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Field efficacy of seed treatment against sucking pests and root rot in *desi* cotton under rainfed condition

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Abstract: The field experiment was conducted at the Agricultural Research Station, Arnej, during the *kharif* seasons of 2017-2018 and 2018-2019 to assess the efficacy of seed treatment with imidacloprid 48 FS and thiamethoxam 30 FS separately and in combination with bioagents *Pseudomonas fluorescens* (108 cfu/ml) 1 per cent WP and *Trichoderma viride* (108 cfu/g) against sucking pests *viz.*, aphid, jassid, thrips and whitefly and root rot disease. The experiment was conducted using a randomized block design with nine treatments in a rainfed environment. Seed treated with imidacloprid 30 FS was applied alone or combine with bioagent found more effective against sucking insect pests *viz.*, aphid, jassid, thrips and whitefly in *desi* cotton. Seed treated with bioagent *P. fluorescens* (108cfu/ml) 1 per cent WP alone or combine with an insecticide which was suppressed root rot incidence to the tolerable level in *desi* cotton. There was no germination difference among all seed treatments. The results showed that seed cotton treated with imidacloprid 48 FS + *P. fluorescens* (108 cfu/ml) 1 per cent WP yielded more and had a better cost-benefit ratio. Thus, seed treated with imidacloprid 48 FS + P. *fluorescens* (108 cfu/ml) 1 per cent WP was found to be effective against sucking pests and root rot disease, as well as economical, making it more compatible component for pest's managementin *desi* cotton.

Keywords: Bio agents, *desi* cotton, root rot, seed treatment, sucking pests

In the agricultural economy of India, cotton was considered a major cash crop. *Gossypium arboreum*, and *G. herbaceum*, two kinds of cotton emerged millions of years ago in India and are widely known as *desi* cotton. G. *arboreum* fibers were historically produced in India for over 5,000 years as the best cotton textile in the world. India had 97.5 per cent of its territory under *desi* cotton when it became independent. In 1992, India had more 40 per cent *desi* cotton area and it was still around 30 per cent only seventeen years ago. Today it is unfortunate that fewer than 1 per cent of India's territory is part of the previously well known *Gossypium arboreum* Indian king cotton (Kranthi, 2013).

A farmer grows most of *desi* cotton under scarce resource conditions and is less prone to insect pests because of its genetic characters and biochemical composition. However, the insect pests and root rot complex cause significant losses in *desi* cotton. Root rot incidence was observed to be ranging from 31.7 to 69.1 pre cent in cotton (Monga and Sheo, 2002). Chaavan (2007) found avoidable yield loss due to major pests in *desi* cotton is about 28.13 per cent.

Farmers consider *desi* cotton as 'no spraying cotton' so seed treatment is vital for *desi* cotton crop growing farmers. Bhal region of Ahmedabad district is prone to the incidence of root rot and sucking pests under rainfed condition. As a part of solution, the combination of insecticide and bioagent that give protection against sucking pest (*i.e.* aphid, jassid, thrips and whitefly) and soil borne pathogen (*i.e.* root rot). Insecticidal seed treatment gives 30 to 45 days' complete protection against sucking pests and bioagents give long-lasting control management of soil-born pathogen when used as seed dresser. Several reports *viz.*, Karabhantanal *et al.*, (2007), Kumar *et al.*, (2007), Surendran *et al.*, (2012) and Thiruchchelvan *et. al.*, (2013) showed that insecticide and bioagents are compatible and control pests. Hence, the present study was divided to evaluate the insecticides and bio-agents as seed dresser against sucking pests and root rot disease in *desi* cotton.

MATERIALS AND METHODS

The field experiments were conducted at Agricultural Research Station, AAU, Arnej (Bhal and Coastal Agro-Climatic Zone- VIII) during *kharif* 2017-2018 and 2018-2019 in a randomized block design using variety GADC-2 with nine treatments and each treatment repeated thrice. All the agronomical practices were carried out as per local recommendation. All together there were 27 plots with gross plot size of 4.8 x 6 m each and net plot size 2.4 x 5.4 m each. Row to row and plant to plant distance was maintained at 120 and 30 cm, respectively. In the present study, the seed treatment was imposed separately insecticide treatments *viz.*, thiamethoxam 30 FS @ 10 ml/kg seed, imidacloprid 48 FS @ 9 ml/kg seed and bio-agents treatments *viz.*, *Trichodermaviride* (108 cfu/g) (1% WP) @10mg /kg seed and *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) @10mg/kg seed, combine treatments of insecticidal and bio-agents were thiamethoxam @10ml + *Trichoderma viride* (10^8 cfu/g) 1% WP @ 10mg, thiamethoxam @10ml + *Pseudomonas fluorescens* (108 cfu/ml) (1% WP) @ 10mg, imidacloprid 48 FS @ 9 ml + *Trichoderma viride* (10^8 cfu/g) (1% WP) @ 10mg, imidacloprid 48 FS @ 9 ml + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) @ 10mg and the untreated check.

Plastic bags were used for seed treatments, and the required quantity of insecticide was mechanically mixed with 200 g of cotton seeds. The treated seed was allowed to dry in the shade. Treated and dried seeds again treated with bioagents. Completely dried seeds were utilized for sowing. A sucking insect pest (aphid, jassid, thrips, and whitefly) was observed on five randomly selected plants with three leaves from each net plot area from one week of germination to 60 (DAS) days after sowing. Each month, a healthy plant and a disease-infected/dead plant was observed, and the per cent disease incidence was calculated as per following formula.

$$PDI = \frac{\text{Total no. of plants}}{\text{No. of diseased plants}} X100$$

It recorded cotton yield from each of the net plot area. The data obtained from field experiments were analyzed in a simple randomized block design by 'F' test for significance. The critical difference values were calculated at a 5 per cent probability level, and the treatment mean values of the experiment were compared using Duncan's Multiple Range Test (DMRT). The incremental cost-benefit ratio (ICBR) was calculated to determine the economics of the different treatments tested against sucking pests infesting cotton. For the purpose, the total cost of treatments per hectare for each treatment was calculated using the market price. The net gain (yield) over control was calculated by subtracting the yield obtained in the control treatment from the yield obtained in each treatment. Then, the realization was worked out for each treatment based on increased yield (q/ha) over control. The net profit (/ha) for each treatment was calculated by subtracting the treatment cost from the value of realization above control. The ICBR *i.e.* net gain in rupees/rupee cost of treatment was calculated by diving net profit with the cost of treatment.

RESULTS AND DISCUSSION

1. Effect of seed treatment on germination

In 2017-2018, significantly maximum germination was observed in *Trichoderma viride* (10^8 cfu/g) (1% WP) which was *at par* with Imidacloprid 48 FS, *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP), *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP), Thiamethoxam + *Trichoderma viride* (10^8 cfu/g) (1% WP), Imidacloprid 48 FS + *Trichoderma viride* (10^8 cfu/g) (1% WP) and Imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP).

The untreated control had the lowest germination rate in 2017-2018. (43.75 %). In 2018-2019, there was non-significant difference in germination among treatments. This experiment was conducted on rainfed, which allowed for a clear observation of the influence of rainfall on germination in both years. The analysis of pooled year-to-year data revealed no statistically significant difference between treatments. (Table 3).

2. Effect of seed treatments on sucking pests

Aphid population was not observed in 10 DAS and 20 DAS, but continued to increase in 30 to 60 DAS in both years. The cotton seeds treated with imidacloprid 48 FS and thiamethoxam + *Pseudomonas fluorescens* (10^8 cfu/ml) recorded significantly lowest aphid population which was remained *at par* with each of the insecticidal treatments during 2017-2018. In 2019-2020, significantly lowest aphid population observed in imidacloprid 48 FS + *Trichoderma viride* (10^8 cfu/g) treatment was *at par* with imidacloprid 48 FS and imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8 cfu/ml) to compare with the untreated control. The pooled of the both the year data show that significantly lowest aphid population observed in imidacloprid 48 FS + *Trichoderma viride* (108 cfu/g) (1% WP) which was at par with imidacloprid 48 FS compared to the untreated control (Table 1). These findings show that seed treated with imidacloprid 48 FS to *G. arboreum* cultivars found suppress aphid population up to 60 DAS. Hanumanthararay *et al.*, (2004), Kolhe *et. al.*, (2009), Mote *et. al.*, (1995) supported this finding effectiveness of imidacloprid @ 10g/kg seed up to 40-45 days. According to Nauenand Elbert (1994) and Satpute, *et al.*, (2003) dosage of 5 to 10g/kg seed recorded significantly less population of aphids upto 50-56 days in *G. hirsutum* cotton cultivars. Karabhantanal *et. al.*, (2007) registered significantly lowest aphid population up to 40 days in *desi* (*G. herbaceum*) cotton cultivar, DB-3-12 when imidacloprid 70 WS was treated @ 10g/kg of seed at Raichur in Karnataka.

In both years, the jassid population had not appeared at 10 DAS. The cotton seeds treated with the insecticidal treatments (imidacloprid 48 FS and thiamethoxam 30 FS) which was the significantly effective against jassid compared to untreated control during 2017-2018 and 2018-2019 except thiamethoxam 30 FS and thiamethoxam + *Trichoderma viride* (10^8 cfu/g) in 2018-2019. The data on pooled over years of jassid incidence was significantly lower in imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8 cfu/ml) and imidacloprid 48 FS which was remained *at par* with thiamethoxam 30 FS + *Pseudomonas fluorescens* (10^8 cfu/ml), imidacloprid 48 FS + *Trichoderma viride* (10^8 cfu/g) (1% WP), thiamethoxam 30 FS + *Trichoderma viride* (10^8 cfu/g) (1% WP) (Table 1). Seed treated with imidacloprid at 10ml/kg seed and seed treated with thiamethoxam at 10/kg seed both suppressed the jassid population until 60 DAS in *desi* cotton. These present finding deviates that confirm by Mote *et al.*, (1995) seed treated with imidacloprid @ 10g/kg seed was effective against jassid up to 45 days under irrigation cotton. A low dose of imidacloprid to 5 g suppress the population of leaf hoppers for 70 to 80 days. Gill *et al.*, (1996), Hanumanthararay *et al.*, (2004), Kolhe *et al.*, (2009) reported that imidacloprid seed treatment (10 g/kg) was highly effective on cotton hybrids cultivated in an irrigated system. According to Kumar and Santhatam (1999), Sreelatha and Divakar (1997), Vadodaria *et al.*, (2001) found that an imidacloprid dosage of 7 to 7.5 g/kg seed was effective for 35 days and up to 60 days.

At 10 DAS, the thrips population had not appeared in both years. Thrips population was rising; at around 20 to 60 DAS the population had nearly doubled. At 2017-2018, significantly lowest thrips population was observed in thiamethoxam 30 FS and it was *at par* with imidacloprid 48 FS, thiamethoxam + *Trichoderma viride* (10^8 cfu/g), thiamethoxam +

Table 1: Effect of seed treatment against sucking pests in desicotton

Treat. No.	Treatments		Aphid/ leaf 2017-18	Aphid/ leaf 2018-19	Aphid/ leaf **Pooled**	Jassid/leaf 2017-18	Jassid/leaf 2018-19	Jassid/leaf **Pooled**	Thrips/leaf 2017-18	Thrips/leaf 2018-19	Thrips/leaf **Pooled**	Whitefly/leaf 2017-18	Whitefly/leaf 2018-19	Whitefly/leaf **Pooled**
T_1	Thiamethoxam 30 FS		1.04a	1.07d	**1.06c**	0.87a	0.98c	**0.92a**	0.97a	1.32cd	**1.14b**	0.95bcd	0.90bc	**0.93de**
			(0.58)	(0.65)	**(0.61)**	(0.25)	(0.45)	**(0.35)**	(0.43)	(1.23)	**(0.80)**	(0.41)	(0.32)	**(0.36)**
T_2	Imidacloprid 48 FS		0.97a	0.96ab	**0.97ab**	0.89a	0.90abc	**0.91a**	0.98a	1.07a	**1.02a**	0.86a	0.82a	**0.84a**
			(0.44)	(0.43)	**(0.43)**	(0.30)	(0.32)	**(0.32)**	(0.45)	(0.65)	**(0.55)**	(0.25)	(0.17)	**(0.21)**
T_3	*Trichoderma viride*		1.23b	1.26e	**1.25d**	1.04cd	1.06d	**1.06b**	1.34b	1.48de	**1.41c**	1.07e	1.03de	**1.05f**
	(108cfu/g)		(1.02)	(1.10)	**(1.06)**	(0.58)	(0.63)	**(0.62)**	(1.28)	(1.68)	**(1.48)**	(0.65)	(0.57)	**(0.61)**
T_4	*Pseudomonas fluorescens*		1.21b	1.23e	**1.22d**	1.07cd	1.07d	**1.09b**	1.26b	1.43cde	**1.34c**	1.03de	0.99de	**1.01f**
	(108 cfu/ml) (1% WP)		(0.96)	(1.02)	**(0.99)**	(0.65)	(0.65)	**(0.68)**	(1.09)	(1.54)	**(1.31)**	(0.55)	(0.47)	**(0.51)**
T_5	Thiamethoxam + *Trichoderma*		1.00a	1.04bcd	**1.02bc**	0.91ab	0.96bc	**0.94a**	1.00a	1.25abc	**1.13b**	0.96cd	0.96cd	**0.96e**
	viride (108cfu/g)		(0.50)	(0.58)	**(0.54)**	(0.32)	(0.42)	**(0.38)**	(0.50)	(1.06)	**(0.77)**	(0.43)	(0.42)	**(0.42)**
T_6	Thiamethoxam + *Pseudomonas*		0.97a	1.06cd	**1.01bc**	0.89a	0.93abc	**0.92a**	0.97a	1.28bc	**1.13b**	0.90abc	0.90bc	**0.90cd**
	fluorescens (108 cfu/ml) (1% WP)		(0.44)	(0.61)	**(0.53)**	(0.29)	(0.36)	**(0.35)**	(0.44)	(1.15)	**(0.77)**	(0.31)	(0.31)	**(0.31)**
T_7	Imidacloprid 48 FS +		1.00a	0.90a	**0.95a**	0.97abc	0.88ab	**0.93a**	0.99a	1.07a	**1.03a**	0.87ab	0.85bc	0.**86abc**
	Trichoderma viride (108cfu/g)		(0.50)	(0.32)	**(0.41)**	(0.44)	(0.28)	**(0.37)**	(0.49)	(0.65)	**(0.57)**	(0.26)	(0.22)	**(0.24)**
T_8	Imidacloprid 48 FS + *Pseudomonas*		1.04a	0.98abc	**1.01bc**	0.96abc	0.85a	**0.91a**	0.96a	1.11ab	**1.03a**	0.86a	0.83ab	**0.84ab**
	fluorescens (108 cfu/ml)		(0.58)	(0.46)	**(0.52)**	(0.41)	(0.22)	**(0.32)**	(0.42)	(0.73)	**(0.57)**	(0.24)	(0.19)	**(0.21)**
T_9	Control		1.18b	1.24e	**1.21d**	1.12d	1.09d	**1.11b**	1.27b	1.51e	**1.39c**	1.03de	1.04e	**1.04f**
			(0.89)	(1.03)	**(0.96)**	(0.75)	(0.68)	**(0.73)**	(1.10)	(1.78)	**(1.43)**	(0.57)	(0.59)	**(0.58)**
		(Treatment) T	0.04	0.03	**0.02**	0.05	0.03	**0.03**	0.03	0.07	**0.04**	0.03	0.03	**0.02**
		(Period) P	0.02	0.02	**0.03**	0.02	0.02	**0.04**	0.02	0.05	**0.08**	0.02	0.02	**0.03**
		(Year) Y			**0.01**			**0.01**			**0.02**			**0.01**
	S. Em. ±	T x P	0.06	0.06	**0.05**	0.09	0.06	**0.05**	0.06	0.15	**0.08**	0.06	0.06	**0.04**
		P x Y			**0.02**			**0.03**			**0.04**			**0.02**
		T x Y			**0.03**			**0.03**			**0.05**			**0.03**
		T x P x Y			**0.06**			**0.08**			**0.11**			**0.06**
	C.D. (p = 0.005)	T	0.10	0.09	**0.06**	0.14	0.08	**0.11**	0.10	0.18	**0.09**	0.09	0.08	**0.05**
		P	0.05	0.06	**0.14**	0.07	0.06	**0.16**	0.05	0.14	**0.31**	0.05	0.06	**0.12**
		Y			**NS**			**NS**			**0.05**			**NS**
		T x P	NS	NS	**0.01**	NS	NS	**NS**	NS	NS	**NS**	NS	NS	**NS**
		P x Y			**0.06**			**0.07**			**0.10**			**0.06**
		T x Y			**NS**			**0.01**			**NS**			**NS**
		T x P x Y			**NS**			**NS**			**NS**			**NS**
C.V. (%)			10.31	10.43	**10.37**	15.18	11.62	13.54	9.43	19.58	16.21	10.24	12.21	11.25

Note: Figures in parentheses are re-transformedvalues and those outside are “x+0.5 transform values.
Treatment mean(s) with a letter (s) in common are non-significant by DNMRT at 5% level of significant.

Pseudomonas fluorescens (10^8 cfu/ml) (1% WP), imidacloprid 48 FS + *Trichoderma viride* (10^8 cfu/g) and imidacloprid 48 FS+ *Pseudomonas fluorescens* (10^8 cfu/ml). The thrips population was lower in all insecticidal treatments than in the untreated check hybrid and bio agent treatments. In 2018-2019, the incidence of thrips was the significantly lowerseed treated with imidacloprid 48 FS and imidacloprid 48 FS + Trichoderma viride (10^8 cfu/g) and imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8 cfu/ml). Analysis of pooled over years of thrips population showed significantly effective treatment was imidacloprid 48 FS *at par* with imidacloprid 48 FS + *Trichoderma viride* (10^8 cfu/g) (1% WP) and imidacloprid 48 FS + *Pseudomonas fluorescens* (108 cfu/ml) (Table 1). In general, all insecticidal seed treatments contained imidacloprid 48 FS, which effectively suppressed thrips populations up to 60 DAS. Hanumanthararay *et al.*, (2004), Karabhantanal *et. a*l., (2007), Kolhe *et al.*, (2009)reported that significantly fewer thrips populations in hybrids, DHH543 (*G. hirsutum*), DB-3-12 (G. *herbaceum*), and LRA-5166 (*G. hirsutum*) cultivars treated with imidacloprid 70 WS@ 10 g/kg seed.

During 2017-2018, seed treatments with imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8 cfu/ml) significantly suppressed whitefly populations, and it was comparable to imidacloprid 48 FS, thiamethoxam + *Pseudomonas fluorescens* (10^8 cfu/ml), and imidacloprid 48 FS + *Trichoderma viride* (10^8 cfu/g). In 2018-2019, seed treated with imidacloprid 48 FS had a significantly lower whitefly population than seed treated with imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8 cfu/ml). Analysis of the pooled over year data show that significantly lowest whitefly population was found in seed treated with Imidacloprid 48 FS and it was at par with Imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) (Table 1). Seed treated with imidacloprid 48 FS was effective against whitefly, supporting the findings of Karabhantanal *et al.*, (2007) who reported imidacloprid (10 g/kg) effectiveness in DCH32, DB312, and JK2764 (*desi* cotton) cultivars for upto 40 days.

3. Effect of seed treatments against root rot

The results showed that imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8 cfu/ml) (1 % WP) caused significantly less root rot damage than thiamethoxam + *Trichoderma viride* (10^8 cfu/g) (1 % WP) during 2017-2018. Root rot damage was found to be higher (30.26%) in the untreated control in 2017-2018. At 2018-2019, significantly lowest root rot damage was found in thiamethoxam 30 FS + *Pseudomonas fluorescens* (108cfu/ml) (1% WP) and it was *at par* with imidacloprid 48 FS + *Pseudomonas fluorescens* 108 (cfu/ml) (1% WP), *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP). During 2018-2019, it was also found that 31.41 per cent of untreated controls had more root rot. Analysis of pooled over year data showed that significantly lowest root rot incidence was observed imidacloprid 48 FS + *Pseudomonas fluorescens* 10^8 cfu/ml) (1% WP) which was *at par* with thiamethoxam + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) and thiamethoxam 30 FS + *Trichoderma viride* (10^8 cfu/g) (1% WP) and *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) (Table 2). Overall, the outcomes showed that seed treatment with *Pseudomonas fluorescens* (10^8 cfu/ml) (1 % WP) was effective in controlling the root rot disease of *desi* cotton. These finding was confirmed by Hagedorn *et al.*, 1990 found that application of *P. fluorescens* strain EG1053 provided larger plant stands and reduced seedling disease symptoms (caused by P. *ultimum* and R. *solani*) on surviving plants of cotton in both potting mix with amended pathogens and naturally infected cotton soils. Demir *et al.*, (1999) study was also showed that isolated 128 isolates of *Pseudomonads fluorescent* from healthy cotton seedlings and rhizosphere soils and tested against *Rhizoctonia solani*, *P. fluorescens* (Gh/R 1810) was the most effective strain resulting in 16.36

Table 2: Effect of seed treatment on root rot disease incidence on *desi* cotton

Treat. No.	Treatments		Root rot disease incidence (%) 2017-2018	2018-2019	**Pooled over years**
T1	Thiamethoxam 30 FS		5.02de (24.66)	4.14c (16.65)	**4.58de (20.46)**
T2	Imidacloprid 48 FS		4.17cd (16.90)	4.14c (16.67)	**4.16cd (16.79)**
T3	*Trichoderma viride* (108cfu/g) (1% WP)		3.40bc (11.08)	4.00c (15.52)	**3.70bcd (13.21)**
T4	*Pseudomonas fluorescens* (108cfu/ml) (1% WP)		3.29bc (10.34)	3.17abc (9.54)	**3.23abc (9.94)**
T5	Thiamethoxam + *Trichoderma viride* (108cfu/g) (1% WP)		2.80ab (7.33)	3.64bc (12.75)	**3.22abc (9.86)**
T6	Thiamethoxam + *Pseudomonas fluorescens* (108cfu/ml) (1% WP)		3.27bc (10.20)	2.32a (4.89)	**2.80ab (7.32)**
T7	Imidacloprid 48 FS + *Trichoderma viride* (108cfu/g) (1% WP)		3.67bc (12.99)	5.27d? (27.24)	**4.47cde (19.48)**
T8	Imidacloprid 48 FS + *Pseudomonas fluorescens*108cfu/ml) (1% WP)		2.19a (4.29)	2.68ab (6.69)	**2.44a (5.43)**
T9	Untreated Control		5.55e (30.26)	5.65d (31.41)	**5.60e (30.83)**
	S.Em. ±	(Treatment) T	0.31	0.36	**0.41**
		(Year) Y			**0.11**
		Y X T			**0.33**
	C.D. (p=0.05)	T	0.94	1.07	**1.26**
		Y X T			**0.97**
C.V. (%)			14.59	15.88	**15.28**

Note: Figures in parentheses are retransformed values and those outside are "x+0.5 transform values.
Treatment mean (s) with a letter (s) in common are non-significant by DNMRT at 5% level of significant.

per cent greater emergence and 57.94 per cent greater survival of cotton seedlings.

4. Effect of seed treatment on seed cotton yield

The differences in seed cotton yield between treatments were found to be statistically significant. At 2017-2018, significantly higher seed cotton yield was found in *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) and it was *at par* with thiamethoxam + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) and imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP). The seed treated with imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) was found significantly higher yield and it was *at par* with imidacloprid 48 FS + *Trichoderma viride* (10^8 cfu/g) (1% WP) and thiamethoxam + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP). Assessments of pooled over-year data revealed that significantly highest yield was observed in imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) was comparable to thiamethoxam + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP), imidacloprid 48 FS + *Trichoderma viride* (10^8 cfu/g) (1% WP) and *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP). Among treatments, the untreated control treatment had the lowest seed cotton yield (387 kg /ha). (Table 3).

5. Economics and cost-benefit ratio

The maximum net profit (Table 4) was found in the seed treated with imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) (20,735/ha) followed by thiamethoxam 35 FS + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) (18,095/ha), imidacloprid 48 FS + *Trichoderma viride* (10^8 cfu/g) (1% WP) (12,870/ha),

Table 3: Effect of seed treatment on seed germination and yield of *desi* cotton

Treat. No.	Treatments	Germination (%)			Cotton seed yield (kg/ha)		
		2017-2018	2018-2019	**Poled over year**	2017-2018	2018-2019	**Poled over year**
T1	Thiamethoxam 30 FS	55.83	82.50	**69.17**	404b	498cd	**451de**
T2	Imidacloprid 48 FS	70.42	85.00	**77.71**	450b	518c	**484cde**
T3	*Trichoderma viride* (108cfu/g) (1% WP)	83.75	88.33	**86.04**	424b	502cd	**463cde**
T4	*Pseudomonas fluorescens* (108cfu/ml) (1% WP)	70.83	90.83	**80.83**	685a	554c	**620abc**
T5	Thiamethoxam + *Trichoderma viride* (108cfu/g) (1% WP)	71.67	85.00	**78.33**	521b	618bc	**570bcd**
T6	Thiamethoxam + *Pseudomonas fluorescens* (108cfu/ml) (1% WP)	60.42	93.33	**76.87**	689a	742ab	**716ab**
T7	Imidacloprid 48 FS + *Trichoderma viride* (108cfu/g) (1% WP)	72.92	91.25	**82.08**	498b	745ab	**621abc**
T8	Imidacloprid 48 FS + *Pseudomonas fluorescens* (108cfu/ml) (1% WP)	80.83	92.50	**86.67**	724a	804a	**764a**
T9	Control	43.75	87.50	**65.62**	418b	356d	**387e**
	S.Em. ± (Treatment) T	7.12	3.37	**6.01**	49.84	51.55	**52.92**
	(Year) Y			**1.86**			**16.90**
	Y X T			**5.57**			**50.70**
	CD at (p=0.05) T	21.36	NS	**NS**	149.42	154.54	**165.11**
	Y X T			**16.06**			**NS**
	CV (%)	18.19	6.60	**12.35**	16.14	15.06	**15.57**

Note: Treatment mean (s) with a letter (s) in common are non-significant by DNMRT at 5% level of significant.

Pseudomonas fluorescens (108 cfu/ml) (1% WP) (12,815/ha) and thiamethoxam 35 FS + *Trichoderma viride* (10^8 cfu/g) (1% WP) (10,065/ha). Similarly, pertaining to ICBR it was highest return in the seed treated with *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) (1:39.42) followed by imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) (1: 36.42), thiamethoxam 35 FS + *Pseudomonas fluorescens* (10^8 cfu/ml) (1% WP) (1: 32.25), imidacloprid 48 FS + *Trichoderma viride* (10^8 cfu/g) (1% WP) (1:22.78), and thiamethoxam 35 FS + *Trichoderma viride* (10^8 cfu/g) (1% WP) (1:18.08). When compared to other treatments, the seed treated with thiamethoxam 30 FS had the lowest ICBR (1:6.44).

In a nutshell, the seed treated with imidacloprid 48 FS, either alone or in combination with a bio agent, was found to have higher residual toxicity against sucking insect pests such as aphid, jassid, thrips, and whitefly in *desi* cotton. *Pseudomonas fluorescens* (10^8 cfu/ml) 1 per cent WP is applied singly or in combination with insecticide as a seed dresser, which reduced root rot incidence to a tolerable level in *desi* cotton. Germination of *desi* cotton seed was found to be non-significantly different between seed treatments. It found that seed cotton treated with imidacloprid 48 FS + *Pseudomonas fluorescens* (10^8cfu/ml) 1 per cent WP had a higher seed cotton yield and cost-benefit ratio. Thus, the direct and indirect effects of the seed treatment combination resulted in significant suppression of sucking pests and root rot disease. Such an action by any intervention is most desirable when selecting it as a compatible component in *desi* cotton IPM.

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Table 4: Economics of different seed treatments used for sucking pests and root rot infesting in *desi* cotton

Treat. No.	Treatments	Quantity of bioagent (ml/ha)	Cost of insecticide (Rs./ha)	Labor and insecticide cost/ha	Total cost/ha	Yield (ha)	Net over (kg/ha)	Realization control (kg/ha)	Net profit (Rs./ha)	ICBR
T_1	Thiamethoxam 30 FS	80	240	307	547	451	64	3520	2973	1:6.44
T_2	Imidacloprid 48 FS	72	248.4	307	555.4	484	97	5335	4779.6	1:9.61
T_3	*Trichoderma viride* (108cfu/g) (1% WP)	80	9.6	307	316.6	463	76	4180	3863.4	1:13.20
T_4	*Pseudomonas fluorescens* (108cfu/ml) (1% WP)	14 80	307	321	620	233	12,815	12,494	1:39.92	
T_5	Thiamethoxam 35 FS + *Trichoderma viride* (108cfu/g) (1% WP)	160	249.6	307	556.6	570	183	10,065	9508.4	1:18.08
T_6	Thiamethoxam 35 FS + *Pseudomonas fluorescens* (108cfu/ml) (1% WP)	160	254	307	561	716	329	18,095	17,534	1:32.25
T_7	Imidacloprid 48 FS + *Trichoderma viride* (108cfu/g) 1% WP	152	258	307	565	621	234	12,870	12,305	1:22.78
T_8	Imidacloprid 48 FS + *Pseudomonas fluorescens* (108cfu/ml) 1% WP	262.4 152	307	569.4	764	377	20,735	20,165.6	1:36.42	
T_9	Untreated control (UTC)					387				

Market price of cotton: 55/ kg Labor charge: For spraying: 307/labor/day

REFERENCES

Chaavan, S. J. 2007. *Estimation of losses due to major pests*. (*M.Sc. Thesis*, Marathwada Agrcultural University, Parbhani,).

Demir, G., Karcilioglu, A. and Onan, E. 1999. Protection of cotton plants against damping-off disease with rhizobacteria. *J. Turkish Phytopathol.*, **28**, 111–18.

Gill, R. S., Jaisingh and Sadhu, B. S. 1996. Imidacloprid as seed treatment a new approach to control cotton jassid. *Proceedings of National Seminar on "Century of cotton in India", Gujarat Agricultural University, Surat*, 3.

Hagedorn, C., Nelson, N. and Skwara, J. E. 1990. Evaluation of a *Pseudomonas fluorescens* strain for repression of seedling disease in cotton. *Virginia Jour. Sci.*, **41** (4B), 492–500. Retrieved from http://vacadsci.org/vjsArchives/V41/41-4B/41-492.pdf

Hanumanthararay, L., Runranaik, V., Raju, S. G. and Yaragoppa, S. D. 2004. Influence of intercropping on the conservation of *Chrysoperla carnea* (Stephens) in *desi* (diploid) cotton ecosystem. *National Seminar on "Operational methodologies and package of practice in organic farming"*, 7-9th October, 2004, Bangalore, 107–108.

Karabhantanal, S. S., Bheemanna, M. and Patil, B. V. 2007. Management of Sucking pests and bollworms in cotton. *J. Cotton Res. Dev.*, **21**, 253–56.

Kolhe, A. V, Nawod, S. S., Patil, B. R., and Ingole, O. V. 2009. Bio-efficacy of newer insecticides against sucking pests of cotton. *J. Cotton Res. Dev.*, **23** :, 146–48.

Kranthi, K. R. 2013. Long live Swadesi cotton. *Cotton Statistics & News*, 1. https://doi.org/www.cicr.org.in/pdf/Kranthi_art/*Desi*_Cotton_Aug_2013.pdf

Kumar, K., Santharam G. and Ridhar, R. S. 2007. Compatibility of imidacloprid with plant pathogenic antagonistic microorganisms, *Trichoderma viride* (Pers) and *Pseudomonas fluorescens* (Migula) in cotton. *Asian J. Bio. Sci.*, **3**, 171–75.

Kumar, K., and Santhram, G. 1999. Effect of imidacloprid against aphids and leafhoppers on cotton. *Ann. Pl. Prot. Sci.*, **7**, 212–51.

Monga, D. and Sheo, R. 2002. Root rot disease of cotton and its management. In *Cicr Techn. Bull.* (pp.1–7). https://doi.org/http://www.cicr.org.in/pdf/rootrot_disease.pdf

Mote, U. N., Dhawkar, R. V. and Lolage, G. R. 1995. Efficacy of imidacloprid as seed treatment against sucking pests of cotton. *Pestology*, **1**, 5–8.

Nauen, R., and Elbert, A. 1994. Effect of imidacloprid on aphids after seed treatment of cotton in laboratory and greenhouse experiments. *P flanzen schutz nachrichten baver*, **47**: 177–210.

Satpute, N. S., Katole, S. R., Dere, U. K. and Mane, N. 2003. Effect of seed dresser insecticides on early season sucking pests, plant growth and yield of cotton. *J. Cotton Res. Dev.*, **17**: 111–13.

Sreelatha and Divakar, B. J. 1997. Impact of imidacloprid seed treatment on insect pest incidence on okra. Indian *J. Pl. Prote.*, **25**, 52–55.

Surendran, M., Kannan, G. S., Nayar, K., and Leenakumary, S. 2012. Compatibility of *Pseudomonas fluorescens* with agricultural chemicals. *J. Biolo. Control*, **26**, 96–99. https://doi.org/10.18311/JBC/2012/3517

Thiruchchelvan, N., Mikunthan, G., Thirukkumaran, G., and Pakeerathan, K. 2013. Effect of Insecticides on Bio-Agent *Trichoderma harzianum* rifai Under *In vitro* Condition. *Environ. Sci.*, **13**, 1357–60. https://doi.org/10.5829/idosi.aejaes.2013.13.10.11243

Vadodaria, M. P., Patel, U. G., Patel, C. J., Patel, R. B. and Maisuria, I. M. (2001). Thiamethoxam (Cruiser) 70 WS/ : A new seed dresser against sucking pests of cotton. *Pestology*, **25**, 13–23.

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