blotch (*Alternaria porri*) (Dhiman *et al*., 1986; Quadri *et al*., 1982); Stemphylium blight (Thind *et al*., 1985; Singh *et al*.,1977), basal rot (*Fusarium oxysporum*) (Mathur and Sankhala, 1963) Rust (*Puccinia porri*) (Sandhu and Kang, 1988); garlic mosaic virus (Ahlawat, 1974), downy mildew (Singh *et al*., 1987) are reported from India. Management approaches for purple blotch, Stemphylium blight, basal rot, rusts, garlic mosaic virus, downy mildew has been worked out in various agro ecological zones of India (Shrivastava *et al*., 1992).

Fungal diseases

Disease	Causal organism	Distribution	Reference
Purple blotch	*Alternaria porri*	Maharashtra, Gujarat, Rajasthan, Punjab	Dhiman (1986), Quadri (1982)
Stemphyliun blight	*Stemphylium vesicarium*	UP, HP, Punjab	Singh (1987), Sharma and Thind (1985)
Basal rot	*Fusarium oxysporum*	Rajasthan, MP, Punjab	Mathur and Sankhala (1963)
White rot	*Sclerorium cepivorum*	Rajasthan, MP, Punjab, UP	Tamire *et al*., (2007)
Smut	*Urocystis cepulae*	Rajasthan, MP, Maharashtra	
Rust	*Puccinia porri*	Punjab, MP, Rajasthan Gujarat	Sandhu and Kang (1988)
Black mold	*Aspergillus niger*	Rajasthan, MP, Punjab	Gupta and Srivastava (1992)
Downy mildew	*Peronospora destructor*	Punjab, UP, MP	
Neck rot	*Botrytis allii*	Rajasthan, MP, Punjab	
Damping off	*Pythium* spp.	Rajasthan, MP, Punjab	

Virus diseases

Disease	Causal organism	Distribution
Garlic common latent carlavirus	GCLV	Maharashtra, Gujarat, Rajasthan, Punjab
Garlic dwarf reovirus	GDV	UP, H.P, Punjab
Leek yellow stripe potyvirus	LYSV	Rajasthan, MP, Punjab
Mite-borne filamentous viruses	MbFV	MP, Punjab, UP
Onion yellow dwarf potyvirus	OYDV	Rajasthan, MP, Maharashtra
Garlic mosaic virus	GMV	Punjab, MP, Rajasthan, Gujarat

Bacterial diseases

Disease	Causal organism	Distribution
Bacterial internal brown rot	*Pseudomonas aeruginosa*	Rajasthan, MP, Maharashtra
Bacterial soft rot	*Pectobacterium carotovorum*	Punjab, MP, Rajasthan Gujarat
Center rot	*Pantoea ananatis* *Erwinia ananatis*	Madhya Pardesh, Gujarat, Harayana
Sour skin	*Pseudomonas cepacia*	Rajasthan, Madhya Pardesh
Xanthomonas leaf blight	*Xanthomonas axonopodis pv allii*	Madhya Pardesh, Gujarat, Harayana
Center rot	*Pantoea ananatis*	Rajasthan, MP, Maharashtra

Nematode diseases

Disease	Causal organism	Distribution
Root-knot nematode	*Meloidogyne hapla*	Rajasthan, MP, Punjab
Stem and bulb nematode(Bloat)	*Dictylanchus alli*	Rajasthan, MP
Sting nematode	*Belonolaimus longicaudatus*	Punjab, Harayana
Stubby-root nematode	*Paratrichodorus allius*	MP, Rajasthan

Prevalence and management of garlic diseases

White rot (*Sclerotium cepivorum*)

Distribution

The disease has been recorded from various part of India and abroad. White rot is one of the most important garlic diseases in the world, including Iran. *Sclerotium cepivorum* Berk. The causal agent of white rot and is found in practically all regions where species of Allium are grown (Entwistle, 1990; Crowe *et al*., 1993; Schwartz and Mohan, 1995; Davis *et al*., 2007).

Management

Allempts have also made to evolve and approchesas IPM technique using sclerotial germination stimulants in a field prior to planting there after introducing a biological control agent at the time of sowing. A number of research groups are investigating multiple approaches to disease control,that include combining solarization, biocontrol and application of vermicompost germination stimulants, fungicides and solarization (Dennis, 1997; Metcalf and Wilson, 1997). Application of microbial antagonists has shown a suitable ecologically-friendly candidate which could replace chemical pesticides. Different fungal and bacterial antagonists have proved to be potential bio control agents for controlling many plant pathogenic fungi (Cook and Baker, 1988). Different species of *Trichoderma* have been successfully used and have produced promising results for controlling garlic seedling basal rot disease (Metcalf *et al*., 2004; Heydari and Pessarakli, 2010; Sharifi *et al*., 2010; Francisco *et al*., 2011; Kakvan *et al*., 2013; Naraghi *et al*., 2013; Blaszczyk *et al*., 2014; Khiyami *et al*., 2014).

Naeimi and Zare (2014) have conducted studies using chemical and bioagent the study was conducted during 2013/14 under greenhouse condition. The results of the study revealed that the efficacy of both fungicides, when tested alone, against *S. cepivorum* was lower than those treated with *Trichoderma* spp. alone and the fungicide combined treatments. Among all treatments, (Apron Star 42 WS fungicide combined with *T. hamatum* and *T. viride*) has provided the best antagonistic activity against *S. cepivorum* with no disease incidence, followed by *T. viride* alone and Tebuconazole combined with *T. hamtum* both 11.1% incidence.

Gupta *et al*. (2011), Ahmad and Tribe (1977) have noticed that biocontrol agents *T. viride, Gliocladium zeae* and *Coniothyrium minitans* provided effective control of white rot disease of garlic.

Trichoderma as a potent fungal biocontrol agent against a range of plant pathogen has attracted considerable scientific attention. Chaube *et al*. (2002) and Harman *et al*. (2004) concluded that bio agent produce volatile and non volatile antibiotic compounds, which inhibit fungal growth at very low concentration and *Trichoderma* species are among the most promising bio control agents against many fungal pathogens (Rini and Sulochana, 2007; Akrami *et al*., 2009).

Fungal and bacterial antagonists have been proved to be potential biocontrol agents for controlling many plant pathogenic fungi (Metcalf *et al*., 2004; Heydari and Pessarakli, 2010; Sharifi *et al*., 2010; Francisco *et al*., 2011; Kakvan *et al*., 2013; Naraghi *et al*., 2013; Blaszczyk *et al*., 2014; Khiyami *et al*., 2014).

White rot disease caused by *S. cepivorum* could be controlled by application of bio agent *Trichoderma* were used in study, because the antagonistic fungus has effectively been used in the control and management of different plant diseases in the previous studies (Francisco *et al*., 2011; El-Hassan *et al*., 2013; Kakvan *et al*., 2013; Naeimi and Zare, 2014).

Purple blotch (*Alternaria porri*)

Distribution

The disease has been observed in all the major onion and garlic producing regions. Purple blotch caused by *Alternaria porri* has been reported in India and abroad (Hausbeck *et al*., 1999; Meyer *et al*., 2000). In Pakistan, fungal diseases cause a lot of problems in the production of onion and garlic. In fungal diseases, purple blotch of onion that is caused by *Alternaria porri* is a major threat for the onion and garlic crop (Lancaster *et al*., 1996). In India, the diseases caused by unseasonal rains have ruined almost 70 per cent of the *kharif* garlic crop in Maharashtra in 2010, which is responsible for the nationwide shortage of the commodity (Shrivastava, 2010).

Management

Use of disease free bulb should be selected for planting. Seeds should be treated with Thiram @ 4 g/kg seed. The field should be well drained. Three foliar sprayings with Copper oxychloride 0.25% or Chlorothalonil 0.2% or Zineb 0.2% or Mancozeb 0.2% were effective (Anonymous, 2011).

Bisht and Thomas (1992) have evaluated several systemic fungicide for the management of the disease. Purple blotch caused by *Alternaria porri* is a major constraint and causesd severe yield loss. Borkar and Patil (1995) reported that purple blotch and stemphylium blight disease of garlic could be managed by 3 to 4 sprays of 0.25% mancozeb at 10 days intervals that reduced the incidence and intensity of foliar diseases of garlic under condition of Maharastra.

Studies conducted on management of purple blotch in Marathwada region of Maharashtraand revealed that lowest disease severity of purple blotch with spray of mancozeb @ 0.25%, hexaconazole @ 0.1% and difenconazole @ 0.05%. systemic fungicides tebuconazole @ 0.1% and azoxystrobin @ 0.1% have effectively controlled purple blotch disease of garlic.The highest percent efficacy of disease control (PEDC) of purple blotch (62.21%) with foliar sprays of mancozeb @ 0.25% followed by tebuconazole @ 0.1% (55.63%) andazoxystrobin @ 0.1% (54.78%) in comparison was noticed (Wangikar *et al*., 2012).

Tripathy *et al*. (2014) reported that purple blotch disease in garlic. Could effectively managed by mancozeb @ 0.25%+methomyl @ 0.8 g per lit. tricyclazole / propiconazol @ 0.01%+carbosulfan @ 2 ml per lit. and copper oxychloride @ 0.25% / hexaconazole @ 0.1%+profenofos 1 ml per lit. At 30, 45 and 60 DAT against purple blotch under Odisha condition efficacy of tricyclozoles, propiconazole and hexaconazole in controlling *Alternaria porri* has been reported.

Maximum disease incidence in field was recorded on plants sprayed with Dora (54.05%) followed by Dorazole (43.31%), Score (36.54%) but the lowest disease incidence was on plants that were treated with Mancozeb (22.22%) as compared to control with 78%. Dithiocarbamate, which is active ingredient of Mancozeb, destroys fungal spores (Koike and Heinderson, 1998).

Pandey *et al*. (2002) tested fungicides against purple blotch which is a common disease of onion and garlic and reported that all fungicides significantly controlled disease but Indofil M-45 (Mancozeb) was found the best in respect to disease control. *In vitro* screening of fungicides revealed to be highly fungitoxic Mancozeb was the effective fungicide against purple blotch and four sprays of Mancozeb @ 0.3% with Monocrotophos @ 0.05% was the best treatment and recorded the least disease incidence and highest yield (Vijay and Rahman, 2004).

Efficacy of bioagents against the disease has been reported. Among the bio agents, *T. harzianum* @ (1%) was found to be effective in delaying diseases severity with optimum yield (1134.44 kg/ha) over check (893.33 kg/ ha) (Vannaci and Harman, 1987; Sharma, 2012; Shahnaz *et al*., 2013).

Aujla *et al*. (2010) noticed that application of Tebuconazole and Propiconazole were the most effective fungicides against purple blotch disease of onion and garlic and resulted in lowest disease severity (6.1 and 7.3 per cent respectively) with 73.0 and 66.6 per cent increase in seed yield over untreated control under Punjab conditions.

Basal rot (*Fusarium oxysporum*)

Distribution

The basal rot disease has been reported around the world, including India, Thailand, China, Japan, Iran, Israel, Australia and Europe (FAO, 1999). Species of Fusarium including *F. oxysporum, F. culmorum* and *F. proliferatum* occur in North America.

In India, the incidence of basal rot was first reported in Coimbatore, Tamil Nadu (Mathur and Shukla, 1963; Ramakrishnan and Eswaramoorthy, 1982).

Management

Trichoderma spp.and *Pseudomonas* sp. were screened against *F. oxysporum* f. sp. *cepae* by the dual culture method (Riker and Riker, 1936; Dennis and Webster, 1971).

Biological controls using fungal and bacterial antagonists have been suggested as a possible control method. Under *in vitro* conditions, fungal antagonists, *Trichoderma viride, T. harzianum, T. hamatum, T. koningii* and *T. pseudokoningii and* bacterial antagonists, *Pseudomonas fluorescens* and *Bacillus subtilis* were effective (Rajendran and Ranganathan,1996).

Stemphylium leaf blight (*Stemphylium vesicarium*)

Distribution

The Stemphylium blight has been reported throughout the regions wherever the garlic is produced. It has now been observed in many countries worldwide, including the USA, South Africa, Spain, Brazil, Australia, Egypt and China (Rao and Pavgi, 1975, Miller *et al*., 1978; Zheng *et al*., 2008).

During the past 20 years the disease has become increasingly important in temperate and tropical regions throughout the world. It is a major disease of garlic in Southeast Asia and India. Stemphylium blight (*Stemphylium vesicarium*) is also an important foliage disease of garlic crop prevalent in almost all the onion cultivated areas of Northern and Eastern India (Gupta *et al*., 1996; Suhag and Bhatia, 2006).

Management

Gupta *et al*. (1996) reported that *Stemphylium vesicarium* is one of the major destructive diseases of garlic crop grown in the state of Maharashtra. Bio-efficacy of eight fungicides was evaluated *in vitro* against *Stemphylium vesicarium*. All the fungicides tested were found/fungicidal against the pathogen and significantly inhibited mycelial growth of the pathogen over untreated control. However, Mancozeb 75 WP recorded significantly highest mean inhibition (90.01%) followed by Carbendazim 50 WP and Copper oxychloride 50 WP which recorded mean growth inhibition, respectively of 89.25 and 86.86 per cent. Chlorothalonil 75 WP (84.77% inhibition), Difenconazole 25 EC (84.02% inhibition), Thiophanate methyl 70 WP (78.21% inhibition), Penconazole 10 EC (77.61% inhibition) and Hexaconazole 5 EC (76.43% inhibition) were promising for effective management of Stemphylium leaf blight of garlic (Srivastava *et al*., 1995).

The fungicide mancozeb and Copper oxychloride have been reported most effective and economical fungicides against stemphylium blight and purple blotch disease *in vitro* as well as under field conditions (Jakhar *et al*, 1996). Among the new fungicides tested Tebuconazole, Propiconazole and the combination of Carbendazim 12% + Mancozeb 63% WP have proved highly effective fungicides against the disease and the fungicides can further be used as an alternate fungicide in place of conventional fungicides (Hug *et al*., 1994).

Studies revealed that Tebuconazole 25.9 EC, Propiconazole 25 EC and the combination of Carbendazim 12% Mancozeb 63% (SAAF) appears to be promising alternatives to the conventional fungicides Mancozeb 75 WP and Copper oxychloride 50 WP for efficient management of stemphylium blight disease of garlic crop. Among the diseases, foliar blight plays an important role in decreasing the yields. A number of pathogens have been found responsible for the disease, of which *Alternaria porri*, *A. alternata* and *Stemphylium vesicarium* are the most common (Gupta *et al*., 1996). They reported that Mancozeb was at par with Hexaconazole (at 0.06%) in which disease intensity of 32.35 and 13.59 per cent was recorded during first and second year, respectively. The efficacy of Mancozeb in the control of foliar blight of garlic (Srivastava *et al*., 1996) has been established.

Srivastava and Tiwari (2003) reported the efficacy of bio-control agents as compared to fungicides might be due to adverse environmental conditions causing their rapid desiccation. *T. viride* was found to increase germination of garlic clove.

The severity of Stemphylium blight was indexed at 30, 45, 60 and 75 days after transplanting on a 0-5 scale and per cent disease index (PDI) was computed (Sharma, 1995).

Identification of diseases at field level

White rot

The initial symptoms of white rot disease were the yellowing of leaves and later roots were destroyed. The leaves of infected plant exhibited girdling and dieback. Leaf decay at the base was observed and older leaves collapsed first. A semi watery decay of the stalks of bulb was recorded. The infected plant was easily pulled out from ground. Root was rotted. White fluffy growth around the base of the bulb was observed. The white fluffy fungal growth became more compact as the disease progressed, at later stage numerous small spherical black bodies (Sclerotia) formed on the mycelial mat, the sclerotia were approximately of the size of pin head, poppy seed, resembling mustard grain, the bulbs became soft and water soaked. Based upon the fungal mycelium and sclerotium the fungus was identified as *Sclerotium ceviporum*.

Pink rot

The garlic affected by basal rot pathogen exhibited progressive yellowing. Affected roots were brown to dark pink. In severe condition of infection white fungal growth was noticed at the base infected bulb, when the infected bulb cut vertically a brown discoloration on the spilt was apparent. In some cases stem plate tissue became pitted and showed dry rot. Under dry conditions the stem plate lead to crick scales. In advanced stage the bulb started decaing from lower and ultimately whole plant died. On the basis of fungal characteristics the pathogen was identified as *Fusarium oxsysporum*.

Purple blotch

The purple blotch symptoms were noticed on stalks as small sunken whitish flacks, with purple coloure. Later the lesion girdled leaves and stalks leading the drooping. Oval shaped tan and deep purple lesions on leaves margin were recorded. Concentric zone were observed within the lesions. The initial symptoms of purple blotch were small water soaked lesion that appeared on older leaves. As the disease progressed the lesion on larged became yellow and concentric ring formed on margins. Based on the fungal characteristics the pathogen was identified as *Alternaria porri*.

Stemphylium tender tip blight

The symptoms appeared as small yellow to orange flacks which turned brown, extended along the blade in both direction from the lesions. In advanced stages lesions girdled and killed leaves and stem, due to infection of *Stemphylium vesicarium*, under field conditions. Purple blotch and Stemphylium disease were differentiated on basis of margins of the lesions. In Stemphylium lesions were elongated spherical shaped surrounded in pinkish margin while in purple blotch small sunken whitish flacks with purple colour centres and the lesions were surrounded by yellow hallow.

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