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Purple blotch of onion and its management: A review

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Abstract
Onion (*Allium cepa*) is an important crop grown throughout the world. This crop is attacked by many pathogens. Among them fungal pathogens are important limiting factor in the yield and quality of the crop. The present review is mainly focus on Purple blotch diseases of onion and their management. The antagonistic effect of various bioagents and antifungal activity of different plant extracts has been studied to control fungal diseases of onion. The present review paper deals with various approaches of Purple blotch of onion such as morphological and cultural characteristics, interaction between host and pathogen, histopathology, epidemiology seed pathology, yield losses and control measures.

Keywords: Purple blotch, onion, characteristics, histopathology, epidemiology, yield losses

Introduction
Onion (*Allium cepa*) is an important temperate crop grown throughout the world. The vegetative growth of the crop is supported by lower temperature and short photoperiod whereas bulb development requires high temperature with longer photoperiod. Onion is grown in all types of the soil. The bulb of onion consists of swollen bases of green foliage leaves and fleshy scales. The major onion producing states are Maharashtra, Tamil Nadu, Andhra Pradesh, Bihar and Punjab. The crop is attacked by many fungal, bacterial pathogens, viruses and nematodes. The prevalence of pathogens depends on seasons, variety and region. Many fungal pathogens have been reported causing foliar and bulb diseases of onion. Soilborne fungal diseases such as Purple blotch (*Alternaria porri*), leaf blight (*Alternaria alternata*), Damping off (*Pythium* spp., *Rhizoctonia solani*), twister (*Colletotrichum gloeosporioides*; *Gibberilla moniformis*), leaf blight (*Stemphylium vesicarium*), smut (*Urocystis cepulae*), anthracnose (*Colletotrichum* spp.)etc. challenge sustainable onion production and storage in a wide range of agro-ecologies (Ramjegathash *et al.*, 2011; Gupta *et al.*, 2012; Sibi *et al*., 2013; Alberto, 2014) [78, 66, 88 2]. These diseases drastically reduce onion productivity, quality and yield. Fungal pathogens are mostly controlled by chemical compounds (Wainwright, 1979; Mathur and Sharma, 2006, Mathur *et al.*, 2007) [65]. These synthesized pesticides cause pollution and disturb the microbiotic balance in the soil. In natural conditions, microbes interact with each other with competition and hyperparasitism, checking the growth and reproduction of several other harmful plant pathogens and maintain ecological balance. In recent times, biological control of plant pathogenic fungi has received a considerable attention due to several advantages such as possibility of multiple pathogen suppression, low cost and maintaining soil fertility over chemical fungicides (Jagtap and Suryawanshi, 2015) [47]. Thus, there is a demand for development of eco-friendly and economical tools for the efficient management of fungal diseases of onion. Integrated fungal disease management programme emphasis the use of eco-friendly and cost effective tools such as use of plant extracts and bioagents for control of fungal disease. Many researchers have been worked on the efficacy of botanicals and bioagents to control the growth of fungal pathogens of onion (Bajwa, *et al.*, 2003; Ghewande, 1989; Mishra *et al.* 2014; Singh and Singh, 2005; Rana *et al.*, 2007; Singh *et al.*, 2007) [10, 31, 67, 86, 79, 87]. The present review paper deals with various eco-friendly biological management approaches and fungicides used to control the Purple blotch of onion.

History

The genus Alternaria was founded by bees in 1817 (Nee von Esenbeck, C.G. 1817) on the single species *A. tenuis*. Fries did not recognize the genus in his Systema Mycologicum in 1832 (Fries, E. 1832), but cited Nees`s species and a synonym of Torula alternate (Angell, 1929) [4]. Cooke and Ellis (1979) first described *Alternaria porri* on leaves of leek collected in New Jersey as *Macrosporium porri* Ellis, and Thaxter (1890) [91] gave a more authentic description of this fungus on onion leaves and scales collected in Connecticut and Maine. Elliot (1917), while working on the taxonomic characters of *Alternaria* and *Microsporum*, concluded that all obclavate, ovate, or elongated-pointed conidia of the *Microsporum-Alternaria* type should be placed under *Alternaria*. Using this criterion of classification, Nolla. (1927) described a new species *Alternaria allii* Nolla. He reported a severe outbreak of the disease in 1924 in three different places in Puerto Rico. Nolla's transfer of *Macrosporium* into *Alternaria* was widely accepted, however, the erection of the new species was not recognized by Angell (1929) [4] who retained the name *Macrosporium porri*. Wiltshire (1992) examined the available type specimens and descriptive literature which were fundamental to the then current concepts of *Alternaria* and *Macrosporium.* One of his major conclusions was that *Macrosporium* should be suppressed in favour of *Alternaria*, typified by *A. tenuis* Nees. Ciferri (1930) [19] used the binomial *A. porri* and hence the present name of the pathogen is *A. porri* (Ellis) Ciferri.

Its presence has been reported in many parts of the world, for instance in Bombay, India, in 1922 (Ajrekar, S.L. 1922), in the West Indies, Japan, Denmark (Neergaard, P. 1945) [70] and in Australia (Anonymous. 1944) [5]. Purple blotch of onions was first recorded in Tanganyika by Wallace (1944) [96] and in Kenya in 1949 (Nattrass, R.M. 1951) [68]. The fungus is distributed throughout the United States, Canada, the West Indies, India, Western Europe, South America and many parts of Africa. (Sherf, A.F. 1986) [83].

In 1967 Boelema and Ehlers (1967) [14] diagnosed a disease in south Africa, on the leaves of onion, as caused by A. porri. Whereas in previous years the disease occurred on the stems of the seed crop only, in the autumn of 1967 it was found on the leaves of small seedlings and older plants where it had never been troublesome before.

Morphology

Mycelium in the lesions is hyaline or brown and the diameter of the hyphae ranges from 2-10 um, but sometimes attains a thickness of 18 um in culture. The mycelium is composed of smooth, septate, short, simple or branching, sub fasciculate hyphae. Conidiophores arise singly or in groups though the stomata or the epidermis as terminal branches of hyphae. Conidiophores are straight or flexuous, septate, pale to dark brown, 5-10 um in diameter and up to 120 um long. An Obclavate conidia are usually 100-300 um in length, 15-20 um in diameter and are borne singly at the apex of the conidiophores (Ellis, M. B. 1971) [22]. Conidia apically attenuate to form a simple, tapering beak, 2-4 um in diameter, which is commonly about the same length as the body, but may be shorter or longer (Allen, S.J. 1983) [3]. The beaks of conidia produced in artificial culture are at first hyaline becoming dark when nature and have 8-12 transverse and no to several longitudinal or oblique septa (Ellis, M. B. 1971) [22].

Cultural characteristics

Gupta *et al*. (1987) [42] found that Czapek`s agar proved best for growth of five different isolates, but that none of the isolates sporulated on any of the media they tested. Nolla (1927) reported that the best growth in liquid media was observed in Czapek`s solution and that maximum growth in agar media occurred at slightly acid concentrations, but that the fungus could tolerate higher concentrations of alkali than acid. Similarly, Angell (1929) [4] and Raju and Mehta (1982) [76] found that the pathogen could grow over a wide range of pH from pH 3.8-9 and 4.0-8.0, respectively, with an optimum of 6.0. Angell and Nolla (1929) [4] reported equally good mycelia growth when cultures were exposed to continuous light or darkness. Raju and Mehta (1982) [76], However, found that the pathogen favoured continuous darkness. The optimal temperature for mycelia growth was found to be between 22 and 30 ^{0}C and growth rate dropped sharply between 30 and 34 ^{0}C and the thermal death point of mycelium ranged between 55 and 60 ^{0}C.

It is well known that *A. porri.* does not sporulate consistently well on artificial media and several studies have been conducted on this topic. Skiles (1953) reported that sporulation occurred on cornmeal agar after using a modification of Rands` (1917) [77] method I which the mycelia mat was macerated and exposed to direct sunlight for 4 days. Neergard (1945) [70] found that maximum sporulation was achieved at 26 ^{0}C and 100% relative humidity. Husain (1960) [46] used a culture that had been I storage for one year to try several methods to induce sporulation but was unsuccessful. He suggested that the culture. Fahim (1966) found that sporulation was abundant on potato agar and moderate on onion and onion leaf agar in cultures which had been exposed to direct sunlight for 2h. the optimum temperature and relative humidity for sporulation were 25^0 C and slightly less than 100% respectively (Fahim, M.M. 1966). Gupta and pathak (1988) [36] induced sporulation by inoculation pearl millet leaf pieces placed on calcium carbonate agar medium with mycelia discs and incubation the petri dishes at 25^{0}C. Aveling (1994) [9] found that the pathogen sporulated well on commeal agar when petri dishes were incubated under a 12 h dark/12 h near-Ultraviolet light regime. Everts and Lacy (1996) placed colonized 6 mm V8-agar discs on sterilized muck soil in test tubes. For conidial production, 0.1 to 0.2 g of infested muck soil from these soil tubes was placed in sterile V8-agar in petri plates. The plates were incubated at room temperature in darkness for 6 to 8 days, exposed to near-ultraviolet for a distance of 0.5 m for 24 h to initiate conidiophores formation and placed in the dark for 1 to 3 additional days.

Conidiogenesis of *Alternaria*

The ways in which conidiogenous cells and conidia develop are now accepted almost universally by mycologists as features of great significances in classifying Deuteromycetes (Minrer, M.E. 1983). Conidia of Alternaria spp. have been called porospores (Hughes, S.J. 1953, Simmons, E.G. 1967) [45, 84] however, as will be seen below, there is some controversy surrounding this concept.

The term porospore was conined by Hughes in 1953 (Hughes, S.J. 1953) for a conidium which develops though a pore in the wall of the conidiophores. Among the example of genera in which porospores are formed he gave *Helminthosporium*, *torula* and *Altermaria*. In 1963, Luttrell (Luttrell, E.S.1963) [53] applied the adjective porogenous to conidia originating as protrusions though pores in the conidiopore wall.

At the Kananaskis workshop on criteria and classification in the fungi Imperfecti held in 1969, a critical evaluation of Hughes`s system was attempted (Kendrick, B.1971) [49].

Particular attention was given to the mode of spore initiation. There it was recognized that conidia previously classified as "porospores" miggt arise in either of two fashions: holoblastically, by a simple blowing out of all wall layers of the conidiophores; or tretically, by the extrusion of the inner wall of the conidiophores though a preformed channel in the thickened outer wall (Ellis, M.B.1971, Kendrick, B.1971)[22, 49].

Interaction Between onion and *Alternaria porri*

Symptomatology

The symptoms are water-soaked lesions with small white centers. Lesions usually appear on older leaves and become purple with light yellow concentric rings on the margins as the disease progresses. Purple blotch pathogen may be associated with many other fungal pathogens and promoted by heavy moisture.

Nolla (1927) gave an excellent description of the disease on both leaves and flower stalks of onion and shallot. The first symptoms are numerous tiny, white, circular or irregular spots, less than 1 mm in diameter. These gradually increase in size until in advanced stages the diseased areas cover several square centimeter of surface. As the spots increase in size, they become oval-shaped or irregular and the white colour eventually changes to violet. Later stages of development show the central portion of the spots changing to purple immediately surrounded by a pale yellow orange to salmon band beyond which is a pale green zone. Dull violet-black zones within the lesions are also observed. The dark purple colour is the most distinctive symptom of the disease. A distinct yellowing usually extends from both ends of the spots, often reaching the tips and bases of the leaves. Gladders (1981) [32] described similar symptoms on the stems and spathes of leek. Bock (1964) [12], Boelema and Ehlers (1967) [14] and Naude (1988) [69], in addition to the symptoms described by Nolla (1927), found that the leaves shrivel, usually from the tip, and that the plant draws on its bulb reserves to produce fresh foliage which is again attacked. Bock (1964) [12] also found that symptoms varied with different environmental conditions. Typically, the lesions are purple or brown. Associated with these, however, under all conditions, are few to many white lesions which remain small. The two types of lesions may be present in varying proportions, depending on the weather at the time of infection and the climatic environment afterwards. He found that extensive development of purple blotch lesions takes place only at comparatively high relative humidities and that the incidence of small white flecks is highest at the low relative humidities. Boelema and Ehlers (1967) [14], Everts and Lacy (1996) [27] and Gladders (1981) [32] also reported similar white fleck symptoms on onions in South Africa and the USA and on leeks in Britain, respectively. These white blotches and later turn light brown often with concentric dark and light brown rings.

Lesions, similar to those on the leaves, are also produced on flower stalks of onion. These lesions cause girdling and as a rule the stalks are destroyed or break in two before the seeds mature (Pandotra, 1964) [73]. These symptoms on seed stalks have also been observed in South Africa (Aveling, 1993) [8].

Histopathology

El-Shehedi (1966) [29] found that the majority of conidia germinated within 24 h. Aveling *et al*. (1994) [9] reported that 74 and 96% of conidia of *A. porri* germinated within 12 and 24 h of inoculation, respectively. Everts and lacy (1996) [27] found that after 3, 6, 12 and 24 h of dew, 73, 84 and 90% of conidia *A. porri* on the onion leaf surface had germinated and 5, 34, 44, and 63% had found appressoria, respectively. Conidia germinated from more than one cell and germ-tubes grew in any direction across the leaf surface usually termination in appressoria over stomata and on epidermal cells (Aveling 1994, Everts and lacy 1996, Fahim 1966) [9, 27, 28]. Bock (1964) [12], Gupta *et al*. (1985) [39] and Khare and Nema (1982) [50] studied various factors that influenced conidial germination of *A. porri in vitro* and in *vivo*. They found that maximum germination occurred at 100% relative humidity prevailing for 6 h or longer a 25 ^{0}C. Bock (1964) [12] reported that optimum appressorium formation occurred at 20-25 ^{0}C.

Van Dyke and Trigiano (1987) [93] found that germ-tubes of *A. cassia* jurair & Khan on cotyledons of *Cassia obtusifolia* L. usually terminated in appressoria although intercalary appressoria were also formed. Appressoria formed directly on epidermal cells or over stomata with about equal frequency. These authors and Allen *et al*. (1983) [3] observed an extracellular matrix associated with germ-tubes and appressoria of *A. cassia* and *A. helianthi* (Hansford) Tubaki % Nishihara, respectively.

Angell (1929) [4] and Nolla (1927) reported that *A. porri* penetrated via stomata of onion leaves and that on direct penetration though the epidermal cells occurred. Walkar (1921) reported penetration though stomata and though wounds in the epidermis. However, Everts and Lacy (1987) [24], Fahim and El-Shehedi (1966) [29] and Sherf and MacNab (1986) [83] found that penetration occurred though the stomata and directly though unwounded epidermal cells. According to Aveling *et al*. (1994) [9] 24 h after inoculation, 52.4% of appressoria formed directly on the epidermal cells and 48.6% on stomata. Everts and Lacy (1996) [27] reported that 40% of conidia had germ-tubes that penetrated through stomata and 69% had germ-tubes that penetrated directly. Aveling *et al*. (1994) [9] found that germ-tubes were not specifically orientated towards stomata and often passed near stomata without forming appressoria. These authors also reported that an extracellular material was associated with germ-tubes and appressoria. Changsri and Weber (1963) [16] revealed that host penetration of crucifers was stomatal by A. brassicae (Berk.) Sacc and stomatal or direct by A. brassicicola and A. raphani Groves & Skolko.

Environmental factors

Bock (1964) [12] found that lesions were produced over a wide temperature range with a broad optimum between 17 and 25^{0}C Khare and Nema (1984) [51] reported that an average temperature of 25^{0}C and a high relative humidity of 90% led to severe disease symptoms. Maximum disease development (75.1%) and shortest incubation period (4.93 days) were recorded by Gupta and Pathak (1986) [34] in plants kept under high relative humidities (100%) for 120 h. Everts and Lacy (1987) [25] reported that sporulation on onion leaves increased with increasing relative humidities. Leaf age had no effect on sporulation.

On calm summer days, peak conidium Concentration above an onion field was found to occur between 08hr and 14hr, with few conidia being trapped between 20hr and 06hr (Meredith (1966) [60]. On windy days, there were marked increases in concentration. He postulated that at night, high relative humidity and dew formation encouraged sporulation of *A. Porri* and few spores were released on account of relatively low wind velocity. The rapid decrease in vapour

pressure between 7.00 and 10.00, and the disappearance of dew, induced hygroscopic movements which weakened the conidial attachments. As wind velocity increased during the morning and afternoon, increasing numbers of mature conidia were passively released until the source was exhausted or until wind velocity decreased Meredith (1966) [60] further suggested that increased sporulation kuring rainy periods and irrigation probably accounted for the increase in daily mean conidium concentration which occurred after such periods. Everts and Lacy (1990) [26] also studied the influence of environment on conidial concentration of *A. porri* in air above an onion field. Correlation between temperature and conidial concentration and between wind velocity and conidial concentration were not found to be significant.

Seed Pathology

Alternaria porri is seed-borne in onion (Neergaard 1945, Simmons 1967) [70, 84]. It has not yet been determined how the onion seed becomes infected with the pathogen or what part of the seed in infected or contaminated. Singh *et al*. (1977) [85] found that, in a sunflower seed lot, profuse mycelium of *Alternaria tenuis* was found in all layers of the pericarp but once the pathogen broke through the thick cuticle of the endosperm, it quickly unvaded the endosperm and embryo. Maude and Humpherson-Jones (1980) [58] reported similar observations after studying *Alternaria brassicicola* on brassica seed and *A. sesamicola* Kawamura on sesame seed, respectively. However, Halfon-Meiri *et al*. (1987) [44] and Knox-Davies (1979) [52] found that an *Alternaria sp.* and *A. brassicicola* were restricted to the seed coat and pericarp of *Ranunculus asiaticus* L. and *Brassica oleracea* L., respectively, and did not infect the endosperm or embryo.

Currently, thiram is considered a standard treatment in South Africa for controlling seed-borne diseases of vegetables (Vermeulen, 1990) [94]. Boelema and Ehlers (1967) [14] and Naude (1988) [69] recommended that onion seed should be treated with thiram prior to planting to control *A. porri*. Maude (1966) [55] found that thiram eliminated infection of carrot seeds by *Alternaria dauci* (Kuhn) Groves & Skolko.However, Maude *et al*. (1969) [59] found that although a thiram soak gave compete eradication of sixteen seed-borne fungal pathogens it did not completely eradicate *Alternaria brassicola* from brassica seeds. These authors also found that the thiram treatment adversely affected the germination of some vegetable seeds. Maude and Bambridge (1991) [56] found that topical applications of iprodione (2.5-5g a.i. ha^{-1}) gave effective eradication of internally seed-borne *A. dauci* of carrot. However, Maude *et al*. (1992) [57] found that this fungicide only reduced infection when added in polyethylene glycol for priming of carrot seeds.

Aveling *et al*. (1993) [8] evaluated six fungicides for their efficacy in reducing *Alternaria porri* on onion seed and in culture. These included anilazine, benomyl, carbendazim/flusilazol mixture, procymidone, tebuconazole and thiram. An untreated control, hot-water soak (50 ^{0}C for 20 min), and a sodium hypochlorite treatment were also included for comparison. Treated seeds were rated for germination using the blotter method and by emergence and seedling growth in seeding trays in the glasshouse. None of the treatments eradicated *A porri* from onion seeds. The hot-water soak proved to be best treatment for reducing this pathogen, although percentage germination and emergence of onion seeds was reduced when compared to the control

Chemical control

Panotra (1965) [74] conducted field trials with eleven different fungicides to control *A. porri* and also found that Bordeaux mixture provided the best control. In spraying trials by bock (1964) [12] in Kinya, good results were obtained with weekly applications of mancozeb (Dithane M45) or dichloran (Allisan). Gupta *et al*. (1987) [35] and Srivastava *et al*. (1990) [90] also found that mancozeb gave the best disease control. Husain (1960) [46] reported that, of the fungicides he tested, anilazine (Dyrene) was most effective against A. porri. Mancozeb and daconil controlled purple blotch of garlic provided it was applied at the rate of 3 kg ha-1 Zineb (Dithane Z78) and captafol (Difolatan) have also been found to effectively control the pathogen. Ahmed and Goyal (1988) reported that a seedling dip followed by a foliar spray with 0.2% copper oxychloride gave the highest disease control and maximm bulb yield. It was followed by zineb, mancozeb and captafol. Maheshwari *et al*. (1996) [54] also found copper oxychloride (0.5kg a.i.ha-1) to be the most effective fungicide followed by mancozeb, dodine and ziram.

In South Africa, two fungicides are commonly used for the control of purple blotch, namely a fentinacetate/maneb mixture (Brestan) and iprodione (Rovral) (Vermeulen *et al*.1990) [94]. According to Naude (1981), Brestan should be applied at 7-14 day intervals after the first signs of thee disease have been observed. Rovral, on the other hand, should be used as a preventative measure Spraying should commence when plants are at the 3-5 leaf stage and should be repeated at 14-21 day intervals.

Biological Management

Chawda and Rajasab (1992) [17] investigated the effect of culture filtrate of Myrothecium A. porri. Undiluted and 1;10 diluted culture filtrate caused 100% and 87% inhibition of germination of conidia, respectively. He suggested that M. verrucaria could possibly be used as a biocontrol gaent in the management of purple blotch. Clove extract of *Allium sativum* at 10% resulted in inhibition of *A. porri* followed by *Aloe vera* at 10%. *Trichoderma viride* was also found effective to control *A. porri* (Mishra and Gupta, 2012) [66]. Neem oil and pongamia oil at 20% showed 76.94 and 69.94 per cent inhibition (Chethana *et al*. 2012) [15]. The disease was found significantly controlled by foliar application of *Pseudomonas fluorescens* (41.03%), *Bacillus subtilis* (39.97%), *P. aeruginosa* (37.97%) and *T. viride* (34.23%). Under glass house and field conditions, seed treatment, seedling dip and three foliar sprays of *Trichoderma harzianum* expressed disease reduction and growth promotion in susceptible onion (Yadav *et al*., 2013) [98].

In another study, extracts of *Solanum nigrum*, *Cleome gynandra* and *Acocanthera schimperi* were used to evaluate their antifungal activity and extract of *S. nigrum* showed fungitoxic while extract of *C. gynandra* showed fungistatic activity against *A. porri* (Makelo *et al.,* 2007) [64]. Seed treatment with *P. fluorescens* (5g/kg) followed by two application of difenoconazole (0.1%) interspersed with spray of *P. fluorescens* (0.5%) at fortnightly interval were found effective to control the disease (Savitha *et al.,* 2014) [81]. Two sprays of neem oil (3%) at the first appearance of the disease and the second on fifteen days later showed significant disease control. *Acorus calamus* rhizome extract (10%) and *Mentha arvensis* extract also reduced the disease incidence (34.78%) (Ramjegathesh *et al.,* 2011) [78]. Seed treatment with

Trichoderma harzianum resulted in less percent disease index and high yield of onion bulb (Chethana *et al.,* 2012) [15].

Removal of crop debris

Gladders (1981) [32] also suggested that crop debris was a possible source of infection of leek by *A. porri*. Pandotra (1965) [75] found that *A. porri* remained viable for 9 months in dried debris left at laboratory temperatures and for 8 months in debris left on the field surface. However, if the diseased debris was buried 5-15 cm deep in the soil, the pathogen lost its viability within 2 months. Lagre onion dumps have also been found to supply primary inoculums (Thomas, 1991). Chawda and Rajasab (1992) [17] found that conidia of *A. porri* were readily dispersed though air currents and were caught in large numbers in a vertical cylinder spore trap. Ajrekar (1922) indicated that in Bombay, India, thrips played an important part in dissemination of *A. porri* inoculums and Nolla (1929) suggested that spattering rain and possibly thrips were responsible for primary inoculations from debris. Boelema and Ehlers (1967) [14] and Naude (1988) [69] recommended that dead foliage and rotten bulbs should be removed from the field and destroyed. Summer ploughing of onion fields reduced purple blotch severity and fields ploughed three times before planting had the lowest disease severity and highest bulb yield (Gupta 1987) [35]. Boelema and Ehiers (1967) [14] suggested that crop rotation should be practiced. Aveling *et al*. (1996) [7] constructed an ethograph for purple blotch of onion.

Resistant cultivars

Miller (1982) [61] screened 117 onion breeding lines for resistance against *A. porri*. He found that progeny from crosses of B*et al*pha and New Mexico Yellow Grano resulted in one line with a high level of resistance and three lines with medium levels of resistance. Gupta and Pathak (1988) [37] screened 21 indigenous and exotic onion cultivars for resistance to purple blotch and found that all the exotic lines proved highly resistant while all the indigenous lines were susceptible. Among the latter-mentioned, Pusa Red` was the least susceptible. According to Jones and Mann (1963) [48], onions such as Yellow Globe Danvers` and Red Creole`, that have a good covering of wax on the foliage and seed stalks, are more resistant to *A. porri* than such cultivars as Yellow Bermuda, Early Grano and Sweet Spanish which have less wax.

Yield losses

A detailed roving survey was undertaken during *kharif* 2011 in Dharwad, Belagavi, Gadag, Haveri and Uttar Kannada districts where onion is extensively grown as commercial crop. The severity of disease was also dependent on inoculum load, environmental conditions prevailing in different localities. Among the districts surveyed, the highest severity (69.33%) of Purple blotch of onion was noticed in fields of Vonnali village in Uttar Kannada district, whereas least (17.33%) per cent disease index of the disease were recorded at Annigeri village in Dharwad district. (S. Ravichandran, 1917) [80]. The highest district average disease incidence was recorded in Uttar Kannda (61.21%) followed by Belagavi (52.86%), Haveri (43.32%), Dharwad (41.48%) and least incidence was noticed in Gadag (39.90%) district indicating that this disease was not consistent in all localities. The causal organism of disease is *Alternaria porri* (Ellis) Among the foliar diseases, purple blotch is one of the most destructive diseases prevails in almost all onion growing areas of the world and causes heavy loss in onions under field conditions The yield loss of onion in India due to this disease under favourable conditions varies from 25-50 per cent (Pandotra, 1964) [73] more so in Karnataka. Seed treatment with *Trichoderma harzianum* resulted in less percent disease index and high yield of onion bulb (Chethana *et al.,* 2012) [15].

Conclusion

Onion crop suffers from various fungal pathogens which cause severe yield and quality losses by causing different diseases. This review concludes that fungal diseases of onion crop can be managed effectively by using different bioagents and plant extracts. Biological control measures are not only environment friendly but are also cost effective. There is need of the time for more research on the evaluation of various biological control measures against fungal pathogens

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