RESEARCH PAPER

Effect of Insecticides on Sucking Pests and Arthropod Predators in Rainfed Bt Cotton

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Abstract

A study was conducted to know the bioefficacy of different insecticides on sucking pests of Bt cotton under rainfed situation at College of Agriculture, Vijayapur. Flonicamid 50 WG was highly effective in minimizing thrips followed by Fipronil 5 SC. Biopesticide *Lecanicillium lecanii* recorded minimum thrips population. Similar effect was there also on aphids and leafhoppers. Thiamethoxam 25 WG was observed as safest insecticide followed by Diafenthiuron 50 WP, Fipronil 5 SC and Acetamiprid 20 SP to the lady bird beetles and green lace wings, however Diafenthiuron 50 WP was safer to spiders followed by Thiamethoxam 25 WG, Fipronil 5 SC and Acetamiprid 20 SP. Significantly highest seed cotton yield was harvested from Flonicamid 50 WG treatment (25.13 q/ha) followed by Fipronil 5 SC (23.95 q/ha), Dinotefuran 20 SG (23.36 q/ha) and Acetamiprid 20 SP (23.05 q/ha) and these are at par with each other. *L. lecanii* treatment yielded 15.52 q/ha. Cost economics of different treatments revealed that among the chemical treatments, highest benefit cost ratio was obtained in Fipronil 5 SC followed by Acetamiprid 20 SP and Flonicamid 50 WG.

Keywords : Bt. Cotton, Sucking Pests, Mirids, Predators

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Introduction

Cotton *(Gossypium* spp.*)*, popularly known as "White Gold" , is grown on about 11.8 million ha as Bt cotton in India with a production of 27.8 million bales and average productivity of 513 kg/ha. In Karnataka it is being cultivated in an area of 0.612 million ha with production of 2.0 million bales and productivity of 556 kg/ha. Sucking pests pose a serious threat to cotton productivity. In recent days many insecticides are incorporated in integrated pest management (IPM) practices to manage the increasing sucking insect pests. But the insecticides not only affect the target pest but also have adverse effect on natural enemies. Hence, it is important to screen them for their safety to natural enemies. Selective insecticides integrated with biological control can minimize adverse effects to natural enemies (Johnson and Tabashnik, 1999). About 90% of approximately 4,200 Coccinellid species are considered beneficial because of their predatory activity, mainly against homopterous insects and mites (Swaminathan *et al.,* 2010). Conservation of natural enemies is very necessary. Thus, an attempt was made to determine efficacy of selected insecticides and bio pesticides against sucking pests along with their safety for natural enemies in Bt cotton ecosystem.

Materials and Methods

The study was conducted at College of Agriculture, Vijayapur, to know the effect of insecticides and bio pesticides on sucking insect pests, natural enemies and yield in Bt cotton ecosystem under rainfed situation during *kharif* season 2016 -17 in a randomized block design (RBD) with 10 treatments and were replicated thrice, with spacing of 90 x 60 cm in plot size of 4.2 x 6.3 m^2. The observations on sucking pests like thrips, aphids, leafhoppers and mirid bug were recorded as number of nymphs and adults per top, middle and bottom three (3) leaves on randomly selected five (5) plants from each treatment, later the population was averaged as number per three leaves. All the insecticidal treatments were imposed four times according to the crop growth stages at 40, 55, 70 and 90 days after sowing. Mirid bug population was recorded as number of nymphs and adults on 5 squares per plant on randomly selected 5 plants. The insecticidal treatments were at 70 and 90 days after sowing. Observations were recorded at one day before, 3, 5 and 10 days after each spray and later data computed for average of three observation.

The major arthropod natural enemies *viz*. lady bird beetles (coccinellids), green lace wings (*Chrysoperla zastrowii selemi*) and spiders were recorded as number per plant on five randomly selected plants. For coccinellids and *Chrysoperla,* eggs, grubs and adults were considered together. Observation was taken on randomly selected 5 plants in each treatment at one day before first spray and three days after last spray. Finally total seed cotton yield per plot harvested was converted into q/ha and cost benefit ratio was worked based on prevailing prices in the market for inputs and kapas selling price in co-operative sale depots.

Results and Discussion

Thrips : Mean thrips population per 3 leaves at first, second, third and fourth spray is presented in **Table 1.** At first spray, significantly lowest thrips population (29.81) was recorded from flonicamid 50 WG treated plot followed by fipronil 5 SC (32.98), acetamiprid 20 SP (38.15) and dinotefuron 20 SG (38.45). During second, third and fourth spray also similar trend was noticed with regard to reduction in thrips population by insecticides, but no impact of bio control agents. Present study is in close agreement with findings of Bhavani Sankara Rao *et al.* (1991) and Ghelani *et al.* (2006) who reported poor efficacy botanicals and microbials against thrips in okra. Gaurkhede *et al.* (2015) reported that fipronil 5 SC, flonicamid 50 WG, dinotefuran 20 SG and acetamiprid 20 SP effectively minimized the thrips density. Ghelani *et al.* (2014) and Ravikumar *et al.* (2016) observed maximum mortality of thrips with flonicamid 50 WG.

Leafhoppers : Minimum population of leafhoppers **(Table 2)** was observed in flonicamid 50 WG (0.06 Leafhoppers / 3 leaves) and dinotefuran 20 SG (0.09 Leafhoppers / 3 leaves) being on par to each other. The next superior treatments were diafenthiuron 50 WP, acetamiprid 20 SP, fipronil 5 SC and thiamethoxam 25 WG with the mean population of 0.15, 0.17, 0.22 and 0.23 Leafhoppers / 3 leaves, respectively). Similar trend was noticed in second, third and fourth spray in leafhopper suppression. Similarly Kadam et al. (2014) revealed maximum mortality of leafhopper by flonicamid treatment. Razaq *et al.* (2005) also found minimum leafhoppers in plots treated with acetamiprid followed by thiamethoxam.

Aphids : The aphid incidence was not noticed during 1^{st} and 2^{nd} sprays. The population was started to appear in the month of September, hence only 3^{rd} and 4^{th} sprays were taken. In the present investigation the treatments flonicamid 50 WG, acetamiprid 20 SP, dinotefuran 20 SG fipronil 5 SC , thiamethoxam 25 WG and diafenthiuron 50 WP were significantly superior and equally effective against aphids over rest of the treatments (4.88,5.25, 5.41, 6.22,6.35 and 6.60 aphids / three leaves, respectively) and were at par with each other **(Table.3)**. The next best treatment was quinalphos 25 EC (9.04 aphids / 3 leaves) and was significantly superior to *Licanicillium lecanii* (11.01) and nimbicidin (12.33). In the next spray similar trend of efficacy was observed. The present investigations are in line with the outcome of Ghelani *et al.* (2014), Gaurkhede *et al.* (2015) and Sathyan *et al.* (2016) who observed minimum aphid population in the plots treated with flonicamid 50 WG, dinotefuran 20 SG and quinalphos 25 EC.

Mirid bugs : Mirid bugs are emerging pests of Bt cotton in Karnataka (Udikeri, 2008) and their presence is low (Rohini *et al.,* 2009) in Vijayapur district. A day before spraying the mirid bugs population was statistically uniform in all the treatments **(Table.3).** The mean of 3, 5 and 10 days after spray at first spray, treatments fipronil 5 SC and flonicamid 50 WG recorded no population of mired bugs/5 squares which were significantly superior in suppressing the mirid bugs. During second spray also the mirid bugs/ 5 squares were 0.04, 0.09, 0.10, 0.16, 0.20 and 0.23 recorded in fipronil 5 SC, acetamiprid 20 SP, thiamethoxam 25 WG, flonicamid 50 WG, dinotefuran 20 SG and diafenthiuron 50 WP treatments, respectively. The present findings confirmed the findings of Bheemanna *et al.* (2010) and Prakash (2012) who observed efficacy of fipronil 5 SC against mirid bugs in cotton. The relative efficacy of other insecticides except flonicamid found here have been verified earlier by Udikeri *et al,* 2011.

Impact of insecticides and bio pesticides on arthropod predators : The present study revealed that, the bio pesticides recorded more number of natural enemies compared to synthetic insecticides **(Table.4)**. The population of all predators was uniform before first application. The impact of treatments at three days after last application could reveal variations in safety. The population of coccinellids was significantly high in nimbicidin and *L. leccani* 2.73/pl and 2.67/pl respectively. The most effective treatment flonicamid could spare only 0.27/pl coccinellids. Similarly nimbecidine and *L. leccani* treated plots were having 1.27 and 1.13 green lace wing populations/plant against nil in flonicamid. Further, such trend was noticed in the spider populations with 2.0, 1.73 and 0.47 per plant in nimbecidine, *L. leccani* and flonicamid, respectively. In untreated control plots there was increase in all predators and population found to be significantly high. The safety of neem based products and insect pathogens does not require any justification. However flonicamid's adverse effect on arthropod predators reported here lack justification from previous reports.

Seed cotton and economics : Significantly highest seed cotton yield was harvested from flonicamid 50WG (25.13 q/ ha) and was superior over other treatments **(Table 5)**. Next best treatments were fipronil 5 SC (23.95 q/ ha), dinotefuran 20 SG (23.36 q /ha) and acetamiprid 20 SP (23.05 q/ ha). These were significantly at par with each other followed by thiamethoxam 25 WG (20.83 q/ ha) and diafenthiuron 50 WP (20.56 q /ha) which is in corroboration with findings of Patil *et al.,* 2009. The yield in biorational treatments *L. lecanii* (15.52 q/ha) and nimbicidin (15.13 q/ha) was less, however better than untreated control (13.05q/ ha). In the present investigation maximum net returns was obtained from flonicamid 50 WG (Rs. 90695 / ha) followed by fipronil 5 SC (Rs. 87327 / ha), acetamiprid 20 SP (Rs. 83889 / ha) and dinotefuran 20 SG (Rs. 81323 / ha). In case of bio pesticides highest net return of Rs. 40479 / ha was obtained from *L. lecanii.* The results on cost benefit ratio revealed that, highest benefit cost ratio was obtained in fipronil 5 SC (2.87) followed by acetamiprid 20 SP (2.86), flonicamid 50WG (2.81). In case of eco friendly bio pesticides, highest B: C ratio was noticed in *L. lecanii* (1.87). Such economic advantage is common with highly effective insecticides in commercial crops like cotton. A similar advantage through newer insecticidal control of sucking management was observed by Bharpoda *et al.* (2014) in terms of cost benefit ratio.

Table 1: Bio efficacy of insecticides and bio pesticides against thrips, *Thrips tabaci* (Lindeman) on Bt cotton

Treatments	Mean population of thrips / 3 leaves							
	First spray		Second spray		Third spray		Fourth spray	
	1 DBS	Mean of (3,5&10DAS)	1 DBS	Mean of (3,5&10DAS)	1 DBS	Mean of 3,5&10DAS	1 DBS	Mean of (3,5&10 DAS)
Diafenthiuron 50 WP @ 0.6g/ litre	74.49 (8.66)	42.04 (6.52)^{ab}	47.19 (6.91)^{bc}	19.05 (4.24)^{a}	23.42 (4.89)	6.62 (2.63)^{b}	15.96 (4.06)^{cd}	3.05 (1.76)^{b}
Dinotefuran 20 SG @ 0.3g/litre	72.71 (8.56)	38.45 (6.23)^{ab}	43.64 (6.64)^{abc}	14.64 (3.76)^{a}	22.70 (4.79)	4.69 (2.25)^{b}	11.90 (3.52)^{bc}	1.85 (1.42)^{a}
Fipronil 5 SC @1 ml/litre	75.48 (8.71)	32.98 (5.77)^{a}	36.15 (6.05)^{ab}	11.25 (3.20)^{a}	22.69 (4.81)	2.43 (1.68)^{a}	7.86 (2.89)^{ab}	0.78 (1.06)^{a}
Flonicamid 50 WG @ 0.3g/litre	75.85 (8.73)	29.81 (5.48)^{a}	31.80 (5.68)^{a}	9.35 (3.10)^{a}	23.06 (4.85)	1.87 (1.50)^{a}	7.02 (2.73)^{a}	0.72 (1.05)^{a}
Quinalphos 25 EC @ 2 ml/litre	72.45 (8.54)	50.84 (7.25)^{b}	59.72 (7.76)^{cd}	25.43 (4.76)^{a}	20.22 (4.50)	10.39 (3.76)^{c}	25.65 (5.11)^{e}	9.29 (3.08)^{c}
Thiamethoxam 25 WG @ 0.2 g/litre	74.01 (8.63)	42.98 (5.59)^{a}	47.45 (6.91)^{bc}	19.29 (4.20)^{a}	22.43 (4.79)	6.79 (2.66)^{b}	17.40 (4.23)^{d}	3.57 (1.88)^{b}
Nimbicidin 1500 ppm @ 2 ml/litre	73.25 (8.59)	64.39 (8.05)^{d}	73.39 (8.59)^{d}	41.85 (6.05)^{b}	25.66 (5.10)	19.63 (4.46)^{d}	43.47 (6.63)^{g}	28.95 (5.41)^{e}
Lecanicillium lecanii (2x10^{-8}cfu) @ 5g/litre	73.72 (8.61)	61.81 (7.88)^{b}	71.57 (8.49)^{d}	33.48 (5.37)^{b}	26.04 (5.14)	16.59 (4.08)^{c}	34.55 (5.92)^{f}	19.20 (4.40)^{d}
Acetamiprid 20 SP @ 0.2g/litre (Std check)	70.03 (8.39)	38.15 (6.21)^{ab}	42.40 (6.54)^{abc}	13.56 (3.68)^{a}	22.48 (4.79)	4.41 (2.18)^{b}	11.52 (3.47)^{bc}	1.62 (1.35)^{a}
Untreated control	74.49 (8.40)	86.26 (9.07)^{e}	104.39 (10.11)^{e}	68.62 (7.44)^{c}	28.33 (5.36)	48.38 (6.94)^{e}	71.62 (8.44)^{h}	90.92 (9.55)^{f}
C. D. @ 5%		1.46	1.22	1.89		0.63	0.69	0.50
S.Em±	NS	0.49	0.41	0.41	NS	0.21	0.23	0.17
C.V. (%)		12.35	9.67	12.26		11.66	8.53	9.40

Note: DBS - Day before spray. DAS - Days after spray.
Figures in the parentheses are $\sqrt{(x+0.5)}$ transformed values.
Means followed by similar alphabets in the column do not differ significantly at 0.05% by DMRT.

Table 2: Bio efficacy of insecticides and bio pesticides against Leafhoppers, Amrasca biguttula biguttula (Ishida) on Bt cotton

Treatments	Mean population of Leafhoppers / 3 leaves							
	First spray		Second spray		Third spray		Fourth spray	
	1 DBS	Mean of (3,5&10DAS)	1 DBS	Mean of (3,5&10DAS)	1 DBS	Mean of (3,5&10DAS)	1 DBS	Mean of (3,5&10 DAS)
Diafenthiuron 50 WP @ 0.6g/ litre	0.67 (1.08)	0.15 (0.80)^{a}	0.40 (0.95)^{a}	0.08 (0.76)^{a}	0.43 (0.96)	0.14 (0.79)^{a}	0.61 (1.05)^{ab}	0.19 (0.82)^{a}
Dinotefuran 20 SG @ 0.3g/litre	0.69 (1.09)	0.09 (0.77)^{a}	0.36 (0.93)^{a}	0.04 (0.73)^{a}	0.38 (0.93)	0.08 (0.76)^{a}	0.48 (0.99)^{a}	0.12 (0.78)^{a}
Fipronil 5 SC @1 ml/litre	0.68 (1.08)	0.22 (0.84)^{a}	0.61 (1.05)^{ab}	0.17 (0.81)^{a}	0.55 (1.02)	0.21 (0.84)^{a}	0.83 (1.15)^{ab}	0.29 (0.89)^{a}
Flonicamid 50 WG @ 0.3g/litre	0.71 (1.10)	0.06 (0.74)^{a}	0.33 (0.91)^{a}	0.03 (0.73)^{a}	0.34 (0.91)	0.05 (0.74)^{a}	0.43 (0.96)^{a}	0.06 (0.74)^{a}
Quinalphos 25 EC @ 2 ml/litre	0.70 (1.09)	0.41 (0.96)^{b}	1.13 (1.28)^{bc}	0.03 (0.88)^{a}	0.63 (1.06)	0.39 (0.94)^{b}	1.27 (1.32^{bc}	0.60 (1.04)^{b}
Thiamethoxam 25 WG @ 0.2 g/litre	0.66 (1.08)	0.23 (0.85)^{a}	0.57 (1.03)^{a}	0.14 (0.80)^{a}	0.53 (1.02)	0.19 (0.82)^{a}	0.81 (1.14)^{ab}	0.26 (0.87)^{a}
Nimbicidin 1500 ppm @ 2 ml/litre	0.74 (1.11)	0.63 (1.06)^{b}	1.50 (1.41)^{cd}	0.84 (1.12)^{b}	0.73 (1.11)	0.59 (1.04)^{c}	2.52 (1.74)^{d}	1.74 (1.49)^{c}
Lecanicillium lecanii (2x10^{-8}cfu) @ 5g/litre	0.74 (1.11)	0.55 (1.02)^{b}	1.42 (1.38)^{cd}	0.73 (1.08)^{b}	0.67 (1.08)	0.52 (1.01)^{c}	2.10 (1.61)^{cd}	1.31 (1.34)^{c}
Acetamiprid 20 SP @ 0.2g/litre (Std check)	0.68 (1.09)	0.17 (0.81)^{a}	0.40 (0.95)^{a}	0.09 (0.77)^{a}	0.51 (1.00)	0.15 (0.80)^{a}	0.67 (1.08)^{ab}	0.22 (0.84)^{a}
Untreated control	0.71 (1.07)	0.99 (1.20)^{c}	2.01 (1.55)^{d}	1.54 (1.34)^{c}	0.86 (1.16)	1.70 (1.46)^{d}	4.03 (2.09)^{e}	4.27 (2.16)^{d}
C. D @ 5%		0.16	0.23	0.19		0.16	0.31	0.24
S.Em±	NS	0.05	0.08	0.06	NS	0.05	0.10	0.08
C.V (%)		10.15	11.91	11.41		10.48	13.56	12.88

Note: DBS - Day before spray. DAS - Days after spray.
Figures in the parentheses are $\sqrt{(x+0.5)}$ transformed values.
Means followed by similar alphabets in the column do not differ significantly at 0.05% by DMRT

Table 3: Bio efficacy of insecticides and bio pesticides against aphids, *Aphis gossypii* (Glover) and mirid bug, *Campylomma livida* (Reuter) *on* Bt cotton

Treatments	Mean population of aphids / 3 leaves				Mean population of mirid bugs / 5 squares			
	First spray		Second spray		Third spray		Fourth spray	
	1 DBS	Mean of (3,5&10DAS)	1 DBS	Mean of (3,5&10DAS)	1 DBS	Mean of (3,5&10DAS)	1 DBS	Mean of (3,5&10DAS)
Diafenthiuron 50 WP @ 0.6g/ litre	15.80 (4.03)	6.60 (2.64)^{a}	16.00 (4.06)^{ab}	3.60 (1.90)^{b}	0.35 (0.92)	0.10 (0.77)^{b}	0.55 (1.02)^{ab}	0.23 (0.85)^{a}
Dinotefuran 20 SG @ 0.3g/litre	14.60 (3.85)	5.41 (2.40)^{a}	12.53 (3.61)^{a}	1.19 (1.20)^{a}	0.34 (0.92)	0.22 (0.77)^{b}	0.53 (1.01)^{ab}	0.20 (0.83)^{a}
Fipronil 5 SC @1 ml/litre	15.80 (4.02)	6.22 (2.56)^{a}	15.20 (3.96)^{a}	3.00 (1.69)^{a}	0.30 (0.89)	0.00 (0.71)^{a}	0.36 (0.93)^{a}	0.04 (0.73)^{a}
Flonicamid 50 WG @ 0.3g/litre	15.33 (3.97)	4.88 (2.29)^{a}	10.80 (3.36)^{a}	0.86 (1.06)^{a}	0.32 (0.90)	0.00 (0.71)^{a}	0.51 (1.00)^{ab}	0.16 (0.81)^{a}
Quinalphos 25 EC @ 2 ml/litre	15.23 (3.92)	9.04 (3.07)^{b}	22.67 (4.81)^{bc}	10.19 (3.20)^{c}	0.39 (0.94)	0.22 (0.85)^{b}	0.83 (1.15)^{bc}	0.48 (0.99)^{b}
Thiamethoxam 25 WG @ 0.2 g/litre	15.53 (3.99)	6.35 (2.59)^{ab}	15.66 (4.02)^{ab}	3.27 (1.80)^{a}	0.31 (0.90)	0.30 (0.73)^{a}	0.44 (0.97)^{a}	0.10 (0.78)^{a}
Nimbicidin 1500 ppm @ 2 ml/litre	15.07 (3.92)	12.33 (3.58)^{c}	35.33 (5.99)^{de}	23.41 (4.87)^{d}	0.45 (0.97)	0.33 (0.91)^{c}	0.97 (1.21)^{c}	0.76 (1.12)^{b}
Lecanicillium lecanii ($2x10^{-8}$cfu) @ 5g/litre	15.33 (3.97)	11.01 (3.38)^{c}	29.53 (5.48)^{cd}	15.88 (4.25)^{d}	0.42 (0.96)	0.30 (0.89)^{b}	0.94 (1.20)^{c}	0.64 (1.06)^{b}
Acetamiprid 20 SP @ 0.2g/litre (Std check)	15.57 (4.01)	5.25 (2.36)^{a}	12.20 (3.56)^{a}	0.97 (1.09)^{ab}	0.30 (0.89)	0.03 (0.73)^{a}	0.41 (0.95)^{a}	0.09 (0.77)^{a}
Untreated control	15.87 (4.03)	34.09 (5.70)^{d}	39.40 (6.23)^{e}	52.34 (7.18)^{e}	0.54 (1.01)	0.69 (1.08)^{d}	1.07 (1.23)^{c}	1.42 (1.35)^{c}
C. D @ 5%	NS	0.55	0.73	0.67		0.04	0.15	0.19
S.Em±		0.19	0.25	0.22	NS	0.12	0.06	0.06
C.V (%)		10.52	9.50	13.83		9.28	9.35	12.28

Note: DBS - Day before spray, DAS - Days after spray, Figures in the parentheses are $\sqrt{(x+0.5)}$ transformed values,
Means followed by similar alphabets in the column do not differ significantly at 0.05% by DMRT

Table 4 : Impact of insecticides and bio pesticides on arthropod predatory populations

Treatments	Mean population of natural enemies / plant					
	Coccinellids		Green lace wing		Spiders	
	1 day before 1st spray	3 days after last spray	1 day before 1st spray	3 days after last spray	1 day before 1st spray	3 days after last spray
Diafenthiuron 50 WP @ 0.6g/ litre	0.53 (0.99)	1.47 (1.40)^{c}	0.33 (0.91)	0.60 (1.05)^{c}	0.27 (0.87)	1.40 (1.37)^{bcd}
Dinotefuran 20 SG @ 0.3g/litre	0.33 (0.88)	0.13 (0.79)^{d}	0.20 (0.83)	0.00 (0.71)^{d}	0.13 (0.79)	0.27 (0.87)^{f}
Fipronil 5 SC @1 ml/litre	0.47 (0.97)	1.33 (1.35)^{c}	0.33 (0.91)	0.53 (1.02)^{c}	0.20 (0.83)	1.13 (1.28)^{cd}
Flonicamid 50 WG @ 0.3g/litre	0.40 (0.93)	0.27 (0.87)^{d}	0.33 (0.91)	0.00 (0.71)^{d}	0.20 (0.83)	0.47 (0.98)^{ef}
Quinalphos 25 EC @ 2 ml/litre	0.33 (0.88)	0.13 (0.79)^{d}	0.20 (0.83)	0.00 (0.71)^{d}	0.20 (0.83)	0.20 (0.84)^{f}
Thiamethoxam 25 WG @ 0.2 g/litre	0.53 (0.99)	1.67 (1.47)^{c}	0.33 (0.91)	0.80 (1.12)^{bc}	0.20 (0.84)	1.27 (1.32)^{cd}
Nimbicidin 1500 ppm @ 2 ml/litre	0.60 (1.05)	2.73 (1.79)^{b}	0.40 (0.95)	1.27 (1.32)^{b}	0.33 (0.91)	2.00 (1.57)^{b}
Lecanicillium lecanii ($2\ x10^{-8}$cfu) @ 5g/litre	0.53 (1.00)	2.67 (1.78)^{b}	0.40 (0.95)	1.13 (1.28)^{b}	0.27 (0.87)	1.73 (1.49)^{bc}
Acetamiprid 20 SP @ 0.2g/litre (Std check)	0.47 (0.97)	1.33 (1.35)^{c}	0.33 (0.91)	0.47 (0.98)^{c}	0.20 (0.83)	0.87 (1.17)^{de}
Untreated control	0.60 (1.05)	4.33 (2.19)^{a}	0.40 (0.94)	3.07 (1.89)^{a}	0.33 (0.90)	4.87 (2.31)^{a}
C. D @ 5%		0.22		0.21		0.24
S.Em±	NS	0.07	NS	0.07	NS	0.08
C.V (%)		9.30		11.30		10.42

Note: DBS - Day before spray, Figures in the parentheses are $\sqrt{(x+0.5)}$ transformed values,
Means followed by similar alphabets in the column do not differ significantly at 0.05% by DMRT

Table 5: Seed cotton yield as influenced by different insecticides and cost benefit ratio

Treatments	Dosage	Seed cotton Yield q/ha	Treatment cost (Rs/ ha)	Other expen-diture (Rs/ha)	Total expend iture (Rs/ha)	Gross returns	Net returns	B:C ratio
Diafenthiuron 50 WP	0.6 g/ litre	20.56	4536	44633	49169	115136	65967	2.34
Dinotefuran 20 SG	0.3 g/ litre	23.36	4860	44633	49493	130816	81323	2.64
Fipronil 5 SC	1 ml/ litre	23.95	2160	44633	46793	134120	87327	2.87
Flonicamid 50 WG	0.3g/litre	25.13	5400	44633	50033	140728	90695	2.81
Quinalphos 25 EC	2 ml/litre	17.80	2160	44633	46793	99680	52887	2.13
Thiamethoxam 25 WG	0.2 g/litre	20.83	1458	44633	46091	116648	70557	2.53
Nimbicidin 1500 ppm	2 ml/litre	15.13	3456	44633	48089	84728	36639	1.76
Lecanicillium lecanii (2×10-8 cfu)	5 g/litre	15.52	1800	44633	46433	86912	40479	1.87
Acetamiprid 20 SP (Standard check)	0.2 g/litre	23.05	558	44633	45191	129080	83889	2.86
Untreated control	---	13.05	0.00	44633	44633	73080	28447	1.64
C.D @ 5 %	-	**1.28**	-	-	-	-	-	-
S.Em +	-	**3.80**	-	-	-	-	-	-
C.V(%)	-	**11.16**	-	-	-	-	-	-

Cost of seed cotton: Rs.5600 /q.
Cost of chemicals: Rs.

Diafenthiuron 50 WP	1050/- : 250g	Flonicamid 50 WG	300/- : 30g	Nimbicidin 1500 ppm	480/- : 500 ml
Dinotefuran 20 SG	450/- : 50g	Quinalphos 25 EC	300/- :500 ml	*Lecanicillium lecanii* (2×10-8 cfu)	100/- : 500g
Fipronil 5 SC	300/- :250ml	Thiamethoxam 25 WG	1013/- : 250g	Acetamiprid 20 SP	155/- : 100g

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Cotton facts: Diseases (ICAC, 2003)
Seeding Diseases

- *Causal organism*

Many species of *Pythium*are known to cause seed rot and are the most common cause of pre-emergence damping-off in cotton, but *Pythium ultimatum* is more prevalent. At an early stage, damping-off symptoms are similar in both fungi. Other fungi, like *Rhizoctonia solani, Thielaviopsis*and various *Fusarium* spp. can also cause damping off. *Xanthomonas campestris*pv.*malvacearum*, the bacterium that causes bacterial blight, can also cause seedling disease. *Rhizoctonia solani*is the most common cause of post- mergence damping off and it can cause seed decay, pre-emergence damping off if seed is planted in cool soil, lesions on the hypocotyls and root rot.

- *Symptoms*

Seedling disease can manifest in different stages from pre-emergence seed rot to post-emergence damping off. In damping-off caused by *Pythium*, seedlings fail to emerge out of the soil. *Pythium* spp. and *Rhizoctonia solani* can cause post- emergence damping-off, and symptoms in both cases are similar. Certain *Pythium*spp. is more damaging at low temperatures and high humidity. Low soil temperatures encourage infection by R. solani. If only minor roots are affected by *Rhizoctonia solani*, only stunting-like symptoms may be seen. At seedling stage, *Colletotrichum*sp. has the potential to cause post-emergence damping-off, but it can also affect the plant at any stage of development. The fungus is carried on the seed and within the seed. Fungicides are effective to control the disease, but in order to avoid infection from within the seed, it is recommended to use planting seed from areas not affected by *Colletotrichum*.

- *Control*

It is very difficult to eradicated soil-borne fungi like *Pythium* spp., *Rhizoctonia solani, Thielaviopsis basicola, Colletotrichum* sp. and *Fusarium*spp. once it has established in the soil. Fungicides, applied as seed dressing or in the soil at planting, are the only solution to control these pathogens. Damping-off caused by *Rhizoctonia solani*can be controlled effectively with fungicides applied as seed treatment or by in-furrow application at planting. A strong genetic resistance source is not available. Any factor that encourages rapid emergence and growth of the seedling is helpful in avoiding the disease.