Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(1): 1848-1852
Received: 18-11-2019
Accepted: 22-12-2019

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Estimation of yield losses and bioefficacy of some novel insecticides against leaf hopper, *Amrasca devastans* in transgenic cotton

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Abstract
Estimation of yield losses and Field efficacy of novel insecticides against leafhoppers on transgenic cotton were assessed during *kharif* 2011. Estimation of yield losses due to, leafhoppers, in RCH-2BG-II, RCH-2N*Bt*, Tulasi-9BG-II and Tulasi-9N*Bt* under protected and unprotected conditions was done with eight treatments and three replications in Factorial Randomized Block Design. RCH-2 was susceptible and Tulasi-9 was tolerant hybrid against leafhoppers. Among the treatments; Tulasi-9 N*Bt* recorded lowest yield loss (13.13%) and RCH-2N*Bt* recorded highest yield loss (19.99%) followed by Tulasi-9 BG-II and RCH-2 BG-II. The bioefficacy of certain novel insecticides against leafhopper recorded Fipronil 5% SC @50g a.i. ha^{-1} and fipronil 80% WG @50g a.i. ha^{-1} were effective in managing leafhopper with a population reduction of 70.9% and 67.6%, respectively.

Keywords: insecticides, Amrasca devastans, transgenic cotton

Introduction
Cotton is an important fibre crop of global significance cultivated in more than seventy countries).In India it is being cultivated in 12.19m ha with a production of 37m bales and productivity of 482kg/ha. In India cotton ecosystem harbours about 162 insect pest species and the monetary value of estimated yield losses due to insect pests has been estimated to be Rs 3,39,660 million annually (Dhaliwal *et al.*, 2010) [3]. Important insect pests of cotton are; 1.sucking pests viz., leafhoppers, *Amrasca biguttula biguttula* (Ishida), aphids, *Aphis gossypii* (Glover), thrips, *Thrips tabaci* (Lind) and whiteflies, *Bemisia tabaci* (Genn) 2. Bollworms viz., American bollworm, *Helicoverpa armigera* (Hubner), spotted bollworm, *Earias vittella* (Fabricius) and pink bollworm, *Pectionphora gossypiella* (Saunders). Generally sucking pests attack the crop during early part of the crop growth and bollworms cause extensive damage during reproductive stage of the crop. Among various sucking insect pests of cotton, the leafhopper, *A. biguttula biguttula* is the most important pest and accounts for 35 per cent reduction in the Cambodian cotton (Neelakantan, 1957) [6] and 25.45% reduction in non-hairy varieties (Bhat *et al.*, 1986).
Several potent insecticides have been recommended for managing sucking pests, but the use of insecticides have resulted in the development of resistance, resurgence, secondary pest out breaks, disruption of natural enemy complex and environmental pollution (Dhaliwal and Arora, 2001) [2]. The newer molecules have a higher stability and superiority over the conventional insecticides to control the pest population density at field level (Vinoth Kumar *et al.*, 2009). In order to get economic and effective management of sucking pests it is essential to know the actual amount of the loss caused by them. The investigation was therefore undertaken to quantify yield losses caused by sucking insect pests of cotton along with determination of the suitable management practices to combat the leafhopper damage.

Materials and Methods
(A) Estimation of yield losses due to leaf hoppers on transgenic cotton hybrids
The field trial was laid out at at Regional Agricultural Research Station, Lam, Guntur in Factorial Randomized Block Design with 8 treatments and 3 replications.
Treatment details as follows:

Factor-1 Hybrids Factor-2 Protection level
1. RCH-2BG-II (H_1) 1. Protected (P_1)
2. RCH-2 N*Bt* (H_2) 2.Unprotected (P_2)
3. Tulasi-9BG-II (H_3)
4. Tulasi-9NBt (H4)

Sowing was taken up after receipt of sufficient rains, under saturated conditions of soil with a spacing of 105 X 60 cm between rows and plants, respectively on Ist of August 2011.
The crop was grown under rainfed conditions without any irrigation during the season. Well opened and dried bolls were picked manually with human labour at appropriate time without contamination of plant parts and trash. Seed cotton yield in each treatment was recorded separately as weight in kg and yields were worked out inq/ha. Sucking pests were kept under check in protected plots by spraying monocrotophos 36 SL @360g a.i. ha^{-1}, acephate 75% SP @750g a.i. ha^{-1} and imidacloprid 17.8 SL @40g a.i. ha^{-1} at 25, 40 and 55 DAS during the crop period. While in the unprotected plots, it was allowed for natural infestation of sucking pests. The tobacco caterpillars and other pests were handpicked and destroyed. Percent loss in seed cotton was calculated by comparing the yield obtained from protected and unprotected plots using the following formula:
The avoidable yield loss in cotton due to sucking insect was worked

$$\text{Per cent avoidable loss in yield} = \frac{\text{T-UT}}{\text{T}} \times 100$$

Where,
T- Seed cotton yield in treated plots.
UT-Seed cotton yield in untreated plots

Incidence of sucking pests per three leaves, per plant was recorded on five randomly selected plants per plot from 30days after sowing (DAS) onwards both in protected and un-protected plots (Plate 2). The average of all five observations was calculated and expressed as mean population. Incidence of leafhoppers per three leaves was recorded. The seed cotton yield from each plot was recorded twice separately as kg/plot and converted intoq/ha.

B) Bioefficacy of different novel insecticides against leaf hopper
The experiment was laid out in Randomized Block Design with ten treatments including control and replicated thrice with plot size of 6.3mX5.4m (Fig. 3.2). Standard agronomic practices were adopted to raise a good crop of cotton. *Bt* cotton hybrid RCH-2BG-II was selected for this experiment. Treatment particulars are presented in table-3.1.

1 Seed Treatment
For delinted seed, 5 ml of gum per kg seed was evenly distributed through thorough shaking in a polythene bag into which 5 g of imidacloprid 70 WS was added for uniform coating over the seed. Then the treated seed was shade dried for about 10 minutes and used for sowing.

2 Application of Treatments

Table 1: Particulars of insecticides used

S. No.	Chemical name	Chemical class	a.i. ha^{-1}
T_1	Diafenthiuron 50% WP	Thiourea	375
T_2	Fipronil 5% SC	Phenylpyrazole	50
T_3	Spirotetramat150 OD	Ketoenols	90
T_4	Imidacloprid 70% WG	Neonicotinoids	21
T_5	Fipronil 80% WG	Phenylpyrazole	50
T_6	Buprofezin 25% SC	Insect growth regulator	150
T_7	Spiromesifen 240 SC	Spirocyclic tetronic acids	40
T_8	Thiacloprid 21.7% SC	Neonicotinoids	24
T_9	Acephate 75% SP	Organophosphate	750

Results and Discussions
Mean incidence of leafhopper on different cotton hybrids under protected and unprotected conditions
The mean data on leafhopper populations as influenced by different hybrids in the protected and unprotected conditions are presented in table-4. Significant differences were observed between protection levels, hybrids and their interaction.
The leaf hopper population differed with different levels of protection irrespective of hybrids. The unprotected plot recorded significantly higher leafhopper population over protected ones with 9.7and 2.4 leafhopper per three leaves respectively with 73.1% overall increase in population in the unprotected plot over protected ones.
The leafhopper population statistically different in hybrids irrespective of protection levels. Among the different hybrids used, RCH-2N*Bt* recorded significantly higher population of leafhopper (7.9/three leaves), but it was on par with RCH-2 BG-II (7.5/three leaves). Tulasi-9BG-2 and Tulasi- 9N*Bt* recorded 4.6 and 4.3 leafhopper/three leaves respectively.
The leafhopper population as result of interaction between protection level and hybrids differed significantly. Among the different treatment combinations, the hybrid RCH-2N*Bt* under unprotected conditions recorded significantly higher population of 12.9/leafhopper per three leaves as compared to the remaining treatment combinations. Among the remaining treatment combinations under unprotected conditions RCH-2BG-II (12.4/three leaves), Tulasi-9BG-II and Tulasi-9N*Bt* (6.9 and 6.6/three leaves) recorded. All the four-treatment combinations pertaining protected conditions were significantly superior to all the treatment combinations under unprotected ones.
Leafhopper injury grades of one and two were recorded in Tulasi-9 and RCH-2 respectively under protected conditions. Injury grades of three and four were recorded in Tulasi-9 and RCH-2 under unprotected conditions are presented in table-2.

Leafhopper injury grade was recorded as follows
Grade 1: Undamaged leaves.
Grade 2: Yellowing of outer margins of leaves.
Grade 3: Brick red color of margins, crinkling and curling.
Grade 4: Entire leaf turns to brick red color and extreme curling and drying of leaves (Plate 1).

Grade 1: No damage symptoms **Grade 2:** Yellow colour margins

Grade3: Brickred colour leaf margins **Grade4:** Brickred colour leaf

Fig 1: Leafhopper injury grades

Table 2: Leafhopper injury grades in different cotton hybrids

S. No.	Hybrids	Injury grade	
		Protected	Unprotected
1	RCH-2BG-II	II	IV
2	RCH-2N*Bt*	II	IV
3	Tulasi-9BG-II	I	III
4	Tulasi-9N*Bt*	I	III

Table 3: Cotton seed yield (q/ha) and yield loss

Hybrids	Cotton seed yield(q/ha)			Yield loss (%)
	Protected	Unprotected	Mean	
RCH-2BG-II	12.50	10.39	11.44	16.82
RCH-2 N *Bt*	12.64	10.11	11.38	19.99
Tulasi-9 BG-II	18.78	15.92	17.35	15.23
Tulasi-9N*Bt*	16.19	14.06	15.13	13.13
Mean	15.03	12.62	13.83	16.29

For comparing	SEm	CD (P=0.05)
hybrids	0.63	1.91
Protection	0.45	1.35
interaction	0.89	NS

NS: Non significant

Estimation of Loss in Cotton Seed Yields

Seed yield

The data pertaining to the seed cotton yield as influenced by different hybrids with protected and unprotected conditions are presented in table-3. Significant differences were observed between protection levels and hybrids while their interaction effect was non-significant. The perusal of data pertaining to seed cotton yield indicated significant differences between protected and unprotected treatments with a yield of 15.03 and 12.62q/ha respectively. Among different hybrids, seed cotton yield ranged from 17.35 to 11.38q/ha with significant differences. Hybrids and protection levels played a pivotal role in determining final seed cotton yield. The hybrids Tulasi-9 BGII recorded the highest seed cotton yield of 17.35q/ha and it is significantly different from all other hybrids. Tulasi9 N*Bt*, RCH-2 BG-II and RCH-2 N*Bt* recorded 15.13, 11.44 and 11.38q/ha. Protection levels also determined final seed cotton yield. Protected plots recorded the yield of 15.03q/ha and unprotected plots recorded the yield of 12.62q/ha. The estimated avoidable yield loss due to sucking pests in RCH-2 N*Bt* RCH-BG-II, Tulasi-9 BG-II and Tulasi-9 N*Bt* was 19.99%, 16.82%, 15.23% and 13.13% respectively. These results are inconformity with the findings of Neelakantan as early as 1957 [6] reported that leafhoppers were the severe production constraint on cotton and estimated the avoidable yield loss of 35% in Cambodian cottons. Bhat *et al*. (1986) [1] and Javed *et al*. (1992) [5] estimated a yield loss of 25.5% and 18.8% due leafhoppers in cotton.

Bioefficacy of different novel insecticides against leafhoppers

Mean data on leafhopper at 3DAT ranged from 2.4 to 10.6/three leaves are presented in table-5, 6. Leafhopper population of around 2.5/three leaves was recorded in fipronil 5% SC @50g a.i. ha^{-1} (2.4/three leaves) and fipronil 80% WG @50g a.i. ha^{-1} (2.6/three leaves). Maximum of 10.6/three leaves was recorded in control which is significantly inferior over all other treatments. The next best treatments were diafenthiuron 50% WP @375g a.i. ha^{-1} (2.9/three leaves), buprofezin 25% SC @150g a.i. ha^{-1} (3.3/ three leaves), acephate 75% SP @750g a.i. ha^{-1} (3.6/ three leaves) and imidacloprid 70% WG @ 21 g a.i. ha^{-1} (4.0/three leaves) which were on par with each other. The least effective treatments were spiromesifen 240 SC @40 g a.i. ha^{-1}(4.5/ three leaves), spirotetramat 150 OD @90g a.i. ha^{-1} (5.0/three leaves) and thiacloprid 21.7% SC @24g a.i. ha^{-1} (5.6/three leaves).

Mean data on leafhopper at 7 DAT ranged from 2.9 to 11.3/three leaves. Minimum of 2.9/ three leaves was recorded in fipronil 5% SC @50g a.i. ha^{-1} treated plot which is significantly superior over all other treatments and it was on par with fipronil 80% WG @50g a.i. ha^{-1} (3.1/three leaves). Maximum of 11.3/three leaves was recorded in control which is significantly inferior over all other treatments. The next best treatments were diafenthiuron 50% WP @ 375g a.i. ha^{-1} (3.4/three leaves), buprofezin 25% SC @150g a.i. ha^{-1}(3.9/three leaves), acephate 75% SP @750g a.i. ha^{-1}(4.5/three leaves) and imidacloprid 70% WG @21 g a.i. ha^{-1} (4.8/three leaves) which were on par with each other. The treatments, spiromesifen 240 SC @40g a.i. ha^{-1} (5.5/three leaves), spirotetramat 150 OD @90g a.i. ha^{-1}(5.8/three leaves) and thiacloprid 21.7% SC @24g a.i. ha^{-1} (6.4/three leaves).

At 10 DAT, the highest reduction was observed in fipronil 5% SC @50g a.i. ha^{-1} (70.9%) followed by fipronil 80% WG @ 50g a.i. ha^{-1} (67.6%), diafenthiuron 50% WP @375g a.i. ha^{-1} (65.9%) and buprofezin 25% SC @150g a.i. ha^{-1}(59.4%) which were on par with each other. The next best treatments were acephate 75% SP @750g a.i. ha^{-1} (53.0%), imidacloprid 70% WG @21g a.i. ha^{-1}(50.0%), spiromesifen 240 SC @40g a.i. ha^{-1} (46.0%), spirotetramat 150 OD @90g a.i. ha^{-1} (42.6%) which were on par with each other. The least effective treatment is thiacloprid 21.7% SC @24g a.i. ha^{-1} (37.2%) which was significantly different from all other treatments.

These findings are at par with Singh *et al*. (2002) [9] and Singh *et al.* (2007) [10] reported that fipronil @50g a.i. ha^{-1} at fortnightly interval was found to be the best treatment against the leafhopper. Wadnerkar *et al*. (2003) [12] reported that treatment with fipronil 5% SC @ 50-75g a.i. ha^{-1} was effective in lowering the population of thrips, aphids and jassid infesting cotton. Jadhav *et al*. (2004) [4] indicated that fipronil 5% SC @100 g a.i. ha^{-1} resulted in 2.2 leafhoppers per leaf and 1.2 thrips per leaf at seven days after application in chilli. Razaq *et al.* (2005) [7] studies suggested that diafenthiuron 500 EC proved to be the most effective in reducing jassid population below ETL (1-1.5/leaf) up to seven days after application on cotton.

Conclusion

It is evident from the present investigation that the yield in all treatments was significantly higher than untreated control. The plot treated fipronil 5% SC @50g a.i. ha^{-1} showed a leafhopper population reduction of 70.9% followed by fipronil 80% WG @50g a.i. ha^{-1} with 67.6% leafhopper population reduction. Hence it could be recommended for safe and economic use in cotton for effective control of leafhoppers.

Table 4: Mean efficacy of different novel insecticides against leafhopper

S. No.	Treatments	3DAT*	7DAT*	10DAT*	% reduction over control at 10DAT **
T_1	Diafenthurion50%WP	2.9 (1.96)^{abc}	3.4 (2.10)^{ab}	4.0 (2.23)^{ab}	65.9 (54.43)^{a}
T_2	Fipronil 5% SC	2.4 (1.84)^{a}	2.9 (1.96)^{a}	3.4 (2.09)^{a}	70.9 (57.50)^{a}
T_3	Spirotetramat 150 OD	5.0 (2.45)^{ef}	5.8 (2.60)^{ab}	6.7 (2.78)^{ef}	42.6 (40.63)^{de}
T_4	Imidacloprid 70% WG	4.0 (2.23)^{cde}	4.8 (2.41)^{cd}	5.9 (2.62)^{de}	50.0 (45.01)^{cd}
T_5	Fipronil 80% WG	2.6 (1.89)^{ab}	3.1 (2.02)^{a}	3.8 (2.18)^{a}	67.6 (55.48)^{a}
T_6	Buprofezin 25%SC	3.3 (2.07)^{abcd}	3.9 (2.21)^{abc}	4.8 (2.40)^{bc}	59.4 (50.51)^{b}
T_7	Spiromesifen 240% SC	4.5(2.34)^{def}	5.5(2.55)^{de}	6.3(2.71)^{de}	46.0(42.68)^{de}
T_8	Thiacloprid 21.7% SC	5.6 (2.56)^{f}	6.4(2.71)^{e}	7.4 (2.89)^{f}	37.2 (37.43)^{g}
T_9	Acephate 75% SP	3.6 (2.14)^{bcd}	4.5 (2.34)^{bcd}	5.5 (2.55)^{cd}	53.0 (46.78)^{c}
T_{10}	Control (untreated)	10.6 (3.39)^{g}	11.3 (3.50)^{f}	11.9 (3.59)^{g}	
	F-TEST	sig	sig	sig	sig
	SEm	0.05	0.04	0.03	0.72
	CD(P=0.05)	0.26	0.25	0.17	3.70

*Figures in parentheses are square root transformed values.
**Figures in parentheses are angular transformed values.
Numbers followed by same superscript are not statistically different.
Sig : Significant.
NS : Non-significant.
DAT : Days after treatment.

Table 5: Bioefficacy of different novel insecticides against leafhopper, *A. biguttula biguttula*

S. No.	Treatments	First spray				Second spray				Third spray			
		3DAT*	7DAT*	10DAT*	% reduction over control at 10DAT**	3DAT*	7DAT*	10DAT*	% reduction over control at 10DAT**	3DAT*	7DAT*	10DAT*	% reduction over control at 10DAT**
T_1	Diafenthurion 50%WP	3.4 (2.10)^{ab}	4.3 (2.31)^{ab}	4.8 (2.41)^{ab}	54.6 (47.75)^{ab}	3.0 (2.00)^{ab}	3.5 (2.11)^{ab}	3.7 (2.16)^{a}	69.4 (56.40)^{a}	2.2 (1.79)^{ab}	2.5 (1.88)^{ab}	3.5 (2.11)^{ab}	72.9 (58.83)^{abc}
T_2	Fipronil 5% SC	3.0 (2.00)^{a}	3.5 (2.13)^{a}	4.0 (2.24)^{a}	61.9 (51.96)^{a}	2.5 (1.86)^{a}	3.1 m(2.02)^{a}	3.3 (2.08)^{a}	72.4 (58.44)^{a}	1.7 (1.65)^{a}	2.0 (1.73)^{a}	2.9 (1.97)^{a}	78.2 (62.19)^{a}
T_3	Spirotetramat 150 OD	5.6 (2.57)^{b}	6.7 (2.78)^{bc}	7.5 (2.92)^{b}	27.7 (31.41)^{de}	5.0 (2.45)^{bc}	6.0 (2.65)^{b}	6.5 (2.73)^{bc}	46.5 (43.00)^{bc}	4.5 (2.34)^{bc}	4.7 (2.38)^{bc}	6.2 (2.68)^{cd}	51.3 (45.70)^{de}
T_4	Imidacloprid 70% WG	4.8 (2.41)^{ab}	5.7 (2.59)^{bc}	6.5 (2.73)^{b}	38.7 (38.47)^{bcde}	4.0 (2.24)^{b}	5.0 (2.45)^{b}	5.8 (2.61)^{bc}	51.6 (45.94)^{bc}	3.2 (2.05)^{bc}	3.8 (2.19)^{bc}	5.3 (2.52)^{bcd}	58.8 (50.46)^{bcde}
T_5	Fipronil 80% WG	3.2 (2.05)^{a}	4.0 (2.24)^{ab}	4.5 (2.35)^{ab}	56.2 (48.67)^{ab}	2.7 (1.93)^{ab}	3.3 (2.07)^{a}	3.5 (2.13)^{a}	71.1 (57.08)^{a}	1.9 n(1.69)^{ab}	2.1 (1.75)^{ab}	3.3 (2.07)^{ab}	75.4 (60.44)^{ab}
T_6	Buprofezin25%SC	3.9 (2.21)^{ab}	4.8 (2.41)^{ab}	5.3 (2.52)^{ab}	49.3 (44.64)^{abc}	3.5 (2.11)^{ab}	4.0 (2.24)^{ab}	4.8 (2.41)^{ab}	59.9 (50.79)^{ab}	2.6 (1.90)^{ab}	3.0 (2.00)^{ab}	4.1 (2.27)^{abc}	68.1 (55.68)^{abcd}
T_7	Spiromesifen 240 SC	5.0 (2.45)^{b}	6.4 (2.72)^{bc}	7.0 (2.83)^{b}	32.5 (34.24)^{cde}	4.5 (2.34)^{b}	5.7 (2.59)^{b}	6.2 (2.68)^{bc}	48.7 (44.29)^{bc}	4.0 (2.24)^{bc}	4.4 (2.32)^{bc}	5.8 (2.61)^{cd}	55.8 (48.34)^{cde}
T_8	Thiacloprid 21.7% SC	6.2 (2.68)^{b}	7.1 (2.84)^{c}	8.0 (3.00)^{b}	24.1 (29.33)^{e}	5.5 (2.56)^{c}	6.5 (2.73)^{b}	7.2 (2.86)^{c}	40.8 (39.69)^{c}	5.0 (2.45)^{c}	5.6 (2.57)^{c}	6.9 (2.82)^{d}	47.2 (43.40)^{e}

T_9	Acephate 75% SP	4.1 (2.25)^{ab}	5.3 (2.52)^{b}	6.1 (2.66)^{b}	42.6 (40.75)^{bcd}	3.7 (2.18)^{ab}	4.5 (2.35)^{ab}	5.5 (2.54)^{bc}	55.1 (47.99)^{b}	3.0 (2.00)^{b}	3.6 (2.14)^{b}	5.0 (2.45)^{bcd}	60.6 (51.34)^{bcde}
	Control (untreated)	8.1 (3.01)^{c}	9.3 (3.21)^{d}	10.5 (3.39)^{c}		11.2 (3.49)^{d}	11.7 (3.56)^{d}	12.1 (3.61)^{d}		12.5 (3.67)^{c}	12.8 (3.71)^{d}	13.1 (3.76)^{e}	
	F-TEST	Sig	sig	sig	Sig	Sig	sig	sig	sig	sig	sig	Sig	sig
	SEm	0.14	0.11	0.11	3.50	0.11	0.11	0.06	1.44	0.14	0.13	0.08	1.89
	CD (P=0.05)	0.43	0.33	0.35	10.42	0.35	0.35	0.32	7.41	0.42	0.40	0.43	9.74

*Figures in parentheses are square root transformed values.
**Figures in parentheses are angular transformed values.
Numbers followed by same superscript are not statistically different

Sig : Significant.
NS : Non-significant.
DAT : Days after treatment

Table 6: Incidence of leafhopper on different hybrids under protected and unprotected conditions

	30DAS				45DAS				60DAS				Mean			
Hybrids	**P**	**UP**	**Mean**	**% Increase in unprotected plot**	**P**	**UP**	**Mean**	**% Increase in unprotected plot**	**P**	**UP**	**Mean**	**% Increase in unprotected plot**	**P**	**UP**	**Mean**	**% Increase in unprotected plot**
RCH-2BG- II	1.6 (1.61)	8.7 (3.11)	5.1 (2.48)	81.5	2.9 (1.98)	12.8 (3.71)	7.9 (2.98)	77.1	3.1 (2.02)	15.9 (4.11)	9.5 (3.24)	80.7	2.5 (1.88)	12.4 (3.67)	7.5 (2.91)	79.6
RCH-2 N*Bt*	1.9 (1.71)	8.9 (3.14)	5.4 (2.53)	78.2	3.1 (2.03)	13.5 (3.81)	8.3 (3.06)	76.8	3.4 (2.10)	16.3 (4.16)	9.9 (3.30)	79.2	2.8 (1.96)	12.9 (3.73)	7.9 (2.98)	78.1
Tulasi-9BG II	1.3 (1.53)	5.1 (2.46)	3.2 (2.05)	73.7	2.7 (1.91)	7.0 (2.83)	4.8 (2.42)	61.9	2.9 (1.97)	8.5 (3.09)	5.7 (2.59)	66.4	2.3 (1.81)	6.9 (2.80)	4.6 (2.36)	66.7
Tulasi-9N*Bt*	1.1 (1.46)	4.9 (2.44)	3.0 (2.01)	77.0	2.5 (1.88)	6.5 (2.73)	4.5 (2.35)	60.8	2.7 (1.91)	8.3 (3.04)	5.5 (2.54)	67.7	2.1 (1.76)	6.6 (2.75)	4.3 (2.31)	67.8
Mean	1.5 (1.58)	6.9 (2.81)	4.2 (2.28)	77.6	2.8 (1.95)	10.0 (3.31)	6.4 (2.72)	69.2	3.0 (2.00)	12.3 (3.64)	7.6 (2.94)	73.5	2.4 (1.85)	9.7 (3.27)	6.1 (2.66)	73.1

	SEm		**SEm**		**SEm**		**SEm**	
For comparing	**CD(P=0.05)**		**CD(P=0.05)**		**CD(P=0.05)**		**CD(P=0.05)**	
Hybrids	0.07	0.21	0.07	0.22	0.06	0.19	0.03	0.10
Protection	0.05	0.15	0.15	0.04	0.04	0.13	0.02	0.07
Interaction	0.10	0.45	0.47	0.08	0.08	0.40	0.04	0.22

P-protected
UP-unprotected
DAS: Days after sowing.
*Figures in parentheses are square root transformed values.

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