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Drone application of insecticides for the management of pink bollworm, *pectinophora gossypiella* (Saunders) in cotton

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ABSTRACT

Spraying of insecticides in agriculture has been carried out through ground and aerial spraying methods. Taking into cognizance of problems associated with the ground spraying using different kind of equipment is needed which is safer and more efficient method for pesticide application in agricultural practices. The use of advanced technologies such as drones which comes under aerial spraying in agriculture offer potential for facing several challenges. Studies were conducted at Regional Agricultural Research Station, Nandyal during rabi,2024 against pink bollworm, Pectinophora gossypiella through drone aerial spray comparision with knapsack sprayer by sequential spraying of insecticides. It revealed that pyridalyl 10% EC @ 1 ml l^{-1} drone spray was found significantly superior over control (8.75% per cent mean rosette flower) in reduction (65.36%) of the rosette flowers due to pink bollworm larvae. The same insecticide had recorded the lowest green boll damage (9.38%), green boll locule damage (12.81%) with the highest per cent reduction (71.00% and 71.26%) and also recorded the highest seed yield (7.15 kg/ha) and lint yield (2.50 kg/ha) with highest benefit-cost ratio (1.90) during first, second and third sprays, respectively.

Keywords: *Pectinophora gossypiella, sequential spraying, drone, rosette flowers, green boll damage, locule damage.*

INTRODUCTION

Cotton *Gossypium hirsutum* L. (Family: Malvaceae) is the major commercial crop cultivated in India across all the zones of north, south, and central, cotton is famously called as 'white gold' due to its higher premium in international markets. The pest spectrum of cotton crop is quite complex comprising of several species of insects. They are primarily divided into sucking pests and bollworms. Bollworm complex contains American bollworm (*Helicoverpa armigera* Hub.), spotted bollworm (*Earias villa* Fab.) and pink bollworm (*Pectinophora gossypiella* Saunders) account for a considerable yield loss to the extent of 36.2 per cent (granthi *et al*., 2005). Among the bollworm complex, pink bollworm is a destructive pest of cotton. It causes locule damage of 37.50% and 13.58% on non-Bt and Bt cotton, respectively, at 160 days of planting resulting in heavy loss in cotton production (Naik *et al*., 2014). Management strategies aimed at containing pink bollworms often become difficult due to its concealed feeding nature and less time spent outside the boll. However, farmers heavily rely often on spraying of pesticides particularly insecticides, due to their quick action, easy availability and perceived reliability. Spraying of pesticides in agriculture has been carried out through ground and aerial spraying methods. The use of advanced technologies such as drones which comes under aerial spraying in agriculture offer potential for facing several challenges.

Unmanned aerial vehicles (UAVs), also referred to as drones, can be employed for tasks such as spraying pesticides and crop protection, allowing a single person to control the UAV from a safe distance. This not only reduces the time required for these activities but also enhances the safety of the farmer (Desale *et al*., 2019). The application of pest control products using UAVs has seen an increase in recent years (Mogili *et al*., 2018). The present study was conducted to evaluate the sequential spraying of selective insecticides for the management of pink bollworms in cotton by using drone technology.

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MATERIALS AND METHODS

An experiment was conducted to evaluate the sequential spraying of selective insecticides against pink bollworm in cotton by using a drone during *rabi* 2024 at RARS, Nandyal. The experiment was conducted under standard agronomic procedure and laid out in Randomized Block Design with five treatments replicated four times, plot size of 25 m × 20 m per replication per treatment. Details of insecticides used in the experiment are represented in Table 1. Sowing was done by hand dibbling with the non Bt variety Sri Rama at a spacing of 60 cm × 30 cm between rows and plants.

Total of three sprays were scheduled at 90, 105 and 120 days after sowing with drone comparison with knapsack sprayer. From which rosette flowers data was taken during 90 DAS, green boll damage was taken at 90,105 and 120 DAS and locule damage was taken during 105 DAS, 120 DAS. Pre treatment data was recorded a day before spray and post treatment data was recorded at seven and fourteen days after spray. The observations on rosette flowers, per cent green boll damage, per cent green boll locule damage per 20 bolls in each treatment were recorded by destructive sampling method. During the crop season, picking of seed cotton was done manually using human labour at the appropriate time without contamination of plant parts. The total cotton yield from each treatment was weighed separately and expressed in kg/ha.

The data was suitably converted to arcsine transformation for conducting statistical analysis with RBD.

Rosette flowers (%) $=\frac{Total\ number\ of\ rosette\ flowers}{Total\ number\ of\ flowers} \times 100$

Boll damage (%) $=\frac{Total\ number\ of\ damaged\ bolls}{Total\ number\ of\ bolls} \times 100$

Locule damage (%) $=\frac{Total\ number\ of\ damaged\ locules}{Total\ number\ of\ locules} \times 100$

$Percentage$ reduction $= \frac{\text{Population in Control} - \text{Population in Treatment}}{\text{Population in Control}} \times 100$

Results and Discussion

Rosette flowers (90 DAS)

A day before spraying, no significant difference was observed among the treatments with respect to rosette flowers due to pink bollworm larvae. At 7 days after spraying pyridalyl 10% EC @ 1 ml l^{-1} drone spray recorded lowest per cent of rosette flowers (8.75%) with highest per cent reduction (65.36%) which was significantly superior over all other treatments. However, at 14 days after spraying pyridalyl 10% EC @ 1 ml l^{-1} drone spray recorded the lowest per cent rosette flowers (10.00%) with highest per cent reduction (71.37%) over control (37.50%). Mean of 7 and 14 days after spraying indicated that pyridalyl 10% EC @ 1 ml l^{-1} drone spray was recorded lowest per cent rosette flowers of 9.38% with the highest per cent reduction of 68.36% over control (33.75%). Graphical representation of mean per cent incidence of rosette flowers (90 days after sowing) were presented in Fig 1.

Green boll damage

First spray (90 DAS)

During first spray, mean of 7 and 14 days after spraying indicated that pyridalyl 10% EC @ 1 ml l^{-1} drone spray recorded lowest per cent green boll damage (9.38%) with highest per cent reduction (71.00%) which was significantly superior over all other treatments. Next best treatments were pyridalyl 10% EC @ 1 ml l^{-1}knapsack sprayer followed by chloropyriphos 20 EC @ 3 ml l^{-1} drone spray and chloropyriphos 20 EC @ 3 ml l^{-1} knapsack sprayer recorded lowest per cent green boll damage (12.50%, 15.63% and 17.50%) with highest per cent reduction (65.77%, 55.61% and 54.65%) over control (31.88%), respectively. Graphical representation of mean per cent incidence of green boll damage (90 days after sowing) was presented in Fig 1.

Second spray (105 DAS)

Mean of the second spraying indicated that pyridalyl 10% EC @ 1 ml l^{-1} drone spray recorded the lowest per cent green boll damage (9.38%) with highest per cent reduction (71.00%) which was statistically at par with pyridalyl 10% EC @ 1 ml l^{-1} knapsack sprayer recorded 11.25% damage with 52.64% reduction. The next best treatments were quinalphos 25 EC @ 2.5 ml l^{-1}drone spray followed by quinalphos 25 EC @ 2.5 ml l^{-1} knapsack sprayer recorded 12.50% and 15.63% with 50.11% and 41.62% reduction, respectively. A graphical representation of mean per cent incidence of green boll damage (105 days after sowing) was presented in Fig 2.

Third spray (120 DAS)

During third spray mean of 7 and 14 days after spraying indicated that lambda-cyhalothrin 5EC @ 1 ml l^{-1} drone spray recorded less per cent green boll damage (13.13%) with the highest per cent reduction (44.19%) which was statistically at par with other treatments over control recorded 51.25% green boll damage.

A graphical representation of the mean per cent incidence of green boll damage (90, 105, and 120 days after sowing) was presented in Fig 3.

Green boll locule damage (105, 120 days after spray)

After two sprays pyridalyl 10% EC @ 1 ml l^{-1} drone spray recorded the highest reduction per cent of green boll locule damage *i.e.,*71.26% during the second spray. The next best treatment was lambda-cyhalothrin 5EC @ 1 ml l^{-1} knapsack sprayer recorded the highest per cent reduction of green boll locule damage *i.e.,*68.60% during the third spray, respectively. The efficacy of different insecticides on pink bollworms of cotton during *rabi*, 2024 was given in Table 2. Graphical representations of the mean percent incidence of green boll locule damage (105, 120 days after sowing) were presented in Fig 2 and 3.

Similar results were observed with Nair *et al.* (2008) who reported that pyridalyl 10 EC provided excellent control of the two bollworm species *i.e.,* spotted bollworm, *Earias insulana,* and American bollworm, *Helicoverpa armiger* of cotton and also with the Dhawan *et al.* (2009) who found that pyridalyl @ 75 g a.i. ha^{-1} along with fenpropathrin @ 100 g a.i. ha^{-1} was found more effective than pyridalyl alone in managing pink bollworms in cotton.

The present findings were in comparison with Saleh *et al.* (2013) who observed that the insecticide pyridalyl was found to be more effective against pink and spiny bollworms with 52.21% and 50.78% reduction.

These results were agree with Krishna *et al*. (2023) who reported that pyridalyl 10 EC effectively control the green boll damage, locule damage caused by the pink bollworm.

Assessment of the phytotoxicity

The phytotoxicity effect of the different insecticidal treatments applied through drone and knapsack sprayer on cotton plants were assessed at 7 and 14 days after spraying did not show any phytotoxicity symptoms *viz.,* leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty in cotton due to the application of various treatments.

Yield

The yield of cotton in different treatments given for the management of *P. gossypiella* infestation under field conditions varied from 3.64 to 7.15 kg/ha (seed cotton yield) and 1.27 to 2.50 kg/ha (lint yield of cotton). Maximum seed yield (7.15 kg/ha) and lint yield (2.50 kg/ha) was recorded in first treatment. The control recorded 3.64 kg/ha of seed yield and 1.27 kg/ha of lint yield, which was significantly lower than all the other treatments.

Benefit-Cost ratio

The comparison of the economic benefits between drone spraying and knapsack spraying is shown in Table 4. Efficient pest management strategies in agriculture aim to maximize crop yield and minimize input costs. The results of our study showed variations among the different pesticide treatments. Among the treatments, the first treatment had the highest benefit-cost ratio (1.90) followed by the third treatment (1.61), second treatment (1.52), and fourth treatment (1.23), respectively. The influence of various treatments used against pink bollworms on yield parameters and the benefit-cost ratio of cotton is given in Table 3.

Conclusions

Based on the findings of the present study, it can be inferred that the insecticide Pyridalyl 10% EC @ 1 ml l^{-1} drone spray was found most effective against pink bollworms as compared to other treatments.

Future scope of study

Ensure the insecticides are compatible with drone spraying systems, considering factors like droplet size, viscosity and stability. Evaluate the economic feasibility of using drones for insecticide application compared to traditional methods.

Conflict of interest

There is no conflict of interest while undertaking research.

Acknowledgement

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Table 1 Details of insecticides used in the experiment

Treatment No.	Type of Spray	First spray	Second spray	third spray
T_1	Drone spray @ 10 L/ acre	Pyridalyl 10% EC @ 150 ml/acre	Pyridalyl 10% EC @ 150 ml/acre	Cypermethrin 10 EC @ 187.5 ml/acre
T_2		Chloropyriphos 20 EC @450 ml/acre	Quinalophos 25 EC @ 375 ml/acre	Lambda cyhalothrin 5 EC @ 150 ml/acre
T_3	Knapsack sprayer @200 L/acre	Pyridalyl 10% EC @ 200 ml/acre	Pyridalyl 10% EC @ 200 ml/acre	Cypermethrin 10 EC @ 250 ml/acre
T_4		Chloropyriphos 20 EC @ 600 ml/acre	Quinalophos 25 EC @ 500 ml/acre	Lambda cyhalothrin 5 EC @ 200 ml/acre
T_5	Untreated control			

Table 2 Efficacy of different insecticides on pink bollworm of cotton during rabi, 2024

Treatment No.	**Mean per cent						**per cent reduction over control					
	First spray		Second spray		Third spray		First spray		Second spray		Third spray	
	Rosette flowers	Green boll damage	Green boll damage	Locule damage	Green boll damage	Locule damage	Rosette flowers	Green boll damage	Green boll damage	Locule damage	Green boll damage	Locule damage
T_1	9.38 (17.81)[a]	9.38 (17.81)[a]	9.38 (17.81)[a]	12.81 (20.85)[a]	11.88 (20.14)[a]	13.44 (21.49)[b]	68.36 (55.78)[a]	71.00 (57.49)[a]	50.23 (45.12)[a]	71.26 (57.71)[a]	41.73 (40.22)[a]	40.81 (39.62)[b]
T_2	13.13 (21.23)[a]	15.63 (23.27)[bc]	12.50 (20.67)[ab]	22.50 (28.30)[b]	13.13 (21.18)[a]	8.44 (16.84)[a]	45.78 (42.52)[bc]	55.61 (48.22)[b]	50.11 (45.05)[a]	44.17 (41.63)[b]	44.19 (41.64)[a]	64.77 (53.67)[a]
T_3	12.50 (20.60)[a]	12.50 (20.67)[ab]	11.25 (19.56)[a]	14.53 (22.38)[a]	13.13 (21.23)[a]	20.63 (27.00)[c]	55.88 (48.36)[b]	65.77 (54.22)[a]	52.64 (46.51)[a]	65.66 (54.14)[a]	40.27 (39.36)[a]	30.93 (33.75)[b]
T_4	20.00 (26.54)[b]	17.50 (24.71)[c]	15.63 (23.27)[b]	27.66 (31.72)[b]	16.25 (23.76)[a]	10.47 (18.85)[ab]	38.18 (38.14)[cd]	54.65 (47.66)[b]	41.62 (40.16)[a]	38.47 (38.32)[b]	34.44 (35.83)[a]	68.60 (55.98)[a]
T_5	33.75 (35.47)[c]	31.88 (34.35)[d]	41.88 (40.31)[c]	42.81 (40.85)[c]	51.25 (45.70)[b]	53.28 (46.87)[d]	0.00 (0.00)[c]	0.00 (0.00)[c]	0.00 (0.00)[b]	0.00 (0.00)[c]	0.00 (0.00)[b]	0.00 (0.00)[c]
SE±(m)	1.17	0.90	1.02	1.32	1.14	1.37	2.48	1.35	2.42	2.40	2.00	1.89
CD(P = 0.05)	4.71	3.62	4.13	5.32	4.60	5.53	10.01	5.45	9.76	9.67	8.06	7.62
CV(%)	6.80	5.26	5.96	6.48	6.11	7.40	9.50	4.60	9.68	8.84	9.00	7.30

***Figures in parentheses are arcsine transformed values*
Alphabet indicating Duncan Multiple Range Test (DMRT)

Table 3 Influence of various treatments used against pink bollworm on yield parameters of cotton

S.No	Type of spray	Seed Cotton Yield (Kg/ha)	Lint Yield (Kg/ha)	Gross returns (Rs/-)	Total cost of cultivation (Rs/-)	B:C ratio
T1	Drone Spray@ 10 L/acre	7.15	2.50	50193.0	26358.5	1.90
T2		5.64	1.97	39592.8	26058.0	1.52
T3	Knapsack Sprayer@ 200 L/acre	6.82	2.39	47876.4	29800.5	1.61
T4		4.95	1.73	34749.0	28292.5	1.23
T5	-	3.64	1.27	25552.8	25500.0	1.00
CD(P=0.05)		**1.11**	**0.56**	--	--	--
CV (%)		**12.71**	**18.30**	--	--	--

T1; Flonicamid 50 WG @ 45 g/acre —> Imidacloprid 17.8 SL @ 60 ml/acre —> Diafenthiuron50WP@187.5 g/acre
Pyridalyl 10% EC @ 150 ml/acre —>Pyridalyl 10% EC @ 150 ml/acre —>Cypermethrin 10 EC @ 187.5 ml/acre
T2; Fipronil 5SC@300 ml/acre —> Thiamethoxam 25WG @ 30 g/acre —> Profenophos50EC@300 ml/acre
Chloropyriphos 20 EC @450 ml/acre —> Quinalophos 25 EC @ 375 ml/acre —> Lambda cyhalothrin 5 EC @ 150 ml/acre
T3;Flonicamid 50WG@60 g/acre —>Imidacloprid17.8SL@80 ml/acre—>Diafenthiuron50WP@250 g/acre
Pyridalyl 10% EC @ 200 ml/acre —> Pyridalyl 10% EC @ 200 ml/acre —> Cypermethrin 10 EC @ 250 ml/acre
T4; Fipronil 5SC@400 ml/acre—>Thiamethoxam 25WG@40 g/acre—>Profenophos50EC@400 ml/acre
Chloropyriphos 20 EC @ 600 ml/acre —> Quinalophos 25 EC @ 500 ml/acre —> Lambda cyhalothrin 5 EC @ 200 ml/acre
T5; Untreated control

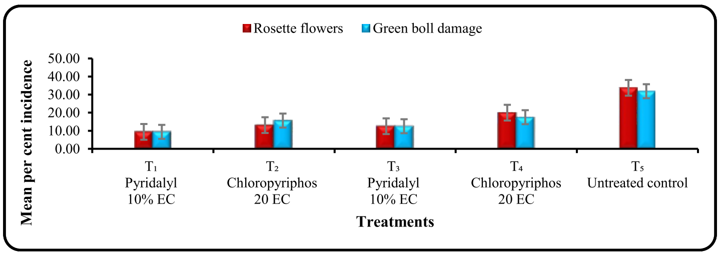

Fig 1 Mean per cent incidence of rosette flowers and green boll damage at 90 days after sowing

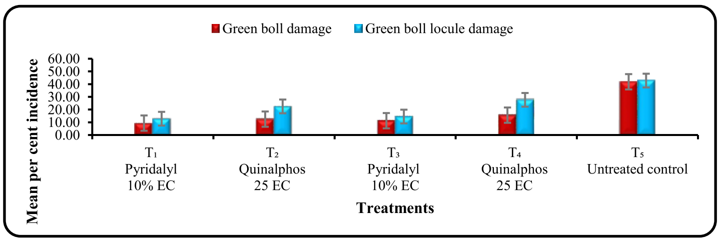

Fig 2 Mean per cent incidence of green boll and locule damage at 105 days after sowing

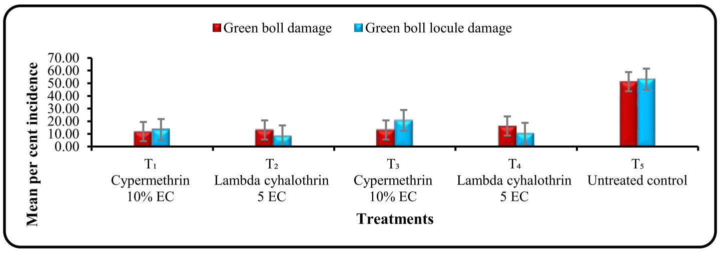

Fig 3 Mean per cent incidence of green boll and locule damage at 120 days after sowing

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