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Disease of Pea and Their Biological Management

Abstract

Pea is an economically important crop grown throughout the world. The crop suffers from various diseases incited by different pathogens viz. fungi, bacteria, virus and nematode. Various strategies have been adopted to control these diseases including chemical and physical measures. The increasing uses of synthesized chemical based pesticides imposed serious hazards on the environment. So there is an urgent need to find alternate measures to control the diseases. The present review article threw a light on the various aspects of different diseases and their control by using economical and eco-friendly measures.

Keywords: World Pea Production, Pea Hovers.

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Introduction

The world pea production of pea hovers around 12 million metric tons, Canada being the largest producer among all. France, China, Russia, India, United States of America, Ukraine, Germany, Australia, United Kingdom, Ethiopia, Spain, Austria, Belarus, Sweden, Czech Republic, Denmark, Pakistan, Peru and Romania are other major pea producing countries. India is one of the largest producers of dry pea in the world and stand at the 4th place in the list of major dry pea producers. The Indian production contributes to around 7% in the world's total produce with the production figures of 8 lacs metric tons. Uttar Pradesh is the major field pea producing state in India producing about 60% of the total country. The other major pea producing states in India are Madhya Pradesh, Bihar, Punjab and Himachal Pradesh (Anonymous, 2010).

Pea (*Pisum sativum*) (fabaceae) is an important vegetable and pulse crop of india covering an area of 7 lacs hectares and producing 6.1 lacs tones of grains. It is cultivated throughout the country but 90% of its total area is confined to Uttar Pradesh (Thind, 1998, Kocchar, 2009, Anonymous, 2010). Early group of pea cultivars are Arkel, Jawahar matar 3 and 4, Azad p1, JP 83 and Mid-season group cultivars are Bonneville, Arka ajit, Jawahar matar 1 and 2. It is a crop of moderately cool growing season, a fair amount of rainfall and a temperature of 13-18˚C. The crop thrives best on soils with a pH 6.0-7.5 (Kocchar, 2009). The whole pod of pea can be eaten as the pod walls contain less fibre. It is a good a source of nutritious food and used as a fresh vegetable or in soup as canned, processed or dehydrated seeds (Thamburaj and Singh, 2005, Kocchar, 2009). Like other pulse crops, diseases caused by Fungi, Bacteria, Viruses and Nematodes are among the notable risk factors of field pea cultivation.

Aim of the Study

The increasing hazardous effect of chemical pesticides used for the treatment of pathogen induced diseases is a great concern to the environment. There is an urgent requirement to find alternative measures to control diseases with greater efficacy through biological means. The present investigated different biological approaches that can be used to control various diseases of pea caused by bacterial, fungal and virus pathogens.

Bacterial Disease

Bacterial blight in pea caused by *Pseudomonas syringae* pv. *pisi. Pseudomonas syringae* pv. *pisi* is a seed-borne bacteria responsible for the surface frost damage in plants causes bacterial blight in pea (Hirano and Upper, 1990, Garden *et al*., 1990). A new strain of *Pseudomonas syringae* pv. *pisi* has been reported in Shizuoka Prefecture, Japan associated with White Top disease of pea. The disease occurs in early autumn when pea plants grow vigorously. The disease is characterized by chlorosis and whitening of apical shoots, including leaflets, stipules and young pods. Incidence of pathogen in Rajasthan, India was reported in the range of 3.5 to 91.5%. The bacterial pathogen found in the seed coat and space

between spermoderm and seed coat. Colonization of bacterial cells caused cell lysis and reduction in seed quality (Verma, Arora and Agrawal, 2016; Verma and Agrawal, 2018). Usually these White Top symptoms are associated with extensive water-soaked lesions on stem and on leaflets at the basal part of the diseased plants (Suzuki, 2003). Optimum temperature for bacterial blight is 22.7˚C while minimum is 7.2˚C and maximum is 37.7˚C (Gupta and Thind, 2006). Pathovars of *Pseudomonas syringae* are known to produce Toxins such as syringomycein E, Syringotoxin, Syringopeptin (Trigiano, Windham and Windham, 2004). Secretion of Caronatin, Phaseolotoxin, Tabtoxin and Tagititoxin has also been reported from *Pseudomonas Syringae* pv. *phaseolicola*, pv. *maculicola*, pv. *tagetis*, pv. *tabaci* (Agrios, 2005). Esterase isozyme profiling was proposed as a new identification procedure for bacterial pea blight agent (Malandrin and Samson, 1998).

Pseudomonas syringae pv. *pisi* also secrete some enzymes during infection in plants namely Pectate lyase, Cutinase, Suberinesterases (Agrios, 2005). Serological (Lyon *et al*,. 1995, Blanka *et al*., 1999, and Mollenbruck and Sander, 1991) and molecular (Bavage *et al*., 1991, Cournoyer *et al*., 1993 and fraaije *et al*., 1993) detection and characterization of the bacterial blight pathogen have also been reported.

Reduction in bacterial blight upto 62 percent by weekly sprays of Streptomycin has been reported (Forbes and Bretag, 1991). Verma and Agrawal (2015) found that plant extracts of *Withania somnifera* (leaf), *Azadirachta indica* (leaf), *Emblica officinalis* (fruit), *Treminelia chebula* (fruit), *Allium sativum* (bulb) and *Zinziber officinalis* (rhizome) were significantly effective to control the pea seed-borne bacterial pathogen *Pseudomonas syringae* pv. *pisi*.

Fungal Diseases

Stem Rot

Stem rot caused by *Sclerotinia sclerotiorum* is a disease restricted to cool and humid areas. Under Indian condition, it is of common occurrence on northern hills and in eastern Uttar Pradesh and is reported to cause 4.4-30.7% yield loss in eastern Uttar Pradesh and 70.3% in Kullu valley of Himachal Pradesh (Thind, 1998). The disease appears at the flowering stage if low temperature and rains prevail. Typical symptoms are quick rotting of the stem and foliage coupled with white cottony growth of the mycelium. The crop subsequently dries up in patches. Late in the season black elongated Sclerotia of irregular shape can be seen over and inside the stem. Thick crop canopy and luxurious crop growth favour the disease. The pathogen survives in the infected crop debris (Thind, 1998).

A number of fungi and bacteria are reported to antagonistic to *Sclerotinia* spp. and application of *Trichoderma koningii* reduced viability of Sclerotia (Trutmann and Keane, 1990). Singh (1991) reported *Penicillium cyclopium*, *Penicillium sheari*, *Paecilomyces lilacinus*, *Aspergillus niger*, *Aspergillus fumigates*, *Acremonium implicatum* and *Trichoderma roseum* as antagonistic against *Sclerotinia sclerotiorum* from Himachal Pradesh. Control of *Sclerotinia* rot can be achieved through carbendazim, captafol or triadimefen sprays (Srivastava and Singh, 1993). Singh *et al*., (1992) suggested combinations of fungicidal seed treatment with carbendazim or thiram.

Powdery mildew

Powdery mildew caused by *Erysiphe pisi* Syd. (Syn. *Erysiphe polygoni* DC.) and *Oidium erysiphoides*. It is characterized by the formation of small, diffused and off-coloured spots on the upper surface of lower leaves. Lesions later appeared as white powdery areas and subsequently cover both surfaces of leaves, petioles, tendrils, stems and pods. Affected tissues turn brown and necrotic. In severe cases, entire plant dries up prematurely (Nyvall, 1999). Reduction in nodulation and nitrogenase activity due to infection is also observed (Singh and Mishra, 1992). Powdery mildew in severely infected crop may cause the reduction in pods per plant up to 28.6% (Rathi and Tripathi, 1994).

Seed bacterization with *Pseudomonas fluorescence* and *Pseudomonas aeruginosa* provides resistance to the disease (Singh *et al*., 2003). Seed treatment with *Trichoderma viridae* in combination with spray of Karathane (0.2%) or Carbendazim (0.1%) or Mancozeb (0.25%) found effective to control powdery mildew and downy mildew of pea (Barnwal, Sah and Kumar, 2009). Low temperature stimulates cleistothecial formation in dry temperature region (Kapoor and Choudhary, 1995). Aqueous extracts of vermicompost (AVC) inhibited spore germination of several fungi. They also affected the development of powdery mildew on balsam (Impatiens balsamina) and pea (Pisum sativum) caused by Erysiphe cichoracearum and Erysiphe pisi, respectively, in the field at very low concentrations (0.1-0.5%) (Singh, Maurya and Singh, 2003). Neemazal, a product of neem (*Azadirachta indica*), induces resistance in *Pisum sativum* against Erysiphe pisi. The effect of the compound on the disease development was correlated with increased phenylalanine ammonia lyase (PAL) activity in pea leaves following treatment with neemazal (Singh and Prithiviraj, 1997). Spraying of Ginger extract at 20000 ppm controlled pea powdery mildew in the field significantly (Singh *et al*., 1991). A multifaceted approach for the management of pea powdery mildew is given by Singh *et al*. (1994).

Rust

Rust of pea caused by *Uromyces viciae fabae*. Rust appears in the form of uredosori as small, oval to round and light brown pustules on leaves at flowering stage. As the crop matures, dark brown telia occur on leaves and stem. Pea rust pathogens are biotrophs. *Uromyces viciae fabae* is an autoecious rust. The pathogen survives on crop debris and collateral host in the sub-mountains and Indo-gangetic plains of north India (Thind, 1998). Wide variation in number of aecial cup in pea against *U. fabae* has been reported (Kushwaha, Chand and Srivastava, 2009). Strains of *U. fabae* were found cross infective between lentil, board been and pea (Singh and Shyam, 2000).

In the *Uromyces fabae*, the transition from the early stages of host plant invasion towards parasitic growth is accompanied by the activation of many genes (PIGs

= in planta induced genes). Two of them PIG1(=THI1) and PIG4(=THI2), were found to be highly transcribed in haustaria and are homologous to genes involved in thiamine (vitamin B1) biosynthesis in yeast (Sohn *et al*., 2000).

Triazole fungicides are reported to provide excellent control against rust (Gupta and Shyam, 2000). Tebuconazole 250ws @0.1% has been reported as the best fungicide for the control of pea rust (Singh, 2007). Two RAPD markers, viz., SC10-82360 (primer, GCCGTGAAGT) and SCRI-711000 (primer, GTGGCGTAGT) linked to gene for resistance to rust in pea were identified (Vijayalakshmi, *et al*., 2005).

Ascochytosis

Ascochytosis is a severe problem in temperate and subtropical zones including hill areas. In India Ascochytosis has been reported from various locations of Himachal Pradesh and Punjab (Rana *et al*., 2009). Three distinct species viz. *Ascochyta pinodella*, *Ascochyta pisi* and *Ascochyta pinodes* (Perfect state–*Mycosphaerella pinodes*) are known to infect pea crop. *Ascochyta pinodella* causes small, irregular to circular, purpulish spot on leaves. Lesions sometimes show concentric rings. Similar lesions are caused on stem and pods. *Ascochyta pinodella* also causes foot rot under humid conditions. *Ascochyta pisi* causes tan coloured lesions instead of brown or black. Tiny black fruiting bodies are also visible on the lesions. *Ascochyta pinodes* causes blight symptoms on leaves, stem and pods. *Ascochyta pinodella* can be distinguished from *A. pinodes* by larger size conidia while *A. pisi* produces light buff to flesh coloured spore mass exudates. These pathogens are known to survive through seed and infected crop debris in the soil. The molecular sequencing of Ascochyta permitted to distinguish *Ascochyta pisi* from *Ascochyta pinodes* and *Ascochyta pinodella* (Tadja *et al*., 2009). *Didymella pisi* has been recognized as telomorph of *Ascochyta pisi* (Chilvers *et al*., 2008).

Two sprays of hexaconazole 5EC@ 0.2% resulted in a good control of Powdery mildew and Ascochyta blight (88%) in pea. Thyme oil and a strain of *Clonostachys rosea* showed some effectiveness against *Ascochyta* spp. (Tinivella, 2009). Seed dressing of benomyl-1½ (42.4g) to 2oz (56.6g) Benlate 50% w.p.per 28lb (12.7kg) of seed gives complete control of *Ascochyta* infection of pea seeds (Maude and Kyle, 1970). Fungicides effective against *Ascochyta* blight are mancozeb, copper oxychloride, orthocide, zineb and orthophalton. Among systemic fungicides, benomyl and carbendazim are quite effective (Thind, 1998).

Wilt and Root Rot

Pea wilt caused by *Fusarium oxysporum* f. sp. *pisi* and *Fusarium solani* f. sp. *pisi*. Pea root rot complex reported by *Alternaria alternate*, *Alternaria euteiches*, *Fusarium oxysporum* f. sp. *pisi*, *Fusarium solani* f. sp. *pisi, Mycosphaerella pinodes*, *Pythium* sp., *Rhizoctania solani* and *Sclerotinia sclerotiorum* are major yield limiting diseases for pea production in Canada (Xue, 2003). *Aphanomyces euteiches* f. sp. *pisi* and *Thielavopsis basicola* are also reported to associated with pea root rot complex. *Aphanomyces euteiches* f. sp. *pisi* shows wide variation in pathogenicity and genotype (Malvick and Percich, 1998). Symptoms appeared as yellowing of lower leaves and stunting of plant. Leaflet margins curl downward, stem may swell slightly at the ground level and plant die soon. The pathogens survives in soil in their saprophytic phase (Thind, 1998).

Integration of seed treatment, bioagent (*Trichoderma hazianum*), soil application of wheat bran based formulation and mulch significantly lowered the wilt-root rot complex of pea (Paul, Devin and Kapoor, 2008). Xue (2003) reported use of *Clonostachys rosea* as single biocontrol agent against all pathogens involved in pea root rot complex. Control of pea root rot caused by *Rhizoctania solani* has also been successfully achieved through the use of *Bacillus subtilis* (Hwang and Chakravarty, 1992) and *Gliocladium virens* (Hwang and Chakravarty, 1993). Arbuscular mycorrhizal fungus *Glomus intraradices* with increased phosphate concentration in plant but reduced root rot disease development in peas caused by *Aphanomyces euteiches* (Bodker, Kjoller and Rosendahl, 1998). Seed meal from *Brassica napus* (rapeseed) produced volatile fungitoxic compounds potentially of value in the control of Aphanomyces root rot of pea (Smolinska *et al*.,1997). Bioprotection of pea roots against *Aphanomyces euteiches* by the arbuscular mycorrhizal fungus *Glomus mosseal* was demonstrated to depend on a fully established symbiosis. This was related with induction of mycorrhiza-related chitinolytic enzymes (Slezack *et al*., 2000).

Anthracnose

Anthracnose is caused by *Colletotrichum gloeosporioides*. Symptoms appeared as large, diamond-shaped lesions with bleached or white centers from on the lower portions of diseased stems. Under magnification, several small, black acervuli, appearing as upright “hairy” structures due to the presence of numerous dark setae can be seen in the center of most lesions. Young dead shoots may droop to form “Shepherd’s crooks,” which is a useful diagnostic symptom. Under experimental conditions, the fungicides benomyl, copper hydroxide and mancozeb reduced diseased severity (Nyvall, 1999).

Other minor diseases such as Grey mold caused by *Botrytis cineria*, Pod spot or Pod rot caused by *Phytophthora parasitica*, *Fusarium semitectum*, *Colletotrichum pisi*, *Alternaria brassicae* var. *phaseoli*, and Damping-off caused by *Sclerotium rolfsii* and *Pythium* spp. have been reported to associated with pea.

Thirty species of fungi belonging to 15 genera were found associated with seed-borne diseases of pea. *Alternaria tenuissima*, *A. tenuis*, *Ascochyta pinodes, A. pisi, Aspergillus flavus, A. niger, Aspergillus* sp*., Cladosporium herbarum, Fusarium moniliforme, F. oxysporum, Penicillium* sp*., Phoma medicaginis* var*. pinodella, Rhizoctania solani* and *Sclerotinia sclerotiorum* were the frequently encountered species (Rathour and Paul, 2004). *Rhizobium leguminosarum* Jordan bv. *Viceae* strains from pea and lentil root nodules have the potential to

be used for biological control of *Pythium* damping-off of field pea (Bardin *et al*., 2004). *Pseudomonas cepacia* AMMD and *Pseudomonas florescens* PRA25, antagonists found effective against *Pythium* damping-off and *Aphanomyces* root rot diseases. Seed treatment with these bioagents increases emergence by 61% and 30% respectively (Parke *et al*.1991).

Virus Diseases

All together 35 virus diseases are reported to infect pea crop worldwide. Among these, pea mosaic incited by bean virus 2 (*bean yellow mosaic virus*) is widespread (Thind, 1998). *pea seed borne mosaic virus* is economically important pathogen with worldwide distribution that causes significant losses in pea yield and reduces seed and produce quality (Frew *et al*., 2002). *pea seed borne mosaic virus* overwinters in the infected seeds of pea and lentil. Under field conditions, the disease spread by aphids from the neighbouring fields. Optimum temperature for the disease is 28-32˚c (Gupta and Thind, 2006). *pea seed borne mosaic virus* belongs to potyvirus group and causes shortening of pea (Sontakk and Chavan, 2007). Others many seed-borne viruses namely *pea early browning virus*, *pea enation mosaic virus*, *pea false leaf roll virus*, *pea mild mosaic*, *pea streak virus* have been reported (Richardson, 1990, Agrios, 2005). *pea enation mosaic virus* (PEMV) is associated with two genera Enamovirus and Umbravirus based on the two distinct RNAs in its genome and is referred to as *pea enation mosaic virus*-1 and *pea enation mosaic virus*-2 respectively (Dembler et el., 1996). Pea cultivars like Frankin and Lifter have been reported to be resistant to pea enation mosaic virus (McPhee and Muehlbauer, 2002, a,b).

A new nanovirus named *pea necrotic yellow dwarf virus* (PNYDV) has been reported in Germany. The agent caused severe yellowing and stunting in naturally infected pea and faba bean, sometimes followed by necrosis (Grigoras and Gronenborn, 2010).

Conclusion

As according the above discussion, it is clear that diseases of pea crop can be efficiently managed by the use of eco-friendly biological management strategies which will reduce the input costs and reduces environmental hazards.

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