Quest Journals
Journal of Research in Agriculture and Animal Science
Volume 9 ~ Issue 10 (2022) pp: 49-53
ISSN(Online) : 2321-9459
www.questjournals.org

Research Paper

A comparative study of various insecticides against eggs of pink bollworm(*Pectinophora gossypiella)* in laboratory conditions (Saunders)

Malsawmtluanga Hnialum, V. Chinna Babu Naik, N. V. Lavhe, Sanap Pavan Vithoba

Abstract
Nine insecticides were tested on the eggs of pink bollworm Pectinophora gossypiella (Saunders) in laboratory. The field recommended doses of each insecticides were used in the experiment. The studies shows that an overall higher reduction of hatching was observed in one day old eggs of P. gossypiella except in cypermethrin 25 EC where there was a higher reduction of hatching in three day old eggs. In the one day old eggs, the highest ovicidal activity was shown by profenofos 50 EC with a reduction of hatching of 80.76% in comparison with untreated eggs, whereas in the three day old eggs cypermethrin 25EC showed the highest ovicidal action of 74.25 % reduction of hatching. In both the one and three day old eggs it was neem oil 0.03% W/W(Azadirachtin 3000 ppm) which showed the least ovicidal activity with the reduction of hatching being 40.62% and 38.49% respectively. In one day old eggs (<24 hours) the order of the ovicidal activity from highest to lowest was profenofos 50 EC (80.76%) > quinalphos 25 EC(75.22%) > cypermethrin 25 EC(74.25%) > fenvalerate 20 EC(71.25%) > chlorpyriphos 20 EC(68.81%) > emamectin benzoate 5 SG(59.26%) > spinosad 45 SC(56.74%) > thiodicarb 75 WP (52.01%) > neem oil 0.3%(40.62%), whereas in less than three day old eggs (<72 hours) the order was cypermethrin 25 EC(77.42%) > quinalphos 25 EC(72.93%) > profenofos 50 EC(71.10%) > fenvalerate 20 EC(68.21)% > chlorpyriphos 20 EC(66.72%) < emamectin benzoate 5 SG(57.45%) > spinosad 45 SC(54.97) > thiodicarb 75 WP(49.58%) > neem oil 0.3%(38.49%).

***R**eceived 15 Oct., 2022; **R**evised 28 Oct., 2022; **A**ccepted 31 Oct., 2022 © The author(s) 2022.*
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I. Introduction

Bollworm complex viz., American bollworm (*Helicoverpa armigera*), spotted bollworm (*Earias vitella*) and pink bollworm (*Pectinophora gossypiella*) account for a considerable yield loss to the extent of 36.2 per cent losses by the bollworm complex (Kranthi et al., 2005). Pink bollworm (PBW) was first reported in 1843 by W.W. Saunders in India. It was named *Depressaria gossypiella* with probable origin in the Indo-Pakistan region (Naranjo *et al.*, 2001). Pink bollworm completes its life cycle in 32-35 days in four stages *viz.*, egg, larva, pupa, and adult. With a longer developmental period in cold winters and shorter during hot summer months is observed (Chaudhari *et al.*, 1999).

Pink bollworm has recently been discovered to be the dominant pest in cotton production (Gutierrez *et al*., 2006). Furthermore, the pink bollworm has become the most economically damaging insect pest of cotton. The larvae are located in the flower after hatching, feasting on the anthers and pollens by dwelling in a web. The flowers of this kind are usually twisted into a rosette shape. Later, the larvae penetrate into the bolls, burrowing deep into immature seeds via the lint. When one seed is damaged, larvae tunnel through the forming lint and travel to another seed, and subsequently to locules in the same way. Bolls that are impacted rot and shed, while those that are left on the plant open early, resulting in stained immature fibre (Agarwal *et al*., 1984), causing an 80 per cent reduction in seed cotton yield and quality of lint. Therefore it is of utmost importance that studies of insecticidal efficacy of different stages of the pest be made.

So, the application of insecticide is the most commonly resorted approach for the management of the PBW infestation in cotton. But, due to the nature of pink bollworm and their tunneling and hiding behaviour, large quantities and repeated application of insecticides must be given for effective control of this pest. In an experiment by Natikar and Balikai (2015) carried out to test ovicidal action of insecticides against *spodoptera litura*. The results revealed the highest egg mortality in one-day-old eggs as compared to two or three day's old eggs. The maximum mortality was recorded in thiodicarb (95.32%) followed by emamectin benzoate (91.30%), flubendiamide (83.47%), chlorantraniliprole (82.62%), cyantraniliprole (74.00%), chlorpyrifos (71.90%), spinosad (69.23%), chlorfenapyr (65.93%) and indoxacarb (54.17%), respectively. Due to the similarity between the pests it may be possible to achieve similar control by targeting the eggs of pink bollworm.

II. MATERIALS AND METHODS

(Table-1) Insecticides used

Sl.no	Treatments	Insecticidal group	Trade name	Formulator	Recommended dose*	
					Per litre	Per ha#
1	Profenofos 50% EC	Organophosphate	Curacron	Syngenta India Limited	2.0ml	1000ml
2	Chlorpyriphos 20% EC	Organophosphate	Tricel	Sumitoto	2.5ml	1250ml
3	Thiodicarb 75% WP	Carbamate	Larvin	Bayer	2.0ml	1000ml
4	Spinosad 45% SC	Naturalyte	Tracer	Dow Agro Sciences India Private Limited	0.3gm	150gm
5	Neem Oil(0.3% W/W) (Azadirachtin 3000 ppm)	Botanical	Neemstin Plus	Ruchi Oyster Mushroom	5.0ml	2500ml
6	Emamectin benzoate 5% SG	Naturalyte	Tracer	Dow AgroScience	0.4gm	200 ml
7	Cypermethrin 25% EC	Pyrethyroid	Cymbush	Syngenta India Limited	1.0ml	500ml
8	Quinalphos 25% EC	Organophosphate	Ekalux	Syngenta India Limited	2.0ml	1000ml
9	Fenvalerate 20% EC	Organophosphate	CAPFEN-20	Sun Brand	1.0ml	500ml
10	Control (No spray)	-	-	-	-	

*CIB&RC list of label claim insecticides updated on 30.11.20 (http://ppqs.gov.in/divisions/cib-rc/major-uses-of-pesticides)
[#]per ha dose is for dilution in 500 litres of water

Rearing of larvae
The standardized procedure for rearing pink bollworm developed at the Central Institute for Cotton Research (Dhara jothi *et al*., 2016,) was used due to its ease of implementation and also its homogenous conditions. The procedure was done in the insectary of the Central Institute for Cotton Research.

Procedure
Eggs of pink bollworm obtained from moth mating jars of stock colony were counted on the twigs and were cut on counting 50 eggs. These twigs were then dipped into pre made insecticidal solutions and were placed individually in plastic insect rearing trays @50eggs/twig. Three replications were maintained for each insecticide treatment and thus a total of 150 eggs were evaluated for each test insecticide. A batch of 3 twigs each holding 50 eggs dipped with only water were kept as control for comparison. The twigs were shade dried, labeled properly with experimental details like treatment and replication number and were placed inside the insect rearing trays (10cm diameter), separately in a batch of three replicated twigs for each of the test insecticides .The insect rearing trays were maintained in laboratory at 27 ± 1°C temperature and 65 ± 5% RH. The post-treatment observations were recorded on number of eggs hatched in each of the insecticide treatments at the regular intervals of 24 hours till hatching is completed (Fand *et al*., 2009). Based on the data recorded, the per centage of egg hatching in different test treatments was calculated using the following formula (Amer *et al.*, 2012):

$$\boldsymbol{Hatching\ (\%)} = \frac{\textbf{Number of eggs hatched}}{\textbf{Total number of eggs}} \textbf{X 100}$$

Accordingly, reduction in the egg hatching due to each insecticide treatment was computed as per the following formula (Zidan and Megeed., 1987)

$$\boldsymbol{Reduction\ in\ hatching\ (\%)} = \mathbf{1 - \frac{t}{c}\ x\ 100}$$

Where,

t = number of eggs hatched in treatment
c = number of eggs hatched in control

Similar experiment on evaluation of ovicidal action of test insecticides was carried out using three days old.

Statistical analysis for laboratory experiment

The mean value of the hatching per cent and reduction in hatching per cent ($\overline{x} \pm SE$) will subjected to analysis of variance (ANOVA), and the mean values were compared by Duncan Multiple Range Test (DMRT) (*P* = 0.05), using SPSS program, version 25 and treatment means were separated at P = 0.05. The values will be compared to each other to estimate the overall ovicidal effectivity of each insecticide formulation.

III. RESULTS AND DISCUSSION

The ovicidal effect on younger eggs (<24 hours)

In terms of egg hatchability per cent the lowest per cent value was the most significant and it was observed that profenofos 50 EC was the most effective at 16.00%, followed closely by quinalphos 25 EC and cypermethrin 25 EC in the next group at 20.10% and 21.30% respectively, following it the next group was fenvalerate 20 EC and chlorpyriphos 20 EC at 24%.00 and 26.00% each, the next finding was emamectin benzoate 5 SG followed by spinosad 45 SC at 34% and 36% respectively, the next was Thiodicarb 75 WP at 40%, the least effective was Neem oil at 49.3%. All the nine treatments were found to be significantly superior in contrast to the control which had a hatching per cent value of 83.3% where no treatment was done.

The reduction in egg hatching was also measured with the control to identify the effectivity of the treatments of the various insecticides in terms of their effectivity in terms of reducing the population in by reducing the number of eggs hatched (Table 2). The highest reduction in egg hatching was found in profenofos 50 EC followed closely by quinalphos 25 and cypermethrin 25 EC at 80.76%, 75.22% and 74.25% respectively, the next group was fenvalerate 20 EC and chlorpyriphos 20 EC at 71.25% and 68.81% respectively, then it was emamectin benzoate 5 SG and spinosad 45 SC at 59.26% and 56.74% respectively, then it was followed by thiodicarb at 75WP at 52.01% then the least effective was neem oil 0.3% at 40.62% reduction of hatching.

(Table -2) Effect of different insecticides against eggs of *Pectinophora gossypiella* (< 24hours)

Treatment details	Concentrations (gm. or ml/l)	Egg hatching (%)*	Reduction in egg hatching (%)**
Profenofos 50 EC	2.0	16.0±1.15^{a} (23.55±0.90)	80.76±1.53^{a} (64.02±1.13)
Chlorpyriphos 20 EC	2.5	26.0±2.31^{b} (30.61±1.51)	68.81±2.59^{b} (56.09±1.62)
Thiodicarb 75 WP	2.0	40.0±1.15^{d} (39.23±0.68)	52.01±0.42^{d} (46.15±0.24)
Spinosad 45 SC	0.3	36.0±1.15^{c} (36.87±0.69)	56.74±1.86^{cd} (48.88±1.08)
Neem oil 0.3%	5.0	49.3±2.40^{e} (44.62±1.38)	40.62±4.19^{e} (39.55±2.47)
Emamectin benzoate 5 SG	0.4	34.0±2.00^{cd} (36.65±1.22)	59.26±1.64^{c} (50.34±0.96)
Cypermethrin 25 EC	1.0	21.3±2.40^{ab} (27.44±1.66)	74.25±3.47^{ab} (59.60±2.25)
Quinalphos 25 EC	2.0	20.1±1.76^{ab} (27.00±1.24)	75.22±1.87^{ab} (60.18±1.25)
Fenvalerate 20 EC	1.0	24.0±2.31^{b} (29.28±1.55)	71.25±2.44^{b} (57.62±1.54)
Control (water spray)		83.3±1.76^{f} (65.96±1.35)	0±0
F stat		sig**	sig**
SEm±		1.31	1.47
CD @ 5%		3.91	4.39

*Figures represent per cent values of total simple size,; **Figures in parentheses are arc sin transformed values

The overall findings in the above experiment was found to be of similar trend with an experiment carried out by Busnoor (2019) in which he reported that the hatching trend in one day old eggs was profenofos 50 EC(20.00%) < cypermethrin 25 EC(22.67%) < emamectin benzoate 5 SG(52.00%) wherein the data on the research done shows very similar per centage of hatching and reduction of hatching

The ovicidal effect on younger eggs (<72 hours)

Among the various insecticides tested, the treatments of cypermethrin 25 EC with egg hatching of 19.33% egg hatching was found significantly superior to rest of the treatments exhibiting strong ovicidal activity against three days old eggs of pink bollworm. The next group of insecticides in descending order of their hatchability as from the lower per centage of egg hatching comprised of quinalphos 25 EC and profenofos 50 EC at 23.33% and 24.67% respectively. The next group comprised of fenvalerate 20 EC and chlorpyriphos 20 EC with hatching per centage 27.33% and 28.67% after this group comes emamectin benzoate 5 SG followed closely by spinosad 45 SC at 36.67% and 38.67% reduction in hatching, the next insecticide was thiodicarb 75 WP with hatchability 43.33% per cent hatching and followed lastly by neem oil 0.3% which has the lowest effect at 52.67% hatchability

After extensive tests it was found that all the treatments had a significant reduction on hatching as compared with the control the most superior of which was found to be cypermethrin 25 EC with egg hatching reduction of 77.42 % when tested with control which was followed closely with quinalphos 25 EC and profenofos 50 EC at 72.93% and 71.10%, the next insecticide was fenvalerate 20 EC at 68.21% reduction and then the next was chlorpyriphos 20 EC, emamectin benzoate 5 SG and spinosad 45 SC at 66.25%, 57.45% and 54.97% followed closely by thiodicarb 75 WP at 49.58% reduction in hatching, lastly we have neem oil 0.3% with a reduction of hatching of 38.49%.

(Table-3) Effect of different insecticides against eggs of *1 gossypiella* (< 72 hours)

Treatment details	**Concentrations (gm. or ml/l)**	**Egg hatching (%)***	**Reduction in egg hatching (%)****
Profenofos 50 EC	2.0	24.67±2.90^{a} (29.70±0.99)	71.10±4.17^{ab} (57.59±2.64)
Chlorpyriphos 20 EC	2.5	28.67±2.90^{b} (32.32±1.83)	66.72±2.88^{b} (54.81±1.77)
Thiodicarb 75 WP	2.0	43.33±0.67^{d} (41.17±0.13)	49.58±0.76^{cd} (44.76±0.44)
Spinosad 45 SC	0.3	38.67±0.67^{cd} (38.45±0.35)	54.97±1.40^{c} (47.76±0.81)
Neem oil 0.3%	5.0	52.67±2.90^{e} (46.53±0.84)	38.49±5.04^{e} (38.27±3.00)
Emamectin benzoate 5 SG	0.4	36.67±2.40^{c} (46.53±0.58)	57.45±1.76^{c} (49.29±1.03)
Cypermethrin 25 EC	1.0	19.33±1.76^{a} (37.25±1.27)	77.42±2.42^{a} (61.69±1.70)
Quinalphos 25 EC	2.0	23.33±2.40^{ab} (26.04±1.56)	72.93±2.27^{ab} (58.69±1.46)
Fenvalerate 20 EC	1.0	27.33±2.40^{b} (28.83±1.15)	68.21±2.71^{c} (55.72±1.65)
Control (water spray)		86.00±2.30^{f} (68.16±1.16)	0.00±0.00^{f} (0.00±0.00)
F stat		sig**	sig**
SEm±		1.57	1.68
CD @ 5%		4.67	4.99

*Figures represent per cent values of total simple size,; **Figures in parentheses are arc sin transformed values

The two experiments carried out at different level of maturity on the pink bollworm eggs show clear parallels with each with the younger eggs being slightly more susceptible to the ovicidal treatments than 72 h old eggs.

The overall findings in the above experiment was found to be of similar trend with an experiment carried out by Busnoor (2019) in which he reported that the hatching trend in one day old eggs was profenofos 50 EC (20.00%) < cypermethrin 25 EC (22.67%) < emamectin benzoate 5 SG (52.00%) wherein the data on the research done shows very similar albeit an overall less per centage of hatching and reduction of hatching also shows a similar trend with a slightly higher overall hatching than the past experiment.

Mustafa (2016) also showed egg hatchability per cent with emamectin benzoate 5 SG to be at 86.54% which was very similar to our findings which indicates lower ovicidal activitiy of this specific treatment.

Hanan and Samiya (2014) also reported similar trend of lower toxicity to the eggs by emamectin benzoate, spinotoram (analogue to spinosad) and pyridalyl against ranaxypyr against one day old eggs of *Spodoptera littoralis* further showing parallels inspite of having the other treatment different along with the test insect, the relatively poor ovicidal performance of spinosad and emamectin benzoate.

Comparision of the ovicidal effect of the insecticide between 24 hour old eggs and 72 hour old eggs.

In was observed that in treatment of 24 h old eggs the per cent hatchability was least in profenofos 50 EC was the most effective at 16.00%, followed closely by quinalphos 25 EC and cypermethrin 25 EC in the next group at 20.10% and 21.30% respectively, following it the next group was fenvalerate 20 EC and chlorpyriphos 20 EC at 24%.00 and 26.00% each, the nest finding was spinosad 45 SC followed by emamectin benzoate 5SG at 36% and 34% respectively, the next was Thiodicarb 75 WP at 40%, the least effective was neem oil at 49.3%. At the second spray profenofos 50 EC with egg hatching of 19.33% egg hatching was found significantly superior to rest of the treatments, next group of insecticides in descending order of their effective ovicidal activity as revealed from lower per centage of egg hatching comprised of cypermethrin 25 EC and quinalphos 25 EC at 23.33% and 24.67% respectively. The next group comprised of fenvalerate 20 EC and chlorpyriphos 20 EC with hatching per centage 27.33% and 28.67% after this group comes emamectin benzoate 5 SG followed closely by spinosad 45 SC at 36.67% and 38.67% reduction in hatching, the next insecticide was thiodicarb 75 WP with hatchability 43.33% per cent hatching and followed lastly by neem oil at 3% which has the lowest effect at 52.67% hatchability.

The trend found in the hatchability was found to be similar to the test carried out by Busnoor (2019) where he recorded that in both the test the order of the hatchability in 24 h and 72 h old eggs of pink bollworm were profenofos 50 EC (20.00%) < cypermethrin 25 EC (22.67%) < emamectin benzoate 5 SG (52.00%) which parallels the data in the above tables.

In the reduction of hatching per centage the order of data for 24 h old eggs was profenofos 50 EC followed closely by quinalphos 25 EC and cypermethrin 25 EC at 80.76%, 75.22% and 74.25% respectively, the next group was fenvalerate 20 EC and chlorpyriphos 20 EC at 71.25% and 68.81% respectively, then it was emamectin benzoate 5 SG and spinosad 45 SC at 59.26% and 56.74% respectively, then it was followed by thiodicarb at 75WP at 52.01% then the least effective was neem oil 0.3% at 40.62% which can be compared to profenofos 50 EC (75.76%) < cypermethrin 25 EC (72.42%) < emamectin benzoate 5 SG (36.82%) from the experiment done by Busnoor (2019).

The results on ovicidal effect of the insecticide on three days old eggs (72 h old) was cypermethrin 25 EC with egg hatching reduction of 77.42 % when tested with control which was followed closely with quinalphos 25 EC and profenofos 50 EC at 72.93% and 71.10% respectively, the next insecticide was chlorpyriphos 20 EC at 66.72 % reduction and then the next was fenvalerate 20 EC, emamectin benzoate 5 SG and spinosad 45 SC at 68.25%, 57.45% and 54.97% followed closely by thiodicarb 75 WP at 49.58% reduction in hatching, lastly we have neem oil 0.3% with a reduction of hatching of 38.49%. These results were slightly different to the data by Busnoor (2019) with a data trend of profenofos 50 EC (71.10%) < cypermethrin 25 (72.42%) EC < emamectin benzoate 5 SG (64.49%).

IV. Conclusion

It could be concluded that in case of younger eggs profenofos 50 EC was the most effective ovicide but in older eggs, cypermethrin 25 EC was more effective but overall profenofos 50 EC, cypermethrin 25 EC and quinalphos 25 EC having overall similar ovicidal effect. The rest of the insecticides are arranged in more or less a similar order in both the younger and older eggs. Neem oil 0.03% was the least effective in both cases.

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