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INSECTICIDAL IMPACTS ON FECUNDITY AND LARVAL DAMAGE POTENTIALS OF PINK BOLLWORM *Pectinophora gossypiella*

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ABSTRACT

Pink bollworm (*Pectinophora gossypiella*) is one of the most notorious insects causing severe damage to cotton crops thought the world. A huge amount of different chemical formulations have been used for the control of *P. gossypiella* population that affects its biology. The present research was executed to determine the influence of insecticides on adult fecundity and boll damage potentials by the larvae. The results elucidated that a mixture of Deltamethrin+Triazophos had a maximum impact in fecundity reduction and boll damage by the larva when tested at one, three and twenty-four hours of post-application intervals (PAIs). The damage to cotton bolls was in the ranges of 27.50±0.57 to 57.50±1.44% at 3 to 144-hours PAIs respectively. Damage to cotton bolls and reduction in fecundity was at the highest 82.50±1.34, and 49.65±1.51% when a mixture of Deltamethrin+Triazophos and Alpha-Cypermethrin were applied at 144-hours PAI respectively. The experimental results highlighted the critical efficacy of the test insecticide for the control of *P. gossypiella* by reducing the boll damage and oviposition at different intervals of application.

Keywords: Oviposition, Pink Bollworm, Feeding capacity, Insecticide exposure, Cotton bolls, Damage potentials, insecticide, insecticide-mixtures

INTRODUCTION:

Agriculture is the backbone of Pakistan's economy and majority of population adhere to the industry through farming. Pakistan ranked 5th in the world after China, India, USA and Brazil with cotton production of 1306 metric tons during 2021 (Arshad *et al*., 2022). The average cotton yield in Pakistan is less as compared to other countries of the world because of the fact that crop is attacked by a number of insect pests and diseases. Cotton crops show a wide insect pest spectrum of about 1326 reported species worldwide (Parmar and Patel, 2016). According to an estimate, approximately 5-10% losses are caused by biotic and a-biotic factors from beginning of the crop till maturity (Khan, 2007; Sharma et al., 2017). Approximately 20-40% yield losses are cause by alone insect-pests in cotton (Makwana et al., 2018). Among these sucking insects such as, Green leafhopper (*Amrasca biguttula*), Aphids (*Aphis gossypii*), Whitefly (*Bemisia tabaci)*, Red cotton bug (*Dysdercus koenigi*), Dusky cotton bug (*Oxycarenus lateus*), Mealy bug (*Phenacoccusso lenopis*) can cause yield reduction upto 80% in server infestation (Naik *et al.*, 2020). Bollworms including Pink bollworm (*Pectinophora gossypiella*), American bollworm (*Helicoverpa armigera*), Spiny bollworm (*Earias insulana* and spotted bollworm (*Earias vittella*) mainly infest the fruiting parts of cotton and cause the losses in quantity and quality of cotton crop with 20-60% loss in the fiber quality (Ahmad, 1980).

Among these bollworms, Pink bollworm (*P. gossypiella*) is considered one of the most harmful cotton insect-pests because it is difficult to control it with insecticides due to its concealed feeding habit (Lykouressis *et al*., 2005). The incidence of *P. gossypiella* has been reported in nearly every cotton producing country in the world thereby causing significant yield losses (Abd-Elhady and Abd El-Aal, 2011; Rajput *et al.*, 2017). *P. gossypiella* causes losses of 10.70% to 59.20%, 2.1 to 47.10% and 2.8% to 6.91% in cotton bolls, cotton seeds and fiber yield respectively (Patil, 2003). In early crop stage, *P. gossypiella* attacks on fruiting parts of cotton its larva feeds on flowers, squares and young green bolls as the females deposit eggs on flowers, axils of petioles,

underside of leaves and young bolls (Perlak *et al*., 2001).

The eggs are hatched within 2-3 days (Kabissa, 1990; Vanilla *et al*., 2007). Neonates (1st and 2nd instar larvae) are creamy white with dark brown prominent head. These first instar larvae require 30 to 120 minutes to search and penetrate into in the flower buds, square or young bolls. Once the larvae grown to third-fourth instar (turn pinkish in color) (Parmar and Patel, 2016). At this stage, it becomes difficult to control *P. gossypiella* even with the application of insecticides because the fat bodies fully developed (Borkar and Sarode, 2012).

The introduction of *Bt*-cotton managed to control the bollworm population, but these insect-pests developed resistance against *Bt*-cotton too. Insecticide resistance and open field resistance have been reported in pink bollworm (Tabashnik *et al.,* 2005; Fabrick and Tabashnik, 2012; Naik *et al.,* 2020). As an ultimate and quick remedy, the farmers rush to apply insecticides for the management of insects. Keeping in view all these facts, the present research was executed to find the most effective insecticide among a few most commonly used, their effect on oviposition, larval mortality and damage potential in cotton bolls.

MATERIALS AND METHODS

The present research was carried out in Pink bollworm Rearing Laboratory, Department of Entomology, University of Agriculture, Faisalabad and Entomological Research Institute (ERI), Ayub Agricultural Research Institute (AARI), Faisalabad. Infested cotton material (square, flowers and cotton bolls) were collected from cotton fields located at Young wala field area (31º26′ 04″ N and 73º03′48″ E), University of Agriculture, Faisalabad and from ERI fields (31°24′09″ N, 73°02′50″ E). Six insecticides along with their mixtures were tested in different concentrations and post-application intervals (PAIs) on potted cotton plant.

Pink bollworms' Population Homogenization: The infested material was inspected and pink bollworm specimens (larvae and pupae) were isolated. The larvae of uniform age were fed on standard artificial laboratory larval diet (Wu *et al.,* 2008). The larvae pupated on the same day were separated and kept on a layer of paper towel set at the bottom of a glass petri plate to avoid trauma. Glass chimney cages were set as adult rearing chambers where 5-days old pupae were placed for moth emergence. The adult rearing chambers were provided with 10% honey solution as adult diet (Hariprasad, 1999; Wu *et al.,* 2006). The top and bottom of the adult cambers were lined with muslin cloth as oviposition substrate (Akhtar *et al.,* 2022). First instar larvae were collected from the egg batches harvested from the adult chambers and reared on standard laboratory diet for having uniform population for the purpose of laboratory experiments.

Preparation of potted cotton plants: The seeds of cotton variety (FH-901) were sown in disposable plastic cups (radius= 2.5,3.75 and 6.75 cm, bottom, top and length respectively) and filled with soil having small holes (0.5cm) 3 to 4 and 7 to 8 at the bottom and sides. After one month these potted cotton were shifted to adult's chambers for further experiments as described in the treatments.

Insecticides Selection and their application: The insecticides, which were commonly used to control pink bollworms, were selected to test their effect on the adults and larvae of pink bollworm at different interval of application. The post-application intervals (PAIs) were defined to study the insecticide's impacts on different biological aspect with the passage of time for the repetition of insecticide application. These PAIs were 1, 3, 24, 48 and 72 hours and 3, 24, 48, 72 and 144 hours (after spray of selected insecticides @ field recommended doses on potted plants by means of a hand atomizer) for adults and larvae of the pink bollworm respectively (Table.1).

Table. 1: Insecticides and post-application intervals (PAIs) tested against *Pectinophora gossypiella* (Adults and Larvae)

Treatments	Description	Manufacturer	Post Application Intervals (PAIs) Hours (Adults)	Post Application Intervals (PAIs) Hours (Larvae)
T_1	Deltamethrin (35% EC) +Triazophos (1.0% EC)	Four Brothers Agri, Services	01, 03, 24, 48 and 72 hours	03, 24, 48, 72 and 144 hours
T_2	Profenophos(60%)+Lambda cyhalothrin (1.5% EC)	Four Brothers Agri, Services		
T_3	Bifenthrin (5% EC)+Abamectin (0.6% EC)	FMC		
T_4	Emamectin Benzoate (1.9% EC)	Jaffer Agrochemicals		
T_5	Beta-Cyfluthrin (25% EC)	Pak China Chemicals		
T_6	Alpha-Cypermethrin (10% EC)	FMC		
T_7	Distilled water Check/Control (0.0% EC)			

These treated potted plants were placed in the adult chambers. After proper identification of male and females, counted number of (fifteen pairs) moths were released in adult's chamber having insecticide treated plants (Dharajothi *et al*., 2010). The pink bollworm neonates (1st instar larvae) of uniform age were collected from egg batches harvested on the same day. Potted cotton plant's (FH-901) culture was maintained

in glass house separately. Cotton bolls (10~15 days old) from these potted plants were collected, treated with selected insecticides and provided to the first instar larvae. Free choice method was used to test the effect of targeted insecticides at different PAIs following completely randomized design (CRD) with ten replications throughout the research work for adults and larvae of pink bollworm. The biological parameter for adults (fecundity, reduction in fecundity/compared to control, mortality) and larvae (mortality and boll infestation) were recorded. The collected data was statistically analyzed using computer based statistical software the "Statistica" and means were calculated and compared following Tukey's HSD, post-hoc.

RESULTS AND DISCUSSION:

The results revealed that maximum fecundity in the females of *Pectinophora gossypiella'*s (eggs. Day^{-1}. Female^{-1}) was obtained when Alpha-Cypermethrin/10% EC was sprayed on the potted cotton plants while minimum when mixture of Deltamethrin/35% EC+Triazophos/1.0% EC tested at different post-application intervals (one, three, twenty-four, forty-eight and seventy-two hours). A gradual increase in fecundity was observed over the time which reflected its persistence duration. The highest reduction in fecundity percentage was recorded with the application of Deltamethrin/35% EC +Triazophos/1.0% EC (as a mixture) and minimum Alpha-Cypermethrin/10% EC. There was no reduction in fecundity percentage in the control/check treatment (Distilled water). The comparison of the *P. gossypiella'*s adult mortality (percentage) the insecticides, Deltamethrin/35% EC +Triazophos/1.0% EC and Alpha-Cypermethrin/10% EC caused the highest and lowest mortality when recorded under laboratory conditions at the same time interval respectively (table. 2).

Table. 2: Effect of various insecticides on *Pectinophora gossypiella* adults' fecundity at different intervals

Post Application Intervals (PAIs)	Biological Parameters	Treatments						
		T_1	T_2	T_3	T_4	T_5	T_6	T_7
Results of 01-hour PAI	**Fecundity (eggs. Day^{-1}±SE)**	6.55±0.03	6.85±0.05	7.25±0.06	7.45±.07	7.80±.08	8.25±0.090	10.20±0.06
	Reduced fecundity±SE (%)	35.78±0.65	32.84±0.10	28.92±0.12	26.96±0.13	23.53±0.15	19.12±0.39	0.00±0.00
	Adult mortality±SE (%)	65.00±2.89	45.00±2.91	55.00±3.12	40.00±5.77	45.00±2.97	40.0±11.55	15.00±2.89
Results of 03-hour PAI	**Fecundity (eggs. Day^{-1}±SE)**	6.85±0.03	7.20±0.07	7.55±0.07	7.90±0.09	8.30±0.12	8.85±0.14	11.90±0.23
	Reduced fecundity±SE (%)	42.40±0.88	39.47±0.69	36.52±.99	33.58±0.80	30.24±0.38	25.62±0.23	0.000±.00
	Adult mortality±SE (%)	55.00±2.89	40.00±1.15	40.00±5.77	35.00±2.87	40.00±1.12	35.00±8.66	5.00±2.89
Results of 24-hour PAI	**Fecundity (eggs. Day^{-1}±SE)**	7.30±0.12	7.60±0.06	8.00±0.05	8.30±0.04	8.80±0.03	9.35±0.03	13.23±0.32
	Reduced fecundity±SE (%)	44.81±0.45	42.52±0.94	39.50±1.01	37.23±1.07	33.45±1.16	29.27±1.48	0.00±0.00
	Adult mortality±SE (%)	40.00±0.40	25.00±2.89	23.33±3.33	25.00±2.79	20.00±5.77	20.00±0.20	3.333±3.33
Results of 48-hour PAI	**Fecundity (eggs. Day^{-1}±SE)**	7.70±0.12	8.10±0.15	8.40±0.13	8.80±0.17	9.30±0.12	9.90±0.14	14.75±0.49
	Reduced fecundity±SE (%)	47.73±0.96	45.02±1.05	42.98±1.12	40.28±0.81	36.86±1.32	32.78±1.46	0.00±0.00
	Adult mortality±SE (%)	35.00±2.89	20.00±2.97	25.00±2.97	25.00±2.69	23.33±3.23	13.33±3.33	0.00±0.00
Results of 72-hour PAI	**Fecundity (eggs. Day^{-1}±SE)**	8.25±0.14	8.65±0.13	9.10±0.12	9.35±0.15	9.95±0.14	10.60±0.06	16.43±0.78

	Reduced fecundity±SE (%)	49.65±1.51	47.21±1.63	44.44±1.93	42.93±1.83	39.26±2.00	35.24±2.72	0.00±0.00
	Adult mortality±SE (%)	25.00±2.89	20.00±2.01	30.00±2.78	25.00±2.54	15.00±2.89	13.00±3.54	3.33±3.33

Further research investigations regarding mortality in larvae those were released on treated cotton plants at boll stage and successfully infested cotton bolls. Among all the tested insecticides under consideration, the highest larval mortality was recorded at three hour PAI that declined at one hundred forty-four hours PAI after treatment with Deltamethrin/35% EC+Triazophos/1.0% EC. Whereas, lowest larval mortality was recorded with the application of Alpha-Cypermethrin/10% EC at three PAI which declined at one hundred and forty-four hours PAI. Infestation by *P. gossypiella*'s larvae increased proportionally to PAIs as the larvae inside the bolls cause maximum damage during concealed feeding.

Minimum boll damage/boll infestation was recorded with the application of Deltamethrin/35% EC+Triazophos/1.0% EC at three PAI which increased at one hundred forty-four hour PAI. Among the tested insecticides, maximum boll damage was recorded at three hours PAI when Alpha-Cypermethrin/10% EC was sprayed. In the same treatment damage peaked at one hundred and forty-four hours PAI (Table. 3)

Table. 3: Effect of various insecticides on larval mortality and boll damage at different intervals in *Pectinophora gossypiella*

Post Application Intervals (PAIs)	**Biological Parameters**	**Treatments**						
		T_1	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**
03-hour PAI	**Larval Mortality±SE (%)**	72.50±1.67	52.50±1.57	47.50±1.27	42.50±1.47	37.50±1.17	32.50±1.37	12.50±0.75
	Boll damage±SE (%)	27.50±0.57	47.50±1.49	52.50±1.37	59.17±1.45	62.50±1.17	65.50±1.41	87.50±1.89
24-hour PAI	**Larval Mortality±SE (%)**	67.50±1.35	47.50±1.27	42.50±1.55	39.50±1.19	35.50±1.31	29.50±1.67	11.67±1.23
	Boll damage±SE (%)	32.50±1.54	52.50±1.07	57.50±1.44	62.50±0.98	72.50±1.41	57.50±1.35	89.67±1.37
48-hour PAI	**Larval Mortality±SE (%)**	65.20±1.67	42.50±1.49	37.50±1.27	35.50±1.49	32.50±1.44	25.50±1.23	09.50±1.27
	Boll damage±SE (%)	37.50±1.52	57.50±1.61	62.50±1.39	67.50±1.55	77.50±1.44	62.50±1.49	91.50±1.49
72-hour PAI	**Larval Mortality±SE (%)**	52.50±1.54	37.50±1.51	22.50±1.44	27.50±1.49	32.50±1.41	22.50±1.47	07.50±1.24
	Boll damage±SE (%)	47.50±1.44	62.50±1.58	67.50±1.37	72.50±1.59	79.50±1.44	67.50±1.43	92.50±1.33
144-hour PAI	**Larval Mortality±SE (%)**	42.50±1.44	37.50±1.49	21.50±1.18	22.50±1.47	28.50±1.41	18.50±1.44	5.00±0.00
	Boll damage±SE (%)	57.50±1.44	62.50±1.43	72.50±1.41	72.50±1.45	80.50±1.44	82.50±1.34	95.00±0.00

The adults of *P. gossypiella* deposit eggs on different part on cotton plants (Zinzuvadiya *et al*., 2017; Fand *et al.,* 2020). While the larvae being the concealed feeders of cotton bolls thereby reduce the quality and quantity in cotton crop. Insecticide chemistry and their application timing determine their efficacy. The efficacy of the insecticide increased if application schedule is based on the factual date of the insect-pest monitoring which likely to coincide with oviposition period the most of the insect-pest population (Naranjo *et al.,* 2002). The present findings elucidate that the insecticide mixture Deltamethrin/35%

EC+Triazophos/1.0% EC has highest ovicidal action as it reduced the fecundity and cause maximum mortality in *P. gossypiella* moths. Many scientists have reported the effect of a number of insecticides on the fecundity, egg hatchability reduction and adult mortality in a variety of insect-pests at different post-application intervals. Sabry *et al*., 2018 reported a decrease in *P. gossypiella*'s egg hatchability with the application of Fipronil and Pyriproxifen at different intervals to varied extent. These are results are contrary to those reported by Rajput, 2017 who found that the application of Triazophos significantly reduced the *P. gossypiella*'s population on both cotton cultivars (*Bt* and non-*Bt*) under field conditions more specifically the reduction in adult population thereby interfering with oviposition. Natikar *et al*., 2015 reviewed the ovicidal action of a number of insecticides against *Spodoptera litura*. In this review, it was reported that the highest ovicidal action of Quinalphos 25 EC (0.005%) (66.54%) was achieved by Patel *et al*., 1995, Raja Reddy and Divakar, 1998 conveyed the effectiveness of Methomyl 12.5 EC against eggs at 83.17 ppm and Thiodicarb 75 WP @ 1 g/l caused 78.11% reduction in fecundity in *S. litura.* These findings are also in agreement with Acharya *et al.*, 2013, who conducted a scientific study for testing Triazophos that tracked Thiocorpid and eco-neem in the field to minimize the bollworm fecundity. Results obtained from this study indicated that the plot treated with Triazophos produced maximum cottonseed yield than the plot treated with water spray. Conclusively, Triazophos is recommended to be incorporated in future integrated pest management programs as an effective chemical tool. The results of the larval mortality and boll infestation resemble those reported by Pedibhotl *et al*., 1999 who achieved an excellent control on all life stages of tobacco budworm using the mixture of Deltamethrin+Triazhophos. Brazzel *et al*., 1959 elucidated the ovicidal effect of organophosphates with Guthion and Parathion more potent than others did.

CONCLUSION:

Keeping in view all verdicts, it is concluded that the selection of the most effective insecticide among the available choices, insect population data, method of application and time interval among the application dates for devising proper management plan. The results revealed that the insecticide mixture Deltamethrin/35% EC+Triazophos/1.0% EC has highest ovicidal action as it reduced the fecundity and cause maximum mortality in *Pectinophora gossypiella* moths.

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