The Pharma Innovation Journal 2022; 11(8): 229-231

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(8): 229-231

www.thepharmajournal.com
Received: 08-06-2022
Accepted: 11-07-2022

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Development of integrated management against bacterial wilt of brinjal

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Abstract
Experimental trails were conducted at All India Coordinated Research Programme, Bhubaneswar, OUAT during pre winter 2018 and 2019 to find out the effective treatments for integrated management of bacterial wilt caused by *Ralstonia solanacearum*. Among 14 different treatments, combination of neem cake+ *P. fluorescens*+ *T. viride* showed less per cent wilt incidence at 120 DAT (27.54%) in Pusa Anupam and (23.43%) in Pusa Uttam was recorded. Further per cent disease reduction over control was significantly highest was observed in combination of neem cake+ *P. fluorescens*+ *T. viride* (50.08%) in Pusa Anupam and 51.31% in Pusa Uttam and highest yield 30.54 t/ha & 33.75 t/ha was obtained in combination of neem cake+ *P. fluorescens*+ *T. viride* treated plot in Pusa Anupam & Pusa Uttam.

Keywords: Mustard cake, neem cake, *Pseudomonas fluorescens, Ralstonia solanacearum* and *Trichoderma viride*

Introduction
The brinjal (*Solanum melongena* L.) belongs to the family solanaceae, is a common and popular vegetable crop in India. Odisha is the second largest state in production of brinjal after West Bengal. In Odisha brinjal is grown in an area of 16.1 thousand ha with production of 2127.46 MT (APEDA, 2020-2021) [1]. Bacterial wilt is a major threat to brinjal production. The characteristic symptoms include wilting of the foliage, followed by collapse of the entire plant. In the xylem vessels the pathogen dissolves the cell walls and produce highly polymerized polysaccharides that increase the viscosity of the xylem and results in plugging. Blocking of vessels by bacteria is the major cause of wilting. The bacterium can survive in soil or infected plant debris for prolonged periods Grey *et al.* (2001) [4]. *R. solanacearum* causes yield loss up to 60 per cent and it taken as a susceptible variety for integrated disease management. Neem seed kernel extract 20% + Copper oxychloride + Streptocycline (73.84) were found effective treatment for integrated management of *R. solanacearum* infecting brinjal Sawant *et al.* (2014) [9].
The destructiveness of the pathogen is attributed to its wide spread occurrence, the existence of different strains, its exceptional ability to survive in soil and its broad host range. Not much effort has been directed towards the production of plant bactericides and as a result, very few effective ones are available today for managing plant bacterial diseases. Considering all these factors, the integrated disease management of *R. Solanacearum* would be ideal and which is very effective, economical, eco-friendly and highly specific in the context of the bacterial diseases such as bacterial wilt.

Materials and Methods
The experiments were conducted in sick plots of AICRP on Vegetables, OUAT, Bhubaneswar, during pre winter of 2018-19 & 2019-2020. The field trial was laid out in split plot design with 14 treatments inclusive of control replicated thrice. The plots measuring 3m x 2.7m were marked and randomly selected five plants in each plot were selected and labelled. The required quantities of the chemicals were weighed and suitably dissolved in a requisite quantity of water to get desired concentrations. Treatments were imposed at the time of transplanting; initially soil application organic amendments was to be taken at the rate of 20 g/plant. Bioagents were applied as seedling dip as well as soil drenching method was followed. Soil application of chemical was carried out at the time of transplanting. Wilt observations were taken at 30, 60, 90 and 120 days after transplanting.

Main plots: 2
Pusa Anupam
Pusa Uttam

Sub plots: Particulars of treatment
T1- Streptomycin sulphate (0.01%)
T2- Application of bleaching powder @12 kg/ha
T3- Neem oil cake (250 kg/ha)
T4- Mustard cake (250 kg/ha)
T5- *Pseudomonas fluorescence* (1.5 kg/ha)
T6- *Trichoderma viride* (1.5 kg/ha)
T7- *P. fluorescens* (1.5 kg/ha) +*T. viride* (1.5 kg/ha)
T8- Neem cake (250 kg/ha)+ *P. fluorescens* (1.5 kg/ha)
T9- Neem cake (250 kg/ha)+ *T. viride* (1.5 kg/ha)
T10- Mustard cake (250 kg/ha)+ *P. fluorescens* (1.5 kg/ha)
T11- Mustard cake (250 kg/ha)+ *P. fluorescens*(1.5 kg/ha) + *T. viride* (1.5 kg/ha)
T12- Neem cake (250 kg/ha) + *P. fluorescens* (1.5 kg/ha) + *T. viride* (1.5 kg/ha)
T13- Neem cake (250 kg/ha)+ Mustard cake (1.5 kg/ha)+ *P. fluorescens* (1.5 kg/ha)
T14- Control

Per cent disease incidence
Disease incidence (DI) was calculated with the following formula (Guo *et al*., 2004):

$$PDI = \frac{\text{Number of wilted plants per plot}}{\text{Total number of plants per plot}} \times 100$$

Results and Discussion
In field condition wilt incidence was reduced significantly in all the treatments over control. The maximum wilt incidence was recorded in control plots of Pusa Anupam was (59.44%). Among all the 14 treatments, combination of T12 (Neem cake+ *P. fluorescens* + *T. viride*) showed lowest per cent of wilt incidence (27.54%) followed by T13 (Neem cake+ mustard cake + *P. fluorescens*) showed wilt incidence of 29.17% statistically at par with T11 (mustard cake + *P. fluorescens* + *T. viride*) wilt incidence was 30.39% followed by T8 (Neem cake + *P. fluorescens*) was 31.64% and T9 (Neem cake+ *T. viride*) showed per cent wilt incidence of 33.74% respectively. In T7 *P. fluorescens* +*T. viride* showed 37.63% followed by T1 (Streptomycin sulphate) wilt incidence was 40.81%. In T5 (*Pseudomonas fluorescens*) wilt incidence (41.79%) statistically at par with T3 Neem cake (45.28%), T4 Mustard cake (47.72%) and T2 bleaching powder (49.29%). The maximum Per cent disease reduction over control was observed in Pusa Anupam was T12 (Neem cake+ *P. fluorescens* + *T. viride*) 52.86%.
The maximum yield was observed in Pusa Anupam was T12 (Neem cake+ *P. fluorescens* + *T. viride*) was 30.54 t/ha followed by T13 (Neem cake + mustard cake + *P. fluorescens*) was 29.26 t/ha.

Table 1: Integrated management of bacterial wilt of brinjal during 2018 to 2020

S. No.	Treatments	Wilt incidence (%)			Per cent disease reduction over control	Yield (t/ha)	
		Pusa Anupam	Per cent disease reduction over control	Pusa Uttam		Pusa Anupam	Pusa Uttam
1	Streptomycin sulphate	40.81 (39.70)	30.15	36.44 (37.13)	33.75	24.93	27.56
2	Bleaching powder	49.29 (44.59)	15.64	38.75 (38.50)	29.56	21.06	26.94
3	Neem cake	45.28 (42.29)	22.50	40.62 (39.59)	26.16	22.53	26.32
4	Mustard cake	47.72 (43.69)	18.32	42.07 (40.44)	23.52	21.62	25.84
5	*Pseudomonas fluorescens*	41.79 (40.27)	28.47	37.46 (37.74)	31.90	24.54	27.69
6	*Trichoderma viride*	44.26 (41.70)	24.25	43.12 (41.05)	21.61	23.22	25.11
7	*P. fluorescens* +*T. viride*	37.63 (37.84)	35.60	35.76 (36.72)	35.00	26.07	28.43
8	Neem cake+*P. fluorescens*	31.64 (34.23)	45.85	30.05 (33.24)	45.37	26.94	31.87
9	Neem cake + *T. viride*	33.74 (35.51)	42.26	33.54 (35.39)	39.03	27.51	29.54
10	Mustardcake+*P. fluorescens*	35.26 (36.43)	39.65	30.92 (33.79)	43.79	28.72	30.04
11	Mustardcake+*P. fluorescens* + *T. viride*	30.39 (33.45)	47.99	25.58 (30.38)	53.50	28.73	32.96
12	Neem cake + *P. fluorescens* + *T. viride*	27.54 (31.65)	52.86	23.43 (28.95)	57.41	30.54	33.75
13	Neem cake + Mustardcake + *P. fluorescens*	29.17 (32.69)	50.08	26.79 (31.17)	51.31	29.26	32.42
14	Control	59.44 (49.85)		55.01 (47.88)		18.36	20.47
	S.Em±	0.16		0.40		0.13	0.31
	CD (5%)	1.09		1.16		0.87	0.94

Interaction (wilt incidence %) Main plot × Sub plot	Sub plot at same level of main plot	Main plot at same level of sub plot
S.Em±	0.62	0.58
CD (5%)	1.98	1.83
Yield Sub plot × Main plot		
S.Em±	0.49	0.45
CD (5%)	1.57	1.43

In Pusa Uttam, among all the 14 treatments, maximum wilt incidence (55.01%) was recorded in control plot. In T12 (Neem cake+ *P. fluorescens* + *T. viride*) showed less per cent wilt incidence (23.43%) followed by T11 (mustard cake + *P. fluorescens* + *T. viride*) with per cent wilt incidence of (25.58%). In T13 (Neem cake+ mustard cake+*P. fluorescens*) wilt incidence was 26.79% and T8 (Neem cake + *P. fluorescens*) showed per cent disease incidence of 30.05% and T10 (mustard cake+ *P. fluorescens*) 30.92% were statistically at par. In Pusa Uttam, the maximum Per cent disease reduction over control was observed in T12 (Neem cake+ *P. fluorescens* + *T. viride*) was 57.41%.

All the treatments increased yield (Table 1) significantly compared to the control in Pusa Uttam. The maximum yield was observed in T12 (Neem cake+ *P. fluorescens* + *T. viride*) was 33.75 t/ha followed by T11 (Mustardcake+*P. fluorescens* + *T. viride*) showed 32.96 t/ha.

The present results were supported by Revathi *et al*. (2018) [8] observed that among the 12 treatments T11 (Neem cake + *P. Fluorescence* + *T. harzianum* + streptocycline + copper oxychloride) was found to be more effective compare to other treatments with respect to less incidence of disease. Biswas and Singh, (2008) [2] tested *Bacillus subtilis*, *Pseudomonas fluorescens* and *Trichoderma viride* against tomato wilt caused by *R. solanacearum* and observed that *Pseudomonas fluorescens* was effective in minimizing the disease.

Because neem cake, *P. fluorescens* and *T. harzianum* applied at the time of transplanting and they acts against *R. solanacearum* though it is a soil borne pathogen. Murthy and Srinivas (2012) [5] observed that the *in vitro* studies of *Pseudomonas fluorescens* and *Trichoderma* species showed antagonistic effects against *R. solanacearum.* Bioagents exhibits competition, antibiosis and induce systemic resistance as well as significantly improved plant growth by producing the growth hormones and other growth promoting substances, *viz*., auxins, indole-3-acetic acid, and gibberellins Ramamoorthy & Samiyappan (2001) [7]. The effectiveness of streptomycin sulphate was observed by Pavithra and Khatib (2014) [6] tested that combination of Streptocycline and Copper oxychloride has maximum inhibition activity among different treatments.

The treatments were used in the present management studies produced minimum final bacterial population in the soil along with less percent wilt incidence. This might be due to the multiple actions of all these treatments. This finding was also supported by Revathi *et al*. (2018) [8].

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