



E-ISSN: 2320-7078

P-ISSN: 2349-6800

www.entomoljournal.com

JEZS 2022; 10(1): 316-322

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Received: 19-11-2021

Accepted: 23-12-2021

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Field evaluation of *Pseudomonas fluorescens* against the cotton leaf roller, *Sylepta derogate* (Crambidae: Lepidoptera) in Bt and non Bt cotton

Manjula TRDOI: <https://doi.org/10.22271/j.ento.2022.v10.i1d.8952>**Abstract**

An investigation was carried out during 2015-16 and 2016-17 to evaluate the *Pseudomonas fluorescens* against the leaf roller, *Sylepta derogata*, in Bt and non Bt cotton at Vanavarayar Institute of Agriculture, Pollachi. Apart from the infestation, comparative seed cotton yield was also assessed. The obtained results indicated that all treatments except control exhibited a great reduction in leaf roller infestation and the larval population. The treatment could be arranged descendingly according to the general reduction of two seasons as follows; Profenophos 50 EC @ 1 lit/ha, Foliar application of *P. fluorescens* @1% and *Beauveria basianna* @ 1%, Soil and Foliar application of *P. fluorescens* @1%, Foliar application of *Beauveria basianna* @ 1%, Foliar application of *P. fluorescens* @1% and Soil application of *P. fluorescens* 2.5 kg/ha against pink bollworm.

Keywords: *Sylepta derogata*, *Pseudomonas fluorescens*, Bt and non Bt cotton

Introduction

Cotton (*Gossypium hirsutum* L.) is currently the superior plant fabric worldwide, grown commercially in the temperate and tropical regions of more than 50 countries. To meet developing fiber demands, the adequate production of cotton, forever booming the world's population is now universally realized (Farooq *et al.*, 2013) [5]. This cotton crop has a significant bequeath to the Indian economy by earning more than 30 percent of the total foreign exchange. Cotton fiber generates high employment at various stages and is commonly called 'White Gold'. It plays a major role in sustaining the livelihood of an estimated 5.8 million cotton farmers and 40- 50 million people engaged in the subordinate event such as cotton processing and trade. India got first place in the world in cotton acreage with around 118.8 lakh hectares are under cotton cultivation i.e. around 39.2% of the World area of 304.5 lakh hectares. Precisely 62% of India's Cotton is produced on rare regions and areas and 38% on irrigated lands. According to the CICR report, India would produce 6.5 million tones (38 m bales of 170 kg/bale) of cotton fiber during 2016-17 and India's Productivity is estimated at 568.3 kg/ha. In India 45% of the pesticides are implemented in cotton alone (David 2008) [4]. In cotton, the insect pests cause deterioration in lint quality and 10–40% losses in crop production and overall nearly 30–45% yield reduction can be provoked by insect pests (Gahukar, 2006) [6].

Polyphagous pests on cotton crops across Indian cotton-growing states, causing serious economic crop damage, are sap-sucking ones, such as aphids, jassids, mealybugs, whiteflies, thrips, mites and a number of caterpillar pests, such as bollworms, *Spodoptera* spp., *Anomis* spp. and leaf roller, *Sylepta derogate*, red cotton bug (cotton stainer bug) such as *Dysdercus* spp. and dust bugs such as *Oxycarenus hyalinipennis* (Costa) and *O. laetus* (Kirby). The cotton leaf roller, *S. derogate* is distributed in rainfed cotton-growing states. Severe infestation results in complete defoliation of the plant. The young larvae feed gregariously on the leaf epidermis under a loose web of threads strung between leaf hairs on the underside of the leaves (Anioke 1989) [1]. At about four days old, the larvae cut the leaf margins perpendicular to the vein, rolled it under towards the midrib and fixed it with silk. They then feed within the protection of the rolled leaf. The leaf remains green and open at the apex. They occur within the leaf roll, but sometimes can occur on shed leaves or in leaf litter on the ground. *S. derogata* hibernates in the larval stage inside a leaf fold on the soil.

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Materials and Methods

The present field experiments were carried out at Vanavarayar Institute of Agriculture, Pollachi (VIA) during kharif 2016 and 2017 to evaluate the efficacy of *P. fluorescens* against cotton leaf roller in Bt cotton and non Bt cotton. The trials were laid out in a randomized block design (RBD) with seven treatments, including control, each replicated four. The treatments namely,

- T1: Foliar application of *P. fluorescens* @1%,
- T2: Soil application of *P. fluorescens* 2.5 kg/ha,
- T3: Soil and Foliar application of *P. fluorescens* @1%,
- T4: Foliar application of *P. fluorescens* @1% and *Beauveria basianna* @ 1%,
- T5: Foliar application of *Beauveria basianna* @ 1%,
- T6: Profenophos 50 EC @ 1 lit/ha and
- T7: Untreated checks were evaluated.

Replicated four times with the plot size of each experimental unit was 6 x 5 m. Row to row and plant to plant distance was maintained as 90 x 60 cm, respectively. The crop was raised following all standard agronomical practices. The surfactant, Teepol was added @ 1ml per litre of water to the treatments. Three rounds of sprays, were given using the hand-operated Knapsac sprayer when the population of *S. derogata* exceeded the ETL 10 percent leaf damage in any one replication. The number of larvae in each plot/replication was recorded on five plants selected at random for the above observations. The observations were made at three stages viz., pretreatment, third and seventh day after each spraying. The seed cotton yield per replication was recorded at harvest. The values were then transformed to square root transformation for number and data was subjected to analysis of variance. The first spray was done at the economic threshold level (ETL) and subsequent spray was given at fortnight intervals.

Statistical analysis

The larval counts in the field experiments were transformed into square root values and arcsine values as per the standard

requisites (Gomez and Gomez, 1984). The analysis of variance in different experiments was carried out in AGRES ver. 7.01 and the means were separated by Duncan's new Multiple Range Test (DMRT) available in the package.

Field experiment during 2015-16

Observations recorded on the larval population prior to treatments showed that the differences were not significant. Table 1 (Bt cotton) revealed that all the treatments had a significant effect in minimizing, recording a pooled mean from 1.07 to 2.94 larvae/ five plants after three spraying as compared to 6.31 larvae/five plants in control. Among all the treatments, the foliar application of *P. fluorescens* @1% and *Beauveria basianna* @ at 1% was found most compelling, gave minimum population of 1.94 larvae/ plants, with 69.26 per cent reduction over control, followed by soil and foliar application of *P. fluorescens* @ 1%. The data predicted in Table 2 (non Bt cotton) revealed that after three sprays pooled mean number of leaf roller *S. derogata* larvae ranged from 1.46 to 8.83 larvae/ five plants, foliar application of *P. fluorescens* @1% and *Beauveria basianna* @ 1% was observed most effective treatment by giving 2.52 larvae/five plants with 71.46 per cent reduction over control. Followed by soil and foliar application of *P. fluorescens* @1%, foliar application of *B. basianna* @ 1%, Foliar application of *P. fluorescens* @1%, and Soil application of *P. fluorescens* 2.5 kg/ha were gave good results.

The statistically analyzed data presented in Fig. 1, showed that after three sprays pooled mean number of *S. derogata* larvae ranged from 1.07 to 6.31 and 1.46 to 8.83 larvae/ plants in Bt and non Bt cotton respectively. The profenophos 50 EC @ 1 lit/ha was found highly effective among all the treatments with of 1.07 and 1.46 larvae/five plants with 83.0 and 83.5 per cent reduction over control in Bt and non Bt cotton respectively. The next treatments in order were foliar application of *P. fluorescens* @1% & *B. basianna* @ 1% was found effective (69.3 and 71.5 per cent respectively) (Fig.2).

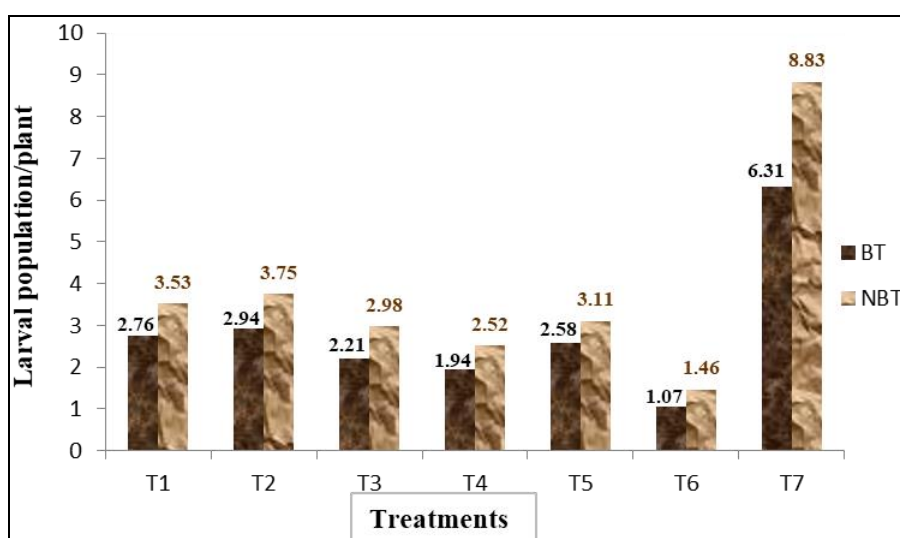


Fig 1: Efficacy of *P. fluorescens* against the leaf roller, *S. derogata* on different transgenic Bt and non Bt cotton (2015-16)

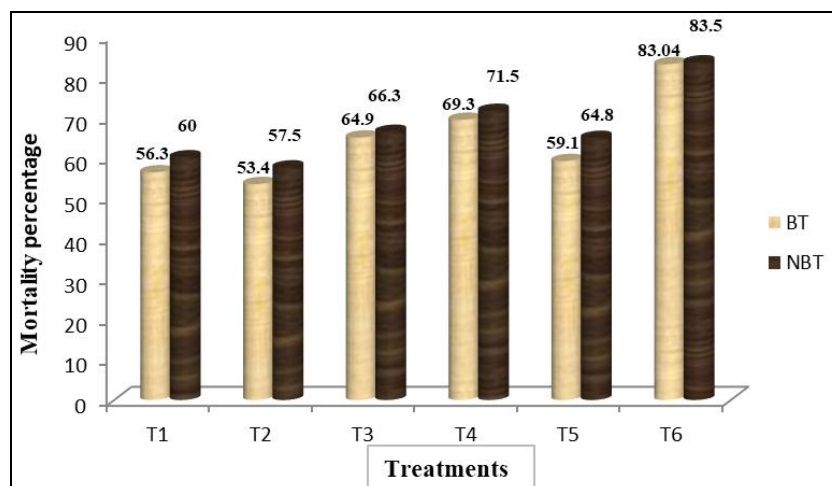


Fig 2: Percentage of the reduction in leaf roller, *S. derogata* larval content after applying *P. fluorescens* during (2015-16)

Table 1: Evaluation of *P. fluorescens* against leaf roller *S. derogata* in Bt cotton (2015-16)

Treatments	Number of <i>S. derogata</i> larvae/ five plant					
	Bt					
	PTC	1 st spray	2 nd spray	3 rd spray	Mean	ROC (%)
T1 - Foliar application of <i>P. fluorescens</i> @1%	4.11	3.49 (1.87)	2.86 (1.69)	1.93 (1.14)	2.76 (1.57)	56.26
T2 - Soil application of <i>P. fluorescens</i> @ 2.5 kg/ha	4.57	4.01 (2.00)	2.98 (1.73)	1.83 (1.35)	2.94 (1.69)	53.41
T3 - Soil and Foliar application of <i>P. fluorescens</i> @1%	3.84	3.12 (1.77)	1.86 (1.36)	1.65 (1.28)	2.21 (1.47)	64.98
T4 - Foliar application of <i>P. fluorescens</i> @1% and <i>B. bassiana</i> @ 1%	4.16	2.84 (1.69)	1.75 (1.32)	1.23 (1.11)	1.94 (1.37)	69.26
T5 - Foliar application of <i>B. bassiana</i> @ 1%	4.05	3.33 (1.83)	3.05 (1.75)	1.36 (1.17)	2.58 (1.58)	59.11
T6 - Profenophos 50 EC @ 1 lit/ha	4.26	1.41 (1.19)	1.01 (1.00)	0.8 (0.89)	1.07 (1.03)	83.04
T7 - Untreated check	3.98	4.2 (2.05)	6.46 (2.54)	8.27 (2.88)	6.31 (2.49)	-
S.Ed		0.008	0.013	0.012	0.011	
CD(.05)		0.016	0.027	0.026	0.023	
F		2974.7	2938.2	5432.2	3781.7	

PTC: Pretreatment count, ROC: Reduction over control. Figures in parentheses are square root transformed values

Table 2: Evaluation of *P. fluorescens* against leaf roller *S. derogata* in non Bt cotton (2015-16)

Treatments	Number of <i>S. derogata</i> larvae/ five plant					
	NBt					
	PTC	1 st spray	2 nd spray	3 rd spray	Mean	ROC (%)
T1 - Foliar application of <i>P. fluorescens</i> @1%	6.23	4.61 (2.15)	3.28 (1.81)	2.7 (1.64)	3.53 (1.87)	60.02
T2 - Soil application of <i>P. fluorescens</i> @ 2.5 kg/ha	5.76	4.87 (2.21)	3.51 (1.87)	2.87 (1.69)	3.75 (1.92)	57.53
T3 - Soil and Foliar application of <i>P. fluorescens</i> @1%	5.99	3.62 (1.90)	2.91(1.71)	2.41 (1.55)	2.98 (1.72)	66.25
T4 - Foliar application of <i>P. fluorescens</i> @1% and <i>B. bassiana</i> @ 1%	6.19	3.23 (1.80)	2.64 (1.62)	1.69 (1.30)	2.52 (1.57)	71.46
T5 - Foliar application of <i>B. bassiana</i> @ 1%	5.72	3.85 (1.96)	3.02 (1.74)	2.46 (1.57)	3.11 (1.76)	64.78
T6 - Profenophos 50 EC @ 1 lit/ha	6.81	2.06 (1.44)	1.64 (1.28)	0.68 (0.82)	1.46 (1.18)	83.47
T7 - Untreated check	6.06	6.67 (2.58)	9.53 (3.09)	10.29 (3.21)	8.83 (2.96)	-
S.Ed		0.015	0.012	0.0141	0.0137	
CD(.05)		0.032	0.026	0.0296	0.0292	
F		1118.1	4169.1	5437.8	3575.0	

PTC: Pretreatment count, ROC: Reduction over control. Figures in parentheses are square root transformed values

Field experiment during 2016-17

The pooled mean number of larvae of *S. derogata* was recorded after three spray showed in Table 3 foliar application of *P. fluorescens* @1% and *Beauveria basianna* @ 1% (T4) was found as best among all the other biopesticides treatments being 1.87 five plants and 65.56 per cent reduction over control. The next effective treatments was soil and foliar application of *P. fluorescens* @1% which showed reduced 2.65 larvae/five plants and 51.20 per cent reduction over control. The similar trend was observed in non Bt cotton trial, 2.22 larvae/five plants and 71.93 per cent reduction in foliar application of *P. fluorescens* @1% and *Beauveria basianna*

@ 1% (T4) (Table 4)

The data predicted in Fig.3, revealed that after three sprays pooled number of *S. derogata* larvae ranged from 0.97 to 5.43 and 1.22 to 7.91 larvae/five plants in *Bt* and non *Bt* cotton respectively. The profenophos 50 EC @ 1 lit/ha was found highly effective among all the treatments with of 0.97 and 1.22 46 larvae/five plants with 82.1 and 84.6 per cent reduction over control in *Bt* and non *Bt* cotton respectively. Followed by foliar application of *P. fluorescens* @1% and *B. bassiana* @ 1% was found better result, 1.87 and 2.22 larvae/five plant with 65.6 and 71.9 per cent reduction over control in *Bt* and non *Bt* cotton respectively (Fig. 4).

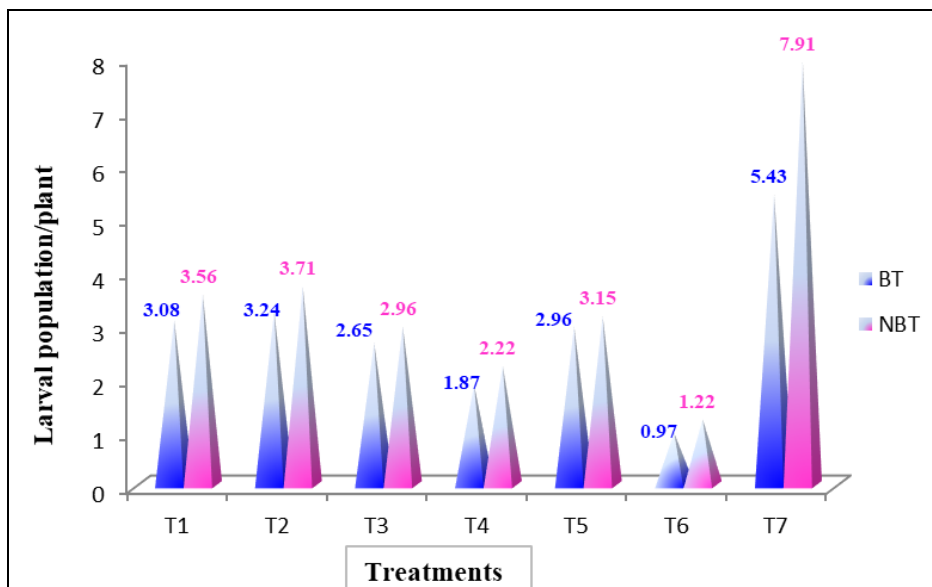


Fig 3: Efficacy of *P. fluorescens* against the leaf roller, *S. derogata* on different transgenic Bt and non Bt cotton (2016-17)

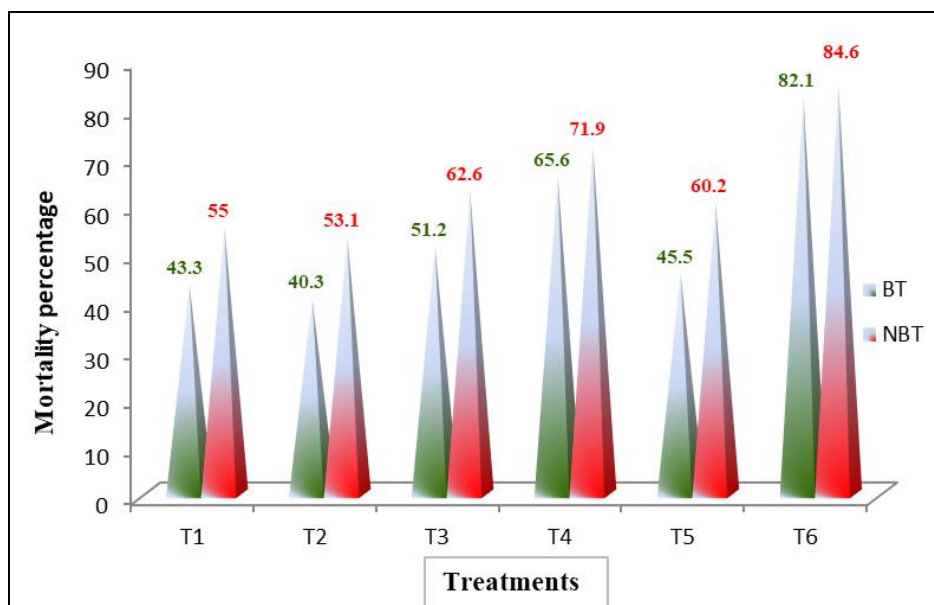


Fig 4: Percentage of the reduction in leaf roller, *S. derogata* larval content after applying *P. fluorescens* (2016-17)

Table 3: Evaluation of *P. fluorescens* against leaf roller *S. derogata* in Bt cotton (2016-17)

Treatments	Number of <i>S. derogata</i> larvae / five plant						
	Bt					Mean	ROC (%)
	PTC	1 st spray	2 nd spray	3 rd spray			
T1 - Foliar application of <i>P. fluorescens</i> @1%	4.22	3.48 (1.62)	2.94 (1.71)	2.82 (1.68)	3.08 (1.67)	43.28	
T2 - Soil application of <i>P. fluorescens</i> @ 2.5 kg/ha	4.37	3.84 (1.96)	3.21 (1.79)	2.67 (1.63)	3.24 (1.80)	40.33	
T3 - Soil and Foliar application of <i>P. fluorescens</i> @1%	3.29	2.82 (1.68)	2.76 (1.66)	2.37 (1.54)	2.65 (1.63)	51.20	
T4 - Foliar application of <i>P. fluorescens</i> @1% and <i>B. bassiana</i> @ 1%	3.94	2.11 (1.45)	1.86 (1.36)	1.65 (1.29)	1.87 (1.37)	65.56	
T5 - Foliar application of <i>B. bassiana</i> @ 1%	4.51	3.69 (1.92)	2.83 (1.68)	2.36 (1.54)	2.96 (1.71)	45.49	
T6 - Profenophos 50 EC @ 1 lit/ha	4.27	1.24 (1.11)	0.92 (0.96)	0.75 (0.87)	0.97 (0.98)	82.14	
T7 - Untreated check	3.86	4.05 (2.01)	5.23 (2.29)	7.01 (2.65)	5.43 (2.32)	-	
SEd		0.0114	0.0153	0.0102	0.0123		
CD(.05)		0.024	0.0322	0.0215	0.0259		
F		1652.6	1403.5	5552.2	2869.43		

PTC: Pretreatment count, ROC: Reduction over control. Figures in parentheses are square root transformed value

Table 4: Evaluation of *P. fluorescens* against leaf roller *S. derogata* in non Bt cotton (2016-17)

Treatments	Number of <i>S. derogata</i> larvae / five plant					
	NBt					
	PTC	1 st spray	2 nd spray	3 rd spray	Mean	ROC (%)
T1 - Foliar application of <i>P. fluorescens</i> @1%	4.42	3.81 (1.95)	3.56 (1.89)	3.31 (1.82)	3.56 (1.89)	55.00
T2 - Soil application of <i>P. fluorescens</i> @ 2.5 kg/ha	3.64	4.13 (2.03)	3.62 (1.90)	3.38 (1.84)	3.71 (1.92)	53.10
T3 - Soil and Foliar application of <i>P. fluorescens</i> @1%	4.29	3.26 (1.81)	3.12 (1.77)	2.5 (1.58)	2.96 (1.72)	62.58
T4 - Foliar application of <i>P. fluorescens</i> @1% and <i>B. bassiana</i> @ 1%	4.07	2.41 (1.55)	2.14 (1.46)	2.11 (1.45)	2.22 (1.49)	71.93
T5 - Foliar application of <i>B. bassiana</i> @ 1%	4.66	3.57 (1.89)	3.49 (1.87)	2.39 (1.55)	3.15 (1.77)	60.18
T6 - Profenophos 50 EC @ 1 lit/ha	5.71	1.38 (1.17)	1.19 (1.09)	1.09 (1.05)	1.22 (1.10)	84.58
T7 - Untreated check	5.29	5.63 (2.37)	8.67 (2.94)	9.43 (3.07)	7.91 (2.80)	-
S.Ed		0.0142	0.0200	0.0119	0.015	
CD(.05)		0.0298	0.0420	0.0251	0.032	
F		1424.4	1612.9	5648.1	2895.1	

PTC: Pretreatment count, ROC: Reduction over control. Figures in parentheses are square root transformed values TA

Seed cotton yield

Bt cotton

The data (Table 5) showed that application of soil and foliar application of *P. fluorescens* @1% was the promising treatment in increasing seed cotton yield, 27.64 and 29.40kg/ha with increased profit of Rs. 47,630 and 57,420in VIA and SIMA respectively. However, this treatment was at par with chemical insecticide profenophos 50 EC @ 1 lit/ha (26.32 and 27.64 kg/ha). Whereas foliar application of *P.*

fluorescens @1% and *B. bassiana* @ 1% (25.34 and 27.53 kg/ha) appeared as next better treatment, produced comparatively higher seed cotton yield. Other bio inoculants treatments like foliar application of *B. bassiana* @ 1% (24.27 and 25.83 kg/ha), foliar application of *P. fluorescens* @1% (23.55 and 25.48 kg/ha), soil application of *P. fluorescens* @1% (23.10 and 24.86 kg/ha) were obtained higher seed cotton yield than untreated check.

Table 5: Seed cotton yield and economics of different treatment (Bt cotton)

Treatments	Seed cotton yield (q/ha)		Mean yield	Profit* Rs/ha
	2015-16	2016-17		
T1 - Foliar application of <i>P. fluorescens</i> @1%	23.20	23.90	23.55	25,135
T2 - Soil application of <i>P. fluorescens</i> @ 2.5 kg/ha	22.80	23.40	23.10	22,660
T3 - Soil and Foliar application of <i>P. fluorescens</i> @1%	26.60	28.68	27.64	47,630
T4 - Foliar application of <i>P. fluorescens</i> @ 1% and <i>B. bassiana</i> @ 1%	24.50	26.18	25.34	34,980
T5 - Foliar application of <i>B. bassiana</i> @ 1%	23.83	24.70	24.27	29,095
T6 - Profenophos 50 EC @ 1 lit/ha	25.60	27.03	26.32	40,370
T7 - Untreated check	19.18	18.78	18.98	-
SEd	0.88	0.71		
CD (.05)	1.86	1.49		

Non Bt cotton

The data (Table 6) showed that application of soil and foliar application of *P. fluorescens* @1% was the promising treatment in increasing seed cotton yield, 19.15 and 20.12kg/ha with increased profit of Rs. 30,780 and 31,185 in VIA and SIMA respectively. However, this treatment was at par with chemical insecticide, profenophos 50 EC @ 1 lit/ha (18.79 and 19.94 kg/ha). Whereas foliar application of *P. fluorescens*

@1% and *B. bassiana* @ 1% (17.13 and 17.90 kg/ha) appeared as next better treatment, produced comparatively higher seed cotton yield. Other bio inoculants treatments like foliar application of *P. fluorescens* @1% (16.72 and 17.15 kg/ha), foliar application of *B. bassiana* @ 1% (16.67 and 17.05 kg/ha) soil application of *P. fluorescens* @1% (16.20 and 16.50 kg/ha) were obtained higher seed cotton yield than untreated check (12.31 and 13.19 kg/ha).

Table 6: Seed cotton yield and economics of different treatment (Non Bt cotton)

Treatments	Seed cotton yield (q/ha)		Mean yield	Profit* Rs/ha
	2015-16	2016-17		
T1 - Foliar application of <i>P. fluorescens</i> @1%	16.91	16.52	16.72	19,845
T2 - Soil application of <i>P. fluorescens</i> @ 2.5 kg/ha	16.64	15.76	16.20	17,505
T3 - Soil and Foliar application of <i>P. fluorescens</i> @1%	19.57	18.73	19.15	30,780
T4 - Foliar application of <i>P. fluorescens</i> @ 1% and <i>B. bassiana</i> @ 1%	17.43	16.82	17.13	21,690
T5 - Foliar application of <i>B. bassiana</i> @ 1%	16.89	16.44	16.67	19,620
T6 - Profenophos 50 EC @ 1lit/ha	19.12	18.46	18.79	29,160
T7 - Untreated check	12.67	11.95	12.31	-
SEd	0.52	0.37		
CD (.05)	0.25	0.18		

Discussion

In the present study, among the treatments, profenophos 50 EC @ 1 lit. /ha was found highly effective among all the

treatments. The next treatments in order were foliar application of *P. fluorescens* @ 1% & *B. basianna* @ 1% was found effective (69.3 and 71.5 per cent respectively) in season

I trials. The trend was similar in season II trials also. This is in agreement with the findings of Radjacommare *et al.*, (2000 and 2002) [15] also demonstrated that rice leaves treated with *P. fluorescens* altered the feeding behavior of leaf folder with reduction in larval and pupal weight. Increased larval mortality and incidence of malformed adults were also recorded *in vitro*. In the same vein, a bio formulation of a combination of two *P. fluorescens* strains was demonstrated to simultaneously reduce the incidence of a herbivorous insect (the rice leaf roller *Cnaphalocrocis medinalis*) and a phytopathogenic fungus (*Rhizoctonia solani*) in rice under greenhouse and field conditions (Commare *et al.*, 2002; Karthiba *et al.*, 2010) [10]. In a similar study, Rajendran, (2003) [20] revealed that maximum control of leaf folder (80.0% and 73.3%) was achieved by application of chlorpyrifos in trial I and II, respectively followed by *Pseudomonas* combination treatments (47.7% and 56.1%). Our results are supported by Saravanakumar, (2008) reported that leaf folder damage was very low in trial plots treated with *P. fluorescens*, bio formulations Pf1 + TDK1 + PY15 (0.98%, 3.48%, 3.92% and 6.12% at 30, 45, 60 and 75 DAP, respectively), whereas untreated control plots recorded the maximum leaf folder damage (12.97%, 15.47%, 30.52% and 45.59% at 30, 45, 60 and 75 DAP, respectively). In field trial II, untreated control plots recorded 23.59% damage at 75 DAP, whereas plots receiving Pf1 + TDK1 + PY15 treatment recorded only 4.71% damage and it was comparable with pesticide treatment (4.35%). Similarly, Karthikeyan and Sosamma, (2010) indicate that both the biocontrol agents *P. fluorescens* and *H. Indica* at all the tested doses were equally effective in reducing the leaf damage caused by blue beetle and whorl maggot. rice seedling dip and 2-3 sprays of *P. fluorescens* @ 15g /litre of water and the EPN *H. Indica* can be applied in rotation sprays in order to manage pests like stem borer, gall midge, leaf folder and whorl maggot in rice.

In the present study, application of soil and foliar application of *P. fluorescens* @1% was the promising treatment in increasing seed cotton yield, 27.64 and 29.40kg/ha with increased profit of Rs. 47,630 on Bt cotton trials. However, this treatment was at par with chemical insecticide, imidacloprid 200 SL @ 200ml/ha/ Profenophos 50 EC @ 1 lit. / ha (26.32 and 27.64 kg/ha). The trend was similar in non Bt cotton trials also. Our results are supported by Mathivanan *et al.*, (2005) [19], Shanmugaiah *et al.*, (2005 and 2008) [19] who indicated that increased dry weight and plant height were recorded with *P. fluorescens* on rice and green gram when compared with the control. In a similar study, Gravel *et al.*, (2007) analyzed pathogenicity might cause little damage and this was also recorded in the case of root and shoot length, fresh and dry weight and vigour index in *P. fluorescens*, *P. fluorescens* subgroup G strain 2, *P. marginalis*, *P. putida* subgroup B strain 1 and *P. syringae* strain 1 were evaluated to determine their promoting effect on the growth of mature healthy tomato plants grown under hydroponic conditions. This result is in line with the finding of Saravanakumar, (2008) recorded an increase in mean root (23.4 cm) and shoot length (10.5 cm) because of *P. fluorescens* TDK1 bacterization was significantly higher followed by *P. fluorescens* PY15, Pf1 treatments compared with non-bacterized seedlings. The maximum vigour index of 3390 was observed in rice seedlings treated with *P. fluorescens* TDK1 suspension while less vigour index of 1018 was recorded in untreated control. Similarly, Shanmugaiah *et al.*, (2009) [20] analyzed the cotton seeds were pre-treated with *P. fluorescens*,

there was an increased 20% in germination over the control. Ardakani *et al.*, (2010) recorded the strain and the types of formulation of *P. fluorescens* were shown to impact the ability of the bacterium to promote plant growth. Influence of seed treatments on germination, imidacloprid recorded the highest germination (82.42%) which was on par with *P. fluorescens* (69.11%) reported by Murugesan and Kavitha, (2009) [13].

This is in agreement with the findings of Jeyalakshmi *et al.*, (2010) [9] reported that seed treatment with *P. fluorescens* and soil application on 30 DAS reached 50 per cent flowering a week earlier than other. Similarly, the presence of *P. fluorescens* in all the beds showed greater increase in the growth parameters than in the absence of it. The maximum improvement was observed in plant weight (95.39 g), pollen fertility (98.29%), number of pods (75.31), number of root-nodules (56.9) and chlorophyll content (4.569 mg/g) in chick pea (Shazia *et al.*, 2016) [21].

Acknowledgement

The author acknowledges the Vanavarayar Institute of Agriculture for providing support for conducting the experiments successfully. Thanks to Tropical Agro Pvt Ltd., Chennai for providing the bio inoculants for the study.

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