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Alka Kumari
Ph.D., Research Scholar, Department of Entomology, Birsa Agricultural University, Kanke Ranchi, Jharkhand, India

Rabindra Prasad
Senior Scientist Cum Associate Professor, Department of Entomology, Birsa Agricultural University, Kanke Ranchi, Jharkhand, India

Corresponding Author:
Alka Kumari
Ph.D., Research Scholar, Department of Entomology, Birsa Agricultural University, Kanke Ranchi, Jharkhand, India

Bio-efficacy of botanical insecticides against rice gall midge (*Orseolia oryzae*) in Ranchi, Jharkhand

Alka Kumari and Rabindra Prasad

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Abstract
A field trial was conducted at Rice Research Farm of Birsa Agricultural University, RAC (Ranchi Agriculture College) Kanke, Ranchi during *Kharif* season of 2017 on rice variety Bhadshah Bhog to evaluate the bio-efficacy of different botanical insecticides including untreated control against rice gall midge, *Orseolia oryzae.* Two sprays at tweenty days interval of ten treatments with three replications were applied in the field. The obtained after each spray revealed that the botanical insecticidal treatments were significantly superior over control in reducing silver shoot infested by gall midge and efficacy was maximum in Neem Baan (Aza. 1.0% EC) @ 1000 ml/ha (4.71% SS) with maximum net profit of Rs. 21325 / ha with B:C ratio 8.5: 1. Neem Baan (Aza. 1.0% EC) could be responsible for realization of the highest grains yield (34.03q/ha) among all the tested botanical insecticides in the present studies. However, when all the treatments including the chemical insecticide, chlorpyriphos (@ 2000 ml/ha) are compared in the context of yield of grains, chlorpyriphos took the lead in the highest yield realization (38.95 q//ha) with net profit of Rs. 31950/ ha with B:C ratio7.7: 1.

Keywords: Rice, *Orseolia oryzae*, gall midge, botanical insecticides

Introduction
Rice is the staple food for over half of the world's population. It holds the key to our country's ability to produce enough food for our people. It is primarily a high energy or high calorific food. Out of nearly 1000 insect pest species recorded on paddy, only two dozen insect & mites are found as key pests in different rice ecologies in India (Prakash *et al*. 2000) [8]. Among these major insect pest species, gall midge (*Orseolia oryzae* Wood Mason*)* is one of the most important pest which is capable of causing considerable loss in Jharkhand in general and gall midge endemic areas of the state in particular. The maggot of rice gall midge is responsible for causing gall formation in the central leaf sheath of rice which results in the formation of silver shoot, which later on cannot bear panicles. As such, the pest could be able to cause loss in yield ranging from 10-25% (Prasad and Prasad, 2006) [5] in the state of Jharkhand under the favourable agro -climatic conditions.
Judicious use of botanical insecticides remains the principal strategy for managing insect pests by rice growers. In India, pioneering work on the isolation and identifications of *A. indica* constituents was initiated in 1942 and has continued in various parts of the world. The products of botanical insecticides are cheap, easy to prepare, eco-friendly and low-cost alternatives to agro chemicals. The extracts of *A. indica* have been compared with commercial pesticides on various crop pests where they have been found to be efficacious, and equally or more cost effective. Leaves have been shown to contain crude fibre (11-24%), carbohydrates (48-58%), crude protein (14-18%), fat (2.3-6.9%), ash (7.7-8.5%), calcium (0.8-2.4%) and phosphorus (0.13-0.24%), as well as a number of amino acids. The azadirachtin-A (Aza A) is the most plentiful and biologically active one which has shown repellent, antifeedent and insecticidal activity against a number of insect pests and it is generally Aza, that is used for commercial insecticide. The products of *A. indica* are cheap, easy to prepare, eco-friendly and low-cost alternatives to agro chemicals. The extracts of *A. indica* have been compared with commercial pesticides on various crop pests where they have been found to be efficacious, and equally or more cost effective. Mahalingam (1984) [7] reported that neem oil 5.0% spray significantly reduced gall midge infestation in rice. Samalo *et al.* (1993) [9] revealed that application of foliar spray with neem oil thrice at 10,25, 40 and 55 days after transplanting or

substitution of a spray with top dressing with neem cake or Hind-o-Meal or mixture of both significantly reduce the population of rice gall midge. Dash *et al.* (1994) [3] found the some neem (*Azadirachta indica*) derivatives (alone or in combination) with synthetic organic insecticides produced no effective control of the cecidomyiid rice pest *O. oryzae.*

Material and Method

Field experimental trial were conducted on variety Badshah bhog of rice crop for the purpose of evaluation of bio – efficacy of botanical insecticides against gall midge (*O. oryzae*).The experiment was conducted in the Rice Research Farm of the university during *kharif* season 2017. The crop was sown in randomized block design in plot size of 5 x 4m^2 in three replications on 27th June, 2017, transplanting and harvesting work were conducted on 28.07.2017 and 26.12.2017, respectively.

Botanical Insecticidal Treatment

Foliar sprays of test botanical insecticides were applied on need based basis in the respective treatments starting 1st spray at 25 DAT followed by 45 DAT i.e. at 20 days interval.

Schedules of the botanical insecticidal application

No. of spray	Date of spray
1st spray	25 DAT
2nd spray	45 DAT

Table 1: Treatment details of botanical insecticide evaluation trial.

Tr. No.	Name of the insecticides		Dose of the formulated insecticides/spray (ml or kg/ha)	Dose* (ml or g /lit of water)	Price of insecticides	Cost of insecticides for 2 sprays (Rs./ha)	Source of manufacturer
	Common name	Trade name					
T1	Camphor oil	-	1000 ml /ha	2.0 ml /l	210Rs/l	420	Natural Biochem, Nashik
T2	Cedarwood oil	-	1000 ml /ha	2.0 ml /l	800 Rs /l	1600	Amarnath Export
T3	Eucalyptus oil	-	1000 ml /ha	2.0 ml/l	1300 Rs /l	2600	Kazima
T4	Lemongrass oil	-	1000 ml /ha	2.0 ml/l	1150 Rs / l	2300	Gyan Flavours Export, New Delhi
T5	Azadiractin 1.0% EC	Neemazal	1000 ml /ha	2.0 ml /l	850 Rs/ l	1700	Bayer Crop science Pvt. Ltd.
T6	Azadiractin 1.0% EC	NeemBaan	1000 ml/ha	2.0 ml/l	700 Rs/l	1400	Pest Control India pvt. Ltd., Mumbai
T7	NSKE -5%		25 kg /ha	5 g/l	30 Rs/ Kg	1500	Local collection
T8	Azadiractin 0.03% EC	Achook	2500 ml /ha	5.0 ml /l	1240 Rs/l	6200	M/S Mehin Total Chemicals Pvt. Ltd.
T9	Chlorpyriphos 20EC*^{IC}	Dursban	2000 ml/ha	4.0 ml/l	615 Rs/lit	3075	Agribegri
T10	Untreated control (water spray)	-	-	-	-	-	-

*IC – Insecticidal check

Preparation of Neem Seed Kernel Extract (NSKE) 5 per cent

Freshly collected 50 g of neem seeds were decorticated and gently crushed. The crushed neem seed kernel powder was taken in a muslin pouch and soaked overnight in 300 ml of water. The pouch was then gently squeezed to extract out the solution and then additional quantity of 700 ml of water was added to make the total volume one litre. A soap with no detergent was used as an emulsifier in the filtrate for making the solution in the sprayable form.

Observations: The following observations were recorded-

- Observations on the incidence of gall midge in terms of silver shoot (SS) were recorded before each spray and at 5th and 10th DAS (days after foliar sprays) on 10 randomly selected rice plants.
- As such total number of tillers and silver shoot (SS) were counted on 10 randomly selected plants (hills) one day before spray and at 5th and 10th DAS (days after foliar spray) for calculating percentage of silver shoot (SS) at the respective dates of observations.
- The percentage of silver shoot (SS%) was calculated by applying the following formula:

$$SS\ (\%)\ x100 = \frac{\text{Total number of silver shoot (SS) in 10 hills}}{\text{Total number of tillers (SS+ healthy tillers) in 10 hills}}$$

- Yields data in terms of Kg/ plot were recorded after harvest and converted into q/ha for their documentation.
- The increase (gain) and decrease(loss) in yield, treatmen-wise, over untreated (control)

Plot was calculated by applying the formulae adopted by Pradhan (1983) mentioned as below:

i) $$\text{Percent increase in yield} = \frac{T\text{-}C}{C} x100$$

ii) $$\text{Percent avoidable loss in yield} = \frac{T\text{-}C}{T} x100$$

Where,
T=yield obtained from treated (protected) plot
C=yield obtained from untreated (control) plot

Net monetary returns (net profit) and benefit cost ratio (BCR) were calculated by following mathematical steps and formulae

i) Computation of additional gain in yield over control (Y_a): Additional gain in the yield over control is the difference between the yield in the respective treatment (s) and yield obtained from control plot (Y_c). i.e., $Y_a = Y_t - Y_c$ whereas Y_t= Yield obtained from the respective treatment(s); Y_c = yield obtained from unprotected crop.

ii) Computation of Net monetary returns (net profit Rs./ha)

Net profit =monetary value of Y_a - cost of pest control. (i.e. CPC) = Rs. /ha

Where, cost of pest control comprises of cost of insecticides and labourer

iii) Computation of benefit cost ratio (BCR)

Benefit cost ratio (BCR)= Net profit (Rs. /ha)/ Cost of pest control (Rs. /ha)

Result and Discussion

Bio-efficacy of botanical insecticides insecticidal against gall midge Before spray

The results revealed that the incidence of silver shoot per cent (SS%) caused by gall midge remained almost evenly distributed and statistically non significant varying between 4.25 and 4.86 percent, one day before the application of insecticides.

Bio-efficacy of botanical insecticides against gall midge after 1st spray at 20 DAT

The results presented in Table-2 showed that all the treatments were significantly superior to the untreated control in reducing the incidence of silver shoot(SS%) at five days after botanical insecticidal spray (DAS) and all the treatments were significantly inferior to the recommended chemical insecticide (i.e. chlorpyriphos) in reducing silver shoot(SS%) at five days after spray (DAS). The SS (%) in different botanical insecticidal treatments varied from 0.10 to 5.70 per cent, while in untreated control it was highest silver shoot per cent (5.70% SS). So far as the efficacy of the test insecticides after 5 DAS of 1st spray is concerned, the lowest level of silver shoot incidence(0.10% SS) was recorded at 20 DAT (days after transplanting) i.e. at 5 DAS which was treated with the insecticide control chlorpyriphos 20EC @2000 ml /ha. Amongst all the botanical insecticides Neemazal (Aza. 1.0% EC) @1000 ml/ha was found to be most effective (0.76% SS) in reducing the incidence of the pest (SS%) and it remained statistically at par with NSKE -5% (0.78% SS) and Neem Baan (Aza. 1.0% EC)@ 1000 ml/ha (0.83% SS) at 20 DAT followed by Achook (Aza. 0.03% EC) @ 2500 ml / ha (1.80% SS) and eucalyptus oil @1000 ml /ha(2.5% SS). The efficacy of the test botanical insecticides against the pest was found to be in descending order: Neemazal (Aza. 1.0% EC)@ 1000 ml/ha (0.76% SS) > NSKE -5% @25 kg /ha (0.78% SS) > Neem Baan (Aza. 1.0% EC) @1000 ml/ha (0.83% SS) > Achook (Aza. 0.03% EC) @ 2500 ml / ha (1.80% SS) > eucalyptus oil @1000 ml /ha(2.5% SS) > camphor oil @1000 ml (3.60% SS) > cedarwood oil @ 1000 ml /ha (3.86%) >lemongrass oil@ 1000 ml/ha (4.41% SS). The highest incidence of silver shoot (10.40% SS) was received in case of untreated (unprotected) crop.

Table 2: Effect of certain botanical insecticides on the incidence of silver shoot (SS) caused by gall midge, recorded after 1st application.

Tr. No.	Treatments	Dose of formulated product / ha	Dose* (ml or g /lit of water)	Percentage of silver shoot (SS) caused by gall midge, recorded after			
				Before spray	1st spray at		Overall Mean
					20 DAT (5 DAS)	25 DAT (10 DAS)	
T 1	Camphor oil	1000 ml	2.0 ml /l	4.95 (12.71)	3.60 (10.82)	4.70 (12.52)	4.15 (11.67)
T 2	Cedarwood oil	1000 ml	2.0 ml /l	4.25 (11.68)	3.86 (11.32)	5.20 (13.18)	4.53 (12.25)
T 3	Eucalyptus oil	1000 ml	2.0 ml/l	5.25 (13.06)	2.50 (9.09)	3.70 (11.08)	3.10 (10.09)
T 4	Lemongrass oil	1000 ml	2.0 ml/l	4.6 (12.30)	4.41 (12.12)	5.12 (12.93)	4.8 (12.52)
T 5	Neemazal (Aza. 1.0% EC)	1000 ml	2.0 ml /l	4.38 (11.86)	0.76 (4.98)	1.77 (7.59)	1.30 (6.40)
T 6	Neem Baan (Aza. 1.0% EC)	1000 ml	2.0 ml/l	4.76 (12.47)	0.83 (5.21)	1.30 (6.52)	1.07 (5.87)
T 7	NSKE -5%	25 kg	5 g/l	4.8 (12.54)	0.78 (5.07)	1.56 (7.01)	1.17 (6.04)
T 8	Achook(Aza. 0.03% EC)	2500 ml	5.0 ml /l	4.3 (11.85)	1.80 (7.70)	2.30 (8.72)	2.05 (8.21)
T 9	Chlorpyriphos 20EC*IC	2000 ml	4.0 ml/l	4.7 (12.41)	0.10 (1.81)	0.17 (2.38)	0.14 (2.10)
T 10	Untreated control (water spray)	-	-	4.86 (12.66)	5.70 (13.80)	7.30 (15.67)	6.50 (14.74)
SEm (±)	-	-	-	(0.88)	(0.46)	(0.63)	(0.55)
CD (p=0.05)	-	-	-	(NS)	(1.38)	(1.86)	(1.62)
CV (%)	-	-	-	(12.27)	(9.83)	(11.12)	(10.48)

Dose of formulated product
*IC – Insecticidal check
Figures under the parentheses are angular transformed values; DAT- Days after transplanting; DAS-Days after spray

Bio-efficacy of botanical insecticides against gall midge after 1st spray at 25 DAT (i.e. at 10 DAS)

The data presented in Table-2 showed that all the test treatments were significantly superior to the untreated control in reducing silver shoot(SS%) at 10 days after botanical insecticidal spray (DAS) and all the treatments were significantly inferior to the recommended chemical insecticide (i.e. chlorpyriphos) in reducing silver shoot(SS%) at 10 days after botanical insecticidal spray (DAS). The SS (%) in different botanical insecticidal treatments varied from 0.17 to 7.30 per cent, while in untreated control it was 7.30 per cent i.e. highest SS (%). So far as the efficacy of the test insecticides after 10 DAS of 1st spray is concerned, the lowest level of silver shoot incidence(0.17% SS) was recorded at 25 DAT (days after transplanting) which was treated with the standard insecticide chlorpyriphos 20EC @2000 ml /ha. Amongst all the botanical insecticides neem ban (Aza. 1.0% EC)@ 1000 ml/ha (1.30% SS) was found to be most effective in reducing the incidence of the pest SS(%) and it remained statistically at par with NSKE -5% (1.56% SS) and Neemazal (Aza. 1.0% EC) @1000 ml/ha (1.77% SS) at 25 DAT followed by Achook (Aza. 0.03% EC) @ 2500 ml / ha (2.3% SS) and eucalyptus oil @1000 ml /ha(3.70% SS). The efficacy of the test botanical insecticides was found to be in order of: Neem Baan (Aza. 1.0% EC) @1000 ml/ha (1.30% SS) > NSKE -5% @25 kg /ha (1.56% SS) > Neemazal (Aza. 1.0% EC)@ 1000 ml/ha (1.77% SS) > Achook (Aza. 0.03% EC) @ 2500 ml / ha (4.70% SS) > eucalyptus oil @1000 ml /ha(3.70% SS) > camphor oil @1000 ml (5.60% SS) > cedarwood oil @ 1000 ml /ha (5.20%) >lemongrass oil@ 1000 ml/ha (5.12% SS). The highest incidence of silver shoot (7.30% SS) was received in case of untreated crop.

Overall mean of silver shoot (SS) caused by the gall midge after 1st spray of the test botanical insecticides

SS% after 1st spray gradually increased with the advancement of age of rice plants.All the treatment are significantly superior to the untreated control and inferior to the standard chemical remained. Neem Baan (Aza. 1.0% EC)@ 1000 ml/ha was found to be the most effective (1.07% SS) to reduce SS(%) followed by NSKE -5% @25 kg /ha (1.17% SS) > Neemazal (Aza. 1.0% EC)@ 1000 ml/ha (1.30% SS) >

Achook (Aza. 0.03% EC) @ 2500 ml / ha (2.05% SS) > eucalyptus oil @1000 ml /ha(3.10% SS) > camphor oil @1000 ml (4.15% SS) > cedarwood oil @ 1000 ml /ha (4.53%) >lemongrass oil@ 1000 ml/ha (4.8% SS). The highest incidence of silver shoot (6.50% SS) was received in case of untreated crop and the lowest incidence of silver shoot (0.14% SS) was received in case of rice plants receiving protection through foliar spray with standard chemical insecticide, chlorpyriphos 20 EC @2000 ml/ha (0.14% SS) (Table-2).

Bio-efficacy of botanical insecticides against gall midge after 2nd spray at 50 DAT after 5 DAS

The experimental data presented in Table-3. showed that all the treatments remained significantly superior to the untreated control in reducing silver shoot(SS%) at 5 DAS and all the treatments were significantly inferior to the resistant chemical control in reducing silver shoot(SS%) at 5 DAS. The SS (%) in different botanical insecticidal treatments varied from 0.44 to 16.67 per cent, while in untreated control it was 16.67 per cent i.e. highest SS (%). As far as the efficacy of the test insecticides after 5 DAS of 4th spray is concerned, the lowest level of silver shoot incidence (0.44% SS) was recorded at 50 DAT at 5 DAS which was treated with chlorpyriphos 20EC@ 2000 ml/ha. Amongst all the botanical insecticides Neem Baan (Aza. 1.0% EC) @1000 ml/ha was found to be most effective (3.66% SS) in reducing the incidence of SS(%) and it remained statistically at par with Achook (Aza. 0.03% EC) @ 2500 ml / ha (4.60% SS), Neemazal (Aza. 1.0% EC)@ 1000 ml/ha (4.88% SS) and NSKE -5% @25 kg /ha (4.95% SS) at 50 DAT followed by eucalyptus oil @1000 ml /ha(9.24% SS) and camphor oil @1000 ml (11.23% SS). The efficacy of the test botanical insecticides was found to be in order of: Neem Baan (Aza. 1.0% EC) @1000 ml/ha (3.66% SS) > Achook (Aza. 0.03% EC) @ 2500 ml / ha (4.6% SS) > NSKE -5% (4.95% SS) > Neemazal (Aza. 1.0% EC)@ 1000 ml/ha (4.88% SS) > eucalyptus oil @1000 ml /ha(9.24% SS) > camphor oil @1000 ml (11.23% SS) > cedarwood oil @ 1000 ml /ha (11.69%)>lemongrass oil@1000ml/ha (11% SS). The highest incidence of silver shoot (16.67% SS) was received in case of untreated crop.

Bio-efficacy of botanical insecticides against gall midge after 2nd spray at 55 DAT (after 10 DAS)

The results (Table-3) showed that all the botanical treatments were significantly superior to the untreated control in reducing silver shoot (SS%) at 10 days after spray (DAS) and all the botanical treatments were significantly inferior to chlorpyriphos in reducing silver shoot(SS%) at 10 DAS. The SS (%) in different botanical insecticidal treatments varied from 0.45 to 20.89 per cent, while in untreated control it was 20.89 per cent i.e. highest SS (%). So far as the efficacy of the test insecticides after 5 DAS of 4th spray is concerned, the lowest level of silver shoot incidence(0.45% SS) was recorded at 55 DAT which was treated with insecticidal control chlorpyriphos 20EC @2000 ml/ha. Amongst all the test botanical insecticides NSKE -5% @25 kg /ha was found to be most effective (5.20% SS) in suppressing the incidence of silver shoot and it remained statistically at par with Neem Baan (Aza. 1.0% EC) @1000 ml/ha (5.76% SS), Neemazal (Aza. 1.0% EC) @ 1000 ml/ha (6.8% SS) and Achook (Aza. 0.03% EC) @ 2500 ml / ha (7.80% SS) followed by eucalyptus oil @ 1000 ml /ha(10.40% SS) at 55 DAT. The efficacy of the test botanical insecticides was found to be in order of: NSKE -5% (5.20% SS) > Neem Baan (Aza. 1.0% EC) @1000 ml/ha (5.76% SS) > Neemazal (Aza. 1.0% EC)@ 1000 ml/ha (6.80% SS) > Achook (Aza. 0.03% EC) @ 2500 ml / ha (7.8% SS) > eucalyptus oil @1000 ml /ha(10.40% SS) > camphor oil @1000 ml (15.60% SS) > cedarwood oil @ 1000 ml /ha (17.30%) > lemongrass oil@1000 ml/ha (18.80% SS). The highest incidence of silver shoot (20.89% SS) was received in case of the unprotected crop of rice.

Overall mean of two observations recorded after 2nd spray

It was found that all the treatments remained significantly superior to the untreated control and inferior to the chlorpyriphos. Neem Baan (Aza. 1.0% EC)@ 1000 ml/ha was found to be most effective (4.71% SS) in reducing SS(%) followed by NSKE -5% (5.07% SS) > Neemazal (Aza. 1.0% EC)@ 1000 ml/ha (5.84% SS) > Achook (Aza. 0.03% EC) @ 2500 ml / ha (6.20% SS) > eucalyptus oil @1000 ml /ha(9.82% SS) > camphor oil @1000 ml (13.42% SS) > cedarwood oil @ 1000 ml /ha (14.50%) >lemongrass oil@ 1000 ml/ha (14.91% SS). The highest incidence of silver shoot (18.78% SS) was registered in case of untreated crop and lowest incidence of silver shoot (0.45% SS) was received in case of chemical check (i.e. chlorpyriphos) (Table-3).

Table-3: Effect of certain botanical insecticides on the incidence of silver shoot (SS) caused by gall midge, recorded after 2nd application

Tr. No.	Treatments	Dose of formulated product / ha	Dose* (ml or g /lit of water)	Percentage of silver shoot (SS) caused by gall midge, recorded after		
				2nd Spray at		Overall mean
				50 DAT (5 DAS)	55 DAT (10DAS)	
T 1	Camphor oil	1000 ml	2.0 ml /l	11.23 (19.55)	15.60 (23.25)	13.42 (21.40)
T 2	Cedarwood oil	1000 ml	2.0 ml /l	11.69 (19.98)	17.30 (24.52)	14.50 (22.25)
T 3	Eucalyptus oil	1000 ml	2.0 ml/l	9.24 (17.68)	10.40 (18.60)	9.82 (18.14)
T 4	Lemongrass oil	1000 ml	2.0 ml/l	11 (19.36)	18.80 (25.55)	14.91 (22.45)
T 5	Neemazal (Aza. 1.0% EC)	1000 ml	2.0 ml /l	4.88 (12.75)	6.80 (15.04)	5.84 (13.89)
T 6	Neem Baan (Aza. 1.0% EC)	1000 ml	2.0 ml/l	3.66 (11.01)	5.76 (13.87)	4.71 (12.44)
T 7	NSKE -5%	25 kg /ha	5 g/l	4.95 (12.82)	5.20 (13.08)	5.07 (12.95)
T 8	Achook(Aza. 0.03% EC)	2500 ml	5.0 ml /l	4.6 (12.28)	7.80(16.20)	6.20 (14.24)
T 9	Chlorpyriphos 20EC*IC	2000 ml	4.0 ml/l	0.44 (3.80)	0.45 (3.84)	0.45 (3.82)
T 10	Untreated control (water spray)	-	-	16.67 (24.07)	20.89 (27.20)	18.78 (25.64)
SEm (±)	-	-	-	(0.75)	(1.30)	(1.02)
CD (p=0.05)	-	-	-	(2.22)	(3.86)	(3.04)
CV (%)	-	-	-	(8.21)	(12.41)	(10.31)

Dose of formulated product
*IC – Insecticidal check
Figures under the parentheses are angular transformed values
DAT- Days after transplanting; DAS-Days after spray

Effect of certain botanical insecticidal application on grain's yields of rice

A persual of results revealed the highest grains yield of rice (38.95 q/ha) was obtained when test standard insecticide, chlorpyriphos 20 EC was applied and receiving almost the minimum incidence of silver shoot (0.45% SS) followed by 34.03 q/ha treated with Neem Baan (Aza. 1.0% EC). Order of yield, amongst all the treatments are as follows: Chlorpyriphos 20 EC (38.95 q/ha)> Neem Baan (34.03 q/ha)> NSKE -5% (33.77 q/ha)> Naamazal (33.60 q/ha)> lemongrass oil (28.73 q/ha) >eucalyptus oil (28.50 q/ha)> cedarwood oil (27.60 q/ha)> camphor oil (27.33 q/ha).

This finding of the present studies are in partial agreement with the results Kaul and Sharma (1999) [2] found that all the neem formulstions *viz*. Nimbicidine, Neemax, Neem gold, Econeem, Neemazol and Fortune were statistically at par with chlorpyriphos for the control of stem borer, gall midge rice hispa and leaf folder infesting rice varieties Kasturi, Basmati. Significantly higher yield (30-31 q/ha) were obtained in treated plots as compared to 28 q/ha in the untreated plants. Dhaliwal *et al*. (2002) [4] showed that four high potency azadiractin based neem formulations, 1% Rakshak,1 and 5% Neem Azal and 0.03% Nimbecidine were evaluated against two major insect pests of rice, namely rice leaf folder(RLF) and yellow stem borer (YSB) for two kharif seasons the incidence of RLF was minimum in case of monocrotophos, which was at par with 5% Neem Azal at 0.50 ml/lit. the highest paddy yield (50.5 q/ha) was recorded in monocotophos followed by 46.4 q/ha in 5% Neem Azal @ 2.00 ml/ lit compared with 34.3 q/ha in untreated control (Table-3).

Table 4: Economics of chemical insecticidal treatments used against rice gall midge

Tr. No.	Treatments	Dose of formulated product (ml or kg/ha)	Yield of rice grain (q/ha)	Additional gain in yield over control (q/ha)	Increase in yield over control (%)	Price of additional yield (Rs.)	Additional Cost of pest control (Rs./ha)	Net profit (Rs/ha)	Benefit cost ratio
T1*	Camphor oil	1000 ml /ha	27.33	2.83	8.46	7075	1520	5555	3.7:1
T2	Cedarwood oil	1000 ml /ha	27.60	3.1	12.65	7750	2700	5050	1.9:1
T3	Eucalyptus oil	1000 ml /ha	28.50	4.00	16.33	10000	3700	6300	1.7:1
T4	Lemongrass oil	1000 ml /ha	28.73	4.23	17.26	10575	3400	7175	2.1:1
T5	Neemazal (Aza. 1.0% EC)	1000 ml /ha	33.60	9.1	37.14	22750	2800	19950	7.1:1
T6	Neem Baan (Aza. 1.0% EC)	1000 ml/ha	34.03	9.53	38.89	23825	2500	21325	8.5:1
T7	NSKE -5%	25 kg /ha	33.77	9.27	37.84	23175	2600	20575	7.9:1
T8	Achook (Aza. 0.03% EC)	2500 ml /ha	32.70	8.2	33.46	20250	7300	12950	1.8:1
T9	Chlorpyriphos 20EC*[IC]	2000 ml/ha	38.95	14.45	58.98	36125	4175	31950	7.7:1
T10**	Untreated control (water spray)	-	24.50	-	-	-	-	-	-

*IC – Insecticidal check

Procurement price of rice (IR-64) – 25 Rs/kg or, 2500 Rs./q

Cost of input: 1100 Rs.

- Cost of insecticide
- Labour cost (4 labours for 2 sprays) - 1000 Rs
  (No. of labours required for one ha/spray = two; Wages of labour = (250 Rs/ labour)
- Sprayer hiring charge-50 Rs
- Misc - 50 Rs

Conclusion

Neem Baan (Aza. 1.0% EC) @ 1000 ml/ha was found to be the most effective (4.71% SS) with maximum net profit of Rs. 21325 / ha with B:C ratio 8.5: 1 in reducing SS (%). Neem Baan (Aza. 1.0% EC) could be responsible for realization of the highest grains yield (34.03q/ha) among all the tested botanical insecticides in the present studies. However, when all the treatments including the chemical insecticide, chlorpyriphos (@ 2000 ml/ha) are compared in the context of yield of grains, chlorpyriphos took the lead in the highest yield realization (38.95 q//ha)) with net profit of Rs. 31950 / ha with B:C ratio 7.7: 1.

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