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Efficacy of spent mushroom compost, *Pseudomonas fluorescens* with microalgae on early blight (*Alternaria solani*) of potato

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Abstract
A field experiment was conducted using Spent Mushroom Compost, *Pseudomonas fluorescens* and Microalgae at Central Research Field of SHUATS. Potato is prone to several deadly pathogens which disrupts the growth of the plant and cause severe economic loss by destroying the whole plant. Early Blight is one among the disease caused by a plant pathogenic fungi *Alternaria solani*, that can lead to heavy losses in the yield of potato. In order to study about mitigating the foliar damage caused by the pathogen through biological control method, an experiment was performed in SHUATS, Allahabad during 2021-2022 to evaluate the different doses of *Pseudomonas fluorescens* 1% and Microalgae *viz*. 1%, 2%, 3%, 4% and 5% along with Bavistin as treated checked against Early Blight of Potato. The result shows that *P. fluorescens* @ 1% + Microalgae @ 5% was superior over all treatments, recording the minimum disease intensity at 60, 75, 90 and 105 DAS (9.34%, 14.33%, 17.52% and 34.60%) over the control (untreated checked). Hence, the biocontrol agent *Pseudomonas fluorescens* and Microalgae can be used to direct *Alternaria solani* causing early blight of potato.

Keywords: Alternaria solani, early blight, Pseudomonas fluorescens, Microalgae

Introduction
Early blight is one of the most important fungal diseases of potato and is spread worldwide in all major potato growing areas. The causal organism of early blight was first described by as *Macrosporium solani* (Waals *et al*., 2001) [14]. Plant diseases result from complex interactions among plants, pathogens, and the environment. Among these control strategies, Biological Control is one of the most economic and eco-friendly methods to control plant diseases by suppression of populations of plant pathogens using living organisms (Heimpel and Mills, 2017) [7].

Fluorescent pseudomonads are the dominant group of bacterial biocontrol agents currently studied as they are aggressive colonisers of plant surfaces and produce a range of broad spectrum antifungal compounds. *Pseudomonas fluorescens* is an effective biocontrol agent of various diseases caused by soil borne pathogens (Defago *et at*., 1990) [5]. The integration of disease management approaches with fewer effects on the environment and humans is important for sustainable agricultural production (Alabouvette *et al*., 2006) [1]. They compete for space and nutrients with *A. solani* and can produce metabolites that hinder pathogen development or parasitise its mycelium (Alabouvette *et al*., 2006) [1].

Microalgae are classified mainly considering their pigmentation, life cycle and cell structure. Microalgae are able to produce biomass that might be used in different sectors such as: Fuel, food, animal feed, pharmaceutical and crop productions (Metting *et al*., 1990) [10]. Regarding crop productions, microalgae contain high levels of macronutrients and micronutrients essential for an optimal crop growth and development. Moreover, microalgae showed to have potential application as biostimulants and biofertilizers (Gracia *et al*., 2016, Shaaban *et al*., 2001, Khan *et al*., 2009) [6, 11, 9].

Bavistin is a broad spectrum systemic fungicide containing 50% WP carbendazim. Carbendazim 50%WP is effective against a wide range of pathogenic fungi and is highly specific in its control of important plant pathogens on a variety of crops, ornamental plants and plantation crops (Choudhary *et al*., 2012) [2].

SMC possesses many beneficial characteristics including a relatively low bulk density, a low level of heavy metals, and an absence of plant pathogens and weed seeds (Curtin and Mullen, 2007; Zhang and Sun, 2014) [4, 15]. Spent Mushroom Compost (SMC) contains appreciable amounts of Potassium and Calcium and other plant nutrients as well high organic matter content and consistently low heavy metal content (Jordan *et al*., 2008) [8].

Materials and Methods

The experiment was conducted at the experimental research plot of the department of Plant Pathology, Sam Higginbottom University of Agriculture, Technology and Sciences, during the Rabi season of 2021 to 2022.

The experiment was laid out in a randomized block design with 7 treatments and 3 replications. Spent Mushroom Compost was first applied @ 3tonnes/ha as basal seven days before sowing the potato tubers. The tubers were sown upon the ridges with a spacing of 60 cm maintaining plant to plant spacing of 15 cm in a plot size of 2×2 m^2.

Procurement of fluorescent pseudomonads

The antagonistic bacteria *Pseudomonas fluorescens* was manufactured by Amruth Organic Fertilizers and bought from AGROSIAA harvesting growth, containing a liquid formulation of 1×10^8 CFU_s/ml. It was applied to the plants in the form of foliar spray after the first appearance of the symptoms of Early blight of Potato at a dose of 1% (1 ml/1000 L) at 15 days interval for 4 times.

Procurement of Microalgae

Microalgae was manufactured by Phycoline Technologies Pvt. Ltd and bought from Biotik^{TM} OGL. It was applied to the plants at Tillering stage and subsequently at 15 days interval at different doses. 1%, 2%, 3%, 4% and 5% for 4 times through irrigation.

Percent Disease intensity

Percent Disease intensity (%) was recorded at 60, 75, 90 and 105 days after incidence of early blight by the formula given by (Vincent, 1947) [13].

$$\text{Disease intensity (\%)} = \frac{\text{Sum of all numerical rating}}{\text{Total no.of compound leaves observed} \times \text{maximum grade}} \times 100$$

Table 1: Rating Scale (0-5) for measuring disease intensity of early blight of potato.

Scale	Description
0	Free from infection (no visible symptoms)
1	1 – 10% leaf area damaged.
2	10.1 – 20% leaf area damaged.
3	20.1 –50% leaf area damaged.
4	50.1 – 75% leaf area damaged.
5	Above 75% leaf area damaged.

Results and Discussion

The results of the experiment under field condition regarding in management of early blight of potato caused by *A. solani* were presented here.

The result presented in table no. 2 reveals that all the treatment was effective and reduced the disease index of early blight. The minimum disease intensity at 60 DAS was recorded in T6 - (9.34%) followed by T5 - (10.42%), T4 - (11.32%), T3 - (12.26%), T2 - (13.97%), over treated checked T1 – (8.53%) and untreated checked T0 – (14.28%). The minimum disease intensity at 75 DAS was recorded in T6 - (14.33%) followed by T5 - (15.28%), T4 - (16.38%), T3 - (16.87%), T2 - (19.39%) over the treated checked T1- (13.22%) and untreated checked T0 – (20.55%). The minimum disease intensity at 90 DAS was recorded in T6 - (17.52%) followed by T5 - (19.21%), T4 - (21.95%), T3 - (22.54%), T2 - (24.63%) over treated checked T1 – (16.41%) and untreated checked T0 – (28.48%). The minimum disease intensity at 105 DAS was recorded in T6 - (34.60%) followed by T5 - (36.93%), T4 - (39.0%), T3 - (39.83%), T2 - (42.17%) over treated checked T1 - (32.97%) and untreated checked T0 – (44.67%). The usage of SMC, *Pseudomonas fluorescens* 1% with Microalgae 5% reduced the disease intensity of Early blight of potato by 22.5% compared to control at 105 DAS.

The above results are in agreement with the findings of Cupples *et al.*, (2013) [3] who evaluated the efficacy of Streptomycetes + Pseudomonad combination in the management of selected bacterial and fungal diseases of tomatoes under field condition. It was revealed that the spray of *Pseudomonas fluorescens* with Streptomycin species showed significant reduction to the foliar infection under field trails conducted on 2005. Toribio *et al*, (2021) [12] whose findings also agrees with the above result as the selected Microalgal strains (*Leptolyngbya*-1267 and *Scenedesmus*-677) were effective in reducing the infectivity index of the tomato plant blocks which are infected with *Clavibacter michiganensis* subsp. *michiganensis.*

Table 2: Effect of Spent Mushroom Compost, P. fluorescens and different doses of Microalgae on disease intensity of Early Blight of Potato on 60, 75, 90 and 105 DAS.

Treatment No.	Treatment name	Disease Incidence (%)				Reduction in Disease Intensity (%) 105 DAS
		60 DAS	75 DAS	90 DAS	105 DAS	
T0	Control + SMC	14.28	20.55	28.48	44.67	-
T1	Bavistin + SMC	8.53	13.22	16.41	32.97	26.2
T2	Pseudomonas fluorescens + SMC + Microalgae 1%	13.97	19.39	24.63	42.17	5.6
T3	Pseudomonas fluorescens + SMC + Microalgae 2%	12.26	16.87	22.54	39.83	10.8
T4	Pseudomonas fluorescens + SMC + Microalgae 3%	11.32	16.38	21.95	39	12.7
T5	Pseudomonas fluorescens + SMC + Microalgae 4%	10.42	15.28	19.21	36.93	17.3
T6	Pseudomonas fluorescens + SMC + Microalgae 5%	9.34	14.33	17.52	34.60	22.5
CD at 5%		0.44	0.61	0.94	1.35	
S.Ed (±)		0.20	0.28	0.43	1.97	

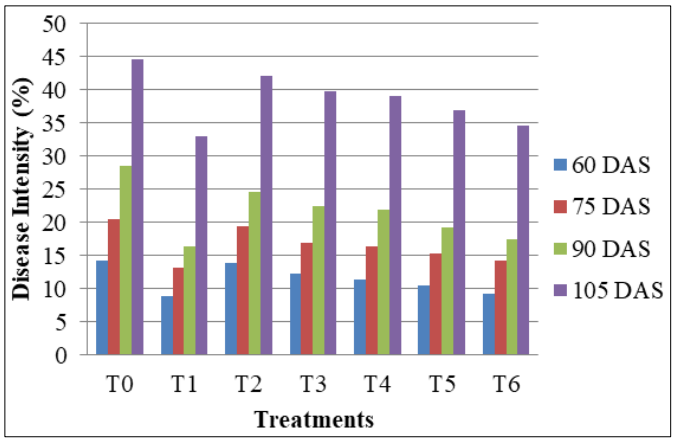

Fig 1: Effect of Spent Mushroom Compost, *P. fluorescens* and different doses of Microalgae on disease intensity of Early Blight of Potato on 60, 75, 90 and 105 DAS

Conclusion

Different concentrations of *Pseudomonas fluorescens* with Microalgae and Bavistin were evaluated against early blight of potato caused by *Alternaria solani*. Based on the result, it was concluded that applications of selected antagonists suppressed the effects of early blight by 22.5% in potato under field conditions. Integrating the microbial antagonists in the management of potato early blight will be beneficial for the sustainable production of potatoes as microbial antagonists have fewer negative effects on the environment and human health. However, the present study was limited to one crop season under Prayagraj conditions, therefore to substantiate the present result more trials are needed for 2-3 seasons for further recommendations.

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