United Republic of Tanzania Ministry of Agriculture

Tanzania Agricultural Research Institute (TARI)
Ukiriguru and Ilonga Centres

COTTON INSECTICIDE BIO-EFFICACY REPORT

ON

Evaluation of *Bacillus thuringiensis* Sub Spp Kurstaki (Thurisave 24) For control of Cotton Bollworm in Tanzania

Submitted to Tanzania Biotech Products Limited (TBPL) Kibaha in December, 2022

ABSTRACT

Cotton is one of the most important cash crops which contributes to the national foreign earnings and family cash necessary for domestic requirements. The crop is attacked by several pests and

can be grouped into chewing and sucking pests. Hence sustainable and effective pesticides are important. Little is known about efficacy *Bacillus thuringiensis* subspecies Kurstaki (Thurisave 24) on controlling bollworm (*Helicoverpa armigera)* on cotton. Hence, a field trial on the performance of *Bacillus thuringiensis* on the control of the pest was conducted. The trial was carried out in Eastern and Western Cotton Growing areas. In Eastern the trial was conducted at Makuyu and Ilonga. In Western the trial was conducted at Ukiriguru Research station, Mwanhala and Bwanga experimental substations. A Randomized Complete block design with four replications was adopted. The treatments were; *Bacillus thuringiensis* (6 L/ha), *Bacillus thuringiensis* (4 L/ha), *Bacillus thuringiensis* (2 L/ha), and Unsprayed. Banofos (Profenofos 720 EC) and Mostrong (Thiamethoxam 141g/l + Lambdacyhalothrin 101g/l SC) were used as standard control in Eastern and Western cotton growing areas respectively. Data on insect pests and their associated natural enemies were collected using standard procedures. *Bacillus thuringiensis* at a rate of 6 L/ha and standard control pesticides recorded low and comparable number of *H. armigera* and consequently resulted in high seed cotton yield and quality. The effect of the product on the most of the natural enemies is comparable with untreated control. Generally, *Bacillus thuringiensis* is can be used in suppression program of bollworms on cotton. However, the product showed mild efficacy against sucking pest, particularly jassid and thrips.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an important fibre crop grown in more than 80 countries worldwide (Rawal *et al.*, 2017). It is a source of natural fibre and food for humans and livestock. Cotton is not only used a source of income and employment, but also used as a drought resistance and rotation crop (Baoqi, 2020).

In Tanzania, cotton is mainly produced by small-scale farmers and it is the second largest export crop after coffee accounting for 24% of its total agricultural export (Atenbunchner *et al.*, 2018). Cotton is cultivated in the average area of 400,000 ha with farm sizes of 0.6-1.5 hectares (Mkumbo, 2014). According to Mkumbo (2014), employing over 500,000 rural households and it contributes more than 3.7% of the Nation's GDP.

Despite the contribution of cotton in Tanzania, the farmer's average seed cotton yield is about 300 kg/acre; which is significantly lower compared to 1200kg/acre under recommended management. The low productivity of cotton in this country is caused by a combination of biotic, abiotic and social economic constraints. The most biotic constraints include weeds, diseases and insect pests. The most devastating insect pest of cotton includes Jassid (*Jacobiasca sp.*), American bollworms (*Helicoverpa armigera*) and Aphid gossypii (El-Heneidy *et al*, 2015; Sarwar and Sattar, 2016; Rawal *et al*., 2017). These pests affect cotton in all growth stages (Mahale, 2017) in ECGA and cause a yield loss of approximately 76% depending on the management.

Various control measures for pests including Cultural, Biological, host resistance and chemical have been suggested for insect pest management. The use of insecticide application is one of the best control measures against insect pests in Tanzania (Kabisa, 1996). It is widely used for insect pest population reduction. The use of different insecticides reduces chances of resistance development. Therefore, different insecticide groups needed to be tested for farmers to use more alternative insecticides.

Tanzania Biotech Product Limited (TBPL) is a company working with biological (Thurisave 24 composed of *Bacillus thuringiensis var. kurstaki* H-3 strain LBT-24) control of pests of different crops. *Bacillus thuringiensis* is a Gram-positive, soil-dwelling bacterium, commonly used as a biological pesticide. *B. thuringiensis* also occurs naturally in the gut of caterpillars of various types of moths and butterflies, as well on leaf surfaces, aquatic environments, animal feces, insectrich environments, and flour mills and grain-storage facilities. It has also been observed to parasitize other moths such as *Cadra calidella* in laboratory experiments working with *C. calidella*, many of the moths were diseased due to this parasite.

During sporulation, many Bt strains produce crystal proteins (proteinaceous inclusions), called δendotoxins, that have insecticidal action. This has led to their use as insecticides. Thurisave -24

is used to control *H. armigera* and *S, Frugiperda* including *Heliothis, Diaphania, Plutella, Trichoplusia* and *Ascia*. The insecticide is shown to be effective in the control of defoliating lepidopteran larvae in crops like cabbage, watercress, grasses, cassava, sweetpotatoes, corns, cucurbits and tobacco.

In order for the product (Thurisave- 24) to be in the market, it has to be tested either under screen or field conditions and follow procedures. The test of the product was done with the agreement with TARI, aiming of proving the efficacy of the product. The areas where the product was tested are Morogoro, Mwanza, Geita and Tabora, Site selection was done depending on the history of occurrence of the insects. The experiment was very important to ensure the farmers are getting an effective and sustainable control measures of cotton pests

OBJECTIVES

Overall objective:

To improve cotton production on cotton in Eastern and Western growing areas of Tanzania.

Specific objectives:

- To assess efficacy of Thurisave 24 against key insect pests of cotton.

- To assess effect of Thurisave 24 on yield and quality of cotton.

METHODOLOGY Site selection

The testing of Thurisave 24 was done in four regions, which are Morogoro, Mwanza, Geita and Tabora. In Morogoro, both two crops experiments were set at TARI-Ilonga in Kilosa district and Makuyu village at Mvomero districts. In Mwanza the experiment was set at TARI-Ukiliguru station, Bwanga substation in Geita and Mwanhala substation in Tabora region. The criteria for selection of these sites was based on difference in Agro ecologies, accessibility of place, history of *Spodoptera frugiperda* and cotton pests and growth habit of the crop in an area.

Experimental design and treatments

Experiment was laid out in a Randomized Complete Block Design (RCBD) with four- replications. A space of one and two meter was left between plots and replications, respectively to avoid interplots drifts of insecticides during the spraying. The plot size used was 216 m^2 (gross plot) with a harvest net plot of 81 m^2. Planting spacing used was 90 cm x 30 cm and 60 x30 in Eastern Cotton Growing Areas (ECGA) and Western Cotton Growing Areas (WCGA) respectively. Sowing was done in mid-February for ECGA Early December for (WCGA). Four to five seeds were sown per hill. The rest of the cultural practices includes; thinning, weeding and spraying upon scouting and when threshold reach.

The test product Thurisave 24 was compared with commercial (standard) insecticides Banofos (Profenofos 720 EC) and Mostrong in ECGA and WCGA respectively. A trial consisted of five treatments including a recommended rate of standard insecticide, three levels of tested product and unsprayed (control). The dose rates used were 2, 4, and 6 L/ha of test product (Thurisave 24) and standards at 0.25 L/ha.

Spraying of insecticides and data collection

Sampling and spraying started at flowering stage, 8-9 weeks after germination. A tested product (Thurisave 24) and standard were applied using a knapsack sprayer at a walking speed of 1 m/s and water spray volume of 120 L/ha. The sampling for key insect pest of cotton, predator and damaged plant parts made at two days after each scheduled spraying dates. On each sampling occasion, ten plants were randomly selected from net plots. At harvest, seed cotton was handpicked from the net plots at interval of ten days. The harvested samples were weighed and converted to kg/ha then sorted to obtain AR grade.

Data analysis

Data on counts of insect pests, plant parts damaged by insect pests, natural enemies, seed cotton yield and quality (AR grade) ware subjected to analysis of variance (ANOVA) using GenStat computer software. The means were separated using Duncan's multiple range tests at ($p < 0.05$).

RESULTS Efficacy of THURISAVE 24 on the Key Cotton Pests

In Eastern Cotton Growing Areas, the results on the effectiveness of THURISAVE 24 against the population of key insect pests of cotton (i.e. American bollworms (*Helicoverpa armigra*), Spine bollworm (*Earias biplaga*), Pink bollworms (*Pictinophora gossypiella*), cotton strainer (*Dysdercus spp)*, cotton aphids (*Aphids gossypii*) and Jassid (*Jacobiasca* sp)) are presented in Table 1. These results showed significant differences ($p< 0.05$) between treatment means of *Helicoverpa armigra, Pictinophora gossypiella*, *Pictinophora gossypiella* and *Dysdercus sp* while*, Aphids gossypii, Jacobiasca* sp did not differ significantly ($P >0.05$) among treatments. The tested product sprayed plots at 6 L/ha dose rate gives significantly low mean number of *Helicoverpa armigra and Pictinophora gossypiella* while standard sprayed plots showed a relatively similar

performance with tested products on *Earias biplaga and Dysdercus sp.* The unsprayed plots recorded with the highest mean number of the pests.

In Western Cotton Growing Areas the results revealed significant differences among the treatments at $p<.001$. *Bacillus thuringiensis* (6 L/ha) and Mostrong insecticide results in the lowest number of American bollworm eggs at Ukiriguru station while Unsprayed treatment revealed the highest number of American bollworm eggs. A significantly ($P >0.05$) low number of cotton bollworm larvae (very small and small) were observed in the plots treated with *Bacillus thuringiensis* (6 L/ha) and Mo strong insecticide in all experimental sites (Ukiriguru station, Bwanga and Mwanhala) as shown in table 2 while the highest number of the larvae was recorded in Unsprayed plots. Aphids grades differed significantly among the treatments ($P <0.05$) with the lowest in the plot treated with Mostrong while the lowest grade was recorded in the unsprayed plots. The plots treated with *Bacillus thuringiensis* recorded similar scores of the pest with untreated plots except *Bacillus thuringiensis* at a rate of 6L/ha (Table 3). Similar trend was recorded on thrips grade (Table 4). Jassid grade also differed significantly among the treatment ($P <0.05$) in all experimental sites with the lowest grade in the plot treated with Mostrong. The highest was recorded in the unsprayed plots. The plots treated with *Bacillus thuringiensis* recorded similar jassid grade with unsprayed plots (Table 5).

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Table 1: Efficacy of THURISAVE 24 against key insect pest of cotton across two locations (Makuyu and Ilonga), 2021-2022 cropping seasons

	# ABW per 100 p		# SBW per 100 p		Aphids per 100 p		# Stainer per 100p		# PBW per 100 p		# Jassid per 100 p	
TRT	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
A	6.2ab	12.0ab	1.02a	0.6a	19.0a	43.5a	8.4a	8.0ab	2.3a	0.7a	214.3a	255.4a
D	5.3a	10.6a	1.5ab	0.7a	24.9a	23.8a	6.9a	5.6ab	1.8a	0.5a	154.6a	172.1a
C	7.3ab	12.4ab	2.0b	0.9a	26.7a	23.9a	7.7a	3.9a	2.1a	0.8a	141.3a	183.5a
B	8.7b	19.0b	1.6ab	1.2a	27.0a	30.5a	9.7a	8.6b	1.2a	2.3b	162.1a	196.2a
E	14.9c	16.4ab	3.7c	0.7a	34.9a	24.9a	13.3a	8.4ab	4.7b	0.6a	175.9a	182.6a
Mean	8.49	14.1	1.97	0.83	26.5	29.3	9.2	6.91	2.39	0.977	170	198
LSD	3.094	6.65	0.716	0.671	20.33	26.23	7.27	4.206	0.982	0.5273	88.8	185.5
CV (%)	1.5	16.8	6.3	14.1	22	17.5	20.1	25.7	7.7	12.7	14.4	13.4

Note: Means followed by the same latter(s) between treatments in the table are not significantly different at (P>0.05) according to LSD comparison test, CV = Coefficient of variation; LSD = Least Significant Differences, # = Number of , p = plants, A=Banofos at 0.25 L/ha, B =Thurisave 24 at 2 L/ha, C = Thurisave 24 at 4 L/ha, D = Thurisave 24 at 6 L/ha, E= Unsprayed, ABW= *Helicoverpa armigera*, SBW= *Earias sp*, PBW=*Pictinophora Gassypiella*

Table 2: Effects of THURISAVE 24 across two seasons (2021 and 2022) on Cotton bollworm at Ukiriguru, Mwanhala and Bwanga stations.

Treatments	Ukiriguru			Mwanhala	Bwanga	
	Eggs	ABW VS + S	ABW M + L	ABW M + L	ABW VS + S	ABW M + L
Bacillus thuringiensis (6 L/ha)	1.500 ab	1.00 a	1.25 ab	0.925 b	4.75 b	2.50 a
Bacillus thuringiensis (4 L/ha)	3.250 b	2.25 ab	2.75 b	1.500 c	8.00 c	5.00 b
Bacillus thuringiensis (2 L/ha)	5.750 c	3.50 b	5.00 c	2.020 d	10.50 d	7.50 c
Mo strong	1.000 a	0.25 a	0.50 a	0.450 a	1.75 a	0.75 a
Unsprayed	9.250 d	6.00 c	7.25 d	2.675 e	12.75 e	10.50 d
Grand mean	4.15	2.60	3.35	1.515	7.55	5.25
s.e.d	0.588	0.970	0.791	0.1956	0.936	0.931
l.s.d	1.281	1.495	1.218	0.3013	1.427	1.434
P value	<.001	<.001	<.001	<.001	<.001	<.001

Means within columns followed by the same letters are not significantly different (P >0.05) (Duncan's Multiple Range Test)

Table 3: Effects of THURISAVE 24 across two seasons (2021 and 2022) on Aphids at Ukiriguru, Mwanhala and Bwanga stations

Treatments	Aphids grade		
	Ukiriguru	Mwanhala	Bwanga
Bacillus thuringiensis (6 L/ha)	1.75 a	1.513 a	1.450 a
Bacillus thuringiensis (4 L/ha)	2.00 ab	1.875 ab	1.175 b
Bacillus thuringiensis (2 L/ha)	3.50 ab	2.425 ab	1.275 b
Mo strong	0.75 a	1.025 a	0.925 ab
Unsprayed	5.25 b	2.975 b	2.975 b
Grand mean	2.45	1.843	1.360
s.e.d	1.568	0.1948	0.2288
l.s.d	2.416	0.3002	0.3524
P value	<.001	<.001	<.001

Means within columns followed by the same letters are not significantly different (P >0.05) (Duncan's Multiple Range Test)

Table 4: Effect of THURISAVE 24 across two seasons (2021 and 2022) on Thrips at Ukiriguru, Mwanhala and Bwanga stations

Treatments	Thrips		
	Ukiriguru	Mwanhala	Bwanga
Bacillus thuringiensis (6 L/ha)	1.70 a	1.105 a	0.865 a
Bacillus thuringiensis (4 L/ha)	2.08 a	1.263 a	0.900 a
Bacillus thuringiensis (2 L/ha)	4.08 ab	2.045 ab	0.992 a
Mo strong	1.30 a	0.665 a	0.587 a
Unsprayed	5.93 b	2.888 b	2.388 b
Grand mean	2.81	1.433	1.026
s.e.d	0.595	0.0950	0.3091
l.s.d	0.917	0.1464	0.4762
P value	<.001	<.001	<.001

Means within columns followed by the same letters are not significantly different (P >0.05) (Duncan's Multiple Range Test)

Table 5: Effects of THURISAVE 24 across two seasons ((2020/2021 and 2021/2022) on Jassids grade at Ukiriguru, Mwanhala and Bwanga stations

Treatments	Ukiriguru		Mwanhala	Bwanga
	Jassids nymph	Jassids adults	Jassids adults	Jassids adults
Bacillus thuringiensis (6 L/ha)	2.367 b	1.900 ab	1.733 b	1.367 b
Bacillus thuringiensis (4 L/ha)	2.667 b	2.233 ab	1.867 b	1.533 b
Bacillus thuringiensis (2 L/ha)	2.767 b	2.400 ab	1.933 b	1.667 b
Mo strong	0.633 a	1.53 a	0.400 a	0.633 a
Unsprayed	2.933 b	2.633 b	2.233 b	1.733 b
Grand mean	2.27	2.14	1.63	1.387
s.e.d	0.330	0.429	0.340	0.2563
l.s.d	0.761	0.990	0.785	0.5909
P value	<.001	0.184	0.005	0.016

Means within columns followed by the same letters are not significantly different (P >0.05) (Duncan's Multiple Range Test)

Efficacy of Thurisave 24 against natural enemies of key insect pests of cotton

In Eastern Cotton Growing areas, results for two seasons for natural enemies (Syrphids larvae, Green lacewing (eggs and larvae), Ants, Spider and coccinnellids) are presented in Table 6. There were no significant variations ($P<0.05$) in the mean number of natural enemies except coccinellids and syrphids. Large number of coccinellids recorded in unsprayed plots while the lowest number was recorded in the plots sprayed with standard pesticides at a rate of 0.25 L/Ha. In addition, a tested product at a rate of 2 and 4 L/ha noted with the similar performance. Results on natural enemies (Syrphids larvae, Green lacewing (eggs and larvae), Ants, Spider and coccinnellids) are presented in Table 3. There were no significant variations ($P<0.05$) on the mean number of natural enemies except coccinellids and syrphids. The highest number of coccinellids was recorded in unsprayed plots while the lowest number was recorded in the plots sprayed with standard pesticide at a rate of 0.25 L/Ha. In addition, a tested product at rate of 2 and 4 L/ha was noted with a similar performance.

In Western Cotton Growing areas, results revealed significant differences among the treatments at $p<.001$. The highest number of *Coccinelid* larvae and adults had revealed on unsprayed plots followed with the plots treated with *Bacillus thuringiensis* (2 L/ha) at Ukiriguru station. Other treatments were comparable as described in table 7. The number of Chrysopid eggs did not differ significantly ($P>0.05$) among the treatments. Results revealed non-significant differences among the treatments at Mwanhala and Bwanga sub-stations (Table 8). Similarly, the number of Syrphid fly larvae did not differed significantly ($P>0.05$) among the treatments in all tested sites (Table 9).

Table 6: Effect of THURISAVE 24 across two locations (Makuyu and Ilonga) to show effect of THURISAVE 24 on natural enemies 2021-2022 cropping seasons

	# Syrphids / 100 plants		# GLW Eggs / 100 plants		# GLW Larvae / 100 plants		# Ants / 100 plants		# Spiders / 100 plants		# Coccinellids / 100 plants	
TRT	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
A	2.0a	4.2b	2.0a	1.4a	0.9a	1.5a	21.2a	7.7a	2.9a	4.0a	4.0a	2.6a
D	3.4a	1.4a	2.3a	2.4a	1.2a	1.2a	14.3a	6.7a	2.9a	3.8a	10.4bc	2.4a
C	3.3a	1.5a	3.3a	1.7a	0.7a	1.8a	18.4a	7.1a	3.7a	3.8a	7.5ab	1.4a
B	2.0a	3.4ab	3.3a	1.3a	0.9a	0.8a	20.2a	8.7a	2.5a	3.4a	8.2ab	2.8a
E	2.0a	3.1ab	2.0a	3.1a	0.8a	0.7a	18.3a	10.8a	3.1a	3.3a	13.3c	21.6b
		2.74	2.55	1.99	0.915	1.18	18.5		Mean	3.65	2.53	8.2
	3.03								8.65	6.2		
LSD	2.597	1.905	1.939	2.887	0.6278	1.046	12.53	4.689	1.597	2.338	4.779	6.79
CV (%)	29.6	30.7	39.9	34	12.8	24.5	30.3	33.7	33.7	38.2	7.6	3.6

Note: Means followed by the same latter(s) between treatments in the table are not significantly different at (P>0.05) according to LSD comparison test, CV = Coefficient of variation; LSD = Least Significant Differences, # = Number of, GWL=Green lacewing, A=Banofos at 0.25 L/ha, B =Thurisave 24 at 2 L/ha, C = Thurisave 24 at 4 L/ha, D = Thurisave 24 at 6 L/ha, E= Unsprayed

Table 7: Effects of THURISAVE 24 across two seasons (2020/2021 and 2021/2022) on *Coccinelid* beetles at Ukiriguru, Mwanhala and Bwanga stations

Treatments	Ukiriguru		Mwanhala		Bwanga	
	Coccinelid larvae	Coccinelid adults	Coccinelid larvae	Coccinelid adults	Coccinelid larvae	Coccinelid adults
Bacillus thuringiensis (6 L/ha)	5.25 ab	4.75 a	1.15 a	1.30 a	2.25 a	1.25 a
Bacillus thuringiensis (4 L/ha)	5.72 ab	4.90 a	1.17 a	1.50 a	2.50 a	1.32 a
Bacillus thuringiensis (2 L/ha)	6.30 ab	5.73 a	1.25 a	1.75 a	2.65 a	1.50 a
Mo strong	2.25 a	2.75 a	1.00 a	1.20 a	1.00 a	0.250a
Unsprayed	10.00 b	11.25 b	4.50 b	4.75 b	5.50 b	3.75 b
Grand mean	5.70	5.35	1.75	1.90	2.30	1.45
s.e.d	1.479	1.497	0.811	0.880	0.859	0.52
l.s.d	1.223	2.307	0.8811	1.356	1.871	1.134
P value	0.001	<.001	<.001	<.001	0.001	<.001

Means within columns followed by the same letters are not significantly different (P >0.05) (Duncan's Multiple Range Test)

Table 8: Effects of THURISAVE 24 across two seasons (2020/2021 and 2021/2022) on Chrysopid eggs at Mwanhala and Bwanga stations

	Chrysopid eggs Treatments	
	Mwanhala	Bwanga
Bacillus thuringiensis (6 L/ha)	0.75 a	0.750 a
Bacillus thuringiensis (4 L/ha)	0.25 a	0.500 a
Bacillus thuringiensis (2 L/ha)	0.75 a	0.750 a
Mo strong	0.50 a	0.750 a
Unsprayed	0.25 a	0.250 a
Grand mean	0.50	0.60
s.e.d	0.866	0.606
l.s.d	1.334	1.319
P value	0.390	0.890

Means within columns followed by the same letters are not significantly different (P >0.05) (Duncan's Multiple Range Test)

Table 9: Effect of THURISAVE 24 across two seasons (2020/2021 and 2021/2022) on Syrphid larvae at Mwanhala and Bwanga stations

	Syrphid larvae Treatments	
	Mwanhala	Bwanga
Bacillus thuringiensis (6 L/ha)	0.50 a	0.75 a
Bacillus thuringiensis (4 L/ha)	0.25 a	1.00 a
Bacillus thuringiensis (2 L/ha)	0.25 a	0.50 a
Mo strong	0.25 a	0.50 a
Unsprayed	0.25 a	0.25 a
Grand mean	0.30	0.60
s.e.d	0.47	0.51
l.s.d	1.03	1.12
P value	0.976	0.66

Means within columns followed by the same letters are not significantly different (P >0.05) (Duncan's Multiple Range Test)

Effect of THURISAVE 24 on seed cotton yield and quality

In Eastern Cotton Growing Areas, results on the performance of Thurisave 24 in comparison with controls are shown in Table 10. There was significant differences observed at ($P<0.05$) between treatments tested on seed cotton yield. The tested insecticide (Thurisave 24) sprayed plots at 4-6 L/ha recorded to have comparable mean to the standard insecticide (Banofos 720 EC) at 0.25 L/ha which was 263.05, 282.55 and 344.05 L/ha respectively. The mean of seed cotton yield obtained from tested insecticide at 2 L/ha and unsprayed was 194.25 and 200.55 Kg/ha respectively which were significantly lower as compared to that of standard and tested insecticide at rate of 4-6 L/ha.

Significance differences between treatments mean on seed cotton "A" grade percentage (AR %) was recorded in Table 4. The test product at 4-6 L/ha dose rates showed high "A" grade percentage compared to unsprayed plots however the standards was relatively higher mean of AR % to that of test product. Test product at rate of 4 L/Ha recorded with higher AR % (57.16%) than other test product dose rates

Similarly, in western Cotton Growing Areas, the results revealed significant differences among the treatments at $p<.001$. The plots treated with Mostrong had the highest yield at Ukiriguru, Mwanhala and Bwanga stations followed with *Bacillus thuringiensis* (6 L/ha) which were not statisticaly different except Ukiriguru site. Unsprayed plots had the lowest yield at Ukiriguru, Mwanhala and Bwanga stations. The highest %AR had observed on plots treated with Mo strong and *Bacillus thuringiensis* (6 L/ha) while the lowest one on unsprayed plots as described on Table 11.

Table 10: Effect of THURISAVE 24 across two locations (Makuyu and Ilonga) on seed cotton yield and quality, (2020/2021 and 2021/2022) cropping seasons

Insecticide applied	Dose rates used (L/ha)	Seed yield (kg/ha)		Grade percent	
		2021	2022	2021	2022
Banofos	0.25	238.7a	449.4b	58.51b	61.15c
Thurisave 24	6	185.9a	379.2ab	54.39ab	59.41bc
Thurisave 2	4	205.2a	320.9ab	51.35ab	62.96c
Thurisave 24	2	168.8a	219.7a	49.51ab	51.86ab
Unsprayed	0	194.5	206.6a	44.74a	48.93a
Mean		199.0	315.16	51.7	56.86
LSD		118.0	204.875	17.19	8.136
CV (%)		22.6	9.7	12.5	7.7

Note: Means followed by the same latter(s) between treatments in the table are not significantly different at (P>0.05) according to LSD comparison test, CV = Coefficient of variation; LSD = Least Significant Differences

Table 11: Effect of THURISAVE 24 across two seasons (2020/2021 and 2021/2022) on seed cotton yield and quality % AR at Ukiriguru, Mwanhala and Bwanga stations

Treatments	Ukiriguru		Mwanhala		Bwanga	
	Yield (Kg/ha)	% AR	Yield (Kg/ha)	% AR	Yield (Kg/ha)	% AR
Bacillus thuringiensis (6 L/ha)	1643 c	83.00 c	1929 cd	89.50 cd	850.0 bc	73.75 bc
Bacillus thuringiensis (4 L/ha)	1250 b	74.00 b	1607 bc	81.50 bc	685.7 b	68.50 b
Bacillus thuringiensis (2 L/ha)	1143 b	73.75 b	1536 b	78.50 b	621.4 b	63.00 b
Mo strong	2000 d	90.75 d	2179 d	95.00 a	953.6 c	80.75 c
Unsprayed	714 a	60.00 a	1036 a	65.75 a	250.0 a	50.25 a
Grand mean	1350	76.30	1657	82.05	672	67.2
s.e.d	90.4	2.153	105.9	2.901	72.4	3.52
l.s.d	196.9	4.692	230.8	6.321	157.8	7.68
P value	<.001	<.001	<.001	<.001	<.001	<.001

Means within columns followed by the same letters are not significantly different (P >0.05) (Duncan's Multiple Range Test)

Conclusions and recommendations

The trial evaluated a biopesticide Thurisave 24 in two Agro ecological zones and cropping seasons. Following the observed field performance, the product (*Bacillus thuringiensis*) showed significant differences in efficacy against *H. armigera* when compared with unsprayed plots. Moreover, performance of *B. thuringiensis* at a rate of 6L/ha is comparable with standard pesticides (Profenofoc 720 g/l) and Mostrong (Thiamethoxam 141g/l + Lambdacyhalothrin 101g/l SC) used in cotton in both agroecological zones. The effect of the product on the most of the natural enemies is comparable with untreated control. Hence, Thurisave is satisfactory for control of bollworms on cotton. However, the product showed mild efficacy against sucking pest such as Jassid and Thrips.

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