The Pharma Innovation Journal 2021; 10(5): 1259-1263

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(5): 1259-1263

www.thepharmajournal.com
Received: 12-03-2021
Accepted: 16-04-2021

Tejaswini Pundlik Urkude
Department of Plant Pathology, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Corresponding Author:
Tejaswini Pundlik Urkude
Department of Plant Pathology, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Dry root rot of pea caused by *Rhizoctonia solani* by using Trichoderma strains: A review

Tejaswini Pundlik Urkude

Abstract

Pea (*Pisum sativum*) is one of the most important economic pulse crops which is infected by a serious disease is known as dry root rot which is caused by *Rhizoctonia solani.* Pea root rot complex, which is caused by several soil-borne fungi, is a significant yield-limiting factor for pea production around the world. *Trichoderma* species are well-known antagonists with high bio-control ability against phytopathogenic fungi that live in the soil. The *Trichoderma* isolates coiled around the *Rhizoctonia solani* hyphae, causing cell wall lysis, according to ultrastructural tests. Rather than antibiosis, parasitism accompanied by lysis was reported to be the mode of antagonism. Seed priming increased the efficacy of *Trichoderma harzianum* in controlling root rot diseases, with bio-priming seed treatments showing the highest rates of disease reduction. Seed coating with biocontrol agents was found to be more effective than fungicide seed treatment in reducing the occurrence of pea root rot disease.

Keywords: Pea, Dry root rot, *Rhizoctonia solani*, *Fusarium solani f. sp pisi*, Biocontrol agents, *Trichoderma spp*

Introduction

Pea (*Pisum sativum* L.) (Family: Leguminosae/ Fabaceae), the world's second most important food legume crop, has seen substantial production increases. Root diseases are more common and can damage production-critical root functions (Va, 2016) [18]. Root rot disease is considered the most dangerous in pea as it influences its underlying plant stand and over 20 distinct microorganisms have been reported for the Disease from various parts of the world (USDA, 1960).

Pea as a nutrient booster of soil

Peas are usually thought to increase soil nitrogen levels for subsequent crops, with estimates ranging from 17 to 83 kg/ha. (Askin *et al.*, 1985) [5]. Moreover, a large portion of the nitrogen fixed by peas is removed in the crop, particularly in threshed peas. When peas are vined, less nitrogen is lost in the crop, but if pea vines or pea straw are removed as well, the only nitrogen added to the soil is from roots and abscised leaves. Nothing is known about the impact of peas on subsequent crop yields, but trials in Canterbury found that Tama ryegrass or wheat after peas (with all residues removed) yielded 42 percent or 67 percent more than after barley. (Askin *et al.*, 1985) [5]. The yields after peas and after decrepit were indistinguishable, demonstrating that peas held as opposed to raised nitrogen levels.

Nutritive importance of peas

Peas are whole grain, with a high extent of absorbable proteins, sugars, and fats, just as minerals (Ca, P, and Mg) and nutrients A, B, and C. Disengages with great sugar, high quality starch, or oligosides are extracted from pea seeds that have been dried. Because dry pea seeds consist a small amount of anti-nutritional factors, they act as a protein source. Furthermore, the dry seeds have not many enemies of nourishing elements and are broadly utilized as a sort of protein. (Dhall, 2018).

Diseases of pea

Downy mildew. (*Peronospora viciae* (berk.) Casp.), Powdery mildew (*Erysiphe polygoni*), Pea rust (*Uromyces viciae fabae*), Grey mold (*Botrytis spp.*), Ascochyta blight (*Pseudomonas syringe pv. Pisi*), White rot (*Sclerotinia sclerotiorum*), Dry Root rot (*Rhizoctonia solani*) and Wilt (*Fusarium oxysporum f. sp. pisi*).

Symptoms

Early symptoms of dry root rot of pea causes rigid, straw-colored lesions in the cortex, which darken to a honey-bown colour as the cortical tissue softens.

Then pea plants are pulled, all that is left is a filament of vascular tissue. The leaves turn yellow as they rise from the base of the shoot. The pea plant will not enter the reproductive process if the infection happens within 10 days of planting. Burke *et al.* (1969) [7] found that *Rhizoctonia solani* infection could occur at field-capacity water content: a 24-hour span of saturation water content increased infection significantly; *Rhizoctonia solani* infection was not temperature-dependent, but disease progress was accelerated by higher temperature, and infection was most susceptible near the base of the epicotyl of the pea seedling.

Production & Yield

Peas are cultivated on an area of 11.50 lakh ha in India, producing around 10.36 lakh tonnes between 2012 and 2015.Singh, *et al*., (2019) [16] The major pea-growing region in India is Uttar Pradesh. It contributes about 49% of total pea production in India. The major pea-producing states are Uttar Pradesh, Madhya Pradesh, Bihar, and Maharashtra. Field peas will yield 20-25 qtls of grain and grains straw per ha (irrigated) and 10-15 qtls per ha (rain-fed) with an improved package of practises.

Identification and occurrences of Root Rot.

The disease causes early inhibition of root development, which affects the uptake of supplements and water and is subsequently showed as the hindrance in development and the infected plants bear few partially filled pods, which mature early (Oyarzun, 1993) Under ideal ecological conditions, it can cause even complete failure of the crop (Tu, 1987).

Root diseases are likely to cause more crop losses than any other form of pea disease. During rainy seasons, the damage is normally the most serious. Low-lying areas and fields or gardens that drain gradually lose more than well-drained, fertile ones. Root rot usually occurs in patches that become larger as the season progresses. When the pea plant is in the pre-emergent or post-emergent seedling stage, root rot may develop. These early infections also result in death, leaving a bad standing. Root decay usually starts on the fine feeder roots and progresses to the main taproot over time. The taproot, on the other hand, is often the first to be attacked. In certain situations, all of the roots are damaged, leaving just a few remnants below the seed's attachment. Shelled peas may also be harmed by root-rotting fungi. Infected plants produce peas that are irregular in size and variable in maturity with a lowered sugar content. Root rot of pea may be caused by anyone or a combination of several common soil fungi. (IPM., The University of Illinois at Urbana-Champaign, 2002.)

Rhizoctonia solani

The *Rhizoctonia solani* complex is an economically beneficial community of soil-borne basidiomycete pathogens found on a wide range of plant species around the world. (Martin & English, 1997) [14]. Decandolle described the genus *Rhizoctonia* in 1815. *Rhizoctonia crocorum* (Pers.) DC. was named as the type species, and Rhizoctonia solani, the most significant Rhizoctonia species, was described by Kühn in 1858. *Rhizoctonia solani* is a soilborne pathogen that causes significant losses in favorable conditions. Due to the pathogen's long saprophytic survival capacity in the soil, control of this disease is difficult. The most effective way to solve the problem is to reduce or eliminate soil-borne inoculum, which can be done with the help of effective fungal antagonists. Biological control of soil and seed-borne plant pathogenic fungi has been addressed using bacterial and fungal antagonists. *Rhizoctonia solani* multinucleate isolates were grouped into 14 anastomosis classes (AG), which are called isolated, non-breeding populations. AG-2-1 reduced seedling emergence and caused severe root rot on pea (Sharma-Poudyal *et al*. 2015). The pathogen can exist as hyphae in contaminated seed litter, as sclerotia in soil (Hanson 2005; Howard *et al.* 1994; Porter *et al*. 2011), and as chlamydospores in thick-walled hyphae (Hanson 2005; Howard *et al.* 1994; Porter *et al.* 2011). It may also survive as a saprophyte in soil (Papavizas *et al*. 1975). It can be spread by blowing infested soil or crop litter, and it can also be spread to a small degree by contaminated seed (Dillard 2001). (Howard *et al.* 1994; Porter *et al.* 2011). There are contradictory studies on the significance of *Thanatephorus cucumeris* (a teleomorph of *Rhizoctonia solani*) basidiospores in pathogen dispersal (Hanson 2005; Howard *et al*. 1994). Crop rot, damping-off, and seedling blight are all typical signs of seedling infection (Kaiser and Horner 1980). Infection of older plants causes sunken, reddish-brown, penetrating lesions on taproots, hypocotyls, epicotyls, and seed bases, as well as soft rot of stems and roots in peas (Hanson2005; Howard *et al.* 1994). -Serious root symptoms can also encourage the development of adventitious roots near the soil surface (O'Brien *et al*. 1991) thus reducing root nodulation (Chang *et al*. 2008). In old lesions and within infected roots, small, spherical, or irregularly shaped brown to black sclerotia may form (Howard *et al*. 1994; Porter *et al*. 2011). Rhizoctonia solani is a soil-borne pathogen that causes major losses when conditions are favorable (Seema and Devaki, 2010).

Management

Cultural method

Root rot fungi live in the soil, and the frequency and severity of root rots are proportional to the amount of inoculum present. (Baker 1980) Various cultural practices like crop rotation at the interval of four years, proper drainage systems, and planting green manure crops are found to be helpful in reducing the severity of root rot of pea. (Liu 1980)

Biological

It is an important part of "Integrated Disease Management", Biological control of soil and seed-borne plant pathogenic fungi has been addressed using bacterial and fungal antagonists. Pseudomonas spp., Bacillus spp., and Trichoderma spp. strains have been shown to be important not only in controlling plant infections, but also in assisting plants in mobilising and acquiring nutrients. (Perner *et al*., 2006).

Chemical

In new formulations, captan and the new fungicides benalaxyl and Metalaxyl were used. 0.75 fl oz/100 lb seed plus dye Allegiance-FL Re-entry limits are listed on the label. Ridomil Gold SL may be banded or sprayed on the surface at a rate of 0.5 to 1 pint/A. For used, incorporate 2-inches deep. Re-entry is allowed after 48 hours. (Tu, J.C. 1988)

Side effects of chemical fungicides

For the prevention of Rhizoctonia root rot in peas, chemical fungicides are widely used. (Khan *et al.,* 1998). Their field application, on the other hand, could not always be desirable. Chemicals were prohibited because of their toxic effects on non-target species, the unfavorable changes they cause in the environment, and the emergence of pathogens resistant to various chemical fungicides. Various fungicides have been used successfully to treat this disease. However, the emergence of fungicide-resistant phytopathogenic strains, as well as the negative effects of pesticides on soil, plant health, and crop materials, have forced plant pathologists to seek out environmentally sustainable plant disease control solutions. Furthermore, since the fungus is soil-borne, using fungicides to control it has proven difficult. As a result, the emphasis is on creating an effective management strategy. Since biological control is an important part of "Integrated Disease Management," there has been no research on this aspect of the disease. As a result, the aim of this research was to characterize and classify the most common pathogen associated with pea root rot, as well as to investigate the effectiveness of *Trichoderma viride* and *Trichoderma harzianum* against the root rot of pea to improve the yield and production of the pea.

To see how good *Trichoderma viride* and *Trichoderma harzianum* effective on Pea dry root rot. Root diseases are normally affected by a spatially complex soil ecology, which influences pathogen survival and inoculum capacity both before and during infection. Plant stress and disease progression following infection are all affected by soil ecology. (Va, 2016) [18]. Because of favorable soil water connections for sustained survival below a tillage pan (Allmaras *et al*., 1988a) [3], and because of comparatively more serious plant stress caused by root damage below the tilled sheet, the Rhizoctonia solani organism is generally a danger to pea development (i.e., below 20 cm) (Rush and Kraft, 1986).

Trichoderma spp.

Trichoderma is a fungus genus belonging to the Hypocreaceae family. *Trichoderma spp*. are said to target other fungi, develop antibiotics that eliminate other bacteria, and function as biocontrol microbes. **(**Kuehn, n.d.), that is present in all soils, where they are the most prevalent culturable fungi. Many of the plants in this genus are opportunistic avirulent plant symbionts. This refers to the ability of many Trichoderma species to form endophytic symbiosis with a wide range of plant species. Several Trichoderma strains have been developed as biocontrol agents for plant fungal diseases. Antibiosis, parasitism, causing host-plant resistance, and competition are among the various mechanisms. T. asperellum, T. harzianum, T. viride, and T. hamatum are the most common biocontrol agents. Since the biocontrol agent grows on the root surface in its local habitat, it affects root disease in particular, but it can also be active against foliar diseases. (Harman, G.E. 2006).

Trichoderma as a biocontrol agent.

Trichoderma was first introduced as a biocontrol agent in the early 1930s by **(**Weindling, 1934). The species of *Trichoderma* are well known for their biocontrol activity against many pathogens of plant that can cause major losses in the current agricultural scenario. (Naher *et al*., 2014) *Trichoderma spp*. are anaerobic, facultative, and metropolitan fungi occurring in excess in agricultural soils and other substrates such as rotting wood. They are part of the Deuteromycetes subdivision, which does not have or possess a fixed sexual state and most species are suited to an asexual life cycle. *Trichoderma spp*. has many other functions besides controlling pathogenic microbes development, including

1. Stimulating rhizosphere invasion,
2. Stimulating plant growth, root growth, and
3. Enhancing plant defense responses.

Trichoderma is an opportunistic, avirulent plant symbiont fungus that functions as an antagonistic and parasitic fungus against many plant pathogenic fungi, providing immunity against phytopathogenic plant diseases. *Trichoderma spp*. have been shown in several studies to be effective biocontrol agents for plant disease management, and commercial *Trichoderma* products are also available as biopesticides, soil additives, and plant growth enhancers. *Trichoderma* species are used as a biocontrol agents because they have more advantages on plant growth such as promoting plant growth, increasing the nutrient uptake from soil, decreasing the activity of soil borne pathogens that ultimately affect growth of the plant (Sharma *et al*., 2011) [17]

Biocontrol mechanisms of *Trichoderma* spp

Trichoderma spp. are fungal phytopathogenic biocontrol agents. They can act indirectly, such as by competition for nutrients and space, changing environmental conditions, or stimulating plant growth, plant defense mechanisms, and antibiosis, or they can act directly, such as by mycoparasitism. The mechanisms can be described as:

1. Biocontrol by competition for nutrients and living space

Trichoderma spp. are fast-growing fungi with persistent conidia and a wide range of substrate adaptations. They are direct rivals regarding food and living space. *Trichoderma spp*. are also totally resistant to a variety of harmful chemicals, such as herbicides, fungicides, and phenolic compounds. As a result, they can develop quickly and influence pathogens by developing metabolic compounds that prevent spore germination (fungi stasis), destroy cells (antibiosis), or change the rhizosphere (for example, by acidifying the soil to prevent pathogen growth).

2. Biocontrol by mycoparasitism

Mycoparasitism relates to the close association between *Trichoderma* and the pathogen. Trichoderma spp. was first described by Weindling (1932), as a biocontrol agent, and he also observed mycoparasitism of *Trichoderma lignorum* (*viride*) hyphae coiling and killing *Rhizoctonia solani* at the same time. Mycoparasitism is a complex process that involves the synthesis of a cell wall lytic enzyme.

3. Plant growth enhancement by *Trichoderma* spp

Trichoderma spp. not only controls pathogens but also promotes plant defense mechanisms and improves plant growth and root production (biofertilizer). Any *Trichoderma* strains have been shown to invade the epidermis and colony root surfaces in a reliable and long-lasting way. *Trichoderma spp.* also developed gluconic and citric acids, lowered soil pH, and improved phosphate, micronutrient, and mineral solubilization, such as iron, magnesium, and manganese.

4. Induction of plant defense by *Trichoderma* spp

Trichoderma spp. has been shown to stimulate gene expression in plants for antimicrobial proteins such as chitinase, glucanase, and peroxidase. Pre-treating plants with Trichoderma spp. have also been shown to improve plant resistance to pathogen invasion. Trichoderma spp. are spore producers, fast growers, and opportunistic invaders. They develop antibiotics and include cell wall degrading enzymes (e.g., celluloses, chitinase, and glucanases). Consequently, the presence of Trichoderma spp. in plants activates the hypersensitive response, systemic acquired resistance (SAR), and induced systemic resistance (ISR).

Efficacy of *Trichoderma* against Dry root rot of Pea caused by *Rhizoctonia solani*

(Ilan Chet and Ralph Baker, 1980) reported that *Trichoderma harzianum* conidia are germinated in a liquid salt medium (PH 6.0) containing *Rhizoctonia solani* live mycelium. Every seven days, samples were taken from the populations that had been mixed. Coiling of *Trichoderma* on the pathogen's hyphae may be seen after 7 days of incubation. *Rhizoctonia* solani mycelium was fully lysed in 5-6 weeks. On the *Rhizoctonia* selective medium, no growth from this lysed mycelium was observed. The mechanism of antagonism proved to be parasitism, based on the capacity of *Trichoderma harzianum* hyphae to coil around, and lyse *Rhizoctonia solani* hyphae. Even if there may be some interaction between *Trichoderma harzianum* and *Rhizoctonia solani*, the findings support the view that parasitism, followed by lysis, is the most important mechanism in this host-parasite relationship.

(Hamid *et al.*, 2012) [11] Reported that All four biocontrol agents tested inhibited radial mycelial development effectively in an *in vitro* bioassay. In dual culture, *Trichoderma harzianum* was found to be a good antagonist, causing the pathogen to develop to a minimum of 19.20 mm, followed by *Trichoderma viride* (21.80 mm). Under *in vitro* conditions, *Trichoderma spp*. had good antagonistic activity against *Rhizoctonia solani*.

(Muhanna *et al*., 2018) [15] Reported that Biocontrol agents (*Trichoderma)* can reduce disease incidence and severity by activating plant defense mechanisms and inducing systemic resistance in plants to *Rhizoctonia solani*, causing the plant to produce proteins that function as antifungal agents. The biocontrol agent *Trichoderma harzianum* plant growth-promoting activity is thought to be due to the development of antagonistic compounds against root pathogens, which often act as plant hormones and promote root growth. The effectiveness of biological agents (BCAs) such as *Trichoderma harzianum*, *Rhizobium sp*., in controlling pea root rot complex was investigated. After application, soil treated with *Trichoderma harzianum* and *Rhizobium sp*. showed a substantial reduction in disease severity.

(Yobo *et al*., 2004) [19, 21] reported that the pathogen contacted one of the antagonists within three days after inoculation, according to the dual culture samples. On all plates where the pathogen and antagonist first interacted, a brownish discoloration was detected. As the two *Trichoderma* isolates began to expand over the *Rhizoctonia solani* and colonize the entire plate, the brownish discoloration expanded over the plates. Within 6 days of inoculation, the antagonists had fully colonized the plates, with spores forming on all parts of the plates. The two *Trichoderma* isolates had mycoparasitic activity against *Rhizoctonia solani*, according to ESEM (Environmental Scanning Electron Microscope). *Trichoderma* coiled around *Rhizoctonia solani*, demonstrating lytic behavior and the weakening of the host's cell wall. The diameter of the hyphal separated *Trichoderma* mycelium from *Rhizoctonia solani*. The average hyphal diameter of *Trichoderma* isolates was around 2 micrometers, while *Rhizoctonia* solani hyphal diameters ranged from 5 to 6 micrometers. Where the *Trichoderma* isolates contacted the *Rhizoctonia solani* cell wall, the integrity of the *Rhizoctonia solani* cell surface started to disintegrate. *Rhizoctonia solani* hyphae had pronounced breakdown and lack of turgor, which were common characteristics of advanced alteration. Cell wall penetration with the indication of penetration holes or points, as well as significant cell damage, resulted from direct contact with *Rhizoctonia solani*. Total cell death, cell wall breakdown, and hyphal disintegration were all observed.

(Lewis & Lumsden, 2001) [13] reported that the activated VBA-FB (vermiculite, powdered wheat bran, and dry fermenter-produced biomass) formulation has previously been shown to reduce *Rhizoctonia solani* survival and saprophytic development in a variety of soils. In these soils, the formulation also provided for a 1000-fold proliferation of various biocontrol fungal isolates. The soil reports were very similar to the soil-less mix results in this study. Another activated solution, made of cellulose granules (Biodac) instead of vermiculite bran was recently found to effectively minimize *Rhizoctonia solani* growth while allowing biocontrol fungus proliferation in a soil-less mixture.

(Asad *et al*., 2014) [4, 10] reported that the findings revealed that *Trichoderma* has a potent pathogen antagonistic capacity. After making physical contact, a strong zone of interaction between antagonist and pathogen was observed, where the greater inhibited the other's development. Around the hyphae of *Rhizoctonia solani*, light microscopic examination showed a common coiling pattern of *Trichoderma* species. After 72 hours of incubation, this hyphal interaction started. Pathogen hypha quickly faded after seven days of incubation, and *Trichoderma asperellum*, *Trichoderma harzianum*, and *Trichoderma spp*. finally started losing the pathogen. All the *Trichoderma* isolates water-soluble metabolites were found to be very effective at inhibiting *Rhizoctonia solani* formation. When water-soluble metabolites were compared to the control procedure, *Trichoderma asperellum* (74.4%), *Trichoderma spp.* (70.0%), and *Trichoderma harzianum* (67.8%) showed considerably higher growth inhibition (p 0.01). For volatile metabolites, all *Trichoderma* isolates showed less than 20% growth inhibition. When related to control management, the values for *Trichoderma harzianum*, *Trichoderma asperellum*, and *Trichoderma spp*. were 15.3 percent, 11.8 percent, and 10.6 percent, respectively.

Conclusion

Pea plants diseases occurs due to use of susceptible cultivars, lack of proper crop rotation, poor tillage and cultural practices, soil compaction and lack of organic matter in soil. Because of impractical and contamination and pollution in environment, the chemical controls are not beneficial to manage the dry root rot of peas. The different kinds of *Trichoderma* species were included for their biocontrol activity and their mechanism against dry root rot of peas (*Rhizoctonia solani*). On the basis of this observation, the purpose of the work described in this paper was to achieve the study of effect of Trichoderma spp., used as a biocontrol agent Againt the pathogen of dry root rot of pea (*Rhizoctonia solani*). By using various *Trichoderma spp.*, as a biocontrol agents, this problem has been reduced.

Acknowledgment
Authors are thankful to the Department of Plant Pathology, School of Agriculture, Lovely Professional University, Punjab. The authors are Thankful to Dr. Vipul Kumar, Department of Plant Pathology, Lovely Professional University, Punjab for their assistance in the completion of this review paper. Conflict of interest authors indicates agreement that this article contains all the information true and correct.

References

1. Al-Askar A, Rashad Y. Efficacy of some plant extracts against rhizoctonia solani on pea. Journal of Plant Protection Research, 2010;50(3):239-243. https://doi.org/10.2478/v10045-010-0042-0
2. Ali HZ, Nadarajah K. Evaluating the efficacy of *Trichoderma isolates* and *bacillus* subtilis as biological control agents against *rhizoctonia solani.* Research Journal of Applied Sciences, 2013;8(1):72-81. https://doi.org/10.3923/rjasci.2013.72.81
3. Allmaras RR, Kraft JM, Miller DE. Effects of soil compaction and incorporated crop residue on root health. Ann. Rev. *Phytopathology* 1988a;26:219-243.
4. Asad SA, Ali N, Hameed A, Khan SA, Ahmad R, Bilal M, *et al*. Biocontrol efficacy of different isolates of Trichoderma against soil borne pathogen Rhizoctonia solani. Polish Journal of Microbiology 2014;6*3*(1):95-103. https://doi.org/10.33073/pjm-2014-014
5. Askin DC, White JGH, Rhodes PJ. Nitrogen fixation by peas and their effect on soil fertility. Proceedings-Easter School in Agricultural Science, University of Nottingham 1985.
6. Bokhari NA, Perveen K. Antagonistic action of Trichoderma harzianum and Trichoderma viride against Fusarium solani causing root rot of tomato. African Journal of Microbiology Research 2012;6(44):7193-7197. https://doi.org/10.5897/AJMR12.956
7. Burke DW, Mitchell JE, Hagedorn DJ. Selective conditions for infection of pea seedlings by Aphanomyces euteiches in soil. Phytopathol 1969;59:1670-1674.
8. Dhall RK. Pea cultivation. Bulletin No. PAU/2017/Elec/FB/E, 29. 2017.
9. El-Mohamedy RSR, El- Baky MMH. Evaluation of Different Types of Seed Treatment on Control of Root Rot Disease, Improvement Growth and Yield Quality of Pea Plant in Nobaria Province. Research Journal of Agriculture and Biological Sciences 2008;4(6):611-622.
10. Asad SA, Ali N, Hameed A, Khan SA, Ahmad R, Bilal M *et al*. Biocontrol efficacy of different isolates of Trichoderma against soil borne pathogen Rhizoctonia solani. Polish Journal of Microbiology, 2014;63(1):95-103. https://doi.org/10.33073/pjm-2014-014
11. Hamid A, Bhat NA, Sofi TA, Bhat KA, Asif M. Management of root rot of pea (*Pisum sativum* L.) through bioagents. African Journal of Microbiology Research, 2012;6(44):7156-7161. https://doi.org/10.5897/AJMR12.565
12. Kuehn R. (n.d.). *Trichoderma viride, T. harzianum*. *5*(1):27.
13. Lewis JA, Lumsden RD. Biocontrol of damping-off of greenhouse-grown crops caused by Rhizoctonia solani with a formulation of *Trichoderma* spp. Crop Protection, 2001;*20*(1):49-56. https://doi.org/10.1016/S0261-2194(00)00052-1
14. Martin FN, English JT. Population genetics of soilborne fungal plant pathogens. Phytopathology, 1997;87(4):446-447. https://doi.org/10.1094/phyto.1997.87.4.446
15. Muhanna N, Elwan S, Dib N. Biological Control of Root Rot Complex of Pea (*Pisum sativum* L.). Egyptian Journal of Phytopathology, 2018;46(1):49-67. https://doi.org/10.21608/ejp.2018.87766
16. Singh YV, Dey P, Meena RN, Verma SK, Bharteey PK. Soil test based fertilizer prescription model under integrated plant nutrient management system for pea on alluvial soil. Journal of Pharmacognosy and Phytochemistry 2019;8(1):177-180.
17. Sharma P, Vignesh Kumar P, Ramesh R, Saravanan K, Deep S, Sharma M *et al*. Biocontrol genes from Trichoderma species: A review. African Journal of Biotechnology, 2011;10(86):19898-19907. https://doi.org/10.5897/AJBX11.041
18. Va F. compaction effects in fine-textured mollisols Common root rot oCpea (*Pisum sativum* L.): Oat pre- crop and traffic compaction effects in fine-textured mollisols. 2016, January 1998. https://doi.org/10.1007/978-94-011-5270-9
19. Yobo KS, Laing MD, Hunter CH, Morris MJ. Biological control of Rhizoctonia solani by two Trichoderma species isolated from South African composted soil. South African Journal of Plant and Soil, 2004;21(3):139-144. https://doi.org/10.1080/02571862.2004.10635039
20. Xue AG. Biological control of pathogens causing root rot complex in field pea using Clonostachys rosea strain ACM941. Phytopathology 2003;93(3):329-335.
21. Yobo KS, Laing MD, Hunter CH, Morris MJ. Biological control of Rhizoctonia solani by two Trichoderma species isolated from South African composted soil. South African Journal of Plant and Soil, 2004;21(3):139-144. https://doi.org/10.1080/02571862.2004.10635039