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Management of major soilborne diseases of brinjal using different bioagents and fungicides

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Abstract
Eggplant is one of the important economic vegetable crop which is attacked by several serious diseases. Among them, soilborne diseases *viz*., root rot, fungal and bacterial wilts are the major constraints in brinjal cultivation. Two field experiments were conducted to test the efficacy of different bioagents and fungicides against major soilborne diseases (root rot, fungal and bacterial wilt) of brinjal during March 2015- July 2015 and August 2015-December 2015. The results revealed that, seed treatment with *Pseudomonas*-TNAU-Pf1 (10 g/kg) + soil drenching with copper hydroxide (0.2%) at 30 and 60 days after planting recorded minimum incidence of root rot, fungal and bacterial wilt and also higher fruit yield compared to other treatments.

Keywords: Bioagents, brinjal, fungicides, management, root rot, wilt

Introduction
Brinjal or egg plant (*Solanum melongena* L.) is one of the most common, highly productive and popular vegetable crops grown in India. The yield of brinjal has been affected by various fungal, bacterial, viral and phytoplasma diseases. Among them root rot (*Rhizoctonia solani*), fungal (*Fusarium solani*) and bacterial wilt (*Ralstonia solanacearum*) are the most wide spread and serious soilborne diseases (Singh, 1998; Sharma *et al*., 2004; Chakravarty and Kalita, 2012) [1, 2, 3]. Although fungicides have shown promising results in controlling the soilborne diseases, phytotoxicity and fungicide residues are major problems leading to environmental pollution and human health hazards. Further, it remains too expensive for the majority of small holders.

The integrated approach (fungicides and biocontrol agents) is the novel idea to manage crop diseases as it involve minimum fungicidal load in nature. Many fungal and bacterial agents have been examined over a period of time for their potential as biocontrol agents. Several species of *Pseudomonas* and *Trichoderma* have been reported to suppress soilborne diseases caused by various fungal and bacterial pathogens (Ramamoorthy *et al*., 2001; Radjacommare *et al*., 2002; Latha *et al*., 2011; Anand, 2021) [4, 5, 6, 7]. Thus, in the present study, the objective was formulated to investigate the effect of different bioagents and fungicides against major soil borne diseases of brinjal under field conditions.

Materials and Methods
Biocontrol agents
The isolates of *Pseudomonas*-TNAU Pf1 and *Trichoderma asperellum* were obtained from the Culture Collection Section, Department of Plant Pathology, Tamil Nadu Agricultural University (TNAU), Coimbatore, India.

Preparation of talc-based bioformulation
A loopful of *Pseudomonas* strain was inoculated into sterilized Kings'B (KB) broth (20 g peptone; 1 g each magnesium sulphate and potassium dihydrogen phosphate; 10 ml glycerol; 1 l distilled water) and incubated in a rotary shaker at 150 rpm for 48 h at room temperature (28±2 °C). After 48 h of incubation, the broth containing 9 x 10^8 cfu/ml was used for the preparation of talc-based formulation. To the 400 ml of bacterial suspension, 1 kg of the talc powder (sterilized at 105 °C for 12 h), calcium carbonate 15 g (to adjust the pH to neutral) and carboxymethyl cellulose (CMC) 10 g (adhesive) were mixed under sterile conditions, following the method described by Nandakumar *et al.* (2001) [8]. After shade drying for overnight, it was packed in polypropylene bag and sealed.

At the time of application, the population of bacteria in talc formulation was 2.5–3 x 10^8 cfu/g.

Trichoderma asperellum isolate was multiplied in molasses-yeast broth (30 ml molasses; 5 g yeast; 1 l distilled water). The sterile broth was inoculated with an actively growing mycelial disc (8 mm) and incubated for 10 days. The biomass (3 ± 10^8 cfu/ml) along with the medium was incorporated into the sterilized talc powder at the rate of 50 ml of suspension per 100 g of talc powder and thoroughly mixed with 500 mg CMC as described by Ramakrishnan *et al*. (1994) [9].

Effect of different bioagents and fungicides against root rot and wilt diseases under field conditions

Two field experiments were conducted during March 2015-July 2015 and August 2015-December 2015 at Regional Research Station farm, Paiyur to test the efficacy of different bioagents and fungicides individually and in combination against major soilborne diseases of brinjal. The treatments of the experiments were

The treatments of the experiments were

T1- *Pseudomonas* TNAU-Pf1 [Seed Treatment (ST): 10g/kg+ Soil application (SA): 2.5 kg/ha]
T2- *Trichoderma asperellum* [ST: 4 g/kg+ SA: 2.5 kg/ha]
T3- ST with TNAU-Pf1+ Soil drenching (SD) with carbendazim+mancozeb (0.2%)
T4- ST with Ta+SD with carbendazim+mancozeb (0.2%)
T5- ST with TNAU-Pf1+SD with copper hydroxide (0.2%)
T6- ST with Ta+SD with copper hydroxide (0.2%)
T7- ST (2g/kg) + SD (0.2%) with carbendazim+mancozeb
T8- ST (2g/kg) + SD (0.2%) with copper hydroxide
T9- Untreated control

The experiment was conducted in Randomized Block Design (RBD) with three replications using the hybrid Dhuruva.

Method of application

Before sowing, brinjal seeds (Hybrid Dhuruva) were treated with talc-based formulation of bioagents and fungicides as per the treatment schedule. The seeds not treated with bioagent or fungicide served as control. The talc-based formulation of bioagents and fungicides were applied at 30 and 60 days after planting (DAP) as soil application/soil drenching.

Disease assessment

The incidence of root rot, fungal and bacterial wilt was recorded at 30, 60 and 90 days after planting and % disease incidence was calculated using the formula:

% disease incidence = (No. of infected plants/Total number of plants) x 100.

The fruit yield in different treatments was also recorded.

Statistical analysis

The data were subjected to analysis of variance (ANOVA) using the IRRISTAT version 92-1 programme developed by the Biometrics Unit, International Rice Research Institute, The Philippines. Disease incidence data were arc-sine transformed before analysis. The treatment means were compared by Duncan's multiple range test (DMRT) (Gomez and Gomez, 1984) [10].

Results and Discussion

The bioagents and fungicides individually and in combination significantly reduced the incidence of root rot, fungal and bacterial wilt of brinjal compared to untreated control (Table 1). Among the different treatments, seed treatment (ST) with *Pseudomonas* (TNAU-Pf1) plus soil drenching (SD) with copper hydroxide (0.2%) recorded only 0.66, 0.33 and 0.00% incidence of root rot, fungal and bacterial wilt, respectively followed by ST with TNAU-Pf1 plus soil application of TNAU-Pf1 and ST with TNAU-Pf1 plus soil drenching with carbendazim+mancozeb at 30 and 60 days after planting and both treatments were on par with each other. The fungicide *viz*., copper hydroxide and carbendazim+mancozeb alone treated plots recorded 6.43, 5.70 and 0.00% and 8.85, 6.94 and 0.33% incidence of root rot, fungal and bacterial wilt, respectively. Untreated control plot recorded the incidence of 17.17, 12.84 and 2.26% root rot, fungal and bacterial wilt, respectively.

The results on fruit yield revealed that the highest fruit yield of 27.91 tonnes/ha with BC ratio of 1:3.9 was obtained in ST with TNAU-Pf1 plus SD with copper hydroxide. This was followed by ST with TNAU-Pf1 plus soil drenching with carbendazim+mancozeb and ST with TNAU-Pf1 plus soil application of TNAU-Pf1 which recorded a fruit yield of 26.85 and 26.20 tonnes/ha and both treatments were on par with each other. Untreated control plots recorded a minimum fruit yield of 18.23 tonnes/ha (Table 2).

In the second season also, similar trend of results were obtained. Seed treatment (ST) with TNAU-Pf1 @ 10 g/kg +SD with copper hydroxide (0.2%) at 30 and 60 DAP recorded only 1.22, 0.96 and 0.00% incidence of root rot, fungal wilt and bacterial wilt, respectively, whereas untreated control plots recorded the incidence of 21.13% root rot, 18.05% fungal wilt and 7.42% bacterial wilt (Table 3). The data on fruit yield revealed that ST with TNAU-Pf1 @ 10 g/kg +SD with copper hydroxide (0.2%) at 30 and 60 DAP recorded higher fruit yield of 24.04 tonnes/ha with BC ratio of 1:3.6. Untreated control recorded only 12.80 tonnes/ha (Table 4).

Tewari and Mukhopadhyay (2003) [11] reported that seed treatment with antagonist followed by fungicide application gave excellent control of chickpea and lentil wilt-complex. The present findings are supported by other workers that integration of biocontrol agents with fungicides provided significantly higher yields in several crops against seed and soil-borne pathogens than obtained by either biocontrol agents or fungicides alone (Vyas, 1994; Deepak and Dubey, 2001; Pant and Mukhopadhyay, 2001; Anand *et al*., 2011) [12, 13, 14, 15].

Table 1: Effect of bioagents and fungicides on the incidence of soilborne diseases in brinjal (Season I)

S. No.	Treatments	Root rot (%)	Fungal wilt (%)	Bacterial wilt (%)
1.	TNAU-Pf1 (ST @ 10 g/kg + SA @ 2.5 kg/ha)	3.58^{b}	2.72^{b}	0.00^{a}
2.	*T. asperellum*-Ta (ST @ 4 g/kg + SA @ 2.5 kg/ha)	7.05^{de}	5.93^{d}	0.66^{a}
3.	ST with TNAU-Pf1 + SD with carbendazim + mancozeb (0.2%)	3.03^{b}	3.44^{bc}	0.00^{a}
4.	ST with Ta + SD with carbendazim+mancozeb (0.2%)	6.77^{cd}	5.35^{cd}	0.33^{a}
5.	ST with TNAU -Pf1 + SD with copper hydroxide (0.2%)	0.66^{a}	0.33^{a}	0.00^{a}
6.	ST with Ta + SD with copper hydroxide (0.2%)	5.48^{c}	2.70^{b}	0.00^{a}
7.	ST (2 g/kg) + SD (0.2%) with carbendazim+mancozeb	8.85^{e}	6.94^{d}	0.33^{a}
8.	ST (2 g/kg) + SD (0.2%) with copper hydroxide	6.43^{cd}	5.70^{d}	0.00^{a}
9.	Untreated control	17.17^{f}	12.84^{e}	2.26^{b}

Values are means of three replications. In a column, means followed by a common letter are not significantly different at 5% level by DMRTs

Table 2: Effect of bioagents and fungicides on the fruit yield of brinjal (Season I)

S. No.	Treatments	Yield/plot (Kg)	Yield/ha (tonnes)	BCR
1.	TNAU-Pf1 (ST @ 10 g/kg + SA @ 2.5 kg/ha)	34.06^{b}	26.20^{b}	3.2
2.	*T. asperellum*-Ta (ST @ 4 g/kg + SA @ 2.5 kg/ha)	28.63^{f}	22.03^{e}	2.6
3.	ST with TNAU-Pf1 + SD with carbendazim + mancozeb (0.2%)	34.90^{b}	26.85^{b}	3.2
4.	ST with Ta + SD with carbendazim+mancozeb (0.2%)	30.47^{e}	23.43^{d}	2.6
5.	ST with TNAU -Pf1 + SD with copper hydroxide (0.2%)	35.95^{a}	27.91^{a}	3.9
6.	ST with Ta + SD with copper hydroxide (0.2%)	32.37^{c}	24.89^{c}	3.0
7.	ST (2 g/kg) + SD (0.2%) with carbendazim+mancozeb	31.37^{d}	24.13^{c}	2.7
8.	ST (2 g/kg) + SD (0.2%) with copper hydroxide	31.80^{d}	24.56^{c}	2.8
9.	Untreated control	24.70^{g}	18.23^{f}	-

Values are means of three replications. In a column, means followed by a common letter are not significantly different at 5% level by DMRTs

Table 3: Effect of bioagents and fungicides on the incidence of soilborne diseases in brinjal (Season II)

S. No.	Treatments	Root rot (%)	Fungal wilt (%)	Bacterial wilt (%)
1.	TNAU-Pf1 (ST @ 10 g/kg + SA @ 2.5kg/ha)	3.14^{b}	2.95ab	1.65^{b}
2.	*T. asperellum*-Ta (ST @ 4g/kg + SA @ 2.5kg/ha)	6.96^{de}	5.20cd	4.40^{c}
3.	ST with TNAU-Pf1 + SD with carbendazim + mancozeb (0.2%)	4.53^{bc}	3.48bc	1.94^{b}
4.	ST with Ta + SD with carbendazim+mancozeb (0.2%)	6.25^{cd}	6.52d	3.92c
5.	ST with TNAU -Pf1 + SD with copper hydroxide (0.2%)	1.22^{a}	0.96a	0.00^{a}
6.	ST with Ta + SD with copper hydroxide (0.2%)	5.92^{cd}	5.63^{cd}	0.33^{ab}
7.	ST (2g/kg) + SD (0.2%) with carbendazim+mancozeb	8.97^{e}	8.99^{e}	3.37^{c}
8.	ST (2g/kg) + SD (0.2%) with copper hydroxide	7.20^{e}	6.41^{d}	1.42^{b}
9.	Untreated control	21.13^{f}	18.05^{f}	7.42^{d}

Values are means of three replications. In a column, means followed by a common letter are not significantly different at 5% level by DMRTs

Table 4: Effect of bioagents and fungicides on the fruit yield of brinjal (Season II)

S. No.	Treatments	Yield/plot (Kg)	Yield/ha (tonnes)	BCR
1.	TNAU-Pf1 (ST @ 10 g/kg + SA @ 2.5 kg/ha)	28.6^{b}	22.88^{b}	3.2
2.	*T. asperellum*-Ta (ST @ 4 g/kg + SA @ 2.5 kg/ha)	25.7^{cd}	20.56^{c}	2.7
3.	ST with TNAU-Pf1+SD with carbendazim + mancozeb (0.2%)	28.1^{b}	22.48^{b}	3.1
4.	ST with Ta + SD with carbendazim+mancozeb (0.2%)	25.8^{cd}	20.64^{c}	2.6
5.	ST with TNAU -Pf1 + SD with copper hydroxide (0.2%)	29.8^{a}	24.04^{a}	3.6
6.	ST with Ta + SD with copper hydroxide (0.2%)	26.1^{c}	20.92^{c}	2.7
7.	ST (2 g/kg) + SD (0.2%) with carbendazim+mancozeb	23.6^{e}	18.88^{e}	2.3
8.	ST (2 g/kg) + SD (0.2%) with copper hydroxide	24.8^{d}	19.28^{d}	2.5
9.	Untreated control	16.0^{f}	12.80^{f}	-

Values are means of three replications. In a column, means followed by a common letter are not significantly different at 5% level by DMRTs

Conclusion

Based on the findings of the present investigation it may be concluded that, seed treatment with *Pseudomonas* (TNAU-Pf1) (10 g/kg) + soil drenching with copper hydroxide (0.2%) at 30 and 60 days after planting was found to be effective in controlling root rot, fungal and bacterial wilt diseases and also gave the higher fruit yield.

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