International Journal of Economic Plants 2023, 10(2):143-148

Full Research

Doi: HTTPS://DOI.ORG/10.23910/2/2023.0513d

Integrated Approaches for Management of Phytophthora Blight in Sesame (*Sesamum indicum* L.)

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Article History

Article ID: IJEP0513d
Received on 11th January, 2023
Received in revised form on 29th April, 2023
Accepted in final form on 21st May, 2023

Abstract

The present investigation was conducted in the experimental field of Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India during July to October of 2021. Phytophthora blight caused by *Phytophthora parasitica* var. *sesame* is prevalent in all the sesame grown areas in the country. It may occur at any stage of the crop and can cause up to 80% yield loss. The combination of biological control agents *viz. Trichoderma harzianum* (Th) & *Pseudomonas fluorescens* (Pf), application of farm yard manure, spent mushroom substrate (SMS) of oyster mushroom and the fungicide (Metalaxyl 8%+Mancozeb 64% WP) were assessed against Phytophthora blight of sesame in terms of incubation period, disease incidence, disease severity and yield under natural epiphytotic field conditions during *kharif* 2021. Among the treatments assessed, soil application of SMS+Th prior to sowing showed the highest enhancement in terms of incubation period (35.63%) and yield (44.55%) over the control. However, it was at par with respect to the incubation period and yield in the treatment of soil amended with the combination of SMS and (Th+Pf) before sowing. Maximum reduction in disease incidence (20.04%) and severity (51.41%) of Phytophthora blight over the control was recorded in treatments *viz.,* soil amendment with combination of SMS+ (Th+Pf) and SMS+Th, respectively. The results revealed that all the treatments applied as prophylactic treatment, significantly reduced the Phytophthora blight and increased the incubation period and yield over the unprotected crop.

Keywords: FYM, mancozeb, phytophthora blight, Phytophthora parasitica, sesame

1. Introduction

Sesame (*Sesamum indicum* L.) had been cultivated particularly in Asia and Africa, particularly for its high content of edible oil and protein. The primary marketable products of sesame are the whole seeds, seed oil and meal (Morris, 2002, Raghavan et al., 2010). The area, production and productivity of sesame in the world were estimated to be 11.743 m ha, 60.16 lakh MT and 512 kg ha^{-1}, respectively in 2018. In India, the area, production and productivity of sesame in 2018 were 17.3 lakh ha, 7.46 lakh MT and 431 kg ha^{-1}, respectively, and it contributed about 12.40% of world production (Anonymous, 2020, Myint et al., 2020). Despite the increasing demand and price of sesame in the world market, its productivity is declining in most parts of the country. The major reasons are the lack of knowledge and skill in land preparation and agronomic practices, weather uncertainties and pest outbreaks (Terefe et al., 2012). Abiotic and biotic stresses including diseases are the key factors contributing to reduction of sesame output and productivity. Earlier workers observed that a total of 72 fungi, 7 bacteria, one phytoplasma and one viral pathogen were identified as the pathogen of sesame (Vyas, 1981, Ransingh et al., 2021, Weiss et al., 2000, Boureima et al., 2012, Tripathy et al., 2019, Ucan et al., 2007). Among the diseases, Phytophthora blight is one of the important fungal diseases prevalent in most part of the country and responsible for low production and productivity. Singh et al. (1976) reported that the disease may lead to mortality of plants as high as 72 to 79%. The disease may occur at any stage of the crop and becomes very serious and up to 80% was recorded if infections occur at the seedling stage (Singh et al., 2005). The initial symptom of the disease appears as chestnut brown, water-soaked spots on leaves and stems and later turns into black causing premature leaf fall. The disease becomes severe under continuous rainy days affecting all the aerial parts of plants and covers entire field within few days. Main root is also affected, diseased plants can easily be pulled out and produce shrivelled seeds and gives blighted appearance (Roy et al., 2007). The application of fungicide is found to be effective for management of the diseases, but their use is being discouraged because it is hazardous to the environment. Moreover, residue problems, resistance development in pathogens and different health hazards to human beings and other living organisms are the major problems of the disease management with the chemicals (Goswami et al., 2018, Fairbrother et al., 2007, Harmsen, 2007, Katayama et al., 2010). In general, the ability and population of antagonistic microorganism introduced into the soil, decline with time mainly due to lack of food and stimulants available for the antagonists. Addition of specific substrates enhance the desired activity of antagonists to great extent (Paulitz, 2000, Prasad and Srinivasaraghavan, 2020, Prasad and Singh, 2018). It is well established that soil amendment with organic matter and bio-agents promote the population of antagonistic microorganisms which interfere with the activities of pathogenic fungi. They stimulate the natural disease defense system in plants and minimize the effect of soil borne fungal pathogens through antagonism (Debosz et al., 2002, Crecchio et al., 2001, Crecchio et al., 2001, Debosz et al., 2002, Verma et al., 2017). Therefore, to evolve a sustainable IDM measure against Phytophthora blight the experiment was undertaken to elucidate the influence of integrated and single application of bio-agents (*Trichoderma harzianum* &*Pseudomonas fluorescens*), farm yard manure, spent mushroom substrate (Oyster) and fungicide against Phytophthora blight of sesame under natural epiphytotic field conditions.

2. Materials and Methods

The present investigation (Figure 1) on Phytophthora blight of sesame was conducted in the experimental field of Banda

Figure 1: Field trial: evaluation of effect of bioagents, organic substrates and fungicide against Phytophthora blight & seed yield in sesame

University of Agriculture and Technology, Banda, Uttar Pradesh, India which is located at 25º4'N latitude, 80º3'E longitudes and at an altitude of 141 m above the mean sea level. Experiments were conducted in 2021 during July to October to evaluate the efficacy of single and integrated application of different organic substrates, bio-agents and fungicides on Phytophthora blight disease of sesame under natural epiphytotic field conditions. The crop was sown in mid-July and harvested in the third week of October. The NPK fertilizers were applied @ 20:10:00 kg ha^{-1}, respectively at the time of last harrowing besides ensuring recommended agronomy package of the crop. The mean of maximum temperature, minimum temperature, relative humidity was 34.31°C, 25.55°C, 94.91% and 61.52%, respectively. The mean rainfall was 38.64 mm during the period from July to October, 2021.The field experiment was conducted in Randomized Block Design with twelve treatments replicated thrice. The experimental field was prepared by proper ploughing and harrowing and individual plot size was 4×3 m^2. The sesame cultivar RT 351was used for the present investigation. Seeds were sown uniformly in all the plots and thinning was done at 15–20 days after germination maintaining a spacing of 30×10 cm^2.

The treatments consisted of application of Metalaxyl 8%+Mancozeb 64% WP@ 0.25% for seed treatment and spraying/ drenching of plant/ soil nearby blighted stem and soil application of *Trichoderma harzianum* (10^6 CFUg^{-1}) and *Pseudomonas fluorescens* (10^5 CFU g^{-1}) @ 0.2% along with organic substrates i.e., Farm Yard Manure (FYM) @ 10 t ha^{-1} and Spent Mushroom Substrate (SMS) @ 6 t ha^{-1}. The following treatment combinations were followed.

T1-Seed treatment with *Trichoderma harzianum* (Th), T_2: Seed treatment with Metalaxyl 8%+Mancozeb 64% WP, T_3: Soil amendment with SMS, T_4: Soil amendment with combination of SMS+Th, T_5: Soil amendment with combination of SMS+*Pseudomonas fluorescens* (Pf), T_6: Soil amendment with combination of SMS+(Th+Pf), T_7: Soil amendment with FYM, T_8: Soil amendment with combination of FYM+Th, T_9: Soil amendment with combination of FYM+Pf, T_{10}: Soil amendment with combination of FYM+(Th+Pf), T_{11}: Treated control (spraying/ drenching of plant/ soil nearby blighted stem with Metalaxyl 8%+Mancozeb 64% WP) and T_{12}: Untreated control (water spray). The bio-agents (Th & Pf) formulation were mixed thoroughly in FYM and SMS @ 0.2% and spread as a layer (6" thick) under shade. It was covered with rice straw. Water was sprayed on the top to keep the FYM& SMS moist. It was incubated (approx. 25 to 32°C) for 15 days. The air-dried mixture of bio-agents+FYM/ SMS containing higher population of bio-agents were used directly for the soil application. Spraying/ drenching of plant and soil nearby blighted stem with Metalaxyl 8%+Mancozeb 64% WP @ 0.25%, was done immediately after appearance of initial symptoms (Figure 2) developed on lower leaves. The subsequent application was done at 15 days interval. Leaf infections of Phytophthora blight disease was assessed on randomly selected five plants from each plot under natural epiphytotic conditions at 75 days after sowing using 0 to 5 rating scale (Rajpurohit, 1993).

The Percent Disease Index (PDI) was calculated with the scale mentioned by Wheeler (1969). The incubation period and seed yield were also recorded and expressed in days and q ha^{-1}, respectively. The data of each observation recorded in above investigation were statistically analysed and calculations were made after applying the test of significance for the treatment means. Analysis of data was carried out using

Figure 2: Symptoms of Phytophthora blight on sesame under natural field conditions

angular transformation at 5% level of significance with the help of OPSTAT software (Sheoran, 2006). Percent increase in yield and the percent decreased in disease incidence were calculated on the basis data recorded in control.

The percent disease incidence was calculated as per following equation-

Percent disease incidence=(Number of plants infected in a micro plot/Total number of plants in a micro plot)×100

Percent disease index (PDI)=(Sum of all numerical rating/Total number of ratings × Maximum grade)×100

Percent disease control=(PDI in control-PDI in treated/PDI in control)×100

Per cent yield Increase=(Yield under protected-Yield under unprotected/Yield under unprotected)×100

3. Results and Discussion

The data presented in Table 1 revealed that all the treatments which were applied as prophylactic, significantly reduced the intensity of Phytophthora blight and increased the incubation period and yield over control (unprotected crop). Maximum incubation period (33.67 days) was recorded in the treatments where pre sowing soil amendment was done with the combination of SMS +'Th+Pf' or combination of SMS+Th. However, it was at par with respect to the incubation period i.e., 33, 32.67, 30.67 and 30 days noticed in treatments T2 (seed treatment with Metalaxyl 8%+Mancozeb 64% WP), T1 (seed treatment with Th), T10 (soil amendment with combination of FYM+'Th+Pf') and T8 (soil amendment with

Table1: Effect of bioagents, organic substrates and fungicide on Phytophthora blight & seed yield in sesame.

Treatment details	Incubation period (Days)		Disease incidence (%)		Disease severity (%)		Yield (q ha^{-1})	
	Mean	Increase (%)	Mean	Reduction (%)	Mean	Reduction (%)	Mean	Increase (%)
T_1: Seed treatment with Th	32.67	33.66	77.05 (61.37)*	16.71	47.36 (43.47)*	48.51	26.05	32.52
T_2: Seed treatment with Metalaxyl l8% + Mancozeb 64% WP	33.00	34.33	77.83 (61.97)	15.87	46.90 (43.20)	49.01	26.26	33.05
T_3: Soil amendment with SMS	27.33	20.72	79.79 (63.27)	13.75	52.93 (46.66)	42.46	22.82	22.97
T_4: Soil amendment with combination of SMS+Th	33.67	35.63	75.42 (60.26)	18.47	44.70 (41.94)	51.41	31.70	44.55
T_5: Soil amendment with combination of SMS+ Pf	27.33	20.72	78.90 (62.74)	14.71	52.35 (46.33)	43.09	23.26	24.41
T_6: Soi l amendment with combination of SMS + (Th+Pf)	33.67	35.63	73.97 (59.30)	20.04	45.33 (42.30)	50.72	30.78	42.88
T_7: Soil amendment with FYM	25.67	25.67	89.63 (71.21)	3.11	59.19 (50.28)	35.66	21.47	18.13
T_8: Soil amendment with combination of FYM + Th	30.00	27.77	83.86 (66.33)	9.35	56.52 (48.73)	38.55	24.70	28.84
T_9: Soil amendment with combination of FYM+Pf	26.33	17.71	87.69 (69.49)	5.21	55.87 (48.36)	39.26	22.27	21.05
T_{10}:Soil amendment with combination of FYM+(Th+Pf)	30.67	29.34	78.70	14.93	51.88 (46.06)	43.61	25.88	32.08
T_{11}:Treated control (Metalaxyl 8% + Mancozeb 64% WP	21.67	0.00	80.51 (63.80)	12.97	58.42 (49.83)	36.49	23.51	25.23

Table 1: continue...

Treatment details	Incubation period (Days)		Disease incidence (%)		Disease severity (%)		Yield (q ha^{-1})	
	Mean	Increase (%)	Mean	Reduction (%)	Mean	Reduction (%)	Mean	Increase (%)
T_{12}- Control (Untreated)	21.67	0.00	92.51 (74.25)	-	91.99 (73.88)	-	17.58	-
CD (p=0.05)	5.27	-	3.31	-	3.35	-	2.96	-
SEm±	1.79	-	1.12	-	1.13	-	1.00	-

*The figure in the parenthesis is arc sin transformed value

combination of FYM+Th), respectively. The least incubation period (21.67 days) was noticed in treatments T12 (untreated control) and T11 (spraying/ drenching of plant/ soil nearby blighted stem with Metalaxyl 8%+Mancozeb 64% WP). Minimum incidence (59.30%) of Phytophthora blight was observed in the treatment where soil amendment was done with combination of SMS+'Th+Pf' and was statistically at par with T4 (soil amendment with combination of SMS+Th), T1 (seed treatment with Th), T2 (seed treatment with Metalaxyl 8%+Mancozeb 64% WP) and T10 (soil amendment with combination of FYM+'Th+Pf') as presented in Table 1. The disease incidence (74.25%) noticed in untreated control (T12) was significantly higher in comparison with rest of the treatments except T7. Minimum disease severity (41.94%) was recorded in treatment T4 (soil amendment with combination of SMS+Th) and it was at par with treatments T6 (soil amendment with combination of SMS+'Th+Pf'), T2(seed treatment with Metalaxyl 8%+Mancozeb 64% WP) and T1 (seed treatment with Th). Phytophthora blight severity (73.88%) noticed in untreated control was significantly higher than rest of the treatments where organic substrates, bio-agents or fungicide was applied as prophylactic or curative. Maximum enhancement (44.55%) in yield was obtained in treatment T4 where soil amendment was done with combination of SMS+Th prior to sowing and was followed by the treatment- T6 (42.88%) over control. Subsequently, 33.05% yield enhancement was obtained in treatment T2 where seed was treated with Metalaxyl 8%+Mancozeb 64% WP and was followed by 32.52% increase in yield resulted in treatment T1 (seed treatment with Th) over unprotected crop. The yield obtained in untreated control was significantly lower than the yield recorded in rest of the treatments. In biological control or organic amendment of soil, the metabolites of bio-agents or decomposition products of organic matter may induce physiological resistance in the plant and reduce the incidence of root rot, wilt, root knot, etc. (Singh, 1984). According to Davis et al. (2005) SMS exhibits suppressive characteristics against various plant diseases caused by fungi. Shitole et al. (2013) reported the combination of *Trichoderma viride* @ 5 g kg^{-1} SMS + *Pseudomonas fluorescens* @ 5 g kg^{-1} SMS found highly effective against damping off in tomato. Several researchers had reported lower incidence of disease on using SMS as manure in vegetable crops (Ahlawat et al., 2007). Ntougias et al. (2008) reported the effect of SMS on suppression of damping off caused by *Pythium aphanidermatum*. Many researchers reported that the organic substrates such as SMS can suppress a variety of plant pathogenic fungi including soil borne pathogens (Segarra, 2007).

Application of *T. viride* and *T. harzianum* in combination or with *P. fluorescens* as seed treatment and soil application were most effective in minimising the root rot incidence (Pandey et al., 2014). Combination of seed and soil application of *P. fluorescens* is most effective in soil borne diseases (Kavitha et al., 2005). Organic amendments are one of the most effective ways to combat soil-borne diseases (Deshmukh et al., 2016a). Oil cakes, farm yard manure etc. are few of the suitable organic products that can be used as soil amendments (Ransingh et al., 2021, Khamari et al., 2021). Seed treatment using *T. viride* along with soil application of FYM @ 10 t ha^{-1} has found to be effective against soil borne diseases (Upadhyay et al., 2016). Combination of FYM with seed treatment with *P. fluorescens* reduced root rot incidence (Deshmukh et al., 2016a). Myint et al. (2000) found that Metalaxyl was effective against Phytophthora root rot. Vyas (1981) reported that application of dithiocarbamate fungicides such as Mancozeb (0.30%) or Zineb (0.30%) were found effective for the control of Phytophthora blight of sesame. Application of Metalaxyl and mancozeb found effective against fungal pathogen including *Phytophthora* (Garzon et al., 2011). The findings of present investigation are quite in conformity with the reports of earlier workers.

4. Conclusion

The present study revealed that integrated application of SMS + Th or SMS + (Th+Pf) prior to sowing were found to be effective in minimizing the Phytophthora blight effectively and enhanced the seed yield significantly over the unprotected crop. Hence, it can be applied as an eco-friendly measure for management of Phytophthora blight in sesame. Seed treatment with Metalaxyl 8%+Mancozeb 64% WP or with *Trichoderma harzianum* were found to be next effective treatments to reduce the Phytophthora blight significantly and they can also be applied as prophylactic measure for management of this disease.

5. Acknowledgement

The author is grateful to Directorate of Research, Banda University of Agriculture and Technology (BUAT), Banda-210001, Uttar Pradesh for financial assistance in the experiment. The experiment was conducted by the Author Dr. Durga Prasad during his tenure of Assistant Professor (Plant Pathology) at BUAT, Banda from 2018 to 2022.

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