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Effect of rhizobium, alone and in combination with Neem product against early blight *Alternaria solani* (Ell & Mart) disease of potato

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Abstract
An experiment was conducted to evaluate the effect of plant extracts, bioagents and fungicide *in-vivo* and *in situ* against *Alternaria solani* causing early blight of potato. Carbendazim @ 0.1% as treated check was found effective in the disease reduction (48.74%), followed by neem oil @ 1% (38.96%), NSKE @ 5% (38.09%) followed by neem leaf extract @ 1% (37.96%), neem cake 5% (37.45), rhizobium @ 10 g/kg (35.36%) and neem bark @5% (34.17) was found effective in disease reduction (37.96%).

Keywords: Plant extracts, fungicide, potato, *Alternaria solani*

Introduction
Potato (*Solanum tuberosum* L.) popularly known as 'The king of vegetables', has emerged as fourth most important food crop in India after rice, wheat and maize. Indian vegetable basket is incomplete without potato. Because, the dry matter, edible energy and edible protein content of potato makes it nutritionally superior vegetable as well as staple food not only in our country but also throughout the world. The potato crop attacked by a number of pathogen like late blight of potato (*Phytophthora infestans*), early blight of potato (*Alternaria solani*), Wart disease of potato (*Synchytrium endobioticum*), scab disease of potato (*Reptomyc esscabies*) but *Alternaria solani* causing early blight, plays an important role in potato production. (Fontein and Aighewi, 1992). Early blight is also enhanced through continuous potato production. The young plants of potato show high resistance to early blight caused by *A. solani* as compared to older ones. Within the same plant, the lower leaves which are physiologically different from middle and top ones are more susceptible to certain pathogens with resistance increasing in an acropetal direction. Potato early blight symptoms first occur on the lower senescing leaves, which become chlorotic and abscise prematurely. Excessive defoliation may lead to death of the plant and consequent yield loss The pathogen causes consider arable damage to the crop throughout the country wherever the crop grown. In India it may cause up to 40% loss in yield of tubers (More *et al.*, 2016).
The first symptoms usually appear on older leaves and consist of small, irregular, dark brown to black, dead spots ranging in size from a pinpoint to ½ inch in diameter. As the spots enlarge, concentric rings may form as a result of irregular growth patterns by the organism in the leaf tissue (Singh *et al.*, 2016). The losses due to early blight of potato can be managed through the foliar application of plant extracts in disease management is considered as eco-friendly, without any environmental pollution. Plant extracts have been used in disease management for long time as seed treatment but their use as foliar spray is rarely followed approach. The present study was carried out to explore, the efficiency of some plant extracts against early blight of potato caused by *Alternaria solani in vivo* at Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, (U. P), India.
Neem, *Azadirachta indica* commonly known as neem, is native of India and naturalized in most of tropical and subtropical countries are of great medicinal value and distributed wide spread in the world. Every part of neem tree have been known to possess a wide range of pharmacological properties, especially as antibacterial, antifungal, antiulcer, antifeedant, repellent, pesticide, inhibitor and sterilant and is thus commercially exploitable, and hence, traditionally used to treat large number of diseases. This eco-friendly native tree of India is perhaps most researched tree in the world. Fungal diseases of crop plants have always been one of the major constraints in successful crop production which causes severe yield loss every year.

Materials and Methods

In situ Experiment

In order to check effect of foliar spray of fungicide and plant extracts on early blight of potato under field condition, field experiments was laid-out in Randomized block design with three replications. Two sprays were given at an interval of 15 days. Treatments were imposed after appearance of the first disease symptoms. Observations on disease severity of *Alternaria solani* were recorded by using 0-9 disease rating scale of Wheeler (1969) [12] at 15 days interval and yield data were obtained after the harvest on physiological maturity.

Results and Discussion

The plant extracts like neem oil (1%), Azadirachta *indica* (10%), NSKE (5%) neem bark (5%), and neem cake (5%) were tested against *Alternaria solani*. All the botanicals tested were significantly effective in inhibiting the growth of pathogen over control (Table 1). Among different plant extracts tested neem oil at 1 per cent showed maximum inhibition (48.74%) followed by NSKE (46.13%) and least effectiveness was found in neem bark (34.17%).

Table 1: evaluation of plant extracts and fungicide against *alternaria solani in-vitro*

Treatments	Dosage (%)	Per cent inhibition (%)
Propiconazole (Treated check)	0.1%	85.21 (67.35)
Tulsi leaf extract (*Ocimum sanctum*)	10%	34.38 (35.88)
Garlic bulb extract (*Allium sativum* L)	10%	46.13 (46.13)
Neem leaf extract (*Azadirachta indica*)	10%	48.71 (44.24)
Control	-	-
S.Ed. (±)		0.38
C.D (P=0.05)		1.21
Cv %		2.01

The fungus *Trichoderma harzianum* and *Trichoderma asperellum* bio-agents were evaluated *in-vivo* against *Alternaria solani* by dual culture technique and using Potato dextrose agar as basal medium. From the *in-vivo* evaluation of bio-agents, the observations revealed that the maximum reduction in colony growth of *Alternaria solani* was recorded in *Trichoderma harzianum* (63.37%) followed by *Trichoderma asperellum* (58.16%). The results (Table 2) revealed that *Trichoderma harzianum* exhibited fungistatic activity and significantly inhibited mycelial growth of *Alternaria solani*.

Table 2: Evaluation of bio-agents against *Alternaria solani in-vitro*

Treatments	Per cent inhibition (%)
Trichoderma harzianum	63.37 (52.73)
Trichoderma asperellum	58.16 (49.67)
Control-	
S.Ed. (±)	0.33
C.D (P=0.05)	1.15
Cv %	1.66

A field study was carried out to assess the Effect of Rhizobium, alone and Incombination with Neem Product Against Early Blight *Alternaria solani* with two sprays taken up at 60 DAT and 90 DAT during *rabi* season 2016-2017 (Table 3). Two sprays were given at 60 DAT and 90 DAT. Minimum disease intensity was recorded in *Azadirachta indica* at 60, 75 and 90 days after spray (20.33%, 27.45% and 30.44% respectively) followed by, *Allium sativum* (21%, 31.27%, 35.24% respectively), *Ocimum sanctum* (23.67%, 36.69% and 41.20% respectively), *Trichoderma harzianum* (26.33%, 47.36% and 44.46% respectively) *Trichoderma asperellum* (27.67%, 45.05% and 52.39% respectively) and treated check propiconazole showing disease intensity (16.67%, 20.51% and 22.32% respectively) was also found effective and found statistically significant from control (29%, 50.47% and 60.82%, respectively).

Table 3: Effect of treatments on disease intensity at 60, 75 and 90 DAT

Treatment No.	Treatments	Disease Intensity (%)		
		45DAS	60DAS	90DAS
T_1	Rhizobium	2 (24.08)	20.51 (26.91)	22.32 (28.18)
T_2	Carbendazim (Treated chek)	27.67 (31.72)	45.05 (42.14)	27.10 (46.35)
T_3	Neem oil		27.45 (31.58)	30.44 (33.47)
T_4	Neem Leaf Extract (*Azadirachta indica)*	20.33 (26.79)	31.27 (33.98)	35.24 (36.40)
T_5	Neem cake	26.33 (30.86)	42.48 (40.65)	47.36 (43.46)
T_6	Neem bark	23.67 (29.10)	36.69 (37.26)	41.20 (39.91)
T7	Neem Seed Kernel Extract			
T_0	Control	29 (32.57)	50.47 (45.25)	60.82 (51.22)
S.E d(±)		1.22	0.78	0.52
C.D.(P=0. 05)		2.67	1.70	1.14

Conclusion

Based on the results *Azadirachta indica* (10%) were found the most effective treatments showing minimum disease intensity and produced maximum grain yield (t/ha) and recorded highest cost benefit ratio as compare to other treatments except propiconazole, which was taken as treated control. *Azadirachta indica* @ 10% concentration were found as best treatment to management of sheath blight disease of paddy. Since chemicals have many harmfull effects on the environment as well as the human health, they would be considered as better as they are eco-friendly and can also be recommended to the farmers for the efficient management of disease. The present research findings are limited to one crop season under Allahabad agroclimatic conditions as such more trails are required in future to validate the findings.

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