REVIEW ARTICLE Agricultural Reviews, Volume 41 Issue 1: 51-58 (March 2020)

Stemphylium Blight of Onion: A Review

Mudasir Hassan[1], Vaseem Yousuf[1], T.A. Shah[1], N.A. Bhat[2], Z.A. Bhat[3], Misba Majeed[1], Rabia Latief[3]

10.18805/ag.R-1902

ABSTRACT

Onion (*Allium cepa*) is one of the most important crop grown throughout the world. Onion suffers from many diseases caused by fungi, bacteria, viruses, nematodes and abiotic factors. Among them fungal diseases stemphylium blight is the most serious and devastating disease of onion limiting the quality and quantity of both bulb and seed. The present review is mainly focused on variability associated with *Stemphylium vesicarium* and its integrated management. Variability studies are important to document the changes occurring in the population and individuals with variability in morphological, cultural and pathogenic characteristics so as to breed the varieties with durable resistance to the stemphylium blight of onion andidentification of source of resistance against the range of virulence present in the pathogen population. Further, management of stemphylium blight of onion through fungicide application is feasible, however, long term usage of fungicides has led to the resistance development in pathogens besides hazardous environmental consequences associated with their use. The most efficient and economical method to mitigate the menace of this disease is therefore, integrated disease management (IDM) approach where other non-chemical ecofriendly management strategies are integrated with chemical methods in order to manage the diseases more efficiently with reduced use of chemicals. Among non-chemical ecofriendly management strategies biological control is gaining interest as an alternative or complement to chemical treatment of the disease. The present review paper deals with distribution, symptomatology, pathogenicity, variability and integrated management.

Key words: Biological control, Integrated disease management, Stemphylium blight, *Stemphylium vesicarium*, Variability.

Onion (*Allium cepa* L.) is one of the most important and familiar crop throughout the world that belongs to the family Alliaceae. It is also used as a common spice, salad and vegetable in many countries of Asia. Onion has manifold uses as spices. It is also used as a condiment for flavouring a number of foods and medicines (Vohra *et al.,* 1974; Hassan, 2007). Onion bulbs are rich source of minerals like phosphorus, calcium andcarbohydrates besides being rich in proteins and vitamin C. Onion contains chemical compounds with potential anti-inflammatory, anti-cholesterol andanti-cancer properties (Slimestad *et al.*, 2007). The fungicidal and insecticidal properties of onion are well identified (Mishra *et al.*, 2014). Out of 15 important vegetables and spice crops listed by FAO, onion stands second in terms of annual world production (Anonymous, 1997). Onion is grown worldwide over an area of 3991.51 thousand hectares, with a total production of 76377.21 thousand MT of which fifty per cent is grown in Asia (FAO, 2015). India with 12013.59 hectares of area under onion and productivity of 21.2 million tonnes, ranks second in production after China (Anonymous, 2013).

Onion suffers from many diseases caused by fungi, bacteria, viruses, nematodes and abiotic factors (Paibomesai *et al*., 2012). Among the fungal diseases stemphylium blight is the most serious and devastating disease of onion limiting the quality and quantity of both bulb and seed (Nisha, 2013).

The disease is characterized by appearance of small yellow to orange streaks which soon develop into elongated, spindle shaped to ovate elongated diffused spots surrounded by pinkish margins. It can cause severe damage, especially to the onion seed crop and losses of about 80-85% on the crop by affecting leaves and seed stalk (Tomaz and Lima, 1988). The most efficient and economical method to manage plant diseases is the use of resistant varieties. In order to breed the varieties with durable resistance to the stemphylium blight of onion, there is need for identification of source of resistance against the range of virulence present in the pathogen population. Variability studies are important to document the changes occurring in the population and individuals with variability in morphological, cultural and pathogenic characteristics. Under natural epiphytotics, *S. vesicarium* has been found to express a wide range of

[1]Division of Plant Pathology, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore-193 201, Jammu and Kashmir, India.
[2]Mountain Research Centre for Field Crops, Khudwani-192 101, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, Jammu and Kashmir, India.
[3]Division of Plant Pathology, Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar-190 019, Srinagar, Jammu and Kashmir, India.

Corresponding Author: Mudasir Hassan, Division of Plant Pathology, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore-193 201, Jammu and Kashmir, India. Email: hmudasir72@gmail.com

How to cite this article: Hassan, M., Yousuf, V., Shah, T.A., Bhat, N.A., Bhat, Z.A., Majeed, M. and Latief, R. (2020). Stemphylium Blight of Onion: A Review. Agricultural Reviews. 41(1): 51-58.

Submitted: 21-05-2019 **Accepted:** 14-02-2020 **Published:** 23-03-2020

variability in disease symptoms expression depending upon the onion cultivars, environmental conditions etc as observed by various workers (Hosen *et al.*, 2009; Arzanlou *et al.,* 2012; Nisha, 2013).

Management of stemphylium blight of onion through fungicide application is feasible, however, long term usage of fungicides has led to the resistance development in pathogens besides hazardous environmental consequences associated with their use. Further, disease management through host resistance is a potential and desirable mean of disease management, yet it has its own limitations. Main problem is the durability or effectiveness of genes once exposed to field conditions. However, resistance can serve longer period provided it is supported by other measures of disease management, which keeps pathogen under control. Therefore, the most efficient and economical method to mitigate the menace of this disease is therefore, integrated disease management (IDM) approach where other non-chemical ecofriendly management strategies such as biological methods are integrated with chemical methods in order to manage the diseases more efficiently with reduced use of chemicals. The present review paper deals with various aspects such as distribution, symptomatology, pathogenicity, variability and integrated management of the disease.

Distribution and status of the disease

Stemphylium blight of onion, caused by *S. vesicarium* [(Wallr.) E. Simmons], with its perfect state as *Pleospora allii* [(Pers. er. Fr.) Rabenh.], was first reported by Rao and Pavgi in 1975 from Varanasi (U.P.) in India. Later, *S. vesicarium* was reported to cause leaf blight of onion and garlic in Spain and leaf blight of garlic in Brazil (Basallote *et al.*, 1993; Boiteux *et al.*, 1994). Polat *et al.* (2012) reported the first occurrence of *S. vesicarium* causing stemphylium blight of garlic in Turkey.

The disease is now widespread throughout the world and is now known to occur in Australia, Korean Republics and Venezuela (Meah and Khan, 1987; Hyesun and Hun, 1998; Suheri and Price, 2000; Cedeno *et al.*, 2003). After the first report of occurrence of this disease from India in 1975, thereafter its occurrence has been reported from other states of the country like Punjab (Thind *et al.*, 1985), Maharashtra (Patil and Patil, 1992) and Bihar (Sinha *et al.*, 1995). Jakhar *et al.* (1996) reported widespread occurrence of the disease after surveying various districts of Haryana andobserved higher disease incidence on the seed crop of onion than on bulb crop.

Wu (1979) while surveying the seed-borne diseases of vegetables observed that *Alternaria porri* and *S. botryosum* resulted in severe reduction in germination of onion seeds. Miller *et al.* (1978) reported significant damage caused by stemphylium blight of onion in South Texas whereas, Miller (1983) while assesing the severity of infected leaves from bulb initiation to bulb maturity of onion observed that the leaf damage levels were significantly lower on younger than older ones. Singh and Sharma (1977) reported another spp. of *Stemphylium* namely *S. botryosum* responsible for leaf blight of garlic (*Allium sativum*) in Kullu valley of Himachal Pardesh. Later, Thind *et al.* (1985) reported both species of *Stemphylium* namely *S. botryosum* and *S. vesicarium* associated with leaf blight of onion from Punjab. Gupta *et al.* (1996) stated that stemphylium blight (*S. vesicarium*) and purple blotch (*A. porri*) are important diseases causing considerable damage to onion crops in India.

While, conducting the survey of onion in Canada during the year 2012 and 2013 to assess the occurrence and severity of stemphylium leaf blight, it was observed that severity ranged from 2 to 60 per cent (Tesfaendrias *et al.*, 2014).

Symptomatology

Stemphylium blight of onion caused by *Stemphylium vesicarium* (Wallr.) E. Simmons [Teleomorph: Rabenh.) *Pleospora allii* (Pers.ex.Fr.) affects the seed as well as bulb crop. The symptoms of the disease have described by a number of workers in different parts of the world. Singh and Sharma (1977) reported initial symptoms on the leaves of garlic as small, yellowish circular to oblong spots, 2-3 mm in diameter, which rapidly enlarge to spindle shaped lesions of dirty white or grey colour attaining a size of 4-5 cm in length and 1-1.5 cm in width with profuse sporulation in the centre of the lesion. According to Tomaz and Lima (1986) stemphylium leaf blight of onion is associated with purple coloured lesions on leaves and inflorescence stalk. However, Shishkoff and Lorbeer (1989) observed pale, oval lesions that turned brown as they expanded eventually coalescing and killing leaves affected by *Stemphylium vesicarium.*

Basallote *et al*. (1993) reported that Stemphylium blight of onion initially developed dark purple and white leaf spots followed by extensive necrosis mainly on older leaves. Dark purple spots were eye shaped (5-15 mm long) with a purplish black centre surrounded by a straw coloured halo. However, Sharma and Sharma (1999) reported that infection caused by *Stemphylium vesicarium* occurred on the leaves and inflorescence stalks of onion in the form of small, light yellow to brown water-soaked streaks in the middle of leaves which soon became spindle shaped to ovate-elongate.

According to Thind (2001) disease initiated as small, yellow to pale orange flecks which develop in the middle of leaf and soon became elongated, spindle shaped to ovate spots surrounded by characteristic margins. Later these spores turn grey at centre with the development of conidiophores and conidia and giving the leaves a blightened appearance.

Pathogenicity and host

Stemphylium vesicarium has wide host range both a pathogen and saprophyte. In addition to onion, *S. vesicarium* been found to be pathogenic on garlic (Basallote, 1993), leek (Suheri and Price, 2001), Welsh onion (Misawa and Yasuoka, 2012), asparagus (Falloon, 1987) andEuropean pear (*Pyrus communis* L.) (Llorente and Montesinos, 2006). Also, in addition to known hosts, the pathogen can cause

asymptomatic infections and develop as endophytes in the living tissues of various plants (Kohl *et al.,* 2009; Misawa and Yasuoka 2012). In order to prove the pathogenic nature of *Stemphylium vesicarium*, different workers have adopted different methods on different bulbous vegetables. Singh and Sharma (1977) observed the development of typical spindle shaped lesions with profuse sporulation in seven days both in injured and uninjured inoculated leaves. According to Shishkoff and Lorbeer (1989) the fungus cause lesion development on leaves of all ages of onion plants, especially on older ones, when incubated in a moist chamber after inoculation with the pathogen. Further, Basallote *et al.* (1993) observed either dark purple or white leaf spots or both lesion types after 5 to 8 days.

Disease initiation occurs as small, yellow to pale orange flecks or streaks which develop in the middle of leaf and soon become elongated, spindle shaped to ovate elongate spots surrounded by characteristic pinkish margins and dark brown to black when sporulation occurs (Thind, 2001; Hassan *et al.*, 2006 ; Hussein *et al.,* 2007). Pattori *et al.* (2006) while studying pathogenicity and virulence of *S. vesicarium* strains observed high variability for both progress of necrotic spot appearance and final disease incidence among isolates of *S. vesicarium*. These fungal strains showed only small sporadic necrosis at the end of incubation.

White spots were observed on inoculated leaves after five days of incubation. The occurrence of conidiophores and conidia on onion and garlic leaves were noticed after 15 days of inoculating with fungus isolate from garlic, in a moist chamber (Zheng *et al.*, 2007; Cedeno *et al.*, 2003). The pathogenic nature of *S. vesicarium* isolates from different hosts demonstrated that isolates originating from pear orchards and dead grass leaves, were pathogenic on pear leaves or fruits in bioassays. It was also reported that *S. vesicarium* from asparagus or onion, were not pathogenic to pear (Kohl *et al.*, 2009).

After inoculating, the spore suspension (2×10^6 conidia ml^{-1}) on onion leaves of each isolate under the controlled environment conditions, the apperrance of lesions of *S. vesicarium* were observed on onion leaves at 9-14 days after inoculation. There were significant differences observed among isolates in relation to the number of lesions per leaf (Tayviah, 2017).

Cultural variability

The colonies of *S. vesicarium* on potato carrot agar media (PCA) were effuse grey to brownish grey in colour, olivaceous brown to black and somewhat velvety, formed concentric rings, were flat, attaining a diameter of 50 mm after 7 days with sparse aerial mycelium growth (Arzanlou *et al.,* 2012; Polat *et al.*, 2012). Twenty four isolates of *S. vesicarium* collected from different onion growing areas in terms of cultural, morphological and molecular aspects. It was observed that colony colour were greenish brown to dirty white, deep grey to whitish, light grey to whitish, deep greenish white, light grey and dirty white to greenish. Reverse colony colors were brown, deep brown and light brown. Colony shapes were circular and irregular with umbonate, raised and flat type of colony elevation. Colony texture were cottony, fluffy and velvety with entire, undulate and filiform type of colony margins (Nisha, 2013).

Morphological variability

Conidia of *S. vesicarium* were described as oblong to ovoid, densely verrucose with 1-5 transverse and several longitudinal septa, 25-40 × 13-21 µm in size (Ellis, 1971) while as it was concluded that conidial dimensions of *S. botryosum* isolated from lucerne (*Medicago sativa*) varied from 33-35 × 24-26 µm, length/width ratio near 1.0-1.5, single conspicuous constriction at the median transverse septum, having densely echinulate walls (Simmons, 1985). Simmons (1969) observed that the pseudothecia are black and bear several cylindrical asci in *P. allii*. Pseudothecia release ascospores in the spring, coinciding with rainfall events. Ascospores are yellowish brown and ellipsoidal, with the upper half narrowly tapered. Matured ascospores have 5-7 complete transverse septa and zero to several longitudinal septa. The average size of a mature ascospore is about 18×38 µm.

The conidiophores of *S. botryosum* were short, septate and light brown in colour with frequent nodolar swellings. The spores from lesions and culture were dark brown to black, ovate, muriform and echinulate having 3-4 cross septa. Slightly constricted at the septa measuring 20-35 × 16-24 µm (Singh and Sharma, 1977). Miller (1995) observed that the conidia of *S. vesicarium* were medium golden brown to olive brown, oblong to broadly oval and sometimes inequilateral, measuring 25-42 × 12-22 µm in size, having 1-6 transverse and 1-3 longitudinal septa. Conidiophores measuring 33-47×5-8 µm in size were straight to variously curved, simple or occasionally one branched, cylindrical but enlarging epically to the site of conidium production. Sharma and Sharma (1999) observed that the perfect state fruiting body (Pseudothecia) of *S. vesicarium* matured in 3-6 months. The asci were cylindrical to clavate shaped and young ascospores are ellipsoidal with upper half narrowly tappered. Ascospores measured 18-38 ìm with seven transverse septa.

In case of *S. botryosum,* conidia were olive brown, oblong or muriform in shape with three constricted transverse septa while as, the size of conidia varied from 78 × 24 to 13 × 8 µm andthat of conidiophores varies from 25×2 to 285× 6µm in different species of *Stemphylium* (Bayaa and Erskine, 1998; Camara *et al.,* 2002).

Polat *et al.* (2012) observed that conidia of *S. vesicarium,* were pale to mid brown or olivaceous brown, verrucose, with upto six transverse and several longitudinal septa mostly constricted at the major transverse septa.

Arzanlou *et al.* (2012) propounded that immature conidia of *S. vesicarium* on PCA were ellipsoid, rounded at the ends. Mature conidia were 20-24 ×12-15 µm, with length/ width ratios approaching 1.5-2.3, solitary, acrogenous, oblong to broadly ellipsoid, sub-truncate basally, rounded

to sub-truncate apically, golden-brown to olive-brown, with 1-3 transverse and 1-4 longitudinal or oblique septa, often constricted at one or more of the septa. After about 2 months, mature perithecia were visible in the cultures. Perithecia were superficial or sometimes completely or slightly immersed in the agar, gregarious, black, spherical to sub-spherical, rostrate, up to 500×1,000 µm and the neck was usually 25 µm long. Asci were cylindrical, short-stalked, thick-walled, 8-spored andup to 180×45 µm. Mature ascospores were yellowish brown, oblong to ovoid, obtuse basally, domical apically, 34-36 ×14-17 µm, wider in the upper half with 7 transverse and numerous longitudinal septa, more or less constricted at the septa, uniseriate to slightly overlapping, with the 3 main transverse septa thickened, darkened and more constricted while as, Nisha (2013) studied 24 isolates of *S. vesicarium* collected from different onion growing areas in terms of morphological aspects and observed that the length of conidia varied from 14.6 µm to 30.6 µm. The horizontal septation varied from 1-3. The longitudinal septation varied from 0-4.

McKenzie (2013) found that ascomata of *S. vesicarium* are globose, up to 0.5 mm wide. Asci are bitunicate, narrowly cylindrical to clavate, 110-150 × 24-35 µm. Ascospores are uniseriate, ellipsoidal, upper half narrowly tapered to somewhat of a point, base rounded, pale yellow to brown, 33-38 × 15-20 µm, 3-7 transverse septa and 6-14 longitudinal septa, constricted especially at major transverse septa. Conidiophores often arising in groups, pale to mid brown, up to 70 µm long, 3-8 µm thick, with one or more nodose swellings and dark bands from which conidia arise, smooth or minutely verrucose. Conidia single, straight or slightly curved, broadly ellipsoidal, 20-50 × 15-26 µm, pale to olivaceous brown, verrucose, up to 6 transverse septa andseveral longitudinal or oblique septa, often constricted at the 3 major transverse septa, basal scar very obvious.

Five pathogens from onion were isolated and identified as *S. vesicarium*, based on conidial morphology. The conidia were oblong in shape andranged from 19-23 × 22-46 µm in size. Isolates OO46 sporulated on vegetable 8 agar media (V-8) and the mean number of conidia collected per colony was 1×10^4 ml^{-1} for each isolate, except NO35, conidia recovery was only 1×10^2 ml^{-1} (Tayviah, 2017).

Molecular variability

The identification of *Stemphylium* spp. is based principally on morphological characteristics of conidium and conidiophore that often overlap among species, making determination of species difficult. More ever these characteristics vary on different substrates and at different temperatures (Leach and Aragaki, 1970). Shenoy *et al.* (2007) observed that recognition based on morphology of a fungal species is not always easy and in many instances incorrect. Hence, DNA sequence data are now being used to test morphological concept and other taxonomic hypotheses (Hunter *et al.,* 2006). The internal transcribed spacer regions (ITS) sequence is a widely accepted DNA marker for identifying fungi (Nguyen and Seifert, 2008). Genetic diversity is commonly measured by genetic distance of genetic similarity both of which imply that there are either differences or similarities at genetic level (Weir, 1990). Availability of a large number of polymorphic markers enables precise classification of the fungal species. Several molecular markers *viz.,* RFLP, RAPD, SSR, ISSR and SNP based markers are presently available to assess the variability and diversity at molecular level. Chaisrisook *et al.* (1995) while analyzing genomic similarity of geographically diverse isolates of *Stemphylium* species isolated from alfalfa using random amplified polymorphic DNA (RAPD) markers detected DNA polymorphisms among 28 monoconidial isolates from five morphology based taxonomic species of *Stemphylium* and one isolate each of *Pithomyces chartarum* and P. *atro-olivaceus.* Eleven oligodeoxynucleotide 10-base primers generated 205 RAPD fragments from total genomic DNA. Principal component analysis of RAPD fragment occurrence grouped the 28 *Stemphylium* isolates into two clusters. One cluster included S. *botryosum* and S. *globuliferum.* The second cluster included *S. alfalfae, S. herbarum* and *S. vesicarium.* A separate analysis of the second cluster separated the three species. *P. chartarum* and *P. atro-olivaceous* were widely separated from *Stemphylium* and from each other. One major RAPD fragment of about 2.5 Kb was common to all *Stemphylium* isolates but was absent in the *Pithomyces* species. Southern analysis revealed strong cross-hybridization of major RAPD fragments across species, inferring that they were of the same nucleotide sequences. No cross-hybridization to the *Pithomyces* fragments was detected. These results supported recent morphologically based taxonomic revisions and indicated that at least five genetically distinct species of *Stemphylium* can cause leaf spot of alfalfa.

More ever, Wang (2010) described two new species of *Stemphylium* on the basis of morphological characters and molecular phylogenetic analyses. *S. phaseolina* and *S. variabilis* were isolated respectively from diseased leaves of beans (*Phaseolus vulgaris* L.) in Hebei Province of China andfrom diseased leaves of onion (*Allium sativum* L.) in Angres, France. The two species exhibit characteristic *Stemphylium* morphology but were distinct from similar species based on the morphology and development of conidia. The internal transcribed spacer (ITS) nuclear rDNA region and glyceraldehyde-3-phosphate dehydrogenase (gpd) genes were sequenced. The results of phylogenetic analyses of the combined DNA sequences of these two gene regions supported *S. phaseolina* and *S. variabilis* as two distinct phylogenetic species.

During molecular variability study of 18 isolates out of 24 *S. vesicarium* isolate of onion, it was observed that testing of seven decamer primers (OPA-01, OPA-02, OPA-03, OPA-04, OPA-13, OPB-04, OPB-18) showed no band of DNA of *S. vesicarium* isolates. Finally DNA sequencing was done by identifying the ITS regions from DSTR 01 isolate by using ITS primer (ITS1F and ITS4R). SV-DSTR 01 showed no significant similarity with any gene through NCBI-BLAST

program (Nisha, 2013). While working on *S. lycopersici* causing leaf spot of tomato, seventy nine isolates were isolated and identified as *S. lycopersici* based on sequence analysis of combined dataset of the internal transcribed spacer and glyceraldehyde 3 phosphate dehydrogenase regions. The 79 isolates were subjected to amplified fragment length polymorphism (AFLP) analysis using three primer combinations. The *S. lycopersici* population from the two cultivars were found to have a very low level of genetic diversity (H = 0.0948). Cluster analysis showed intermixing of isolates from the two cultivars. In addition, analysis of molecular variance showed the presence of a very low level of genetic differentiation between populations obtained from the two cultivars i.e. Fst = 0.0206 (Alamiri *et al.*, 2016).

Management of the disease

Disease incidence of *S. vesicarium* gets influenced with the sowing date and spacing. It was highest (52.2%) when the crop was sown on 30 September. with spacing 45×30 cm and lowest when sown on 30 October at 60×45 cm (Jakhar *et al.*, 1996). The effects of major nutrients on the incidence of stemphylium blight (*S. botryosum*) were significant and maximum mean yield of onion cv. N-53 (136.25 q ha^{-1}) was obtained when only K was applied at 100 kg ha^{-1}. At this level of K, mean disease intensity and incidence of 32.1 and 53.8% were recorded, respectively. Maximum mean yield of 155.4 q ha^{-1}, mean disease intensity (33.9%) and mean disease incidence (58.5%) were recorded when N and P was applied in the ratio of 100:100 kg ha^{-1}. The highest mean yield of 161.3 q ha^{-1} was recorded when N, P and K were applied in the ratio of 100:50:100 kg ha^{-1}. At this level the mean disease intensity and incidence of 31.9 and 49.2% were recorded, respectively (Barnwal *et al.*, 2005). The results of 3-year study on the effects of different nitrogen rates and frequency of irrigation for the management of stemphylium blight disease indicated that irrigation at 7 day intervals restricted the prevalence of stemphylium blight disease and recorded higher yield. While as 10 day irrigation interval and high doses of nitrogen (125-150 kg ha^{-1}) were found better in reducing stemphylium blight disease and obtaining higher bulb yield (Srivastava *et al.*, 2005).

Mohan *et al.* (2003) recorded promising activity of triazoles *viz.,* Folicur 25 EC (tebuconazole), Score 25 EC (difenaconazole) and Contaf 5 EC (hexaconazole) and contact fungicides such as Antracol, Indofil M-45 and Kavach in combating the stemphylium blight (*S. botryosum*) of onion both under laboratory and field conditions. Mishra and Gupta (2012) while investigating the effects of eight fungicides on the mycelial growth of *Stemphylium* spp. observed that the inhibition was greatest with the contact fungicides Indofil M-45 (mancozeb), Antracol (propineb) and with the systemic fungicide azoxystrobin and propiconazole.

The lowest stemphylium blight intensity was recorded after giving four foliar sprays of propiconazole @ 0.1% followed by Indofil M-45 (mancozeb @ 0.25%) and Blitox (copper oxychloride @ 0.3%) (Gupta and Gupta, 2013).

Barnwal *et al.* (2003) reported the efficacy of *Pseudomonas fluorescens* and hexaconazole in controlling *Stemphylium botryosum* causing blight in onion during the field experiment conducted during the rabi season of 1998-2000. The methods of application used were seed treatment, root dip or foliar spraying, used alone or in combination. All the treatments reduced the severity of the disease compared to the control, with hexaconazole treatment resulting in lower disease severity compared to *P. fluorescens* treatment. Crop yield was higher with hexaconazole than *P. fluorescens* treatment. Within treatments, twice foliar spraying resulted in the lowest disease severity in onion and highest yield.

Various bioagents *Bacillus subtilis*, *P. fluorescens*, *Trichoderma harzianum, Gliocladium* spp. and *Saccharomyces cerevisiae* were tested against stemphylium blight under, *in vitro* conditions. The highest inhibition of *S. vesicarium* mycelial growth was achieved by *P. fluorescens, B. subtilis* and *T. harzianum* and in *in-vivo* study the bioagents *viz., B. subtilis*, *S. cerevisiae* and *P. fluorescens* exhibited the highest reduction in disease severity whereas, *T. harzianum* gave the lowest (Hussein *et al.*, 2007). Ihsanul and Nowsher (2007) observed that while evaluating the effect of seven different fungicides such as Rovral 50WP @ 0.2%, Dithane M-45 @ 0.2%, Tilt 250EC @ 0.05%, Cupravit @ 0.3%, Macuprax @ 0.25%, Ridomil MZ-72 @ 0.2% and Bavistin 50WP @ 0.15% in the field during 1998-2001 to control stemphylium blight lentil, fungicides Rovral 50WP @ 0.2% was found as most effective fungicide followed by Dithane M-45 @ 0.2% and Tilt 250EC @ 0.05%.

Furthermore, six extracts of plant species *viz., Azadirachta indica*, *Datura metel, Lantana camara, Parthenium hystorophorus, Ociumum spp., Argimone mexicana* and five bioagents *viz., T. harzianum, T. viride, Aspergillus niger, Penicillium citrinum* and *G. virens* against *S. botryosum* were evaluated. Among plant extracts *A. indica* (66.5%) and *D. metel* (64.5%) were the best in restricting the growth of pathogen over control and in evaluation of bioagents, *T. harizianum* (81.2%) and *T. viride* (74.5%) had significantly inhibited the growth of pathogen. Under field condition suppression of pathogen by treating the garlic cloves with *T. harzianum* @ 0.2% along with two foliar sprays of *A. indica* @ 0.2% and *T. harzianum* @ 0.2% at 15 days interval found to be most effective for management of this disease (Kumar *et al.*, 2012).

Similarly, Mishra and Gupta (2012) evaluated eight plant extracts and bioagents under *in vitro* conditions stemphylium blight of onion caused by *S. vesicarium*. Among the plant extracts, clove extracts of *Allium sativum* @ 10% resulted in maximum inhibition of growth (57.31%), followed by *Aloe vera* @ 10% (47.15%). Among the bioagents, *T. viride* was highly effective in inhibition of growth (56.15%). Bhatia and Chahal (2014) observed 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 such as mancozeb 75 WP and copper oxychloride 50 WP for efficient

management of stemphylium blight disease of onion on seed crop.

While working on integrated disease management of foliar blight disease of onion, six pathogens were found associated with the disease, *viz., A. alternata, A. porri, A. tenuissima, S. vesicarium, Colletotrichum circinans* and *Cladosporium allii-cepae*. It was observed that using chemicals (mancozeb @ 0.25% and hexaconazole @ 0.06%), bio-control agents such as *Trichoderma viride* (Tv-1) and *T. harzianum* (Th-1), each at 1×10^9 spores ml^{-1} and phyto extracts (*Cannabis indica* @10% and *Curcuma longa* @10%), mancozeb @ 0.25% proved most effective in managing foliar blight of onion but was at par with hexaconazole @ 0.06%. Among bio-control agents used, application of *T. harzianum* (Th-1) resulted in lower disease intensity as compared to *T. viride* (Tv-1), though both were statistically at par with each other, but were significantly superior over the control. The phyto-extracts, *C. indica* and *C. longa* proved ineffective in the disease management (Shahnaz *et al.,* 2013).

REFERENCES

Alamiri, K., Abdullah, M.S., Adel, A.S., Abbas, N., Issa, A. M. and Mike, L.D. (2016). Population structure of *Stemphylium lycopersici* associated with leaf spot of tomato in a single field. Springer Plus. 1642*:* 2-8.

Anonymous (2012). *Vegetables Package of Practices.* Directorate of Extension Education SKUAST-K, Shalimar pp. 90-91.

Anonymous (2013). Directorate of Economics and Statistics, Market Intelligence System, Horticulture Division, Govt. of India, New Delhi pp. 7-9.

Anonymous (2014). Information Status of Vegetables, Spices and Mushrooms of Kashmir Division. Agriculture Production Department, Jammu and Kashmir pp. 1-2.

Arzanlou, M., Khodaei, S. and Babai Ahari, A. (2012). *Helianthus annuus*as a natural host for *Stemphylium vesicarium* in Iran. Australasian Plant Disease Notes 7: 167-170.

Barnwal, M.K., Prasad, S.M. and Agarwal, B.K. (2005). Effect of major nutrients on Stemphylium blight disease and yield of onion. Journal of Plant Protection and Environment. 2: 92-98.

Barnwal, M.K., Prasad, S.M. and Maiti, D. (2003). Efficacy of fungicides and bioagents against Stemphylium blight of onion. Indian Phytopathology. 56: 291-292.

Bassalote, M.J., Prados, A.M., Perez-de-Algaba, A. and Melero-Vara, J.M. (1993). First report in Spain of two leaf spots of garlic caused by *Stemphylium vesicarium.* Plant Disease. 77: 952.

Bayaa, B. and Erskine, W. 1998. Lentil Pathology, In: Pathology of Food and Pasture Legumes (Eds. D. Allen and J. Lenné). Commonwealth Agricultural Bureaux International, U.K in association with: International Crop Research Center for the Semi-Arid Tropics, Patancheru. pp. 324-502.

Bhat, S., Beig, M.A., Sagar, V. and Khan, N.A. (2008). First record of stemphylium blight of onion [*Stemphylium vesicarium* (Wallr.) E. Simmons] from Jammu and Kashmir. Applied Biological Research. 10: 63-65. Bhatia, J.N. and Chahal, D. (2014). Studies on effectiveness of certain new fungicides in controlling stemphylium blight of onion seed crop. Agricultural Science Digest. 34: 237-239.

Boiteux, L.S., Lima, M.F., Menezes Sobrino, J.A. and Lopes, C.A. (1994). A garlic (*Allium sativum*) leaf blight caused by *Stemphylium vesicarium* in Brazil. Plant Pathology. 43: 412-414.

Byung-Soo, K., SeungHun, Y., HyunJung, C. and HeeSuk H. (2004). Gray leaf spot in peppers caused by *Stemphylium solani* and *S. lycopersici*. Plant Pathology Journal. 20: 85-91.

Camara, M. P. S., Neill, N. R. and Van-Berkum, P. (2002). Phylogeny of *Stemphylium* spp. based on ITS and glyceraldehyde-3-phosphate dehydrogenase gene sequences. Mycologia. 94: 660-672.

Cedeno, L., Carrero, C., Quitero, K., Pino, H. and Espinoza, W. (2003). *Stemphylium vesicarium*: casual agent of severe foliar blight on garlic and onion in Meride, Venezuela. Interciencia. 28: 174-177.

Chaisrisook, C., Skinner, D.Z. and Stuteville, D.L. (1995). Molecular genetic relationships of five *Stemphylium* species pathogenic to alfalfa. Sydowia. 47: 1-9.

Daljeet, S., Dhiman, J.S., Sidhu, A.S. and Singh, H. (1992). Current status of onions in India. Strategies for distance resistance breeding for sustained production. Onion News Letters for the Tropics. 4: 43-44.

Ellis, M.B. (1971). *Dematiaceous Hyphomycetes*. Commonwealth Mycological Institute, Kew Surrey, England pp. 608.

Falloon, P.G. (1987). Etiology and epidemiology of stemphylium leaf spot and purple spot of asparagus in California. Phytopathology. 77: 407-413

FAOSTATS (2015). Food and agriculture organization of the United Nations statistics division [online]. Production figures. Available from: http://www.fao.org/3/ai4691e.pdf [Accessed 16 Oct 2016].

Gupta, R.C. and Gupta, R.P. (2013). Effect of integrated disease management packages on disease incidence and bulb yield of onion (*Allium cepa* L.). SAARC Journal of Agriculture. 11: 49-59.

Gupta, R.P., Srivastava, P.K. and Sharma, R.C. (1996). Efficacy of fungicides and their spray interval on the control of purple blotch and stemphylium blight diseases of onion. News Letter National Horticultural Research and Development Foundation. 16: 11-13.

Hassan, M.H.A. and Hussein, M.A.M. (2007). New Disease Report. Plant Pathology Department, Faculty of Agriculture, Assiut University, Egypt pp. 724.

Hassan, M.H.A., Allam, A.D., Abo-Elyousr, K.A.M. and Hussein, M.A.M. (2006). First report of stemphylium leaf blight of onion caused by *Stemphylium vesicarium* in Egypt. New Disease Reports. 14: 24.

Hosen, M.I. (2010). Cultural, physiological comparison and fungicidal sensitivity between two isolates of *Botrytis cinerea* and *Stemphylium botryosum*. Journal of Food Agriculture. 23: 120-129.

Hosen, M.I., Ahmed, A.U., Zaman, J., Ghosh, S. and Hossain, K.M.K. (2009). Cultural and physiological variation between isolates of *Stemphylium botryosum* the causal of stemphylium blight disease of lentil (*Lens culinaris*). World Journal of Agricultural Sciences. 5: 94-98.

Hunter, G.C., Wingfield, B.D., Crous, P.W. and Wingfield, M.J. (2006). A multi-gene phylogeny for species of *Mycosphaerella* occurring on Eucalyptus leaves. Studies in Mycology. 55: 147-161.

Hussein, M.A.M., Hassan, M.H.A., Allam, A.D.A. and Abo-Elyousr, K.A.M. (2007). Management of stemphylium blight of onion by using biological agents and resistance inducers. Egyptian Journal of Phytopathology. 35: 49-60.

Hyesun, C. and Hun, Y.S. (1998). *Stemphylium vesicarium* on garlic and other *Allium* spp. in Korea. Korean Journal of Plant Pathology. 14: 567-570.

Ihsanul, H.M. and Nowsher, A.K. (2007). Efficacy *in-vivo* of different fungicides in controlling stemphylium blight of lentil during 1998-2001. Bangladesh Journal of Scientific Industrial Research. 42: 89-96.

Jakhar, S.S., Duhan, J.C. and Suhag, L.S. (1996). Studies on epidemiology and survival of *Stemphylium vesicarium* [(Wallr.) E. Simmons] in debris and seed of onion. Seed Research. 24: 135-140.

Kohl, J., Groenenboom-de-Haas, B., Goossen-van-de-Geijn, H., Speksnijder, A., Kastelein, P., Hoog, S. and Ende, B.G. (2009). Pathogenicity of *Stemphylium vesicarium* from different hosts causing brown spot in pear. European Journal of Plant Pathology. 124: 151-162.

Koike, S., Matheron, M.E. and Toit, L.J. (2005). First report of leaf spot of spinach caused by *Stemphylium botryosum* in Arizona. Plant Disease. 89: 359.

Kumar, P. (2007). Genetics of resistance to stemphylium leaf blight of lentil (*Lens culinaris*) in the cross BARI masur-4 x CDC milestone. Plant Science. 30: 1-68.

Kumar, U., Naresh, P. and Bishwas, S.K. (2012). Ecofriendly management of stemphylium blight of garlic by plant extracts and bioagents. Hort Flora Research Spectrum. 22: 231-245.

Llorente, I. and Montesinos, E. (2006). Brown spot of pear: an emerging disease of economic importance in Europe. Phytopathology. 90: 1368–1375.

Leach, C.M. and Aragaki, M. (1970). Effect of temperature on conidium characteristics of *Ulocladium chartarum* and *Stemphylium floridanum*. Mycologia. 62: 1071-1076.

Lu, Z., Rujing, L., Tom, H. and Junbin, H. (2008). Host range and phytotoxicity of *Stemphylium solani*, causing leaf blight of garlic (*Allium sativum*) in China. European Journal of Plant Pathology. 124: 21-30.

McKenzie, E. (2013). Stemphylium vesicarium *(Stemphylium vesicarium)* http: //www.padil.gov.au.

Meah, B. and Khan, A.A. (1987). Checklist of vegetables and fruit diseases in Bangladesh. Deptartment of Plant Pathology, Bangladesh Agriculture University, Mymensingh pp. 22.

Mehta, Y.R. (2001). Genetic diversity among isolates of *Stemphylium solani* from cotton. Fitopathologia Brasileira. 26: 703-709.

Miller, M.E. (1983). Relationship between onion leaf age and susceptibility to *Alternaria porri.* Plant Disease. 67: 283-286.

Miller, M.E., Taber, R.A. and Amador, J.M. (1978). Stemphylium blight of onion in South Taxas. Plant Disease Reporter. 62: 851.

Mirjalili, M.H., Farzaneh, M., Bonfill, M., Rezadoost, H. and Ghassempour, A. (2011). Isolation and characterization of *Stemphylium sedicola* SBU-16 as a new endophytic taxol producing fungus from *Taxus baccata* grown in Iran. FEMS Microbiology Letters. 328: 1-8.

Misawa, T. and Yasuoka, S. (2012). The life cycle of *Stemphylium vesicarium,* the causal agent of Welsh onion leaf blight. Journal of General Plant Pathology. 78: 18-29.

Mishra, R.K. and Gupta, R.P. (2012). *In vitro* evaluation of plant extracts, bioagents and fungicides against Purple blotch and Stemphylium blight of onion. Journal of Medicinal Plant Research. 45: 5658-5661.

Mishra, R.K., Jaiswal, R.K., Kumar, D., Saabale, P.R. and Singh, A. (2014). Management of major diseases and insect pests of onion and garlic: A comprehensive review. Journal of Plant Breeding and Crop Science. 6: 160-170.

Mohan, C., Thind, T.S., Prem, R. and Arora, J.K. (2003). Promising activities of triazoles and other fungicides against fruit rot of chilli and stemphylium blight of onion. Plant Disease Reporter. 19: 200-203.

Nguyen, H.D.T. and Seifert, K.A. (2008). Description and DNA barcoding of three new species of *Leohumicola* from South Africa and the United States. Persoonia. 21: 57-69.

Nisha, H.A.C. (2013). Cultural, Morphological and Molecular Characterization of *Stemphylium vesicarium* causing White Blotch of Onion. M. Sc. thesis, submitted to Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka pp. 1-92.

Paibomesai, M., Celetti, M. andTesfaendrias, M. (2012). Update on Stemphylium leaf blight in onions in Ontario. Hort Matters, OMAFRA Specialist in Horticulture and Speciality Crops. 12: 11-12.

Patil, A.O. and Patil, B.C. (1992). Stemphylium leaf blight of onion. Journal of Maharashtra Agricultural University. 17: 165-166.

Pattori, E., Rossi, V., Bugiani, R. and Giosue, S. (2006). Virulence of *Stemphylium vesicarium* isolates from pear and other host species. Bulletin OILB/SROP. 29: 195-205.

Polat, Z., Besirli, G., Sonmez, I. and Yavuz, B. (2012). First report of stemphylium leaf blight of garlic (*Allium sativum*) caused by *Stemphylium vesicarium* in Turkey. New Disease Reports. 25: 22-29.

Poursafar, A., Ghosta, Y. and Javan-Nikkhah, M. (2016). A taxonomic study on *Stemphylium* species associated with black (sooty) head mold of wheat and barley in Iran. Mycologia Iranica. 3: 99-109.

Rao, N.N.R. and Pavgi, M.S. (1975). Stemphylium leaf blight of onion. Mycopathologia. 56: 113-118.

Shahnaz, E., Razdan, V.K., Rizvi, S.E.H., Rather, T.R., Gupta, S. and Andrabi, M. (2013). Integrated disease management of foliar blight disease of onion: A case Study of application of confounded factorials. Journal of Agricultural Science. 5: 17-22.

Sharma, R.C. and Sharma, S. (1999). Stemphylium leaf blight and stalk rot. In: Diseases of Horticultural Crops-Vegetables, Ornamentals and Mushrooms (Eds. L. R. Verma and R. C. Sharma). Indus Publishing Company, New Delhi. pp. 356-357.

Shenoy, B.D., Jeewon, R. and Hyde, K.D. (2007). Impact of DNA sequence data on the taxonomy of anamorphic fungi. Fungal Diversity. 26: 1-54.

Shishkoff, N. and Lorbeer, J.W. (1989). Etiology of stemphylium leaf blight of onion. Phytopathology. 79: 301-304.

Simmons, E.G. (1969). Perfect states of *Stemphylium*. Mycologia. 61: 1-26.

Simmons, E.G. (1985). Perfect states of *Stemphylium* II. Sydowia. 38: 284-293.

Singh, B.M. and Sharma, Y.R. (1977). Occurrence of leaf blight of garlic caused by *Stemphylium botryosum* in India. Indian Phytopathology. 30: 272-273.

Sinha, R.K.P., Singh, A.P., Sinha, B.B.P and Asghar, S.M.A. (1995). Stemphyliumblight: A new fungal disease of garlic (*Allium sativum*). Journal of Applied Biology. 5: 93.

Slimestad, R., Fossen, T. and Vangenlm. (2007). Onions. A source of unique dietry flavonoides. Journal of Agriculture and Food Chemistry. 55: 24-34.

Srivastava, K.J., Gupta, R.P., Sharma, H.K. and Pandey, N.K. (2005). Effect of nitrogen doses and irrigation intervals on the stemphylium blight disease and thrips in onion bulb crop. News Letter National Horticultural Research and Development Foundation. 25: 6-9.

Suheri, H. and Price, T.V. (2000). Infection of onion leaves caused by *Alternaria porri* and *Stemphylium vesicarium* and disease development in controlled environments. Plant Pathology. 49: 375-382.

Tayviah, C.S. (2017). Epidemiology and management of stemphylium leaf blight on onion (*Allium cepa* L.). M. Sc., Thesis, submitted to Department of Plant Pathology, University of Guelph, Ontario, Canada, pp. 80-82.

Tesfaendrias, M.T., Paibomesai, M., Celetti, M. and McDonald, M.R. (2014). The battle against stemphylium leaf blight of onion in Ontario, Canada http: //www.hort.cornell.edu/expo/proceedings/2014/Onions/Stemphylium

Thind, T.S. (2001). Symptoms and disease epidemiology of stemphylium blight. In: Disease of Fruits and Vegetables and their Management. Kalyani Publishers, Ludhiana, India. pp. 307-308.

Thind, T.S., Sharma, R.C. and Jhooty, J.S. (1985). Occurrence of two fungal diseases of onion in Punjab. Indian Journal of Mycology and Plant Pathology. 15: 90.

Tomaz, I. and Lima, A. (1988). An important disease of onion caused by *Stemphylium vesicarium* {(Wallr.) Simmons} in Portugal. Horticultural Abstracts. 68: 618.

Vohra, S.B., Rizman, M. and Khan, J.A. (1974). Medicinal uses of common Indian vegetables. Planta Medica 23: 381-393.

Wang, Y., Yun, G., YunFei, P. and XiuGuo, Z. (2010). Molecular and morphological description of two new species of *Stemphylium* from China and France. Mycologia. 102: 708-717.

Wu, W.S. (1979). Survey on seed borne fungi of vegetables. Plant Protection Bulletin. 21: 206-219.

YunFei, P., Wang, Y., Geng, Y., Nichole, R., Neill, O. and XiuGuo, Z. (2010). Three novel species of *Stemphylium* from Sinkiang, China: their morphological and molecular characterization. Mycological Progress. 10: 163-173.

Zheng, L., Huang, J. and Hsiang, T. (2007). First report of leaf blight of garlic *(Allium sativum)* caused by *Stemphylium solani* in China. New Disease Reports. 15: 37-94.