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Integrated management of dry root rot of green gram caused by *Macrophomina phaseolina* by using bioagents, botanicals and fungicides: A review

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Abstract
The green gram is one of India's most valuable pulse crops. Mungbean dry root rot caused by *Macrophomina phaseolina* is a severe disease. *Macrophomina phaseolina* is a soil-borne pathogen that infects Mungbean crops, causing severe damage and yield losses. The biological control of *Macrophomina phaseolina*ca used dry root rot is tested *in-vitro* and *in-vivo*. The aim of this reviewis to see how effective various biocontrol agents, botanicals and fungicides were against *Macrophomina phaseolina*, which causes Mungbean dry root rot. *Trichoderma viride* was found to be the most effective biocontrol agent against *Macrophomina phaseolina*, followed by *Trichoderma harzianum* and *Pseudomonas fluorescens* was found to be the least effective in reducing root rot incidence. Garlic extract was found to be the most effective in preventing root rot, followed by turmeric extract and neem leaf extract. Carbendazim was found to be the most effective fungicide, with the minimal possible of root rot.

Keywords: Green gram, *Macrophomina phaseolina*, Bioagents, Botanicals, Fungicides

Introduction

Green gram (*Vigna radiata*) is one of the India’s most important pulse crop. It is high in potassium and phosphorous and a good source of high-qualityproteins. India is one of the world’s leading producer of Mungbean (Mallaiah. B & Krishna R.V, 2018) [24]. It is primarily grown in Asia, specifically Bangladesh, China, India, Indonesia, and Myanmar. In the global context, India contributes about 25 to 28 percent of total pulse production. India is world’s leading producer of green gram contributes about 75 percent of total production. As per the reports of FAO 2016, total production of pulses was 17.5 mt cultivatedon a 24.8 m ha area and India is importing 3.6 mt of pulses per year sharing 32 percent of global imports (Pollagari, 2013) [33]. “It is the third most important crop, after chickpea and pigeon pea, with a total area of around 29.36 lakh ha and an output of 13.90 lakh tons in 2014-15 (Kumar *et al*., 2019)” [19]. It is grown in North India and in South India during summer and kharif seasons. It iseatenin variety of ways, including as dal, halwa, snack, and variety of different dishes. It can fix atmospheric nitrogen viasymbiotic nitrogen fixation. It can also be grown as a green manure crop (Kumari & KS Shekhawat, 2012) [20]. Mungbean is a good source of protein (24.5%), lysine (460 mg/g N), tryptophane (60mg/g N) as well as riboflavin (0.21mg/100mg) and minerals (Mehta, 2004) [28].

Mungbean is a crop mainly sown in rainfed condition and changes in environmental condition such as fluctuation in temperature and carbon dioxide within rainfed condition leads to varying intensities of biotic stress which cause significant loss in production. Among biotic stresses fungal diseases are very responsible for yield loss upto 40-60% in green gram. Mungbean can be infected by fungi at various stages, including emergence, seedling, vegetative, and reproductive stages. Different species of genera *Fusarium* (Wilt), *Macrophomina* (Dry root rot) are soil borne pathogens which cause diseases in Mungbean crop during seedling stages and *Colletotrichum* (Anthracnose), *Alternaria* and *cercospora* (Leaf spot), *Erysiphe* (Powdery mildew) infect Mungbean plants during vegetative and reproductive stages, these are the major foliage diseases of green gram crop which reduces yield upto 20-60% in different parts of India (Pandey *et al*., 2018) [30]. The damage which is caused by pathogens not only decrease crop yield but also reduce impact on nitrogen fixation that results in increased pathogen density in soil (Khaledi *et al*., 2015) [16]. Soil and seed borne nature of the pathogen causing diseases rises a major problem for an effective Integrated Disease Management.

Pathogen causes biotic stress to infect the plant growth which shows a reduction in root growth and uptake of water and minerals (Hashem *et al*., 2017) [12].

Macrophomina phaseolina causes root rot (Tassi) Goid is an economically significant disease that affects a variety of crop plants. *Macrophomina phaseolina* is a common root-soil fungus which causes dry root rot and charcoal rot. Different physiological and ecological factors, such as low moisture content and high temperature, may increase its prevalence. Over 500 plant species have been identified to be affected by *Macrophomina phaseolina* charcoal rot disease (Tetali *et al*., 2015) [37]. Mungbean is susceptible to *Macrophomina phaseolina* at different stages of development. The fungus attacks all parts of the plant, including the root, stem, branches, petioles, leaves, pods, and seeds. *Macrophomina phaseolina* infected roots have necrotic lesions. The pathogen may prevent seed germination at the pre-emergence stage, causing heavily infected plants to die prematurely. *Rhizoctonia bataticola* (*Macrophomina phaseolina*) seed infection ranges from 2.2-15.7 percent, resulting in a reduction of 10.8 percent in grain yield and 12.3 percent in seed protein content in Mungbean. The fungus is soil-borne as well as seed-borne, which allows it to thrive in hot climatic conditions while it makes difficult to controldry root rot in Mungbean (Shahid & Rahman Kha, 2016) [34]. The pathogen spreads through the soil from one plant to adjacent plants. It spreads within infected plants via the vascular system. Plants die because of the rotting of infected roots, which causes wilting in advanced stages. *Macrophomina phaseolina* produces toxins such as botryodiplodin and phaseolinone during infection, which aid the pathogen in infecting susceptible plants from soil reservoirs, especially during the winter. Dry root rot has been spreading in Asia in recent years because of increased water stress during the crop season because of irregular and reduced rainfall as well as rising temperatures. Dry root rot has emerged as a major Mungbean yield-limiting disease (Pandey *et al*., 2021) [31]. Yellowing of the leaves was a common symptom of root rot, and these leaves would drop off within two to three days. Within a week, the plants may have wilted. Dark lesions on the stem's bark can be seen at ground level. Root rot symptoms can be seen when the plants are pulled from the soil and the basal stem and main roots are examined. Scattered sclerotia bodies can be seen on the affected tissues at an advanced stage (Kumar *et al*., 2019) [19].

Management of dry root rot caused by *Macrophomina phaseolina* is more challenging because of the pathogens long-term survival and wide host variety, managing soil-borne fungal pathogens is difficult. These pathogens are not only saprophytes that coexist with other soil species in the soil, but they are also spread by seed (Mallaiah. B & Krishna R.V, 2018) [24]. Synthetic fungicides are often used to control phytopathogenic fungi, but their use is restricted due to environmental and health concerns. Because of their negative consequences and the emergence of resistance in crop pathogens (Choudhary & Ashraf, 2019) [4]. Biological management of soil-borne pathogenic fungi by using bioagents to the soil is a non-chemical method which is shown to be a cost-effective and efficient way to treat soil diseases. Biological monitoring is environmentally safe, leaves no residual toxicity, cost effective and can be used effectively in the context of advanced disease prevention (Jaiganesh *et al*., 2019) [13]. Plant extracts were also evaluated for antifungal activity and these are more environmentally safe bio-compounds for the treatment of plant diseases using various types of botanicals and it has been found to be environmentally friendly and effective against the targeted pathogen (Kavita, 2020) [15]. The aim of this study was to determine the most effective fungicides, biocontrol agents, and botanicals, as well as their combinations, to develop an integrated strategy to effectively manage the disease.

Efficacy of different bioagents against dry root rot of green gram caused by *Macrophomina phaseolina*

(Kumar *et al*., 2019) [19] reported that when root rot incidence and disease percent inhibition were compared, it was observed that bio-control agents and bio-fertilizer greatly reduced root rot incidence and improved disease percent inhibition in Mungbean. The treatment T13, which used *Trichoderma harzianum* in combination with *Rhizobium* as seed treatment and soil application, had the lowest disease incidence of 13.50 percent and the highest disease inhibition of 79.23 percent, followed by the treatment (T14), which used *Pseudomonas flourescens* in combination with *Rhizobium* records 18.50 percent disease incidence and 71.54 percent disease inhibition. These two methods were extremely successful in reducing disease prevalence and reducing disease severity.

(Elad *et al*., 1986) [10] reported that Antagonistic fungi were isolated from *Macrophomina phaseolina*-infested field soil. When grown against the plant pathogen *Macrophomina phaseolina* on selective media, about 30 of the 96 *Trichoderma spp*. isolates inhibited its development. Therefore, *Trichoderma harzianum* isolates TH 203, TH 243, TH 134, and TH 315 were the most effective in preventing and growing into the host fungus colony. In combination with cultural traditions such as field water management, *Trichoderma* may have a benefit in controlling charcoal root rot. Early in the growth season, the biocontrol agent can prevent pathogen root invasion, whereas later in the season, plants should be kept free of water stress to reduce the chance of the pathogen surviving and establishing itself in infested plants.

(N. Idira& Gayathri S, 2003) [29] reported that when compared to control, seed treatment with *Trichoderma spp*. alone or in combination with biofertilizer decreased root rot incidence by 50% in both glass house and field environments. *Trichoderma*-treated plants had the lowest occurrence of root rot at 15 DAS (Table 1). At 60 DAS, the treatment T13 (*Trichoderma viride* in gypsum formulation with *Rhizobium* treated seeds (29.6%)) had the lowest occurrence of root rot, followed by T12 (*Trichoderma viride* in talc formulation with *Rhizobium* treated seeds (30.16 percent)).*Trichoderma viride* in gypsum formulation (T8) (36.83%) and *Trichoderma harzianum in gypsum* (T9) (37.66%), on the other hand, were on average in regulating root rot incidence at 75 DAS. In general, when antagonist and *Rhizobium* seed treatments were mixed, no decrease in nodule formation was found.

(Ganeshan & Kumar, 2005) [11] reported that seed treatment (2 g/kg seed) was used in field trials in *Vigna mungo* to control root rot disease complex caused by *Macrophomina phaseolina* and *Pseudomonas flourescens*, and the results showed less root rot occurrence. *Macrophomina phaseolina*, the pathogen that causes dry root rot in Black gram, was effectively inhibited by *Pseudomonas flourescens strain* Pf1.

(Khan M.A and Gangopadhyay, 2008) [17] reported that both strains of *Pseudomonas flourescens* substantially decreased *Macrophomina phaseolina* mycelial growth. The paper disc and streaking methods were both similarly successful in decreasing *Macrophomina phaseolina* colony size, according to the report. In the streaking process, however, the inhibition of *Macrophomina phaseolina* mycelial development was significantly higher. Carboxin, chlorothalonil, and carbendazim were shown to be the least toxic to *Pseudomonas flourescens* strain PFBC-25, while captan was found to be the most inhibitory. *Pseudomonas flourescens* is more stable with carbendazim and chlorothalonil, as shown by the current research.

(Alice & Sundravadana, 2012) [2] reported that the basal application of *Trichoderma viride* (soil application @ 2.5 kg/ha) and two sprays, the first at 45 days after germination and the second at 90 days after germination, resulted in a disease occurrence reduction of 12 percent, accounting for a 60 percent reduction in disease. This was equivalent to the disease occurrence of 13% when *Pseudomonas fluorescens* was applied daily (soil application @ 2.5 kg/ha). Following that, a basal treatment of zinc sulphate @ 25 kg/ha + zinc sulphate 0.5 percent spray (twice) was applied, with a disease incidence of 13%.

(S. V. Manjunatha *et al*., 2013) [26] reported that using the dual culture procedure, six isolates of T. viride and eight isolates of *Pseudomonas fluorescens* were tested for their effectiveness as antagonists against *Macrophomina phaseolina*, the cause of chickpea root rot. When compared to the control, all isolates caused a considerable reduction in fungal growth. The ability of the *Trichoderma viride* and *Trichoderma harzianum* isolates to inhibit *Macrophomina phaseolina* mycelial development was found to vary significantly. *Pseudomonas fluorescens* isolates were also found to inhibit *Macrophomina phaseolina* mycelial formation, with *Pseudomonas fluorescens* (Pf4) being considerably more successful than the other isolates.

(Tetali *et al*., 2015) [37] reported that pot culture infested with *Macrophomina phaseolina* and inoculated with *Trichoderma*, the biocontrol effectiveness of *Trichoderma* was tested. T9 - seed treatment + soil application with mixture of all *Trichoderma viride* isolates decreased substantially the percent disease incidence of 5.60, which accounted for 88.79% reduction over control, followed by T3 and T5, which both reported 11.10% root rot incidence.

(Deshmukh *et al.*, 2016) [7] reported that at 7 days after inoculation, *Trichoderma harzianum* (80.5 percent) was found to be the most effective in inhibiting the growth of *Macrophomina phaseolina* (*Rhizoctonia bataticola*), followed by *Pseudomonas fluorescens*. The pathogen's inhibition may be contributing to *Trichoderma harzianum* biocontrol function and *Pseudomonas fluorescens'* antibiosis activity. *Rhizobium phaseoli* and *Pseudomonas fluorescens* have the lowest inhibition region (1.1 mm), followed by *Rhizobium phaseoli* and *Trichoderma harzianum* (1.3 mm). *Rhizobium phaseoli* and *Pseudomonas fluorescens*, as well as *Rhizobium phaseoli* and *Trichoderma harzianum*, were found to be compatible.

(Jamwal *et al*., 2016) [14] reported that in vitro and in vivo tests were performed on *Trichoderma viride*, *Trichoderma harzianum*, and *Trichoderma virens*. During both years of investigation, the radial development of *Macrophomina phaseolina* was greatly decreased in *Trichoderma viride* isolate 2 followed by *Trichoderma viride* isolate 1 after 2, 4, 6, and 8 days after inoculation under in vitro conditions. *Trichoderma viride* isolate 2 was the most successful, with maximal growth inhibition of *Macrophomina phaseolina* of 19.30, 39.50, 56.00, and 72.10 percent. *Trichoderma viride* isolate 1 and *Trichoderma viride* isolate 3 were the next two isolates. Both fungal biocontrol agents started developing naturally rapid sporulation or secretion of cell wall lytic enzymes after the fourth day of inoculation in dual culture.

(Latha *et al*., 2017) [23] reported that total of ten *Trichoderma*, twenty *Pseudomonas spp*, and ten *Bacillus spp* isolates were tested for antagonistic activity against *Rhizoctonia bataticola* mycelial development. The mycelial development of *Rhizoctonia bataticola* was prevented by all ten *Trichoderma* isolates. TL1 had the slowest mycelial development (4 cm), with a 55.6 percent inhibition compared to the control.

(Swamy *et al*., 2018) [36] reported that the activity of bio agents was evaluated in vitro, and the effects on *Macrophomina phaseolina* mycelial growth inhibition were reported. *Trichoderma harzianum* (Th-R) was shown to be more effective than other bio-control agents, inhibiting the most fungal growth (41.86 percent) of *Macrophomina phaseolina*, followed by *Trichoderma viride* (39.07 percent). When compared to other *Pseudomonas spp*. strains, *Pseudomonas putida* (RP- 56) was inhibited by 27.22 percent.

(Mallaiah & V, 2018) [24] reported that using a combination of seed treatment with bio-protection agents, neem oil, and thiram, dry root rot incidence was decreased by 10 to 34.6 percent as compared to control (77.3 percent). Seed treatment with *Pseudomonas fluorescens* + *Trichoderma viride* +neem oil + thiram reduced dry root rot incidence the most (88 percent), led by *Pseudomonas fluorescens* + *Trichoderma viride* + thiram (83 percent), and neem oil was less successful (55.3 percent).

(Lakhran & Ahir, 2018) [21] reported that all the bio-agents reduced the percent disease occurrence in a major way. At 40 and 60 days after sowing, disease incidence was reported (23.00 and 26.08 percent) with seed application of *Trichoderma viride* @ 4g/kg seed, followed by *Trichoderma harzianum* (26.60 and 31.81 percent) relative to control (43.30 and 62.25 percent). *Trichoderma viride* (46.18 and 58.10 percent) had the highest disease control over control, led by *Trichoderma harzianum* (38.56 and 48.89 percent) at 40 and 60 days after sowing, respectively. *Trichoderma spp.*can monitor disease to the greatest extent possible.

(Jaiganesh *et al*., 2019) [13] reported that *Macrophomina phaseolina* mycelial development was greatly inhibited by native *Trichoderma viride* isolates (Tv1–Tv5) studied. However, of the isolates, Tv3 displayed the greatest inhibition and greatly inhibited the growth of *Macrophomina phaseolina* (23.63 mm), indicating a 73.74 percent reduction in pathogen growth as compared to the control. The isolates Tv1 and Tv5, in declining order of merit, inhibited *Macrophomina phaseolina* development by 71.74 and 69.37 percent, respectively, over control. The pathogen's growth was reduced by 66.41 percent over control in the regular isolate used for reference. The isolate Tv5 displayed the least amount of pathogen growth inhibition (69.37 percent).

(CS *et al*., 2020) [5] reported that in comparison to control, a combination seed treatment with T. viride, neem oil, and Vitavax strength severely reduced dry root rot incidence from 16.03 to 47%. (56 percent). Seed treatment with *Pseudomonas fluorescens*, neem oil, and Vitavax power reduced dry root rot the most (71.38 percent), followed by seed treatment with *Pseudomonas fluorescens* and Vitavax power (64.11 percent), and sesame seeds treated with only neem oil had the least reduction in root rot occurrence (16.07 percent).

(Thirunarayanan *et al*., 2020) [38] reported that *Macrophomina phaseolina* mycelial development was severely damaged by the native *Trichoderma* isolates studied. Among the isolates examined, Tv1 demonstrated the greatest inhibition and greatly reduced *Macrophomina phaseolina* growth (27.40 mm), a decrease of 69.55 percent as compared to the pathogen's growth of 90 mm in the control. The isolates TV3 and Tv2, in declining order of merit, inhibited *Macrophomina phaseolina* development by 63.04 and 54.17 percent, respectively, over control. The isolate TV4 recorded the least amount of pathogen growth inhibition (44.75 percent).

(B. Thombre & Kohire, 2018) [39, 40] reported that all the bioagents tested had fungistatic action against *Macrophomina phaseolina* and greatly reduced the test pathogen's mycelial development compared to the untreated control. *Trichoderma harzianum* was shown to be the most successful of the seven fungal antagonists examined, with the least linear mycelial development (20.17 mm) and the highest mycelial inhibition (77.59 percent) of the test pathogen. *Aspergillus niger* and *Trichoderma viride* were the second and third effective antagonists, with mycelial development of 28.64 mm and 31.08 mm, respectively, and reduction of 68.17 and 65.46 percent, respectively.

Efficacy of different botanicals against dry root rot of green gram caused by *Macrophomina phaseolina*

(Dhingani *et al*., 2013) [8] reported that Garlic (*Allium sativum*) cloves extract (24.03mm) allowed the pathogen to expand to a minimum, followed by turmeric (*Curcuma longa*) finger extract (32.05mm) and mint (*Menthe arvensis* L.) leaves extract (24.03mm) (36.31mm). The rhizomes extract of Ginger (*Zingiber officinale*) (60.10 mm), and leaves extract of Neem (*Azadirachta indica*) (66.16 mm) were the next in amount of importance.

(B. Thombre & Kohire, 2018) [39, 40] reported that inin-vitro, both botanicals/plant leaf extracts were found to be considerably successful in preventing the percentage mycelial growth of *Macrophomina phaseolina* as compared to an untreated control. Over untreated activity, *Allium sativum* and *Allium cepa* had the smallest mean colony diameter (4.42 and 6.22 mm) and the largest mean mycelial growth inhibition (95.08 and 93.08 percent).

(Akanmu *et al*., 2015) [1] reported that *Momordica charantia* (4.34 cm) had the maximum mean inhibition activity of 4.34 cm on *Macrophomina phaseolina* mycelial growths, while *Ficus asperifolia* (5.69 cm), *Anacardium occidentals* (5.59 cm), and *Psidium guajava* (5.55 cm), which had a moderate inhibitory effect on the pathogen, were not statistically different from the control (p>0.05) (5.69 cm). The results of the combined treatments of the four extracts, with extracts of *Momordica charantia* and *Psidium guajava* (3.29 cm) as well as *Ficus asperifolia*, *Momordica charantia*, and *Anacardium occidentals* (3.11 cm) on *Macrophomina phaseolina*, were more important (p0.05) in controlling the pathogen.

(Dolas *et al*., 2018) [9] reported that Garlic extracts @ 0.5 percent showed 75 percent seed germination compared to 69 percent in the control condition. This botanical method results in an 8% improvement in seed germination over control. Of all the seed treatments, the seed treatments of mung bean seed with carbendazim @ 0.2 percent was found to be the most successful. It had a seedling vigour index of 1592.1, compared to 1166.1 in the control treatment. This fungicidal treatment increased seedling vigour index by 26.75 percent over control. Among botanicals, garlic extract @ 1% was found to be the most successful in reducing seed-borne pathogens and growing seed germination, seedling vigour index, and field emergence.

(Lakshmeesha *et al*., 2013) [22] reported that out of the ten plants examined, *Datura metel* and *Azadirachta indica* leaf extracts had the best antifungal efficacy against *Macrophomina phaseolina*. *Datura metel* extracts had considerably greater inhibitory activity than *Azadirachta indica* extracts. Antifungal response was observed in both extracts in a dose-dependent manner. When compared to chloroform extracts, methanol extracts had a higher level of antifungal activity. *Macrophomina phaseolina* was not significantly inhibited by the remaining plant leaf extracts. This finding suggests that *Datura metel* and *Azadirachta indica* leaf extracts have fungicidal effects, inhibiting the growth of *Macrophomina phaseolina*.

(B. B. Thombre & Kohire, 2018) [39, 40] reported that the botanicals examined were also found to be as successful as the bioagent. For *Allium sativum* and *Allium cepa*, the mean percentage disease occurrence was 26.40 and 29.34 percent and 27.12 and 30.37 percent, respectively. Against *Macrophomina phaseolina*, the botanicals *Allium sativum* (34.73 and 32.91 percent) and *Allium cepa* (35.44 and 32.97 percent) provided the best disease prevention.

Efficacy of different fungicides against dry root rot of green gram caused by *Macrophomina phaseolina.*

(Maruti1, Savitha, A. S., 2017) [27] has studied efficacy of different fungicides in invitro and reported that carboxin 37.5 percent + thiram 37.5 percent WP, carbendazim 12 percent + mancozeb 63 percent WP, and trifloxystrobin 25 percent + tebuconazole 50 percent EC reported 100% (100%) inhibition at all concentrations (0.10 percent, 0.20 percent, and 0.30 percent and he also concluded that ziram, among the contact fungicides studied, demonstrated 100% inhibition at all concentrations (0.1, 0.2, and 0.3 percent) with a mean inhibition that was slightly superior to all treatments, while mancozeb and thiram showed 100% inhibition at the 0.3 percent concentration. and among the systemic fungicides studied tebuconazole demonstrated full inhibition of *Rhizoctonia bataticola* at all concentrations measured, while propiconazole showed 100% inhibition at 0.10 and 0.15 percent.

(Aravind T and Dr. AB Brahmbhatt, 2018) [3] reported that tebuconazole, among the fungicides studied, had 100% growth inhibition at both 100 and 500 ppm. Carbendazim 12 percent + mancozeb 63 percent inhibited 91.86 and 89.63 percent at 1000 and 500 ppm, respectively. The second highest inhibitor in order was carbendazim 25% + mancozeb 50% at 1000 ppm, which was on average with 1000 ppm each of fenamidone 10% + mancozeb 50% and trifloxystrobin (25%) + tebuconazole (50%) with 88.89 percentage inhibition. Carbendazim 25% + mancozeb 50% (500 ppm), trifloxystrobin 25% + tebuconazole 50% (500 ppm), fenamidone 10% + mancozeb 50% (500 ppm), and carboxin 37.5 percent + thiram 37.5 percent both had significant growth inhibition of 87.86, 85.56, 84.81, and 84.08 percent, respectively. Carbendazim (500 ppm), carboxin 37.5 percent + thiram 37.5 percent (100 ppm), and carbendazim (100 ppm) both had higher mycelia development and slower growth inhibition, respectively, of 83.33, 80.74, and 80.37 percent.

(Khan *et al*., 2012) [18] reported that Indofil M-45, Bavistin, companion, copper oxychloride, and benlate, among other fungicides tested in the lab, totally inhibited the fungus's development. Indofil Z-78, Ridomil, and Sulphur, in descending order of dominance, were also found to be successful in controlling fungus growth.

(Sunil Kulkarni, 2019) [35] reported thatfungicides in various formulations were used to treat dry root rot. The combined findings of the first and second years showed that thetreatment (seed treatment (ST) with carbendazim @ 2 g/kg of seeds followed by one foliar spry (FS) at the time when disease symptoms were found with carbendazim (0.1 percent)) was considerably superior in controlling the disease, with the lowest disease occurrence (8.38 percent) and the highest seedyield (619 kg/ha)compared to untreated check which recorded highest dry root rot incidence (29.44%) and lowest seed yield (425.75 kg/ha).

(Kumari &, KS Shekhawat, 2012) [20] reported that in an invitro test, all the fungicides tested at 100, 200, 500, and 1000 ppm concentrations inhibited the mycelial development of *Macrophomina phaseolina* in Petri plates, including Bavistin, captan, thiram, indofil-M-45, Vitavax, raxil, and copper sulphate. The most effective fungicides in reducing *Macrophomina phaseolina* mycelial growth were Bavistin and captan, which provided full inhibition of mycelial growth at 1000 ppm concentrations. At 100 ppm concentrations, captan, Bavistin, thiram, and rexil effectively inhibited fungus development by 99, 98.80, 98.30, and 92.10 percent, respectively and Vitavax and copper sulphate, were the least successful treatments in inhibiting mycelial development, with values of 63.50 and 61.80 percent, respectively.

(Pawar *et al*., 2018) [32] reported that at 30 DAS, disease occurrence was highest in Thiophanate methyl @0.1% (16.66%), followed by Thiram + carbendazim @0.3%, and was comparable to other seed treatments except regulation. At 45 DAS, the seed treatment with Thiophanate methyl @ 0.1 percent, or 27.78 percent, had the lowest root rot occurrence.

(H. Manjunatha & Saifulla, 2021) [25] reported that in kharif and rabi, the seed treatment with tebuconazole @ 2 g/kg had the lowest dry root rot incidence (11.77 and 7.08 percent), with yields of 666.57 kg/ha and 779.04 kg/ha, respectively.

(Deepa, Sunkad *et al.*, 2018) [6] reported that the mixture of seed treatment with mancozeb 50 percent + carbendazim 25 percent WS @ 3.5 g/kg followed by soil drenching with mancozeb 50 percent + carbendazim 25 percent WS @ 3 g/lit water to contaminated and supporting plants resulted in the largest reduction in dry root rot disease incidence (77.60 percent).

(Lakhran & Ahir, 2018) [21] reported that Carbendazim had the lowest percent disease incidence (13.33 and 15.38 percent), led by carbendazim + mancozeb (16.66 and 20.00 percent), while control had the highest percent disease incidence (46.60 and 62.50 percent) at both stages. At all points, carbendazim (71.39 and 75.39 percent disease control) was the most successful, preceded by carbendazim + mancozeb (64.24 and 68.00 percent disease control).

Conclusion

The aim of this study was biological control methods that could be used to reduce yield losses caused by seed and/or soil-borne fungi that attack Mungbean plants. The effectiveness of *Trichoderma* spp. isolates as biocontrol agents in laboratory conditions revealed the mode of action by which antagonistic fungi inhibited the activity of plant pathogens. The biocontrol agents not only managed dry root rot but also induced plant growth, giving them an advantage over chemical fungicides in the treatment of root rot. The pathogen is also inhibited to the greatest extent by plant extracts. These plant extracts can help to lower inoculum capacity, lowering disease occurrence and severity and the result of this study shows their potential in plant disease control.

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