GLOBAL JOURNAL OF BIOLOGY, AGRICULTURE & HEALTH SCIENCES
(Published By: Global Institute for Research & Education)
www.gifre.org

Diverse options on recent trend of different control methods against plants diseases caused by *Rhizoctonia solani: A review paper*

Yuliar
Research Center for Biology, Indonesian Institute of Sciences
Cibinong Science Center, Jl. Jakarta – Bogor Km 46, Cibinong 16911, West Java

Abstract

This a review describe the development of various methods to control plant diseases caused by *Rhizoctonia solani*. The methods can control the diseases caused by *R.solani* are biologically, chemically, physically, nanotechnologically, and integrated ones. The biocontrol agents (BCAs) were able to control the diseases were as *Rhizophagus intraradices, Rhizophagus clarus and Claroideoglomus etunicatum* which belong to arbuscular mycorrhizal fungi (AMF) group, and from fungi were *Penicillium brevicompactium*, *P. expansium*, *P. pinophilum*, *Trichoderma hamatum*, *T. veride*, *T. virens*, *Laetisaria avails,* and from bacteria were *B. amyloliquefaciens*, *B. brevis*, *B. pantotheinticus*, *B. pumilus*, *Bacillus subtilis Flavobacterium balustinum*, *Pseudomonas cepacia*, *P. fluorescens*, *P. putida*, *Rhizobium*, *Serratia marcescens*, *Streptomyces cyaneofuscatus*, and *S. mutabilis*. Tomato and escarole green manure were the most suppressive ones in suppressing of *R. solani* damping-off on *Lepidium sativum*. While plant extract that can control the growth of *R.solani* are the extraction of garlic bulb with saponins, extraction of *Picea neoveitchii* with four flavonoids, cauliflower with caulilexins, extraction of *Anemarrhena asphodeloides* rhizomes with nyasol (Z)-1,3-bis (4-hydroxyphenyl)-1.4-pentadiene. *Brassica juncea*, *B. napus,* and *Sinapis alba* which are added to the soil can protect wheat from rot root of *R.solani*. Temperature and moisture of soil were also reported that they could influence the level of damping-off of *R.solani*. Although chemical pesticides were not the best solution in plant protection from the diseases, the people still used it, such as one of the wide spectrum of novel fungicide, sedaxane.

Besides, the use of copper and manganese as micronutrient can increase the resistance against *R.solani* rot root on clusterbean. Integrated method of fungicides and BCAs, organic amendment and BCAs, crop rotation and cultivation methods were also use. It was interesting in the development of plant protection by nanotechnology method such as application of silica-silver 10 ppm showed 100% growth inhibition of *R.solani*. Other nanoparticles that have applied into the crop protection are nano forms of copper, iron, silica, silver, alumino-silica and carbon.

The purpose of this paper is to provide an option to addressing the problem plant diseases caused by *R. solani*, that appropriate with the local conditions of the soil, plant species, and the availability of the materials that can be used to suppress the disease.

Key words: antifungal, biocontrol agent, control measures, *R. solani*, nanoparticle, plant diseases

Introduction

World population increase continuously as predicted by Agrios (2005) that world population will be 8.5 billion by the year of 2025. That is why all possible methods that can increase food supply must be done. One of them is by increasing plant protection against the diseases that can cause damaged and yield losses of crop. This review deal with the methods of improvement of crop protection.

Plant diseases, insects and weeds decrease the production of all the crops produced worldwide by 36%, and the diseases alone cause reduction in the crop yield by 14% (Agrios, 2005). Among plant diseases, soil-borne diseases are the main factors in the production of many crops compared to seed-borne or air-borne diseases and account for 10-20% of yield losses annually (USDA, 2003). *R. solani* Kuhn (teleomorph, *Thanatephorus cucumeris* (*A*. B. Frank) Donk) is an important cosmopolitan necrotophic soil-borne fungus. Damping-off caused by *R. solani* results in yield losses in more than 200 crops globally (Lee *et al*., 2008).

The widespread soilborne pathogen *R.solani* is responsible for serious damage to many economically important agricultural and horticultural crops as well as trees worldwide (Grosch *et al*., 2006). High yield losses were reported, up to 50% for sugar beet (Kiewnick *et al*., 2001), up to 70% for field-grown lettuce (Davis *et al*., 1997), and about 20% for potato (Grosch *et al*., 2005). Strategies to control *Rhizoctonia* diseases are limited because of its ecological behavior. It is extremely broad host range and the high survival rate of sclerotia under various environmental condition (Grosch *et al*., 2006). Besides, cultivars with complete resistance are not available at present (Li *et al*., 1995).Therefore, efficient strategies to control the pathogen are urgently required. In the other hand, increasing use of chemical inputs causes several negative effects, such as the development of pathogen resistance to the applied agents and their non-target environmental impacts (Gerhardson, 2002). A growing awareness of agricultural practices in using chemical have a great impact on human health and on the environment has spawned research into the development of effective biocontrol agents to protect crop against diseases. Wang *et al*. (2009) reported that the use of an antagonistic microorganism of a *Bacillus* sp. strain CHM1 against *R. solani* on horsebean (*Vicia faba*), and Kumar *et al*. (2013) who also reported a *Bacillus* sp. strain N antagonized *R. solani*, *Fusarium oxysporum*, and *Penicillium expansum*. *R.solani* causes various kinds of diseases on such as bottom rot on lettuce, black scurf on potato, damping-off of cucumber, pine, and tomato (Tunlid *et al*.,1989; Huang *et al*.,2012 ; Golinska and Dahm, 2013; Asaka *et al*.(1996), late sugar beet rot (Mahr *et* *al*.,1982, Wolf & Verreet 2002), root and hypocotyl diseases of snap bean (Sumner *et al*.,1992), root rot of wheat (Gill *et al*., 2001), sheath blight of rice (Belmar *et al*., 1987; Mutuku and Nose, 2012), sore shin and spot of tobacco (Csinos and Stephenson, 1999; LaMondia, 2012). Furthermore we are talking about the methods which have been used to control *R.solani* plant disease.

Methods used for controlling *R.solani* diseases

1.Biological method

1.1.Biological control agents

Recent studies have shown the potential value of some promising BCAs for controlling *Rhizoctonia* diseases, most of them *Bacillus* spp., *Pseudomonas*, *Rhizobium*, *Serratia*, *Streptomyces* , *Trichoderma*, and other genus. According to Montesinos (2003), most of biopesticides (biocontrol agents) patented are made of bacteria and followed by fungi. The benefits of BCAs are 1) potentially self-sustaining, 2) spread on their own after initial establishment, 3) reduced inputs of non-renewable resources and 4) long-term disease suppression in an environmentally manner (Quimby *et al*., 2002; Whips and Gehardson, 2007). BCAs mechanism is maintained by interaction such as antibiosis, competition of nutrients and space, parasitism, plant growth promotion, rhizosphere colonization, and induced systemic resistance (Agrios, 2005; Bailey *et al*., 2008).

Various inoculation method of BCAs are poured or drenched, dipped of root or seed, and by injection methods to stem of the plants.Hemissi *et al*. (2013) reported their *Rhizobium* strain Pch Azm and Pch S.Nsir2 suppressed root rot of chick pea up to 70% by drenching method with 5 mL of each bacterial suspension (10^8 cells/mL). Whereas Huang *et al*., (2012) observed that damping-off of cucumber reduced 16%, 50%, and 6% with applications of only *B. pumilus* SQR-N43 , a fermented organic fertilizer inoculated with *B. pumilus* SQR-N43 (BIO treatment) and organic fertilizer respectively. Other bacteria, *Pseudomonas fluorescens* increased cotton seedling survival from 30% to 79% and 13% to 70% with its antibiotic of pyrrolnitrin (Howell and Stipanovic, 1978). Furthermore Goudjal *et al*., (2014) stated that damping-off of tomato incidence were 90 and 86% was observed with untreated tomato seeds in sterilized and non-sterilized soils, respectively. In contrast the application of *Streptomyces* sp. strains CA-2 and AA-2 and the chemical compound TMTD (thioperoxydicarbonic diamide, tetramethylthiram) had the greatest incidence of the disease reduction in both sterilized and non-sterilized soils (86.6%, 85.3% and 85.2% healthy seedlings, respectively).

Several new BCAs have been reported to control *Rhizoctonia* diseases such as *Rhizophagus intraradices*, *Rhizophagus clarus and Claroideoglomus etunicatum* which belong to Arbuscular mycorrhizal fungi (AMF) group. The previous names of three AMF were *Glomus intraradices*, *G. clarum*, and *G. etunicatum* respectively. While the strains from fungi have been *Penicillium brevicompactium*, *P. expansium*, *P.pinophilum* (Nicoletti *et al*., 2004), *Trichoderma hamatum* (Lewis *et al*., 1990), *T.harzianum* (Montealegre *et al*., 2010), *T.veride*, *T.virens*, and *Laetisaria avails* (Grosch *et al*., 2006) and from bacteria have been *B. amyloliquefaciens* (Yu *et al*., 2002), *B. brevis*, *B. pantotheinticus*, and *Bacillus* sp. (Yuliar, 2008). *B. subtilis* RB14-C (Kondoh *et al*., 2001), *B.pumilus* (Huang *et al*., 2011), *Flavobacterium balustinum*, *Pseudomonas cepacia*, *P. fluorescens* (Howell and Stipanovic, 1979), *P.putida*, *Rhizobium*, *Rhizophagus intraradices*, *Rhizophagus clarus and Claroideoglomus etunicatum*, *Serratia marcescens* (Song *et al*., 2013), *Streptomyces cyaneofuscatus*, *S.mutabilis*, and *Streptomyces* sp. Di-944 (Sabaratnam and Traquair, 2001; Goudjal *et al*., 2014).

1.2.Organic matter

Organic amendments often contain biologically-active molecules such as vitamins, growth regulators, toxins and low molecular mass humic substances which can affect the soil microorganisms. Larkin (2008) stated that in general, biological amendments can effectively deliver microorganisms to natural soil, resulting in a wide variety of effects on soil microbial communities depending on the particular types, numbers, and formulations of organisms added. All amendments significantly increased estimates of microbial activity and affected soil microbial community characteristics.The feasibility of using organic amendments such as compost, animal manures and organic industrial by-products in order to suppress soilborne plant pathogens has been well documented (Hoitink and Boehm, 1999; Ryckeboer, 2001; Cheuk *et al*., 2005 and Noble and Coventry, 2005). Mushroom compost and manure decreased damping off of flax caused by *R. solani*, with the compost being more efficient than the manure (Alabouvette *et al*., 2004). The control of damping off (*R.solani*) on cucumber in compost-amended pot media was greatly affected by the stage of maturation of the compost: fresh compost actually stimulated pathogen growth and infection, but long-matured compost consistently suppressed it (Tuitert *et al*., 1998). The severity of bean root rot caused by *R.solani* was reduced by compost (Ferrara *et al*., 1996).

1.2. a. Animal waste

Lima *et al*.(2009) stated that application of farmyard manure results in a higher content of organic matter derived from angiosperms, suggested by the higher levels of syringic and vanillic phenols. Spectroscopic studies show an increase of lignin and lignin-like products in the organic matter of the soil, which may be derived from the cereal straw supplied with farmyard manure. Comparing the three organic amendments (sewage sludge, farmyard manure, and compost) the most significant differences were observed after long-term application of farmyard manure, with an increase in lignin and lignin-like products in the soil organic matter, and compost, which appears to contribute to an increase of protein and protein-like, as well as carbohydrates content on soil organic matter. Abbasi *et al*., (2004) reported that incorporation of 0.5% (*m*/*m* soil) fish emulsion into soil 5 days before planting radish provided effective control of cucumber damping-off diseases caused by *R.solani* and *Pythium aphanidermatum*. Suppression of damping-off caused by *R. solani* in compost-amended container media most frequently has been related to the presence of specific microbial antagonists (Krause *et al*., 2001; Kuter *et al*., 1983); Kwok *et al*., 1987; Nelson *et al*., 1983). Damping-off of cress (*Lepidium sativum*)caused by *R.solani* was significantly reduced by compost residues obtained from a viticulture and enological factory and composted cow manure (Pane *et al*., 2011). The effectiveness of manure amendments against disease depends on the type of manure, soil, and other factors.

1.2.b. Plant residue

Alfano *et al*.(2011) revealed that the disease suppressive effect of olive waste compost seem to be due to the combined effects of suppression phenomena caused by the presence of microorganisms competing for both nutrient and space as well as by the activity of specific antagonistic microorganisms. Kasuya *et al*., (2006) observed that the incidence of damping-off of sugar beet caused by *R.solani* was significantly and consistently suppressed in the soils amended with residues of clover, peanut, and *Brassica rapa* subsp. *rapifera* 'Saori. Tomato and escarole green manure were reported as the most suppressive ones in suppressing of *R. solani* damping-off on *Lepidium sativum* (Pane *et al*., 2013). Compost is often reported as a substrate that is able to suppress soilborne plant pathogens, but suppression varies according to the type of compost and pathosystem (Termorsuizen *et al*., 2006). Composts prepared from agricultural waste and used in container media or as soil amendments may have highly suppressive effects against diseases caused by a variety of soilborne plant pathogens such as *Pythium* spp. (Mandelbaum and Hadar, 1990; Pascual *et al*., 2000), *Phytophthora* spp. (Hoitink and Boehm, 1999; Widmer *et al*, 1999), *Rhizoctonia* spp. (Tuitert *et al*., 1998**;** Rivera *et al*., 2004) and *Fusarium* spp. (Cotxarrera *et al*., 2002). While plant extracts that can control the growth of *R.solani* are the extraction of garlic bulb with saponins (Lanzotti *et al*., 2012), extraction of *Picea neoveitchii* with four flavonoids (Song *et al*., 2011), cauliflower with caulilexins (Soledade *et al*., 2006), extraction of *Anemarrhena asphodeloides* rhizomes with nyasol (Z)-1,3-bis (4-hydroxyphenyl)-1.4-pentadiene (Park *et al*., 2003). *Brassica juncea*, *B.napus*, and *Sinapis alba* which are added to the soil can protect wheat from rot root of *R. solani* (Handiseni *et al*., 2013).

2. Chemical methods

Efficiency of chemical pesticides are often low and the legal regulations restrict use. Schreinemachers *et al*., (2012) studied about levels and trends in agricultural pesticide used for large cross-section of countries using FAO data for the period 1990-2009. Their analysis shows that a 1% increase in crop output per hectare is associated with 1.8% increase in pesticide used per hectare but that the growth in intensity of pesticide used level off as countries reach a higher level of economic development. Sumner *et al*., (1992) observed in their research that Pentachloronitrobenzene(PCNB) was as effective as the newer fungicides flutolanil, tolclofos-methyl and mepronil in improving yield of snap bean, but flutolanil had consistently more efficacy in reducing symptoms of disease and population densities of *R. solani* AG-4 in soil. Csinos (1987) reported that flutolanil has been effective in reducing limb and pod rot diseases caused by *R. solani* AG-4 and *S. rolfsii* in peanut and its effectiveness may be equal to, or better than, PCNB in controlling diseases caused by *R. solani* in vegetables.Win and Sumner (1988) revealed that the lack of efficacy of seed treatment with metalaxyl plus carboxin against *R. solani* and the increased incidence of diseases when metalaxyl was used alone compared with combinations with tolclofosmethyl and flutolanil. Furthermore Grosch *et al*. (2004) stated that a new fungicide with the code name BAS 516 00 F, developed by BASF, containing two active ingredients, boscalid and pyraclostrobin. The biochemical consequences of boscalid and pyraclostrobin are the breakdown of essential membrane potentials and concentration gradients and the inhibition of nucleic acid and protein biosynthesis. Fungal spore germination, mycelial growth and the development of infection structures are prevented. Therefore both active ingredients inhibit the fungal growth and colonization of plant tissue. The fungicide BAS 516 00 F was effective against *R. solani* as well as in the leaf-disc bioassay and under various conditions in the climate chamber as in the field. BAS 516 00F reduced disease incidence (DI) significantly from 94 to 0 on bottom rot of lettuce.Other chemical control, iprodine increased yield of lettuce as much as 92% and decreased disease severity compared with untreated control (Mahr *et al*.,1986). Hereafter field study showed that foliar spray of azoxystrobin at 125, 250, and 500 g/ha significantly suppressed (> 64%) the development of sheath blight and enhanced yield level (> 60%) (Sundravadana *et al*.,2007). Under greenhouse conditions, sedaxane showed high levels and consistent protection against *Ustilago nuda*, *Pyrenophora graminea* and *Rhizoctonia* spp. Underfield conditions, efficacy against *Rhizoctonia* spp. resulted in increased yield compared with the untreated check (Zeun *et al*., 2013).

3. Physical method

Temperature, moisture level and biofumigation are used in physical methods to control *R.solani* diseases. Temperature and moisture strongly affect *R. solani* diseases through its effect on the biotic and a biotic components of the disease (Katan, 1981). Moisture is important in relation to leaf diseases and damping-off seedlings, when crops are particularly susceptible to disease at certain of stages of their growth e.g. web blight caused by *R. solani* (Palti and Katan, 1997). Omirou *et al*.(2011) found that biofumigation induces changes on the structure and function of the soil microbial community that are mostly related to microbial substrate availability changes derived from the soil amendment with fresh organic materials. Moisture levels have been observed to affect *Rhizoctonia* diseases. *R. solani* AG-3 caused greater stem canker to potatoes under relatively dry soil conditions than under wet soil conditions (Lootsma and Scholte,1997; Hide and Firmager, 1989). Kumar *et al*. (1999) studied the effect of temperature and moisture on the pathogenicity of *R. solani* AG-11 on lupins. Gross *et al*. (1998) reported that lesion incidence on perennial ryegrass caused by R. solani (AG-1 IA) was increased as hours of leaf wetness increased at all temperatures tested. In addition Dorrance *et al*.(2003) mentioned that there was a significant difference in the number of hypocotyls lesions that developed in the plants across the temperatures (at 20, 24, 28, and 32^{0}C), and was not in root rot severity of soybean. The hypocotyls lesions was lowest at 20^{0}C and the highest at 32^{0}C. While influence of the moisture at 50 and 75% soil moisture holding capacity (MHC) gave significant difference ($P<0.001$) that resulted the highest of percent stand of soybean by 86% on root rot disease caused by *R. solani*.

4. Cultural practices

4.1. Cultivar resistant

Other environmentally safe method for controlling plant diseases is with resistant cultivars. Sugarbeet breeders for *Rhizoctonia* resistance have been reported by Gaskill (1968), then Ruppel and Hecker (1977) have continued this germplasm enhancement effort. Resistance to *R. solani* varied widely among the *Capsicum* accessions. The most resistant chili accessions, PI 439410 and PI 555611, were *C. baccatum* (Muhyi and Bosland, 1995).

4.2. Crop rotation

Cereal crops (e.g., wheat, barley, corn) are considered non-hosts for *R. solani* AG 2-2 and thus, are recommended for rotation with broadleaf crops (sugar beet, soybean, sunflower) in the upper Midwest. Rotation with cereal crops decreases populations of *R. solani*. Mean numbers of sclerotia recovered (per kilogram of soil) were 4.02, 1.43, and 0.07 with an average disease incidence of 5.4, 2.7, and 0.4% for rice- soybean-rice, soybean-soybean-rice, and pasture-pasture-rice cropping systems, respectively. Significantly higher (P = 0.05) inoculum densities and disease incidence were found in alternate year rotations out of rice than in 2-yr rotations out of rice (Belmar *et al*., 1987).

4.3.Soil amendment

Epstein (2009) reported many soil elements found in cell walls influence the susceptibility or resistance of plants to pathogen infections, among them silicon as part of the cell wall, which is considered to be a beneficial element for plants and higher animals. Chen *et al*. (2000) revealed that in nature, silicon is found in the form of silica (SiO2), aluminium silicates, or iron or calcium silicates and is absorbed by the plant as mono-silicic acid (Si(OH)4. Total number of sheath blight lesions, total area under the relative lesion extension progress curve, severity of sheath blight, and the highest relative lesion height on the main tiller decreased by 37%, 40%, 52% and 24%, respectively, as the rate of Si increased from 0 to 1.92 g pot^{-1}. Furthermore Rodrigues *et al*.(2002) stated that silicon may offer a viable method to control sheath blight in areas where soil is deficient in Si and cultivars with sheath blight resistance are not commercially available. Srihuttagum & Sivasithamparam (1991) reported that in field peas, soil amendment with of nitrogen plus phosphorus fertilizer, the application of nitrogen plus phosphorus, phosphorus plus potassium or nitrogen plus phosphorus plus potassium were effective in reducing severity of root rot caused by *R. Solani*.

Plant productivity and disease incidence are influenced by soil nutrients (Ali *et al*., 2008).

5. Nanotechnology methods

The study of nanoparticles dates back to 1831when Michael Faraday investigated gold colloids. It was more than 125 years later in 1959, that the potential benefits of fabricating matter at nano-level were visualized by Noble Laurete Richard Feynman. One Japanese researcher Norio Taniguchi finally engineered materials at nanometer scale in 1974 and coined the term nanotechnology. The term nanotechnology, buzzword of present day science owes its origin from the Greek word "nano" literally meaning dwarf. When it is expressed in terms of dimension one nanometer equals to one billionth of a matter (1 nm=10^{-9} m) (Banik and Sharma, 2011). Some of nanoparticles that have entered into the crop protection are nano forms of copper, iron, silver, silica silver, and carbon. Nano silver whose antimicrobial effects has been tested against plant diseases by Jo *et al*. (2009) with reference to two fungal pathogens of cereals viz. *Bipolaris sorokiana* (spot blotch of wheat) and *Magnaporthe grisea* (rice blast). In case of nanosized silica-silver (Si-Ag) particles were produced and tested by Park *et al*., (2006) against a number of fungal and bacterial pathogens. Nanosized silica silver inhibited the growth and development of both gram-positve and negative bacteria. Besides, nano-copper was reported to be highly effective in controlling bacterial diseases viz. bacterial blight of rice (*Xanthomonas oryzae* pv.oryzae) and leaf spot of mung bean (*X. campestris* pv. Phaseoli) (Gogoi *et al*., 2009).

The antifungal activity of six carbon nanomaterials has been evaluated, the result showed that single-walled carbon nanotubes (SWCNTs) possessed the strongest antifungal activity against *Fusarium graminearum* and *F.poae*, followed by multiwalled carbon nanotubes (MWCNTs), graphene oxide (GO), and reduced praphene oxide (rGO), while fullerene (C_{60}) and activated carbon (AC) showed no significant antifungal activities. The antifungal mechanisms of CNMs were deduced to target the spores in three steps;(i) depositing on the surface of the spores, (ii) inhibiting water uptake and (iii) inducing plasmolysis (Wang *etal*., 2014). The development of plant protection by nanotechnology method such as application of silica-silver 10 ppm showed 100% growth inhibition of *R.solani* (Park *et al*., 2006). However synthesis of nanoparticle by physically and chemically have a limitation in maintaining of the shape, size, and monodispersivity compared with biologically while also lower cost and friendlier environment. Thereby the biosynthesis of nanoparticle using microbes and plants continues develop, such as in plants ; leaf extract of *Peltophorum pterocarphum* containing Quercetin-3-O-β-D-Galactopyranoside, which was reacted with silver nitrate enhanced the antifungal property by forming silver nano cubes (Sivakumar *et al*., 2013). Incase of the bacterial, the extracellular of biosynthesis of silvernanoparticles by the culture supernatant of *Bacillus licheniformis* and the biosynthesis of silver and gold nanoparticle using *Brevibacterium casei* have been done (Kalishwaralal, *et al*., 2008). However they did not report about the antimicrobial activy of these two nanoparticles bacteria against plant pathogens.

6. Integrated method

A combination of *Trichoderma* and manure amendment at 6 and 10% reduced damping off by 33 and 50% respectively after 24 months of incubation (Barakat, 2008). Integration of banodanil and *Trichoderma harzianum* were found effective for the control of *Rhizoctonia* pre-emergence damping-off of radish (Lishitz *et al*., 1985). A granulate biofungicide named PBGG was developed by combining *Pseudomonas boreopolis* with *Brassica* seed pomace, glycerin and sodium alginate. Results of greenhouse tests showed that the most effective treatment was the amendment of pathogen-infested soil by *Streptomyces padanus* + 1% (w/w) PBGG which resulted in a disease incidence of 6.5–8.6%, compared to 27.8–31.7% for the treatment of *S. xantholiticus* + 1% (w/w) PBGG, 36.9–38.6% for the treatment of 1% (w/w) PBGG alone, and 61.8–64.8% for the treatment of control (unamended soil) (Chung *et al*., 2006). Six of 36 compost tested showed significantly suppressed damping-off by *R. solani*, the hemlock bark (*Tsuga heterophylla* bark), dairy fir-bark compost (*Pseudotsugamenziesii* bark+gravity belt separated dairy solids (3:1 vol/vol), mushroom compost (straw+chicken manure+seed meal + others), and nursery regrind compost, were consistently suppressive over three repeated bioassays (Scheuerell, 2005). Noble and Coventry (2005) reviewed the various combinations of biological control agents (including *T. harzianum*) and organic amendment that were reported to control soilborne plant pathogens. They stated that such combinations could significantly reduce the disease caused by *R. solani*. In addition Peng *et al*.(2014) mentioned that in greenhouse experiments, disease control obtained with a combination of *B.subtilis* NJ-18 and fungicide (jinggangmycin) that was better than the control obtained with the bacterium or fungicides alone, and some combinations of bacterium plus fungicide demonstrated a small synergistic effect in reducing disease.

Concluding Remarks

The research aquainted in this review exhibits how many diverse options have been reported on the control methods against plant diseases caused by *Rhizoctonia solani*.This obviously indicates the importance of the diseases worldwide. Most of the agricultural practices in Indonesia tend to use fungicides against *R.solani* diseases. Therefore through this review information, hopely they will replace the method with others more friendlier environmental friendly methods such as green or animal manure, biocontrol agents, and biologically synthesized of nanoparticles. In view of the public concern and environmental impact, we should not apply only on single controlling methods, like chemical fungicides. It is better to use the control methods that based on the density of and crop resistance to the pathogen. Preventing of yield losses of crop by plant pathogens significantly contribute to enhancement of crop production in the world. We will be able to find the solution in the integration of biological control agent, organic matter, agrochemicals and nanoparticles of copper, iron, silver, silica silver, and carbon.

Acknowledgement

I thank the financial supports received from Republic of Indonesia Government in the 2014 fiscal year.

References

Agrios, G.N. 2005. Plant Pathology 5th edition. Academic Press, San Diego, USA

Abbasi, P.A., K.L.Conn, and G.Lazarovits. 2004. Suppression of *Rhizoctonia* and *Pythium* damping off of radish and cucumber seedlings by addition of fish emulsion to peat mix or soil. *Can.J.Plant Pathol*.26:177-187.

Alabouvette C., D. Backhouse, C. Steinberg, N.J. Donovan, V. Edel-Hermann and L.W. Burgess, 2004. Microbial diversity in soil-effect on crop health. In: Managing Soil Quality: Challenges in Modern Agriculture (P. Schjonning, S. Elmholt, B.T. Christensen, ed.), CAB International,Wallingford, UK, 121–138.

Alfano, G., G. Lustrato, G. Lima, D. Vitullo, and G. Ranalli. 2011. Characterization of composted olive mill wastes to predict potential plant disease suppressiveness. *Biol. Control* 58:199-207

Asaka, O. & M. Shoda. 1996. Biocontrol of *Rhizoctonia solani* damping-off of tomato with *Bacillus subtilis* RB14. *Appl. and Environ. Microbiol.* 62 (11): 4081-4085

Ali, S., R.Khan, G.Mairaj, M.Arif, M.Fida, and S.Bibi. 2008. Plant Productivity and disease incidence are influenced by soil nutrients. *Australian J. Of Crop Science* 2(3):150-157

Bailey, B.A, H.Bae, M.D. Strem, J.Crozier, S.E. Thomas, G.J.Samuels, B.T. Vinyard, K.A.Holmes. 2008. Antibiosis, mycoparasitism, and colonization success for endophytic *Trichoderma* isolates with biological control potential in *Theobroma cacao*. *Biol. Control* 46(1):24-35

Bailey, K.L., and G. Lazarovits. 2003. Suppressing soil-borne diseases with residue management and organic amendments. *Soil Till. Res*. 72:169-180

Banik,S., and P. Sharma.2011.Plant pathology in the era of nanotechnology. *Indian Phytopath.* 64(2):120-127.

Barakat, R.M. 2008. The effect of *Trichoderma harzianum* in combination with organic amendment on soil suppressiveness to *Rhizoctonia solani*. *Phytopathol.Mediterr*.47:11-19

Belmar, S.B., Jones,R.K., and Starr,J.L.1987. Influence of crop rotation on inoculation density of Rhizoctonia solani and sheat blight incidence in rice. Phytopathology 77:1138-1143.

Chung, W.C., J.W.Huang, H.C.Huang.2006. Formulation of a soil biofungicide for control of damping-off of Chinese cabbage (Brassica chinensis) caused by Rhizoctonia solani. *Biol. Control*, 32(2):287-294.

Cheuk, W., L.K.Victor, R.copeman, P.Joliffe and B.Fraser. 2005. Disease suppression on greenhouse tomatoes using plant waste compost. *Journal of Environmental Science and Health* 40:449-461

Chen,S., XH,Lin, CG, Xu, Q, Zhang.2000. Improvement of bacterial blight resistance of 'Minghui 63', an elite restorer line of hybrid rice, by molecular marker-assisted selection. *Crop Sci.* 40:239-244

Cotxarrera L., M.I Trillas-gay, Steinberg and C.Alabouvette.2002. Use of sewage sludge compost and Trichoderma asperellum isolates to suppress Fusarium wilt of tomato. *Soil Biol. and Biochem.* 34:467-476

Csinos,A.S.1987.Control of Southern stem rot and Rhizoctonia limb rot of peanu with flutolanil. *Peanut Sci*.14(2):55-58.

Csinos, A.S. 1985. Activity of tolclofos-methyl (Rizolex) on *Sclerotium rolfsii* and *Rhizoctonia solani* in peanut. *Peanut Sci*.12:32-35

Csinos AS, Stephenson MG. 1999. Evaluation of fungicides and tobacco cultivar resistance to Rhizoctonia solani incited target spot, damping off and sore shin. *Crop Protection* 18:373–377.

Davis, R.M., K.V.Subbarao, R.N. Raid, and Kurtz, E.A.1997. Compendium of lettuce diseases.APS Press.pp15-16

Dorrance, A. E., M. D. Kleinhenz, S. A. McClure, and N. T. Tuttle. 2003. Temperature, moisture, and seed treatment effects on *Rhizoctonia solani* root rot of soybean. *Plant Dis*. 87:533–538.

Epstein. 2009. Silicon: its manifold roles in plants. *Ann Appl Biol*. 155:155–160

Ferrara, A.M.,M Avataneo and P.Nappi.1996. First experiments of compost suppressiveness to some phytopathogens.In; The Science of composting (De Bertoli,M., P.Sequi, B.Lemmes, T.Papi, ed.), Blackie Academic & Professional London, UK, 1157-1160.

Gaskill, J.0. 1968. Breeding for *Rhizoctonia* resistance in sugarbeet. *J. Am. Soc. Sugar Beet Technol*. 15:105-119.

Gerhardson,B. 2002. Biological substitutes for pesticides. Trends Biotechnol 20:338-343

Golińska, P., H. Dahm. 2013.Antagonistic properties of *Streptomyces* isolated from forest soils against fungal pathogens of pine seedlings.*Dendrobiology*. vol.69: 87-97

Goudjala, Y, O.Toumatia, A.Yekkour, N.Sabaou, F. Mathieu, A. Zitouni. 2014.Biocontrol of *Rhizoctonia solani* damping-off and promotion of tomato plant growth by endophytic actinomycetes isolated from native plants of Algerian Sahara. *Microbiol. Research* 169:59-65

Gill, J., S.K. Sivasithamparam, K.R.J. Smettem.2001. Soil moisture affects disease severity and colonisation of wheat roots by *Rhizoctonia solani* AG-8. *Soil Biology & Biochemistry*. 33:1363-1370

Grosch,R., T.Koch, A. Kofoet. 2004. Control of bottom rot on lettuce caused by *Rhizoctonia solani* with commercial biocontrol agents and a novel fungicide. *Journal of Plant Diseases and Protection*. 111 (6), 572–582, 2004.

Grosch. R., F.Faltin, J.Lottmann, A.Kofoet, G.Berg.2005. Effectiveness of three antagonistic bacterial isolates to suppress *Rhizoctonia solani* Kuhn on lettuce and potato. *Canadian Journal of Microbiology* 51: 345–353

Grosch, R., K.Scherwinski, J.Lottmann, G.Berg. 2006. Fungal antagonists of the plant pathogen *Rhizoctonia solani*: selection, control efficacy and influence on the indigenous microbial community. *Mycological Research* 110: 1464-1474.

Gross, M. K., J.B. Santini, I.Tikhonova, and R.Latin, R. 1998. The influence of temperature and leaf wetness duration on infection of perennial ryegrass by *Rhizoctonia solani*. *Plant Dis*.82:1012-1016.

Gogoi,R., Dureja,P., and Singh, P.K.2009.Nanoformulations a safer and effective option for agrochemicals. *Indian Farming* 59(8):7-12

Handiseni, M. J.Brown ,R.Zemetra , M. Mazzola. 2013. Effect of Brassicaceae seed meals with different glucosinolate profiles on *Rhizoctonia* root rot in wheat.*Crop Protection* 48: 1-5

Hemissi, I., Y.Mabrouk, S.Mejri, M.Saidi and B. Sifi. 2013. Enhanced Defence Responses of Chickpea Plants Against *Rhizoctonia solani* by Pre-Inoculation with Rhizobia. *J. Phytopathol*., 161:412–418.

Huang, X, N. Zhang, X.Yong, X.Yang, Q.Shen. 2012. Biocontrol of Rhizoctonia solani damping-off disease in cucumber with *Bacillus pumilus* SQR-N43. *Microbiol.Research* 167:135– 143

Howell,C.R., and R.D. Stipanovic . 1978. Control of *Rhizoctonia solani* on Cotton Seedlings with *Pseudomonas fluorescens* and with an Antibiotic Produced by the Bacterium. *Phytopathol*.,69(5): 480-482.

Huang, X., N.Zhang, X.Yong, X.Yang,Q.Shen.2012. Biocontrol of Rhizoctonia solani damping-off disease in cucumber with *Bacillus pumilus* SQR-N43. *Microbiol. Research* 167: 135– 143.

Hoitink, H.A.J., and M.J. Boehm.1999.Biocontrol within the context of soil microbial communities: a substrate-dependent phenomenon. *Annual Review of Phytopathology*, 37:427-446.

Hide,G.A., and J.P.Firmager.1989. Effects of soil temperatures and moisture on stem canker (*Rhizoctonia solani*) disease of potatoes. *Potato Research*,32:75-80

Jo,Y.K., B.H.Kim, G.Jung.2009. Antifungal activity of silver ions and nanoparticles on phytopathogenic. *Plant Dis. 93:1037-1043*

Kalishwaralal,K., V.Deepak, S.Ramkumarpandian, H.Nellaiah, G.Sangiliyandi.2008. Extracellular biosynthesis of silver nanoparticles by the culture supernatant of *Bacillus licheniformis*. *Materials Letters* 62:4411-4413

Kasuya, M., A.R. Olivier, Y. Ota, M.Tojo, H. Honjo, & R. Fukui.2006. Induction of soil suppressiveness against *Rhizoctonia solani* by incorporation of dried plant residues into soil. Phytopathology 96: 1372-1379

Katan,J.1981. Solar heating (solarization) of soil for control of soilborne pests. *Annu. Rev.Phythophatol*.19:211-236

Kiewnick,S., B. Jacobsen, A.B.Kiewnick, J.Eckhoff, J.Bergman.2001. Integrated control and root rot of sugar beet with fungicides and antagonistic bacetria. *Plant Dis*. 11:879-883

Kondoh, M., M.Hirai, and M.Shoda.2001. Integrated biological and chemical control of damping-off caused by *Rhizoctonia solani* using *Bacillus subtilis* RB14-C and flutolanil. *J.of Bioscience and Bioengineering*.91(2):173-177.

Kumar, N., C. Mohandas, B.Nambisan, D. R.S.Kumar, R. S. Lankalapalli. 2013. Isolation of proline-based cyclic dipeptides from *Bacillus* sp. N strain associated with rhabditid entomopathogenic nematode and its antimicrobial properties.*World J. Microbiol. Biotechnol*., 29:355–364

Kumar,S., K.Sivasithamparam, J.S.Gill, M.W. Sweetingham.1999.Temperature and water potential effects on growth and pathogenicity of *Rhizoctonia solani*AG-11 to lupin. Can. J of Microbiol, 45:389-395.

Krause, S.M., L.V.Madden, H.A.J. Hoitink. 2001. Effect of potting mix microbial carrying capacity on biological control of *Rhizoctonia* damping off of radish and*Rhizoctonia* crown and root rot of poinsettia. *Phytopathology* 91, 1116–1123.

Kuter, G.A., E.B Nelson, H.A.J Hoitink, L.V.Madden.1983. Fungal populations in container media amended with composted hardwood bank suppressive and conducive to *Rhizoctonia* damping-off. *Phytopathology*, 73:1450-1456

Kwok, O.C.H., P.C. Fahy, H.A.J.Hoitink & G.A.Kuter.1987. Interaction between bcateria and Trichoderma harzianum in suppression of Rhizoctonia damping-off in bark compost media. *Phythopathol*.77:1206-1212

Lanzotti,V., A. Romano, S.Lanzuise , G.Bonanomi , F.Scala.2012. Antifungal saponins from bulbs of white onion, *Allium cepa* L. *Phytochemistry* 74:133–139

LaMondia, J.A.2012. Efficacy of Azoxystrobin fungicide against sore shin of shade tobacco caused by *Rhizoctonia solani*.*Tobacco Science*.49:1-3

Larkin, R.P. 2008. Relative effects of biological amendments and crop rotations on soil microbial communities and soilborne diseases of potato. *Soil Biol. Biochem*. 40:1341-1351

Lee, T.O., Khan Z, Kim SG and Kim YH. 2008. Amendment with peony root bark improves the biocontrol efficacy of *Trichoderma harzianum* against *Rhizoctonia solani*. *J. Microbiol. Biotechnol.*, 18, 1537–1543

Lewis, J.A., T. H. Barksdale, and G. C. PAPAVIZAS. 1990. Greenhouse and field studies on the biological control of tomato fruit rot caused by *Rhizoctonla solani*. *Crop protection*. 9: 8-14.

Li, Z.K., S.R.M. Pinson, M.A.Marchetti, Stansel,J.W, Park W.D.1995. Characterization of quantitative trait loci (QTLs) in cultivated rice contributing to field resistance to sheath blight (*Rizoctonia solani*).*Theoretical and Applied Genetics* 91:382-388

Lifshitz, R., S.Lifshitz, and R.Baker.1985.Decrease in incidence of Rhizoctonia preemergence of damping-off by use of integrated chemical and biological controls. *Plant Dis*. 69(5):431- 434

Lootsma,M., and K.Scholte.1997. Effect of moisture content on the suppression of *Rhizoctonia* stem canker on potato by Nematode *Aphelenchus avenae* and the springtail *Folsomia fimetaria*. *Plant Pathol*.46:209-215.

Mahr,S.E.R.,W.R.Stevenson, L.Sequeira.1986. Control of bottom rot of head lettuce with Iprodine. *Plant Dis*. 70:506-509

Mandelbaum, R. and Y. Hadar. 1990. Effects of available carbon source on microbial activity and suppression of *Pythium aphanidermatum* in compost and peat container media. *Phytopathol*.80: 794-804

Montealegre ,J., L. Valderrama, S. Sanchez, R.Herrera, X. Besoain, L.M. Perez. 2010. Biological control of *Rhizoctonia solani* in tomatoes with *Trichoderma harzianum* mutants. *Electron. J. Biotechnol*. Vol.3 (2):1-11

Montesinos, E. 2003. Development, registration and commercialization of microbial pesticides for plant protection. *Int. Microbiol*. 6:245-252.

Mahr, S.E.R., W.R. Stevenson, and L.Sequeira.1982. Control of bottom rot of head lettuce with Iprodione. *Plant Dis*. 70(6):506- 509

Muhyi, R and P.W. Bosland.1995. Evaluation of *Capsicum* Germplasm for Sources of Resistance to *Rhizoctonia solani*. *Hort.Science*. 30(2):341-342

Mutuku, J.M., and A.Nose. 2012. Changes in the Contents of Metabolites and Enzyme Activities in Rice Plants Responding to Rhizoctonia solani Kuhn Infection: Activation of Glycolysis and Connection to Phenylpropanoid Pathway. *Plant Cell Physiol*. 53(6): 1017–1032.

Nelson, E.B.,G.A.Kuter, H.A.J.Hoitink.1983. Effect of fungal antagonist and compost age on suppression of *Rhizoctonia solani* damping-off in container media amended with composted hardwood bark. *Phythopathol*. 73:1457-1462.

Nicoletti, R., M.De Stefano, S.De Stefano, A.Trincone &F.Marziano. 2004.Antagonism against *Rhizoctonia solani* and fungitoxic metabolite production by some *Penicillium* isolates. *Mycopathologia* 158:465-474.

Noble R. and E. Coventry, 2005. Suppression of soilborne plant diseases with composts: a review. *Biocontrol Science and Technology* 15(1), 3–20.

Omirou,M., C.Rousidou,F.Bekris,K.K.Papadopoulou, U.Menkissoglou-Spiroudi,C.Ehaliotis, D.G.Karpouzas.2011. The impact of biofumigation and chemical fumigation methods on the structure and Function of the soil microbial community. *Microb Ecol*. 61:201–213

Pane, C., Spaccini, R.Piccolo, A.Scala, F,Bonanomi.G. 2011.Compost amendments enhance peat suppressiveness to *Pythium ultimum*, *Rhizoctonia solani* and *Sclerotinia minor* Biological Control 56:115–124

Pane, C., A. Piccolo, R. Spaccini,R, G.Celano, D.Villecco, M.Zaccardelli .2013. Agricultural waste-based composts exhibiting suppressivity to diseases caused by the phytopathogenic soil-borne fungi *Rhizoctonia solani* and *Sclerotinia minor*. *Applied Soil Ecology* 65 (2013) 43– 51

Pascual,J.A.,T.Hernandez,C.Garcia,F.A.A.M.DeLeij,J.M.Lynch.2000.Long-term suppression of *Pythium ultimum* in arid soil using fresh and composted municipal wastes. *Biol. Fertil. Soils*,30:478–484

Park, H.J., J.Y.Lee, S.S.Moon, B.K.Hwang.2003. Isolation and anti-oomycete activity of nyasol from *Anemarrhena asphodeloides* rhizomes. *Phytochemistry* 64:997–1001

Palti,J., and J.Katan.1997.Effect of cultivation practices and cropping systems on soilborne diseases (in:) Hillocks, R.J and J.M.Waller (eds.) Soil-borne diseases of tropical crops:377-394, CAB International, U.K.

Park HJ., S.H.Kim,H.J.Kim, S.H. Choi. 2006 A new composition of nanosized silica-silver for control of various plant diseases. *Plant Pathol. J*. 22: 295-302.

Peng, D., S.Li, J.Wang, C.Chen, and M.Zhou. 2014. Integrated biological and chemical control of rice sheath blight by *Bacillus subtilis* NJ-18 and jinggangmycin. *Pest Management Science* 70(2):258-263

Quimby, F.C., L.R. King, and W.E. Grey. 2002. Biological control as a means of enhancing the sustainability of crop/land management systems. *Agric. Ecosyst. Environ*. 88:147-152

Rivera M.C., E.R.Wright, M.V. Lopez, D. Garda, and M.Y. Barrague, 2004. Promotion of growth and control of damping off (*Rhizoctonia solani*) of greenhouse tomatoes amended with vermicompost. Phyton, *International of Experimental Botany (*F*UTON)*53: 229–235

Rodrigues,F.A., F.X.R,Valeb, G.H. Korndorfer, A.S. Prabhud, L.E. Datnoffe. 2003. Silicon may offer a viable method to control sheath blight of rice in Brazil. *Crop Protection* 22:23-29.

Ruppel,E.G. and R.J. Hecker.1977. *Rhizoctonia solani* root rot on sugarbeet cultivars having varied degrees of resistance.*Journal of sugarbeet research* 31(3&4):135-142

Ryckeboer J., 2001. Biowaste and Yard Waste Compost: Microbiological and Hygienic Aspects-Suppressiveness to Plant Diseases. PhD Thesis, Katholieke Universiteit Leuven, Belgium

Sabaratnam, S and J.A.Traquair.2002.Formulation of a *Streptomyces* biocontrol agent for the suppression of *Rhizoctonia* damping-off in tomato transplants.*Biol.Control*,23:245-253

Scheuerell, S.J., D.M. Sullivan, and W.F.Mahaffee.2005.Suppression of seedling damping-off caused by Phytium ultimum. *Phytophatol*. 95(3):306-315

Schreinemachers, P., and Tipraqsa, P. 2012. Agricultural pesticides and land use intensification in high, middle and low income countries. *Food Policy* 37:616-626

Sivakumar,P., P.Kartika, P.Sivakumar, N.G.Muralidharan, P.Devendran, S.Renganathan. 2013.Bio-synthesis of silver nano cubes from active compound quercetin -3-O-β-D-Galactopyranoside.*Asian J.Pharmaceutical and Clinical Research* 6(4):76-79

Song, Y.Su., S. Oh, Y.S. Han, D.J. Seo, R.D. Park, W.J.Jung. 2013. Detection of chitinase ChiA produced by *Serratia marcescens* PRC-5, using anti-PrGV- chitinase. *Carbohydrate Polymers* 92 (2013) 2276-2281.

Song, Z., W.Chen, X. Du, H. Zhang, L. Lin, H. Xu.2011. Chemical constituents of *Picea neoveitchii*. *Phytochemistry* 72:490–494

Soledade,M., C.Pedras, M.G.Sarwae, M.Suchy, A.M.Adio.2006.The phytoalexins from cauliflower, caulilexins A, B and C: Isolation, structure determination, syntheses and antifungal activity. *Phytochemistry* 67: 1503-1509

Srihuttagum,M., & K.Sivasithamparam.1991. The influence of fertilizer on root rot of peal peas caused by *Fusarium oxysporum*, *Pythium vexan*, and *Rhizoctonia solani* inoculated singly and in combination. Plant and Soil 132:21-27

Sumner D.R., J.A.Lewis , and R.D.Gitaitis.1992. Chemical and biological control of *Rhizoctonia solani* AG-4 in snap bean double-cropped with corn.*Crop Protection*.11:121-126

Sundravadana, S., Alice, D., Kuttalam, S., and Samiyappan, R. 2007. Azoxystrobin activity on *Rhizoctonia solani* and its efficacy against rice sheath blight. Tunisian Journal of Plant Protection 2: 79-84

Termorshuizen, A.J., E. van Rijna, D.J. van der Gaag, C. Alabouvette, Y. Chen, J. Lagerlof, A.A. Malandrakis, E.J. Paplomatas, B. Ramert, J. Ryckeboerg, C. Steinberg, S. Zmora-Nahum.20006. Suppressiveness of 18 composts against 7 pathosystems: Variability in pathogen response. *Soil Biol. Biochem*.38:2461–2477

Tuitert, G., M, Szczech and G.J. Bollen. 1998. Suppression of *Rhizoctonia solani* in potting mixes amended with compost made from organic household waste. *Phytopathology*,88:764-773.

Tunlid, A., H. A. J. Hoitink,C. Low, And D. C. White. 1989. Characterization of Bacteria That Suppress *Rhizoctonia* Damping- Off in Bark Compost Media by Analysis of Fatty Acid Biomarkers. Applied and Environ Microbiol., 55(6):1368-1374

USDA. 2003. Biological control of Fusarium wilt and other soil-borne pathogenic fungi. http://www.ars.usda.gov/research/projects/projects.htm?ACCN_NO=406590&fy=2003

Wang H, Wen K, Zhao X, Wang X, Li A and Hong H .2009.The inhibitory activity of endophytic *Bacillus* sp. strain CHM1 against plant pathogenic fungi and its plant growth-promoting effect. *Crop Prot*., **28**, 634-639

Whipps, J.M., and B. Gerhardson. 2007. Biological pesticides for control of seed- and soil-borne plant pathogens, p. 479–501. *In* J.D. Van Elsas, J.D. Jansson, and J.T. Trevors (eds), Modern Soil Microbiology 2nd edition. Boca Raton, FL, USA: CRC Press.

Widmer,T.L., J.H.Graham &D.J.Mitchell.1999.Composted municipal solid wastes promote growth of young Citrus trees infested with Phytophthora nicotianae. *Compost science & utilization*.7(2):6-16

Win, H.H., and D.R.Sumner.1988.Root rot induced in snap bean by *Rhizoctonia solani* AG-4 and AG-2 type 2 in conservation tillage following corn. *Plant Dis*. 72:1049-1053

Wolf, P.F.J. and J.A. Verreet 2002. Development and implementation of an integrated pest management system in Germany for the control of fungal leaf diseases in sugar beet. The IPM sugar beet model. *Plant Dis*. 86 (4), 336-344

Yu, G.Y., J.B. Sinclair, G.L. Hartman, & B.L. Bertagnolli. 2002. Production of iturin A by *Bacillus amyloliquefaciens* suppressing *Rhizoctonia solani*. *Soil Biol. Biochem.* (34): 955—963

Yuliar.2008.Screening of bioantagonistic bacteria for biocontrol agent of *Rhizoctonia solani* and surfactin producer. *J. of Biological Diversity* .9(2):83-86

Zeun, R., G. Scalliet, and M.Oostendorp. 2013. Biological activity of sedaxane – a novel broad-spectrum fungicide for seed treatment. *Pest Manag. Sci.*,69: 527–534