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# Evaluation of thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC against pink bollworm (*Pectinophora gossypiella* Saunders) in *Bt* cotton through drone application

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**Abstract**
The present study entitled, "Evaluation of Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC against Pink Bollworm (*Pectinophora Gossypiella* Saunders) in *Bt* Cotton through Drone Application" was carried out at, All India Coordinated Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra during *kharif*-2022-23. Observations were recorded on rosette flowers%, green boll damage%, larval population per 20 bolls, open boll damage%, locule damage% and yield (q/ha). Treatments with the drone and knapsack having dose of @ 88 g a.i./ ha, and @ 66 g a.i./ ha were only for evaluation of phytotoxicity on cotton crop. The results revealed that among the tested insecticidal treatments Thiamethoxam 12.6% + Lamda-cyhalothrin 9.5% ZC @ 44 g a.i./ha through drone recorded minimum number of rosette flowers (5.80%), green boll damage (8.95%), larval population (3.54 per 20 bolls), open boll damage (9.05%), locule damage (4.63%) at harvest and it was at par with the treatment @ 44 g a.i./ ha through knapsack which recorded rosette flowers (6.56%), green boll damage (9.89%), larval population (4.60 per 20 bolls), open boll damage (10.13%), locule damage (5.19%) at harvest. No phytotoxicity symptoms were observed in any of the treatments which indicated that selected treatments were safe and well tolerated by cotton crop at flowering and fruiting condition. Among tested insecticidal treatments, the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC @ 44 g a.i./ ha through drone application recorded higher yield of seed cotton (17.48 q/ha) and had non-significant difference with treatment @ 44 g a.i./ ha through knapsack**.** The drones or UAV's will be better option than conventional method in rainfed or drought prone zone as it requires very less water and aslo it saves the labour. This research is of only one year, it needs more confirmation.

**Keywords:** Drone application, pink bollworm, *Pectinophora gossypiella*, *Bt*, cotton

## Introduction

Cotton popularly known as 'White Gold' or 'King of natural fibres' is an important commercial crop. It is a major fiber crop of global significance, cultivated in more than seventy countries in the world. India's cotton sector provides huge employment opportunities to around 50 million people in related activities like cultivation, trade and processing (Pandey and Mathur, 2013) [10]. At national level, Maharashtra ranked first in area, second in production and twelfth in productivity. The pink bollworm is major pest of cotton and inflicted 30-80 percent yield losses (Kranthi *et al*., 2009) [7]. The pink bollworm causes damage to locules, amounting to around 55 percent, leading to seed cotton yield reductions ranging from 35 to 90 percent. As a consequence of this insect, the country incurred a loss of 6525 metric tons of lint valued at Rs 1216 million (Agarwal and Katiyar, 1979) [1].

Unmanned aerial vehicles (UAVs), also referred to as drones or unmanned aerial systems (UASs), have garnered significant attention in precision pest management due to their flexibility, high efficiency, and reduced labour intensity (Filho *et al*., 2019) [5]. Drone technology has emerged as a valuable tool in the agriculture sector, offering various advantages and proving useful in farming operations. 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 safety for the farmer (Desale *et al.*, 2019) [4]. The development of UAVs has become more practically feasible and affordable in precision agriculture (Beloev 2016) [2]. The application of pest control products using UAVs has seen an increase in recent years (Mogili *et al.*, 2018) [9]. The present study was conducted to evaluate different insecticidal treatments through drone and knapsack against pink bollworm at AICCIP Rahuri, Dist. Ahmednagar (M.S.).

## Material and Methods

A field study was conducted to evaluate the different insecticides against pink bollworm, *P. gossypiella* during *kharif* 2022-23 under randomized block design (RBD) at AICCIP, Rahuri, Dist. Ahmednagar (M.S.) with seven treatments including an untreated control and were replicated thrice. A popular *Bt* cotton hybrid Ajeet-199 was sown with a spacing of 90 cm x 90 cm. Insecticides were sprayed twice during the investigation period through drone and knapsack sprayer.

The pre-treatment count was taken before spraying for taking decision to initiate imposition of treatments and subsequently post treatment count were recorded after ten days of each spray application. The observations on rosette flowers, percent green boll damage, larval population per 20 green bolls, percent open boll damage and percent locule damage in open boll in each treatment were recorded. During the crop season, picking of seed cotton was done manually using human labour at the appropriate time without contamination of plant parts or trash. Individual plot seed cotton yields were recorded in separate pickings and expressed as quintal per ha.

$$\text{Percent Rosette flowers (\%)} = \frac{\text{No. of Rosette flowers}}{\text{Total No. of flowers}} \times 100$$

$$\text{Percent Green boll damage (\%)} = \frac{\text{No. of damage green boll}}{\text{Total No. of green bolls}} \times 100$$

$$\text{Percent Locule damage (\%)} = \frac{\text{Number of damaged locule}}{\text{Total number of locule}} \times 100$$

$$\text{Percent Open boll damage (\%)} = \frac{\text{Number of bad open boll}}{\text{Total number of open boll}} \times 100$$

## Results and Discussion

### Rosette flower

It is clear from the Table 1. that all tested insecticidal treatments were found significantly superior over control (15.51 percent mean rosette flower) in reduction of the rosette flowers due to pink bollworm larvae *P. gossypiella* during the 1st and 2nd spray. Mean percent rosette flower ranged between 4.52 to 6.56 percent in different treatments. Amongst the tested treatments, the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC @ 88 g a.i./ha through drone application induced highest effect, representing 70.85% reduction in rosette flower over untreated control and reducing rosette flowers upto 4.52 percent and was consistently at par with @ 88 g a.i./ha through knapsack, @ 66 g a.i./ha and @ 44 g a.i./ha through drone having reduction over control 67.89 percent, 65.50 percent and 62.60 percent while reduction in number of rosette flowers percentage upto 4.98, 5.35 and 5.80 percent sequentially. It was followed by the treatments with dose @ 66 g a.i./ha and @ 44 g a.i./ha through knapsack sprayer which recorded its reduction over control by 59.89 percent and 57.70 percent and reduction in number of rosette flower percentage upto 6.22 and 6.56 percent respectively against 15.51 percent in untreated control. Treatments with the drone and knapsack having dose of @ 88 g a.i./ ha, and @ 66 g a.i./ ha were only for evaluation of phytotoxicity on cotton crop.

### Green Boll Damage

It is evident from Table 2. that the mean percent green boll damage due to pink bollworm ranged between 7.21 to 9.89 percent in different treatments which were significantly superior over control (25.21 percent) in reduction of the green boll damage during 1st and 2nd sprays. Data showed that amongst tested treatments, the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC @ 88 g a.i./ha through drone application was found to be most effective treatment which induced highest effect, representing 71.40 percent reduction in green boll damage over untreated control and reducing green boll damage upto 7.21 percent and was consistently on par with Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC @ 88 g a.i./ha through knapsack, @ 66 g a.i./ha and @ 44 g a.i./ha through drone application having reduction over control 68.86 percent, 66.83 percent and 64.49 percent while reduction in percent of damaged green bolls percentage upto 7.85,8.36 and 8.95 percent sequentially. It was followed by the treatments with dose @ 66 g a.i./ha and @ 44 g a.i./ha through knapsack sprayer which recorded its reduction over control by 62.19 percent and 60.76 percent and reduction in number of green boll damage percentage upto 9.53 and 9.89 percent respectively against 25.21 percent in untreated control. The treatments with drone and knapsack sprayer having dose @ 88 g a.i./ha and @ 66 g a.i./ha were only to check the phytotoxic effect on cotton crop.

### Pink Bollworm Larvae/ 20 Bolls

The results of the present study (Table 3) indicated that, all treatments proved superior over the control. Mean pink bollworm larval population per twenty bolls ranged between 2.01 to 4.60 in different treatments. Obtained results showed that among all the treatments, Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC with dose of 88 gm a.i./ha through drone application was proved to be the most effective treatment which induced highest effect, representing 79.36 percent reduction over untreated control and reducing larval population upto 2.01 per 20 bolls and was consistently on par with Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC @ 88 g a.i./ha through knapsack, @ 66 g a.i./ha and @ 44 g a.i./ha through drone application having reduction over control 74.43 percent, 68.78 percent, 63.65 percent while reduction in number of larvae upto 2.49, 3.04, 3.54 larvae sequentially. It was followed by the treatments with dose @ 66 g a.i./ha and @ 44 g a.i./ha through knapsack sprayer which were recorded its reduction over control by 55.54 percent and 52.77 percent respectively and reduction in number of larvae upto 4.33 and 4.60 larvae respectively against 9.74 larvae per 20 bolls in untreated control. The treatments with drone and knapsack sprayer having dose @ 88 g a.i./ha and @ 66 g a.i./ha were only for phytotoxocity study on cotton crop.

## Open Boll Damage

Based on number of bad opened bolls and good opened bolls at each picking, the percent open boll damage was calculated and presented in table 4.

The mean percentage of open boll damage was significantly lower in all treatments (7.15 to 10.13%) which were superior over control (26.67%). The results showed that among the tested insecticidal treatments, Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC with dose of 88 gm a.i./ha through drone application induced highest effect, representing 7.15 percent open boll damage and 73.19 percent reduction in open boll damage over control. However, it was followed by Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC @ 88 g a.i./ha through knapsack, @ 66 g a.i./ha and @ 44 g a.i./ha through drone application which were at par with superior treatment and recorded 7.94 percent, 8.44 percent, 9.05 percent open boll damage as well as 70.22 percent, 68.35 percent and 66.06 percent reduction over control respectively. Next best treatments were Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC @ 66 g a.i./ha and @ 44 g a.i./ha through knapsack which had recorded 9.65 percent and 10.13 percent open boll damage while 63.81 percent and 62.01 percent reduction in open boll damage over control. The treatments with drone and knapsack sprayer having dose @ 88 g a.i./ha and @ 66 g a.i./ha were only for phytotoxocity effect on cotton crop.

## Locule Damage

It is evident from table 4. that the mean percent locule damage was significantly less in all treatments (3.48 to 5.19 percent) which were superior over control (22.29 percent). Obtained results showed that amongst tested insecticidal treatments Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC with dose of 88 g a.i./ha through drone application induced highest effect, representing 3.48% locule damage and 84.38% reduction in locule damage over control. However, it was followed by Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC @ 88 g a.i./ha through knapsack, @ 66 g a.i./ha and @44 g a.i./ha through drone application which were at par with superior treatment and recorded 3.92%, 4.41% and 4.63% locule damage as well as 82.41%, 80.21%, 79.22% reduction over control respectively. Next best treatments were Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC @ 66 g a.i./ha and @44 g a.i./ha through knapsack which had recorded 4.95% and 5.19% locule damage while 77.79% and 76.71% reduction in locule damage over control.

## Yield

The higher seed cotton yield was obtained in Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC with dose of 44 g a.i./ha through drone application (17.48 q/ha) but non significant than the treatment Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC @ 44 g a.i./ha through knapsack (15.96 q/ha). The remaining treatments through drone application and knapsack sprayer @ 66 g a.i./ha and @ 88 g a.i./ha were only to evaluate the phytotoxic effect on cotton plants. However, lowest yield was recorded in untreated control 8.85 q/ha among all treatments.

There are scanty of similar researches in cotton through drone application. Results showing resemblance with findings of Xiofeng *et al.*, (2021) [11] who recorded the significance of Thiamethoxam + Lambda-cyhalothrin through drone application against lepidopteran pest of walnut *Cnidocampa flavescens*. Also, Changfen *et al.*, (2022) [3] found effectiveness of UAV spraying at different volume and concentration against fall army worm population. The result showed close resemblance with Joker (2021) [6] who reported superiority of UAV Spraying over traditional sprayers.

## Assessment of the phytotoxicity

The phytotoxicity effect of the different insecticidal treatments with different doses applied through drone and knapsack sprayer on cotton plants were assessed.

Observations were recorded when the crop was at its flowering and fruiting stage. The result obtained showed that none of the phyototoxic symptoms like Chlorosis, epinasty, hyponasty, stunting, leaf injury, vein clearing, necrosis, scorching and wilting or any was observed which showed that the crop at flowering and fruiting stage was found tolerant for these treatments.

These results found similar with Kumar *et al*., (2010) [8] who reported that ready mix insecticidal formulation each at 120, 240 and 480 g a.i. $ha^{-1}$ doses did not show any phytotoxic symptoms like epinasty, hyponasty, leaf injury, wilting, vein clearing and necrosis on the cotton crop.

**Table 1:** Efficacy of different insecticidal treatments on rosette flower due to the pink bollworm under the field conditions

| Tr. No. | Treatments | Method | Dose gm or ml a.i./ha | Rosette flower (%) | | | | ROC (%) |
|---|---|---|---|---|---|---|---|---|
| | | | | Precount | 1st Spray | 2nd Spray | Mean | |
| 1. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Drone | 44 | 9.38 (17.83) | 7.71 (16.11) | 3.89 (11.37) | 5.80 (13.93) | 62.60 |
| 2. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Drone | 66 | 8.41 (16.85) | 7.21 (15.57) | 3.48 (10.75) | 5.35 (13.37) | 65.50 |
| 3. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Drone | 88 | 8.61 (17.06) | 6.37 (14.61) | 2.66 (9.38) | 4.52 (12.27) | 70.85 |
| 4. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Knapsack | 44 | 9.38 (17.83) | 8.48 (16.92) | 4.63 (12.42) | 6.56 (14.83) | 57.70 |
| 5. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Knapsack | 66 | 9.67 (18.11) | 8.17 (16.60) | 4.27 (11.92) | 6.22 (14.44) | 59.89 |
| 6. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Knapsack | 88 | 8.78 (17.23) | 6.83 (15.14) | 3.13 (10.19) | 4.98 (12.89) | 67.89 |
| 7. | Untreated (control) | | - | 9.33 (17.78) | 13.19 (21.29) | 17.82 (24.96) | 15.51 (23.18) | - |

| | | | | | |
|---|---|---|---|---|---|
| SE(m) | 1.08 | 0.63 | 0.74 | 0.69 | - |
| CD at 5% | NS | 1.93 | 2.28 | 2.11 | - |
| CV% | 12.48 | 7.13 | 8.67 | 7.90 | - |

*(Figures in parenthesis are arcsine transformed values) (ROC- Reduction Over Control) (NS- Non significant)

**Table 2:** Efficacy of different insecticidal treatments on green boll damage due to the pink bollworm under the field conditions

| Tr. No. | Treatments | Method | Dose gm or ml a.i./ha | Green boll damage (%) | | | | ROC (%) |
|---|---|---|---|---|---|---|---|---|
| | | | | Precount | 1st Spray | 2nd Spray | Mean | |
| 1. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Drone | 44 | 11.67 (19.97) | 10.78 (19.16) | 7.12 (15.47) | 8.95 (17.40) | 64.49 |
| 2. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Drone | 66 | 12.26 (20.49) | 9.96 (18.39) | 6.75 (15.05) | 8.36 (16.80) | 66.83 |
| 3. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Drone | 88 | 11.33 (19.66) | 8.69 (17.14) | 5.73 (13.84) | 7.21 (15.57) | 71.40 |
| 4. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Knapsack | 44 | 12.48 (20.68) | 11.62 (19.92) | 8.16 (16.59) | 9.89 (18.32) | 60.76 |
| 5. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Knapsack | 66 | 11.67 (19.97) | 11.23 (19.57) | 7.82 (16.23) | 9.53 (17.97) | 62.19 |
| 6. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Knapsack | 88 | 11.83 (20.11) | 9.32 (17.77) | 6.38 (14.62) | 7.85 (16.26) | 68.86 |
| 7. | Untreated (control) | | - | 11.45 (19.77) | 19.14 (25.93) | 31.28 (33.99) | 25.21 (30.13) | - |
| SE(m) | | | | 0.81 | 0.78 | 0.67 | 0.73 | - |
| CD at 5% | | | | NS | 2.35 | 2.02 | 2.19 | - |
| CV% | | | | 9.25 | 9.21 | 7.65 | 8.49 | - |

*(Figures in parenthesis are arcsine transformed values) (ROC- Reduction Over Control) (NS- Non significant)

**Table 3:** Efficacy of different insecticidal treatments on larval population of pink bollworm under field conditions

| Tr. No. | Treatments | Method | Dose gm or ml a.i./ha | Pink Bollworm Larvae/ 20 Bolls | | | | ROC (%) |
|---|---|---|---|---|---|---|---|---|
| | | | | Precount | 1st Spray | 2nd Spray | Mean | |
| 1. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Drone | 44 | 5.36 (2.42) | 4.17 (2.16) | 2.86 (1.83) | 3.54 (2.01) | 63.65 |
| 2. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Drone | 66 | 5.07 (2.36) | 3.68 (2.04) | 2.39 (1.70) | 3.04 (1.88) | 68.78 |
| 3. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Drone | 88 | 5.43 (2.44) | 2.39 (1.70) | 1.63 (1.46) | 2.01 (1.58) | 79.36 |
| 4. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Knapsack | 44 | 5.88 (2.53) | 5.41 (2.43) | 3.79 (2.07) | 4.60 (2.26) | 52.77 |
| 5. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Knapsack | 66 | 5.97 (2.54) | 5.18 (2.38) | 3.47 (1.99) | 4.33 (2.20) | 55.54 |
| 6. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Knapsack | 88 | 5.66 (2.48) | 3.02 (1.88) | 1.96 (1.57) | 2.49 (1.73) | 74.43 |
| 7. | Untreated (control) | | - | 5.56 (2.46) | 7.33 (2.80) | 12.15 (3.56) | 9.74 (3.20) | - |
| SE(m) | | | | 0.44 | 0.21 | 0.18 | 0.20 | - |
| CD at 5% | | | | NS | 0.63 | 0.55 | 0.59 | - |
| CV% | | | | 10.47 | 5.31 | 6.21 | 5.76 | - |

* (Figures in parenthesis are square root transformed value) (ROC- Reduction Over Control), (NS- Non significant)

**Table 4:** Efficacy of different insecticidal treatments on open boll damage, locule damage and yield under field conditions (mean of three picking)

| Tr. No. | Treatments | Method | Dose gm or ml a.i./ha | Open boll damage (%) | ROC (%) | Locule damage (%) | ROC (%) | Yield (q/ha) |
|---|---|---|---|---|---|---|---|---|
| 1. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Drone | 44 | 9.05 (17.50) | 66.06 | 4.63 (12.42) | 79.22 | 17.48 |
| 2. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Drone | 66 | 8.44 (16.88) | 68.35 | 4.41 (12.12) | 80.21 | 17.52 |
| 3. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Drone | 88 | 7.15 (15.50) | 73.19 | 3.48 (10.75) | 84.38 | 18.45 |
| 4. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Knapsack | 44 | 10.13 (18.55) | 62.01 | 5.19 (13.16) | 76.71 | 15.96 |
| 5. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Knapsack | 66 | 9.65 (18.09) | 63.81 | 4.95 (12.85) | 77.79 | 16.23 |
| 6. | Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC | Knapsack | 88 | 7.94 (16.36) | 70.22 | 3.92 (11.41) | 82.41 | 17.62 |
| 7. | Untreated (control) | - | - | 26.67 (31.08) | - | 22.29 (28.16) | - | 8.85 |
| SE(m) | | | | 0.77 | - | 0.59 | - | 0.70 |
| CD at 5% | | | | 2.30 | - | 1.77 | - | 2.11 |
| CV% | | | | 10.28 | - | 12.12 | - | 7.31 |

*(Figures in parenthesis are arcsine transformed values) (ROC- Reduction Over Control) (NS- Non significant)

## Conclusion

The treatments with drone and knapsack sprayer having dose @ 88 g a.i./ha and @ 66 g a.i./ha were only for the evaluation of phytotoxocity on cotton crop. The treatment Thiamethoxam 12.6% + Lamda-cyhalothrin 9.5% ZC @ 44 g a.i./ha through drone recorded minimum number of rosette flowers, green boll damage, larval population per 20 bolls, open boll damage, locule damage and it was at par with the treatment @ 44 g a.i./ ha through knapsack. Also the drone spraying having uniform droplet distribution as compare with knapsack sprayer. No phytotoxicity symptoms were observed in any of the treatments which indicated that selected treatments were safe and well tolerated by cotton crop at flowering and fruiting condition. Also, the Drone spraying demonstrated the significant advantages over knapsack sprayers, achieving water saving about 95%, time saving near about 75% and yield improvement by 4.5 to 5%. In Maharashtra, most of the area belong to the drought prone zone, also there is major problem of labour shortage so drones or UAV's will be better option than conventional method as it required minimum labour and very less amount of water as compared to traditional method. This conclusion is from only one year data the more research work should be done in accordance with the usage of drone as a sprayer in agriculture sector and formulation of the dosage through drone.

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## References

1. Agarwal RA, Katiyar KN. An estimate of losses of seed kapas and seed due to bollworms on cotton in India. Indian J Entomol. 1979;41:143-148.
2. Beloev IH. A review on current and emerging application possibilities for unmanned aerial vehicles. Acta Technol Agric. 2016;19:70-76.
3. Changfeng S, Wu J, Cancan S, Chen S, Wang J, Wang H, Wang G, Lan Y. Control Efficacy and Deposition Characteristics of an Unmanned Aerial Spray System Low-Volume Application on Corn Fall Armyworm Spodoptera frugiperda. Front Plant Sci. 2022;13. https://doi.org/10.3389.
4. Desale R, Chougule A, Choudhari M, Borhade V, Teli S. Unmanned Aerial Vehicle For Pesticides Spraying. 2019;5:79-82.
5. Filho FHI, Heldens WB, Kong Z, De Lange ES. Drones: Innovative technology for use in precision pest management. J Econ Entomol. 2019;113:1-25.
6. Jokar M. Evaluating the effectiveness of a sprayer UAV in controlling cotton bollworm. Arthropods. 2021;10(3):97.
7. Kranthi KR, Kranthi S, Ramesh K, Nagrare VS, Brik A. Advances in cotton IPM, Technical Bulletin. Central Institute for Cotton Research, Nagpur. 2009:1-27.
8. Kumar BV, Boomathi N, Kumaran N, Kuttalam S. Combination of flubendiamide+ thiacloprid 480 SC (RM) against bollworms and sucking pests of cotton. Madras Agric J. 2010;97(apr-jun):1.
9. Mogili UM, Deepak BBVL. Review on application of drone systems in precision agriculture. Procedia Comput Sci. 2018;133:502-509.
10. Pandey G, Mathur AK. Employment intensity of output: An analysis of non-agriculture sectors. Institute of Applied Manpower Research Planning Commission, Government of India. 2013:8-10.
11. Xiaofeng ZHU, Binqiang XU, Bo SONG, Jinming XIONG, Guanrong GAO, Xiaojing YAN, *et al*. Field Control Evaluation of Plant Protection UAV Spreading Pesticide against Chromaphis juglandicola and Cnidocampa flavescens in Walnut Orchard. Xinjiang Agric Sci. 2021;58(11):2077.