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Root Rot Disease in Legumenous Plant Pigeon pea Caused by *Macrophomina phaseolina* (Tassi) Goid and its Management

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Abstract: The fungi Macro *phomina phaseolina* (Tassi) Goid is a soil- and seed-borne pathogen which causes charcoal rot and various rots and blights of more than 500 crop plant species. The dry root rot (DRR) also called as charcoal rot which causes yield loss upto 25-55 per cent. The pathogen is necrotroph and infects a wide range of crops. It is observed that mycelium of M. phaseolina in cotyledons, plumule and radicle, in the naturally infected seeds of Pigeon pea and cowpea. The disease symptoms are clearly visible from the time of emergence and can be evaluated at various stages of development of the plant. The mechanical plugging of the xylem vessels by microsclerotia, toxin production, enzymatic action and mechanical pressure during penetration lead to disease development. In the Management of M. phaseolina purpose to reduce the number of sclerotia in soil or to decrease the contact of the inoculum and the host. Soil solarization can be a cost-effective method for management of soil borne diseases. The disease inhibition by biocontrol agents such as Trichoderma harzianum, T. viride and Bacillus subtilis are the sustained manifestation of interactions among the plant, the pathogen, the biocontrol agent, the microbial community on and around the plant and the physical environment and considerably inhibited growth of M. phaseolina. Essential oils and plant extracts contain a multitude of bioactive substances against fungi, bacteria and nematodes. It has been reported that neem oil, turmeric and garlic was effective against M. phaseolina in in vitro condition. Chemical control is an effective method when seed treatment and foliar spray of carbendazim, topsin M-70, captan, thiram, mancozeb, copper oxychloride against root rot and leaf blight (*Macrophomina phaseolina*) topsin M-70, captan, thiram, mancozeb, copper oxychloride against root rot (*Macrophomina phaseolina*). As non-chemical alternative methods can be time-consuming and less effective against soilborne plant pathogens. Chemical control is an effective method of controlling some soilborne diseases in agricultural crops. Varoius workers are reported compatibility of biocontrol agents with fungicides and found that Carbendazim and biocontrol agents Trichoderma viride, T. harizianum were found effective under in vitro and pot.

Keywords: *Macrophomina phaseolina, Legumenous Plant Pigeon pea, Rot Disease*

INTRODUCTION

Macrophomina phaseolina (Tassi) Charcoal rot and other rots and blights of over 500 crop species are caused by the polyphagous pathogen Goid., which is spread by seeds and soil. Charcoal rot, another name for dry root rot (DRR), reduces yield by 25–55% (Iqbal and Mukhtar, 2014). Numerous crops are infected by the necrotrophic pathogen. When the disease reaches advanced stages, the roots of infected plants rot, the plants wilt, and eventually the plants die (Khan *et al.,* 2017). Southeast and South Asia Common beans (*Phaseolus vulgaris* L.), cowpeas (*Vigna unguiculata* (L.), Walp), urdbeans (*V. mungo* (L.) Hepper), soybeans (*Glycine max* (L.) Merr.), potatoes (*Solanum tuberosum* L.), and cotton (*Gossypium hirsutum* L.) are among the various field crops that are affected by *Macrophomina* species (Suriachandraselvan *et al.,* 2005). The fungus produces a number of hydrolytic enzymes, cell wall-degrading enzymes, and phytotoxins, including phaseolinone and botryodiplodin, when it infects host plants (Ramezani, 2008). M. phaseolina isolates from several legume crops were characterized using both morphological analysis and molecular approaches. Cultural and morphological characteristics, such as colony morphology and microscopic analysis of microsclerotia, pycnidia, and conidia, are insufficient for identifying M. haseolina (Saleh *et al.,* 2010).

Since the causative agent is a pathogen that is spread by seeds and soil, managing DRR of Pigeon pea is difficult. For smallholder farmers, chemical control of the soil-borne fungus is costly and challenging. Under controlled conditions, DRR of mungbean was effectively controlled by combining chemical fungicides with botanical extracts and biocontrol agents (Sundaramoorthy *et al.*, 2013). These biocontrol agents, however, are not yet commercially accessible and also need more field testing. One of the greatest ways to control DRR of mungbean would be to employ host resistance, if it were accessible (Fuhlbohm *et al.*, 2013).

Symptoms

Disease signs in pigeon peas are evident from the moment of emergence and can be assessed at different phases of the plant's growth. Symptoms appear as brown to dark patches on the cotyledons after emergence. Cotyledons, however, only stay on the plant for a few days, particularly in cases of disease. The cotyledon edges first turn brilliant red, then beige or brown, and lastly brown to black. They frequently have a grayish mycelium pad covering them with sporadic sclerotia. This

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mycelium is also seen inside cotyledons that have fully colonized. Pinhead-sized, charcoal-colored patches that are primarily limited to the hypocotyl segment of the stem, including its subterranean portion, are common symptoms at the unifoliate leaf stage.

The plant will typically die as a result of infected patches growing into big necrotic sores. Necrotic roots can also be infected by M. phaseolina. M. phaseolina damages the stems, spikes, pods, and seeds of mature plants. Lesions on stems are beige and show up where the lateral secondary branches ramify. Colonized tissues turn gray and are speckled with tiny black dots. These punctuations are submerged at first, then progressively become more noticeable. The fungus enters grains from pod peduncles and moves to the pods. Necrotic lesions, however, can develop on the pods anywhere. Initially blue-green, infected green pods eventually turn brown or reddish. When mature, dry pods become infected, they become white to gray and are covered in black bodies that can be found locally or extensively. Depending on the degree of tissue invasion, the fungus causes a variety of symptoms after penetrating the pod and grains. Grain that is infected early on either dies or becomes dry and empty. When damaged grains are found at the tip of the pod, the impacted areas of the pod become thin, distorted, and narrow. The abrupt withering and drying of the entire plant, with the majority of the leaves still green, is the most noticeable sign. Then, black bodies blanket the stem and branches, giving the impression of dead plants that are charred or ashy.

From the seedling to the maturity stage, withering is visible and is caused by enzymatic activity, toxin generation, and the necrosis of roots and stems as well as the mechanical blockage of xylem vessels by microsclerotia. Growth stage and environment have an impact on the infection and severity of the root infection caused by the charcoal rot disease. Nonetheless, there have also been reports of M. phaseolina colonization on peanuts increased with a high moisture holding capacity (40–50% MHC) (Husain and Ghaffar, 1995). Higher final densities of the plant pathogenic nematodes *Heterodera trifolii*, *Helicotylenchus dihystera*, and *Meloidogyne trifoliophila* are also frequently linked to M. *phaseolina* in white clover (Zahid *et al.*, 2002) Visible symptoms of the disease in the field are most apparent under conditions that reduce plant vigor, such as poor soil fertility, high seeding rates, low soil water content high temperatures (Odvody and Dunkle, 1979; Mihail, 1989) and root injury (Canaday *et al.*, 1986). The timing of host reproduction is another factor that has a strong influence on charcoal rot development. In *Euphorbia lathyris*, early flowering plants succumb more rapidly to charcoal rot than later flowering ones (Mihail, 1989).

Disease cycle

More than 500 cultivated and wild plant species, including commercially significant crops like soybean, common bean, sorghum, maize, cotton, peanut, and cowpea, are susceptible to seedling blight, root rot, and root and stem rot caused by *Macrophomina phaseolina* (Tassi) Goid (Diourte *et al.*, 1995). The disease is also found in fruit trees (Citrus spp., Cocoa nucifera, Coffea spp.), weed species (Songa and Hillocks, 1996), and softwood forest trees (Abies, Pinus, Pseudotsuga) (McCain and Scharpf, 1989). There have been reports of the fungus throughout Europe, Asia, Africa, and North and South America. However, in tropical and subtropical nations with semi-arid climates, it is more economically significant (Wrather *et al.*, 2001). In order to endure harsh climatic circumstances, M. phaseolina generates sclerotia in the root and stem tissues of its hosts.

Pycnidia are rarely generated in host crops and only under certain incubation conditions (Gaetán *et al.*, 2006). Their significance in the fungus's epidemiology probably varies depending on the host and the fungal isolate. Pycnidia are formed on cowpea at the conclusion of the wet season, although they don't seem to have much of an epidemiological impact. In contrast, *pycnidiospores* generated on early infected stem and leaf tissues have been implicated in secondary disease transmission in jute crops (Anonymous, 1940). The main inoculum is microsclerotia found in soil, infected seeds, or host tissues. Microsclerotia germination and host root infection are induced by root exudates. The infectious hyphae penetrate the plant through wounds or root epidermal cells.

The mycelium enters the root epidermis during the early phases of pathogenesis and is mostly limited to the intercellular gaps of the primary roots' cortex. Neighboring cells collapse as a result, and severely diseased plantlets may perish. The fungal hyphae develop intracellularly through the xylem during the start of flowers, forming microsclerotia that obstruct the capillaries and cause host cell disruption. Necrotic lesions are seen on the stems, branches, and peduncles of the diseased plants. The fungus enters grains from pod peduncles and

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moves to the pods. The development of fungal toxins, such as *phaseolinone* (Bhattacharya *et al.*, 1994), and fungal mycelia that obstruct host vasculature cause severely infected plants to die early. *Microsclerotia* formation in soybeans is dependent on blooming and pod setting and may signal the start of the host's demise. Mycelial colonization and sclerotia development in host tissue persist after plant death until the tissues are dry. The pathogen is spread by the mycelium and *microsclerotia* that are created in infected plant material, including plant leftovers. The primary propagules that survive are *microsclerotia* in soil, host roots, and stems. *Microsclerotia* are discharged into the soil following the decomposition of plant and root waste. They are primarily found at a depth of 0–20 cm and are typically seen in clusters near the soil surface (Campbell and van der Gaag, 1993).

MATERIALS AND METHODS

The field experiment was conducted during *kharif* 2024 at Department of botany Meerut College Meerut for management of *Macrophomina* stem blight and dry root rot diseases in pigeon pea on IPA-203 cultivar. All the treatments had seed treatment with carboxin 37.5 + thiram 37.5 DS in common except in control and bio-controls followed by spraying and drenching with fungicides and bio control agents twice, once immediately after noticing signs of wilting in control and second time at 20 days later.

Ten days after treatments imposing, the disease incidence was recorded and the final observation was taken a week before harvest.

The per cent disease incidence was recorded for wilt due to dry root rot and *Macrophomina* stem blight as below

$$\text{Per cent disease incidence} = \frac{\text{Number of plants wilted}}{\text{Total number of plants examined}} \times 100$$

Table 1: DifferentTreatments, chemical an d Their cocentration

Treatment	**Chemical**	**Trade name**	**Concentration**
T1	ST + foliar spray and drenching with carboxin 37.5 + thiram37.5%	Vitavax power	1g/lit
T2	ST + foliar spray and drenching with copper oxychloride 50WP	Blitox 50 W	1g/lit
T3	ST + foliar spray and drenching with Mancozeb 75WP	M-45	2g/lit
T4	y and drenching with Carbendazim12WP + Mancozeb 63WP	Saaf	2g/lit
T5	ST + foliar spray and drenching with Chlorothalonil 50WP	Kavach	2g/lit
T6	ST + foliar spray and drenching with Thiophanate methyl 70WP	Topsin M	1g/lit
T7	ST + foliar spray and drenching with Propiconazole 25 EC	Tilt	1g/lit
T8	ST + foliar spray and drenching with Carbendazim 50WP	Bavistin	1gm/kg
T9	ST + foliar spray and drenching with *Pseudomonas fluroscenes* +*Trichoderma asperellum*	-	Soil application 2.5kg/ha enriched in 100kg of FYM and foliar spray 5 gm/lit
T10	Control	-	-

ST: Seed treatment with carboxin 37.5+thiram 37.5% @ 2g/kg seeds except in T9 and T10 plots.

RESULTS AND DISCUSSION

According to the field trials, treatment T9 had the greatest disease reduces after 10 days following the initial spray and drenching (1.06%), followed by T4 (4.4%) and T8 (5.11%). Treatment T6 also shown a wilt incidence that was comparable to that of T8 (5.54%). The control group had the highest wilt incidence (22.83%), followed by T2 (16.29%).

Additionally, ten days following the second spray

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and soaking, the T9 plot had the significantly lowest disease incidence (3.13%), followed by the T4 plot (5.45%). Disease incidence was seen in T8 (6.21%) and T6 (6.18%) plots on par. The T2 plot (18.00%) had the second-highest Percent Disease Incidence (PDI) in the control group (31.96%). The pattern in PDI among the treatments was comparable in the observations made a week prior to harvest as it was in the first two observations. T9 plots sprayed and soaked with Trichoderma asperellum+ Pseudomonas fluorescence had the lowest wilt incidence (4.00%), followed by T4 (7.66%), T8 (8.21%), and T6 (8.49%). The control group had the highest wilt incidence (44.66%), followed by the T2 plot (20.08%) in Table 1.

T9 had the significantly lowest mean percentage of disease incidence (2.76%), followed by T4 (5.84%), while T8 and T6 had comparable mean disease incidence. The untreated control plot had the highest percentage of disease incidence (34.38%), followed by the T2 plot (19.12%).

The findings provide insight into the need to implement control methods using both foliar spraying and soil application, rather than either foliar spraying or applying soil. In a previous attempt to control Macrophomina stem canker in pigeonpea, Chikkanna (2014) evaluated seed treatment, foliar spray of fungicides, and biocontrol agents. It was discovered that Trichoderma viride could have the lowest disease incidence (9.87%) compared to check (34.55%) and all fungicides evaluated. This is the first study focusing on controlling the soil inoculums that cause dry root rot and stem blight disease, but no additional efforts were undertaken in this respect. When compared to the studied fungicides, both foliar spraying and soil soaking of biocontrol agents shown encouraging outcomes in lowering the occurrences of wilt.

Additionally, Thombre and Kohire (2018) found that carbendazim 12WP + mancozeb 63WP showed great promise in reducing M. Phaseolina-induced mungbean blight as much as possible in both pot (83.35%) and field (67.07%) conditions compared to control. The biocontrol chemicals always have the dual benefit of safeguarding and fostering the growth of the plant root system while also suppressing the infections. Trichoderma harzianum seed treatment at 10g/kg seed demonstrated a 100% reduction in disease when compared to chemical fungicide seed treatment in chickpea dry root rot management (Lokesh *et al.*, 2021), demonstrating the superiority of biocontrol agents over the fungicides.

Biocontrol agents were found to be more effective than other methods in lowering the incidence of the disease in the current field trial. In the pot experiment, T. viride significantly reduced dry root rot in other crops, such as black gram, and boosted the plant's root and shoot length (Tetali *et al.*, 2016). When T. harzianum and Rhizobium were applied as seed treatments and soil treatments, the disease incidence in mungbean M. Phaseolina was decreased by up to 79.23%, with the least disease incidence (13.50%) and maximum grain yield (14.8 q/ha) (Kumar *et al.*, 2021).

In comparison to the untreated control plot, pigeonpea production was considerably greater in all treatments involving fungicides and bioagents against Macrophomina stem blight and dry root rot that causes wilt. T9 had the highest yield (1311 kg/ha), followed by T4 (1240 kg/ha). Although the T2 had the lowest yield (520 kg/ha), it was still much higher than the untreated control (434 kg/ha). These findings are consistent with those of Thombre and Kohire (2018), who demonstrated that foliar spraying carbendazim 12 WP + mancozeb 63 WP (530 kg/ha) to control Macrophomina blight, followed by Trichoderma harzianum (480 kg/ha), produced the highest grain production of mungbean.

Paramasivan *et al*., (2022) also reported that seed treatment with *Pseudomonas fluorescens* (10g/kg), *T. asperellum* (4g/kg) recorded maximum reduction in root rot with disease incidence of 8.49 and 8.63 per cent respectively over control (34.63%). Furthermore, the incidence of groundnut root rot was reduced by 80.67 percent and 79.27 percent, respectively, when soil applications of biocontrol agents fortified with FYM, namely Trichoderma asperellum and 2.5 kg+FYM @ 200 kg/ha and 2.5 kg Pseudomonas fluorescens + FYM @ 200 kg/ha, were made. Additionally, higher yields of 1176 and 1155 kg/ha were recorded.

Benefit Cost Ratio (BCR)

The benefit to cost ratio of the several fungicides and biocontrol agents that were evaluated was determined in this study. T9 had the highest BCR (2.25), followed by T4 (1.91). Table 2 shows that T5 had the lowest benefit cost (0.13), followed by control (0.19). According to our study's benefit to cost ratio analysis, foliar spraying and soil soaking with fungicides and biocontrol agents were effective in lowering the incidence of wilt and increasing yield when compared to the control (untreated), with the exception of T5.

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Trichoderma harzianum + Pseudomonas fluorescence foliar spray, seed treatment, and foliar application were found to be promising in controlling dry root rot and wilting caused by M. phaseolina with the highest cost-benefit ratio and increased grain yield. These methods were followed by foliar spray and soil drenching of carbendazim 12WP + mancozeb 63WP. The findings of our investigation align with the findings of Mahalakshmi and Devi (2021), who reported the highest

In the management of sesame root rot during the kharifs of 2016 and 2017, the B:C ratios for seed treatment and soil application of Trichoderma harzianum and Pseudomonas fluorescence were 2.6 and 1.5, respectively. They also reported comparable B:C ratios for seed treatment and soil drenching with carbendazim 50WP.

Table 2: Benefit cost ratio for management of wilt in pigeonpea due to stem blight and dry root rot caused by *Macrophomina pheasolina* during kharif 2024.

Tr. No.	Treatments	Yield (q/ha)	Treatment Cost (ha^{-1})	Cost of cultivation (ha^{-1})	Gross returns (ha^{-1})	Net returns (ha^{-1})	B:C ratio
1.	carboxin + thiram	8.7	2480	27480	58485	30994	1.14
2.	Copper oxy chloride	5.3	2440	27440	35365	7914	0.30
3.	Mancozeb	7.3	2935	27935	49234	21304	0.78
4.	Carbendazim +mancozeb	12.50	4045	29045	84325	55285	1.95
5.	Chlorothalonil	6.2	11375	36375	40850	4435	0.13
6.	Thiophanate methyl	10.09	2275	27275	68546	41276	1.53
7.	Propiconazole	10.05	4220	29220	68270	39045	1.32
8.	carbendezim	10.2	1195	26195	68685	42495	1.65
9.	*Trichoderma asperellum + Pseudomonas fluroscence*	13.13	2555	27555	89217	61667	2.25
10.	Control	4.37	00	24500	29000	4500	0.181

Fig 1: *charcoal rot (Macrophomina phaseolina (Tassi) Goidanich)* (Source-Internet)

CONCLUSION

The results of this study show great promise for lowering the incidence of wilt brought on by dry root rot and stem blight. During the germination and seedling stages, the seeds were shielded against fungal pathogen infestations by the use of biocontrol agents. Until the crop was harvested, additional foliar spraying of biocontrol agents

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stopped the target pathogens from infecting the stem and roots.

Certain soil-borne diseases in agricultural crops can be effectively managed using chemical treatment. Alternative non-chemical techniques for combating soil-borne plant diseases can be laborious and less successful. The majority of important diseases in crops grown for the market have been successfully controlled with fungicides of various kinds. Seed-borne diseases, soil-borne diseases, powdery mildews, cereal stem diseases, rusts, and smuts are the commercially significant diseases, in order of relative importance

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