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Efficacy of Sando 60EC and Fytomax 0.1EC on the control of cotton bollworms

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Abstract

Cotton bollworms are a major problem pest of cotton with a potential to cause a yield reduction of 67% if not properly controlled. Four major species are the Red, Heliothis, Spiny and Pink bollworms. The major control method used in Zimbabwe is the use of pesticides except for the Pink bollworm which is a regulatory pest - normally resulting in quarantining of the affected areas. The use of pesticides is the main reason this project was carried out so that useful pesticides may remain available on the market. The newly tested chemicals replace the old and tired chemistry which, if not replaced tends to cause pests to develop resistance. The research was carried out at CRI, Kuwirirana and Chitekete in 2022 - 23 and 2023 - 24 seasons and the chemicals tested were Sando 60EC and Fytomax 0.01EC. Sando 60EC Levels were 750ml, 500ml and 300ml/ha respectively while Fytomax levels were 1000ml, 750ml and 500ml/ha respectively. Decis Forte was used as control at the rate of 50ml/ha while there was also a no control treatment. Results showed Sando 60EC at 300ml/ha and Fytomax 0.1EC at 500ml/ha as the best for the Red, Heliothis and Spiny bollworm larval control. Data transformation was done using square root transformation of $(x + 3/8)$. Data analysis was done using Genstat 18th Edition. Means were separated using Fisher's Protected LSD in ascending order.

Keywords: Chemistry, pesticides, pest, bollworm, major

Introduction

Cotton (*Gossypium hirsutum*) is an important crop in Zimbabwe for both social and national economic improvement as it and its by-products are used in a number of industries such as textile, oil and detergent manufacturing sectors. However, the crop is attractive to a lot of pests which include sap-suckers, leaf - eaters and bollworms which is the main focus of this study. Among these pest groups, bollworms are mostly dangerous in that they affect the economic parts of the plant. *G. hirsutum* bollworm larvae damage bolls and squares (UC IPM, 2013) ^[1]. They also damage flowers. Once such parts are affected, there is a direct impact on the yield of the affected cotton plants. This will have a negative bearing on the overall yield and ultimately the farmer's income. According to Renou and Deguine, 1992 ^[2], four species that make up the major cotton bollworm species in sub-Saharan Africa and these are the red bollworm (*Diparopsis castanea*), African bollworm (*Herlicoverpa armigera*), the pink bollworm (*Pectinophora gossypiella*) and the spiny bollworm (*Earias insulana*). While the *D. castanea*, *H. armigera* and *E. insulana* bollworm species in Zimbabwe are controlled by using different insecticides, the *P. gossypiella* bollworm is a quarantine pest whose presence in a certain cotton growing area or region may lead to the banning of the growing of cotton as a management measure. According to Badii and Asante (2011) ^[3], however, the four bollworm species already mentioned above are among the most serious species that affect the cotton plant. The Spiny bollworm attacks cotton from leaf bud formation to maturity, damaging flower buds and acorns (Qader and Saber 2021) ^[4]. There are different methods used to control these cotton bollworm pests. However, this project was mostly focusing on the use of pesticides as a control method. These pesticides were being tested for their efficacy in bollworm control at different levels. Testing of the new chemicals helps to boost those that are already registered and available on the market. It also helps prevent pesticide resistance and ensures long-term effectiveness of pest control strategies (Michelle, 2024) ^[5]. Pesticides are generally persistent in nature (Shivkumara *et al.*, 2019) ^[6]. Pests can develop resistance to pesticides

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they have never been exposed to when two insecticides have a similar mode of action (Stack, 2025) [7]. Development of resistance by pests leads to a significant decrease in sensitivity to a pesticide - reducing the field performance of these pesticides (EPA, 2025) [8]. Pests (populations and not individuals) change or mutate to become resistant (Buhler, 2025) [9]. Those pesticides that are already available also lose their efficacy due to the continuous use which normally leads to pests developing resistance to them. Management of the bollworm is based on scouting for eggs or small larva (Michaud, 2013) [10]. The two objectives of this research project are to determine the efficacy of Sando 60EC and Fytomax 0.1EC insecticides on cotton bollworms and also to determine the effect of Sando 60EC and Fytomax 0.1EC Insecticides on predators of cotton bollworms. Sando 60EC, a broad spectrum pyrethroid, has 30grams per litre Emamectin Benzoate, 30grams per litre Lambda Cyhalothrin and 940grams per litre inert ingredients in its composition. On the other hand, Fytomax 0.1 EC, a systemic and contact botanical insecticide is composed of 0.1% Azadiractin and 99.9% inert ingredients.

Materials and Methods

Treatments

The experiment comprised of eight treatments including the no chemical control (Table 1) and Decis Forte was the standard

Table 1: Treatments

Treatment	Treatment Level
No control	0
Decis Forte	50ml/ha
Sando 60EC	750ml/ha
Sand 60EC	500ml/ha
Sando 60EC	300ml/ha
Fytomax 0.1EC	1000ml/ha
Fytomax 0.1EC	750ml/ha
Fytomax 0.1EC	500ml/ha

Data Analysis

Data was analysed using GenStat 18th edition and Bollwormlarvae were transformed using the square root of x + ³/₈

Table 2: Bollworm thresholds to determine insecticide spraying timing

Pest	When to spray
Heliothis Bollworm eggs	Eggs ≥ 12 on 24 scouted plants per treatment
Red Bollworm Eggs	Eggs ≥ 6 on 24 scouted plants per treatment
Spiny Bollworm larva	Larva ≥ 6 on 24 plants per treatment

Results and discussion

Effect of treatments on Heliothis Bollworm Larva

There were significant differences of $p<0.001$ for the Heliothis Bollworm Larvae among treatments only at CRI in the 2022 - 23 season. All the treatments except the no control had statistically similar performance to the standard (Decis Forte). However, Sando 60EC, a pyrethroid, had lower heliothis larval levels (0.75). Such pesticides as pyrethroids have high efficiency and low toxicity when compared to the organophosphate and carbamate groups (Yoo *et al.*, 2016) [11]. The no-control recorded the highest larval counts of 2.08 while Sando 60EC at 750ml/ha

- **Experimental Locations:** Trials were established at Cotton Research Institute, Kuwirirana and Chitekete.

Experimental Design: The experiments were laid down using Randomised Complete Block Design (RCBD) with 8 treatments replicated 4 times. Plot sizes were 6 rows x 8metres = 48m². Sprayed area was 4 rows x 6 metres = 24m² and this was also the size of the sampling area. The treatments used in this experiment are as shown in the Table 1

Measurements

Bollworm larvae, predators

How Measurements were recorded

Bollworm larvae were counted and recorded during scouting as described under data collection section below:

Data collection

Six plants were scouted per plot and 24 plants per treatment. The scouting process was done by inspecting the whole plant, counting and recording the score of the bollworm eggs and larva as is indicated by Table 2 below. Scouting was done twice in a week, first to determine the bollworm eggs or larval thresholds, and secondly to determine the efficacy of the sprayed chemicals. The bollworm eggs or their larva were determined by their natural occurrence and not by inoculations. The six plants that were scouted were randomly selected within the sampling area. These selected plants were tagged and are the ones that were used again in the second scouting for efficacy testing. Tagging together with a random selection of plants to use in data collection (scouting) was done to reduce the scout's bias towards plants with certain physiological features. Tagging was also done to identify the sampled plants in the proceeding scouting operations and use untagged ones. This would give all plants within the sampling area an equal chance of being used in data collection. The bollworm eggs and larval counts were scored after scouting using the scoring system as shown in table 2 below. Predator counting was done two days after spraying to also determine the impact of the sprayed pesticides on the predators.

and 500ml/ha recorded 1 each. Kuwirirana had no significant differences among treatments in 2022 - 23 season. In 2023 - 24 season, significant differences ($p=0.071$) for the Heliothis Bollworm larva were only recorded at Chitekete. The highest Heliothis larvae were recorded at the No control treatment while all other treatments recorded statistically similar Heliothis larvae. CRI and Kuwirirana had no significant differences (Table 3) in 2023 - 2024 season ($p= 0.299$ and 0.459 respectively). Only Fytomax 0.1EC at 750ml/ha recorded the larva at Kuwirirana while all other treatments had no Heliothis bollworm record.

Table 3: Effects of treatments on Heliothis Bollworm Larvae in 2022 -23 and 2023 - 24

Treatment	2022 -2023 SEASON		2023 - 2024 SEASON		
	CRI	Kuwirirana	CRI	Kuwirirana	Chitekete
No control	2.08b	0.63	0.75	0.00	3.25b
Decis Forte @ 50ml/ha	0.93a	0.00	0.58	0.00	2.05a
Sando 60EC @ 750ml/ha	1.08a	0.38	0.58	0.00	1.85a
Sando 60EC @ 500ml/ha	1.00a	0.38	0.58	0.00	1.80a
Sando 60EC @ 300ml/ha	0.75a	0.00	0.75	0.00	1.45a
Fytomax 0.1EC @ 1000ml/ha	0.83a	0.13	1.08	0.00	1.70a
Fytomax 0.1EC @ 750ml/ha	0.83a	0.75	0.83	0.08	1.80a
Fytomax 0.1EC @ 500ml/ha	0.83a	0.88	0.92	0.00	1.70a
Grand Mean	1.038	0.391	0.76	0.01	1.95
p-value	0.007	0.206	0.299	0.459	0.001
Se	0.2198	0.2709	0.074	0.020	0.071
LSD (0.05)	0.6466	0.7967	0.219	0.060	0.209
CV (%)	18.5	138.7	14.1	6.5	9.4

Effects of treatments on Red Bollworm larvae

There were significant differences ($p < 0.001$) among treatments for Red bollworm larvae at CRI in 2022 - 23 season. The no control treatment recorded the highest score of 1.60. Decis Forte which was the standard recorded 0.33. This was similar to all treatments from 3 up to 8. For Kuwirirana, there were no significant differences recorded amongst the treatments for the

red bollworm Larvae for both seasons. In 2023 -24 season, there were significant differences ($P = 0.003$) for Red bollworm larvae at Chitekete only with the no control recording the highest level of 1.45. All other treatments were statistically similar. CRI and Kuwirirana recorded no significant differences ($p = 0.818$ and $p = 0.369$ respectively) for the Red bollworm larvae as shown in table 4 below.

Table 4: Effects of treatments on Red Bollworm larvae

Treatment	2022 - 2023 SEASON		2023 - 2024 SEASON		
	CRI	Kuwirirana	CRI	Kuwirirana	Chitekete
No control	1.60 b	1.12	0.50	0.58	1.45b
Decis Forte @ 50ml/ha	0.33 a	0.62	0.92	0.42	0.65a
Sando 60EC @ 750ml/ha	0.68a	0.12	0.83	0.25	0.70a
Sando 60EC @ 500ml/ha	0.43a	0.88	0.67	0.25	0.45a
Sando 60EC @ 300ml/ha	0.33a	0.38	0.92	0.58	0.50a
Fytomax 0.1EC @ 1000ml/ha	0.50 a	0.38	0.92	0.42	0.80a
Fytomax 0.1EC @ 750ml/ha	0.50 a	0.75	1.00	0.83	0.55a
Fytomax 0.1EC @ 500ml/ha	0.33 a	1.38	1.08	0.25	0.70a
Grand Mean	0.584	0.70	0.85	0.45	1.035
p-value	<.001	0.195	0.818	0.369	0.003
Se	0.0938	0.331	0.286	0.104	0.092
LSD (0.05)	0.2759	0.975	0.378	0.305	0.192
CV (%)	19.8	0.975	23.7	23.5	12.6

Effects of treatments on Spiny Bollworm larvae 2023 - 2024

Season: There were no significant differences for Spiny

bollworm larvae in 2023 - 24 season for all sites (Table 5). No Spiny bollworm larvae was recorded in 2022 - 23 season

Table 5: Effects of treatments on Spiny Bollworm larvae 2023 - 2024 Season

Treatment	CRI	Kuwirirana	Chitekete
No control	0.08	0.00	0.50
Decis Forte @ 50ml/ha	0.17	0.08	0.40
Sando 60EC @ 750ml/ha	0.00	0.00	0.35
Sando 60EC @ 500ml/ha	0.00	0.00	0.40
Sando 60EC @ 300ml/ha	0.17	0.00	0.20
Fytomax 0.1EC @ 1000ml/ha	0.00	0.00	0.20
Fytomax 0.1EC @ 750ml/ha	0.25	0.00	0.35
Fytomax 0.1EC @ 500ml/ha	0.25	0.00	0.10
Grand Mean	0.11	0.01	0.312
p-value	0.123	0.459	0.384
Se	0.0528	0.020	0.074
LSD (0.05)	0.1553	0.059	0.216
CV (%)	15.3	6.5	18.1

Note: For 2022 - 2023 Season, no Spiny Bollworm was recorded across all the three sites, hence the table only showing 2023 - 2024 season data.

Effect of Treatments on predators 2022 -23 and 2023 -24

Season: 2022 - 23 Season: In 2022-23 season, significant

differences ($p < 0.001$) were recorded for the ladybird (*Coccinellid*) adult at CRI while Ladybird larvae and Chrysopa (*Chrysopa carnea*) eggs recorded no significant differences among treatments for the same site as shown in table 6 below. For the ladybird adult at CRI, the highest counts of 1.25 were recorded on Sando 60EC at 500ml/ha. This was higher than the

grand mean of 0.463. It was also above the check standard, Decis Forte at 50ml/ha (0.08). This highest record for Ladybird adult at CRI was followed by Sando 60EC at 300ml and Sando 60EC at 750ml/ha respectively (0.68 and 0.65). These two were similar to Fytomax 0.1EC at 750ml/ha. Fytomax 0.1EC at 1000ml/ha and 500ml/ha were comparable to Fytomax 0.1EC at 750ml/ha. Both ladybird adult and larvae feed on soft bodied

insects like the first instar larvae of cotton bollworms (Royer, 2022)^[12]. At Kuwirirana, significant differences among treatments were recorded on the ladybird larvae at $p = 0.044$. But even then, records were only found at no control and Sando 60EC at 300ml/ha. All other treatments recorded zeros for the ladybird larva at Kuwirirana. There were no significant differences among treatments for Chrysopa eggs at Kuwirirana.

Table 6: Effect of Treatments on predators at CRI and Kuwirirana 2022 - 2023 Season

Treatment	CRI			Kuwirirana	
	L.A	L.L	C.E	L.L	C.E
No control	0.00a	0.15	0.85	0.25b	3.75
Decis Forte @ 50ml/ha	0.08a	0.40	0.60	0.00a	3.50
Sando 60EC @ 750ml/ha	0.65b	0.08	0.85	0.00a	4.00
Sando 60EC @ 500ml/ha	1.25c	0.33	0.90	0.00a	5.25
Sando 60EC @ 300ml/ha	0.68b	0.15	1.33	0.25b	3.12
Fytomax 0.1EC @ 1000ml/ha	0.23ab	0.50	0.83	0.00a	5.12
Fytomax 0.1EC @ 750ml/ha	0.58b	0.58	0.85	0.00a	4.00
Fytomax 0.1EC @ 500ml/ha	0.25ab	0.33	0.50	0.00a	3.25
Grand Mean	0.463	0.31	0.84	0.062	4.00
p-value	<.001	0.188	0.268	0.044	0.631
Se	0.0794	0.1403	0.2931	0.0722	0.921
LSD (0.05)	0.2335	0.4125	0.6095	0.2122	2.707
CV(%)	18.0	89.8	49.5	230.9	46.0

Note: L.A – Ladybird adult, L.L – Ladybird larvae, C. E – Chrysopa eggs

Table 7: Effect of Treatments on predators at CRI, Kuwirirana and Chitekete in 2023 - 2024 Season

Treatment	CRI				Kuwirirana				Chitekete				
	L.A	L.L	C.E	Spider	L.A	C.E	C.L	Spider	C.E	C.L	L.L	L.A	Spider
No control	0.08	0.17	0.67	0.17	0.00	2.08a	0.08a	0.67c	1.33bc	0.05	0.00	0.45	0.45ab
Decis Forte @ 50ml/ha	0.08	0.58	0.25	0.00	0.33	4.08c	0.00a	0.25abc	1.08a	0.05	0.05	0.55	0.30ab
Sando 60EC @ 750ml/ha	0.08	0.00	0.67	0.08	0.08	3.75bc	0.00a	0.33abc	1.26b	0.15	0.00	0.45	0.40ab
Sando 60EC @ 500ml/ha	0.17	0.42	0.58	0.08	0.00	4.17c	0.00a	0.08a	1.44c	0.05	0.00	0.40	0.55bc
Sando 60EC @ 300ml/ha	0.42	0.25	0.42	0.08	0.25	2.92ab	0.08a	0.17ab	1.47c	0.05	0.00	0.35	0.20a
Fytomax 0.1EC @ 1000ml/ha	0.25	0.33	0.75	0.58	0.17	3.75bc	0.00a	1.17d	1.83d	0.05	0.00	0.50	0.45ab
Fytomax 0.1EC @ 750ml/ha	0.17	0.25	0.50	0.25	0.17	3.50bc	0.33b	0.58bc	2.05e	0.05	0.00	0.45	0.55bc
Fytomax 0.1EC @ 500ml/ha	0.67	0.33	0.75	0.33	0.00	2.75ab	0.17ab	0.33abc	2.25f	0.05	0.00	0.65	0.75c
Grand Mean	0.24	0.29	0.57	0.20	0.12	3.38	0.08	0.45	1.589	0.062	0.006	0.475	0.456
p-value	0.086	0.589	0.922	0.081	0.135	0.004	0.025	0.003	<.001	0.928	0.459	0.979	0.026
Se	0.083	0.104	0.146	0.077	0.061	0.092	0.045	0.084	0.022	0.041	0.013	0.093	0.054
LSD (0.05)	0.243	0.306	0.429	0.228	0.179	0.271	0.132	0.247	0.065	0.120	0.038	0.274	0.159
CV (%)	21.7	26.2	31.0	21.0	17.5	9.6	13.4	19.1	3.2	12.4	4.2	20.5	12.0

Note: L.A – Ladybird adult, L.L – Ladybird larvae, C. E – Chrysopa eggs, C.L – Chrysopa larvae

Effect of Treatments on predators at CRI, Kuwirirana and Chitekete in 2023 - 2024 Season

For 2023 -24 season, there were no significant differences for recorded predators at CRI. There were significant differences for Chrysopa Eggs ($p = 0.004$), Chrysopa larvae ($p = 0.025$) and Spiders ($p = 0.003$) at Kuwirirana. The highest Chrysopa egg levels was recorded at Sando 60EC @ 500ml/ha (4.17) - statistically similar to Decis Forte @ 50ml/ha with 4.08. No control treatment recorded the lowest Chrysopa eggs (0.08a) which is comparable to Sando 60EC @ 300ml and Fytomax 0.1EC at 500ml/ha respectively. The highest level of Chrysopa larvae were recorded at Fytomax 0.1EC at 750ml/ha (0.33) which was comparable to Fytomax 0.1EC at 500ml/ha (0.17) in Kuwirirana. All other treatments were statistically similar for the Chrysopa larvae. There were significant differences for spiders also at Kuwirirana ($p = 0.025$). The highest number was recorded at Fytomax at 1000l/ha treatment (1.17). It was followed by the No control treatment (0.67) which was

comparable to Decis Forte (0.25), Fytomax 0.1EC at 750ml/ha (0.58), Fytomax 0.1EC at 500ml/ha (0.33), Decis Forte (0.25), the standard (Decis Forte at 50ml/ha) and Sando 60EC at 750l/ha (0.33).The lowest was recorded at Sando 60EC at 500ml/ha (0.08)

There were significant differences among treatments for Chrysop eggs ($p<.001$) and Spiders ($p =0.026$) at Chitekete. The highest Chrysopa eggs were recorded at Fytomax at 500ml/ha (2.25). This was followed by Fytomax 0.1EC at 750ml/ha (2.05). The No control recorded 1.33 while the standard (Decis Forte) recorded 1.08 of Chrysopa eggs. The highest number of spiders were recorded at Fytomax 0.1EC at 500ml/ha (0.75). The lowest was recorded at Sando at 300ml/ha (0.20). This was comparable to the No control, Decis Forte at 50ml/ha, Sando 60EC at 750ml/ha and Fytomax 0.1EC at 100ml/ha which were statistically similar. Fytomax at 750ml/ha (0.55) was comparable to Fytomax 0.1EC at 500ml/ha (0.75).

Bollworms Across sites

In an across site analysis, significant differences ($p < 0.001$) were recorded on *Heliothis* larvae. The no control recorded the highest level (1.33) while all other treatments were statistically similar. But even then, Sando 60EC (a pyrethroid) at 300ml/ha

recorded the lowest *Heliothis* larvae (0.73). Insecticides of the pyrethroid group are 2250 times more poisonous to insects than to higher organisms (Royer, 2022) ^[12]. Red and spiny bollworm larvae recorded no significant differences across sites.

Table 8: Across sites results for bollworms

Treatment	<i>Heliothis</i> Larvae	Red Larvae	Spiny Larva
No control	1.33b	0.84	0.19
Decis Forte @ 50ml/ha	0.88a	0.66	0.22
Sando 60EC @ 750ml/ha	0.81a	0.59	0.12
Sando 60EC @ 500ml/ha	0.79a	0.46	0.13
Sando 60EC @ 300ml/ha	0.73a	0.67	0.12
Fytomax 0.1EC @ 1000ml/ha	0.93a	0.71	0.07
Fytomax 0.1EC @ 750ml/ha	0.91a	0.79	0.20
Fytomax 0.1EC @ 500ml/ha	0.87a	0.68	0.12
Grand Mean	0.91	0.68	0.15
p-value - SITE	<.001	<.001	<.001
p-value - TRT	0.002	0.459	0.525
p-value - SITE x TRT	<.001	0.118	0.294
Se	0.097	0.121	0.055
LSD (0.05)	0.273	0.341	0.156
CV (%)	11.8	20.2	16.2

Across sites - Predators

There were significant differences ($p < 0.001$) among treatments for spiders across the sites. The highest number of spiders (0.73) was recorded on Fytomax 0.1EC at 1000ml/ha while the lowest was recorded on Sando 60EC at 300ml/ha which was statistically similar to the standard Decis Forte at 50 ml/ha (0.18). The no control recorded 0.43 which was comparable to Sando 60EC at 750ml and 500ml respectively for the spiders.

Chrysopa eggs and Ladybird adult recorded no significant differences across sites. Fytomax 0.1EC at 500 ml/ha recorded 0.47 spiders, outperforming Decis Forte at 50 ml/ha (0.18). Fytomax 0.1EC is a botanical pesticide and as in Zimbabwe, botanicals are used by 100% of farmers in some areas (Iqbal, 2021)^[13]. Botanicals lower threat to beneficial insects while also reduce the risk of pests developing pesticide resistance (Hetland, 2019)^[14]

Table 9: Across sites results for predators

Treatment	C. Eggs	Spider	L. Adult
No control	1.36	0.43bc	0.18
Decis Forte @ 50ml/ha	1.80	0.18a	0.32
Sando 60EC @ 750ml/ha	1.89	0.27abc	0.21
Sando 60EC @ 500ml/ha	2.06	0.24ab	0.19
Sando 60EC @ 300ml/ha	1.60	0.15a	0.34
Fytomax 0.1EC @ 1000ml/ha	2.11	0.73d	0.31
Fytomax 0.1EC @ 750ml/ha	2.02	0.46c	0.26
Fytomax 0.1EC @ 500ml/ha	1.92	0.47c	0.44
Grand Mean	1.85	0.37	0.28
p-value - SITE	<.001	<.001	<.001
p-value - TRT	0.061	<.001	0.321
p-value - SITE x TRT	0.002	0.021	0.400
Se	0.177	0.076	0.082
LSD (0.05)	0.500	0.215	0.231
CV (%)	14.7	17.1	19.9

Note: C. E – Chrysopa eggs, L.A – Ladybird adult

Conclusion

Sando 60EC at 300ml/ha was able to control Red bollworms by 7%, *Heliothis* by 44% and Spiny bollworms by 10% more than the standard Decis Forte at 50ml/ha. The combined bollworm reduction percentage was 20.3% more than that of the standard. Fytomax 0.1EC at 500ml/ha was comparable to Decis Forte at 50ml/ha in its ability to combat all recorded bollworms. Both insecticides were able to preserve predators better than the standard especially the spiders. Sando 60EC at 300ml/ha and Fytomax 0.1EC at 500ml/ha can be registered for the control of Red, *Heliothis* and Spiny bollworms in cotton. The two insecticides may rotate each other in the pest management

programmes since one (Fytomax 0.1EC) is a botanical insecticide. This will reduce pesticide resistance development by the bollworms

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