Perceived Ineffectiveness of Insecticides Used to Control Cotton Pests in the Western Cotton Growing Areas of Tanzania

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Abstract

The ineffectiveness of insecticides against cotton pests has been a haunting scourge to cotton farmer, for almost a decade. Cotton farmers blame Tanzania Cotton Board (TCB) while the later blames the Tropical Pesticides Research Institute (TPRI) for registering and allowing the unrestricted sale of ineffective and counterfeit products. Lack of correct information about proper use of insecticides brought about the knowledge gaps that had to be fixed. Survey on the source, acquisition, storage and use of insecticides supplied by Tanzania Cotton Development Trust fund (CDTF) and agro dealers was conducted in some selected Districts (Meatu, Maswa, Bariadi, Kwimba and Misungwi) of Western Cotton Growing Areas (WCGA) of Tanzania followed by two-years field experiments at Tanzania Agriculture Research Institute (Ukiriguru centre) to determine the efficacy of five insecticides commonly used by farmers. Zetabestox (Zeta-Cypermethrin 5% E.C), Duduall (Cypermethrin 150 g/L + Chlorpyrifos 300 g/L E.C), Ninja (Lambdacyhalothrin 50 g/L E.C), Bamethrin (Deltamethrin 2.5% E.C) and Agromethrin (Alfa-Cypermethrin 5% E.C) against key insects pest of cotton in Tanzania. The results showed that, most of the insecticides supplied to cotton farmers of selected Districts of WCGA were acquired from CDTF yet some cotton farmers acquire insecticides from agro shops within their proximities. The results also showed that all insecticides were statistically equally effective against major cotton insects pest when sprayed at 20% and 30% threshold during the first, second, third and fourth round compared to unsprayed check of the experiment for both two years 2015/2016 and 2016/2017. The unsprayed check had more insect pests, more damaged buds, leaves and bolls than all other treatments at P<0.05.

Keywords: Ineffectiveness, Cotton pests, active ingredient, insecticides efficacy, conformity, Tanzania

Introduction

Cotton, *Gossypium hirsutum* L., is an economically most important cash crop for textile fibre, natural or artificial. It is cultivated on about 0.5 million ha which is approximately 9% of the total arable land in Tanzania (TCB, 2010). Cotton farming is a major source of livelihoods in Tanzania as it provides employment to about 500,000 rural households as well as a source for both direct and indirect benefits to more than 40% of the Tanzanian population (FAO and MAFAP, 2013). Available data for 2009 indicates that the crop contributed up to US$ 92 million per annum of the GDP (TCB, 2015). There are two major cotton growing zones, the Western Cotton Growing Areas (WCGA) which includes Simiyu, Mwanza, Geita, Kigoma, Shinyanga, Tabora and Mara Regions which produces more than 95% of the crop and Eastern Cotton Growing Areas (ECGA) which mainly includes Morogoro, Coastal, Tanga and Manyara in Tanzania which produce the remaining 5% (Mrosso, Mwatawala and Rwegasira, 2014).

Tanzania still faces yield losses of up to 60% due insect pests alone (Mrosso, Temu and

Kabissa, 2006). The nature of losses varies from feed holes on leaves (which reduces effective leaf area index for photosynthesis) to enormous damages on squares and bolls. Leaf curling, mottling, chlorosis and sooty mould caused by succulent sapping pests reduce photosynthetic efficiency and the exudates stains the lint. Transmission of fungal, bacterial, and viral diseases is among the secondary outcome of sucking insect damages (Yoshida & Toscano, 1994).

The major pests of cotton in WCGA included; *H. armigera*, *A. gossypii* and *Dysdercus* spp Lygus, *Taylorilygus vosseli* (Pop), Jassid, *Empoasca lybica* (Berg), Spiny bollworm, *Earias insulate* (Boisd) and *E. biplaga* (de Berg) (Mrosso, Temu & Kabissa, 2006. Insects damage and subsequent yield losses in cotton increase with plant growth stages, notably from a seedling by cutworms, vegetative stage by aphids and Jassids through flowering by bollworm and the cotton strainers (Mrosso & Temu, 2008). The most notable loss is caused by bollworm damage, which exhibits sequential attack on plants (Yoshida & Toscano, 1994).

WCGA farmers use various insecticides as a Silva bullet to control insets pests. Organophosphates (OP) being very common (Mrosso & Temu, 2008). Commonly used Carbamates includes; Carbosulfan, Flucythriate, Primicarb, Aldicarb, Methomyl and Menazon (ICAC 1998). Nevertheless, synthetic Pyrethroids are probably the most popular and widely used. Insecticides in this group include Cypermethrin, Lambda-cyhalothrin, Deltamethrin and many others (Kabissa *et al.,* 1998)

Complaints against the ineffectiveness of insecticides procured and distributed by the TCB through CDTF by the cotton farmers in the WCGA have been of concern for more than a decade (TCB, 2010). Suspicion of counterfeits insecticides, expired insecticides, misuse of the insecticides and probability of insecticides resistance have been the shared purported blame among the cotton farmers and to some workers in Tanzania cotton sector (TCB 2010). Therefore, this study's objectives were (i) to identify the commonly used insecticides against cotton pests in the Western Cotton growing areas of Tanzania, (ii) to examine the authenticity of the supplied insecticides and, (iii) to determine the effectiveness of the used insecticides..

Materials and Methods

Identification of commonly used insecticides against cotton pest in the WCGA of Tanzania

Structured open end questionnaires with were administered to a total of 3000 respondents (600 respondents from five Districts namely; Itilima, Maswa and Meatu of Simiyu Region; Kwimba and Misungwi of Mwanza Region. 550 were cotton farmers and 50 were key informants (agricultural extension officers, cooperatives officers and districts cotton inspectors). At least 10 good cotton producing villages were randomly selected in each District. The number of respondents per village varied by ±10 depending on the availability of farmers and key informants

Data collection

The collected data included common used insecticides, source of the insecticides, types of insecticides, availability and accessibility of the recommended insecticides. Selected commonly used insecticides samples were purchased from the primary society, cotton farmers, or agro shops for both laboratory chemical analysis at TPRI for authenticity and field experiment at TARI-Ukiriguru.

Data analysis

Data were examined, cleaned, coded and organized before were subjected to analysis using Statistical Package for Social Science (SPSS-version 18.0 Inc. Chicago, 2008)

Determination of the insecticides' active ingredients

The collected samples of insecticides from survey were kept in duplicate, labeled by numbers and letters, repacked in small vials of 50 mls as, A1 & A2, B1 & B2, C1 & C2, D1 & D2, and E1 & E2 to disguise their identity and sent to TPRI Arusha for the determination of active ingredient's conformity and authenticity. The analytical balance was used to weigh 4 grams of each pesticide (E.C). Each individual samples were accurately weighed into 10 ml of appropriate solvent in a volumetric flask. Acetone for Ninja, Deltamethrin and Chlorpyrifos, Hexane for Alpha and Zeta–cypermethrin (Worthing and Hence, 1991). The samples were mounted on a mechanical shaker for five minutes of cold extraction, then the syringe micro-filtered to remove particles (Franco and Jasionowska, 2013). Before analysis, two injections were performed to equilibrate the system and then carried out in duplicate injections of calibrations standard. Using a syringe, 3 µl analytes were injected into the Gas Chromatography; the operating conditions for the stationary phase was; injector (250 °C), detector (280 °C) and (270 °C, programmed at 80 0C initially held for 1 minute, then 270 °C at the rate of 5 °C/minute and held for 10 minutes) the mobile phase (carrier) was Nitrogen gas, Hydrogen gas and Oxygen gas for FID combustion (Karthikeyan and Srinivasan, 2010; Rusibamayila *et al.,* 1998). The concentrations of the active ingredients were computed by comparing the peak retention time and area of the sample of unknown concentration against that of the known concentration of standard. A computerized Gas Chromatography (Varian CP 3800), equipped with Flame Ionization Detector (FID) was used. The Megabore column 1.83 m*2 m (i.d) was packed with 5% Silcone 30, 3-5 µm capacity (Table 1). The units were evaluated using FAO/WHO standards, and obtained data were computed as;

$$A.I\%content = \frac{(Area\ of\ a\ sample \times Dilution\ factor \times purity\ of\ the\ standard)}{(Slope \times weight\ of\ sample \times conventional\ factor)}$$

With A.I% means Percentage active Ingredient

Determine the effectiveness of the used insecticides

Location of the study, experimental details and treatments

Field experiment was conducted at TARI Ukiriguru Mwanza with the GPS coordinates 2.7267 °S, 33.0187 °E for two crop seasons (2015/16 and 2016/17). Six treatments Dudu all 450 E.C (Chlorpyrifos 300 g/L+ Cypermethrin 150 g/L), Ninja 55 E.C (5% Lambda Cyhalothrin 50 g/L), Zetabestox 10 E.C (Zeta-cypermethrin 100 g/L), Agromethrin 10 E.C (Alpha-Cypemethrin 100 g/L), Bamethrin 2.5 E.C (Deltamethrin 25 g/L) and unsprayed check were used. Each treatment was replicated four times in a randomized complete block design using the following model

$$Y_{ij} = \mu + T_i + B_j + random\ error$$

With Y_{ij} equal to any observation for which treatment factor occurs, *i* is the treatment factor and *j* is the blocking factor, µ is the mean, T_i is the effect for i treatment while B_j is the effect for being in block *j*.

The plot sizes were 100 m^2 (10 m length by 10 m width). A distance of 4 m was left between plots to minimize the drift of insecticides (Reference) coupled with shielded lance nozzle. Delinted and treated cotton seeds of UK M08 variety by nordox fungicide. Spacing of 0.9 m x 0.4 m and basal dressed with Diammonium Phosphate fertilizer (18% N and 46% P). Gap filling was done one week later and thinning was done three weeks later after planting cotton. First weeding for all four replications was done four weeks later after emergence before first split application of Urea (46% N) as top dressing. All plots were re-weeded whenever necessary to exclude confounding effects. Second split of Urea was applied at six weeks after emergence third split was done 8 weeks after emergence Scouting was kick started at flowering and repeated weekly using the peg-board method as described by Kabissa *et al.,* (1998). A decision to spray insecticides to control exocarpic and endocarpic bollworms was made at 20 and 30% action threshold equivalent to two to three larvae per plant (Ting 1986; Plantwise knowledge bank 2012; MSUES, 2015). Spraying of insecticides was based on manufacturers recommended rates Table 1.

Five different knapsack sprayer (Matabi Super green 16L) were used for spraying each individual insecticides at the walking speed of approximately 1 m/s.

Data collection

For two season 2015-2016 and 2016-2017 captured data sets included types and abundance of insect pests after each spray, crop damage (dead bolls, perforated bolls and oozing bolls), seed cotton yield (Kg/ha) and grade of seed cotton.

Table 1:

Insecticide name	Active ingredient (a.i)	Mode of Action	Application rate/plot (mls)	Mixing rate (L of water)
Dudu all 450 E.C	Chlorpyrifos 300 g/L+ Cypermethrin 150 g/L	Contact and systemic	7.813	7
Ninja 55 E.C	Lambda Cyhalothrin 50 g/L	Contact	10.000	7
Zetabestox 10 E.C	Zeta-cypermethrin 100 g/L	Contact	3.750	7
Agromethrin 10 E.C	Alpha-Cypemethrin 100 g/L	Contact	0.375	7
Bamethrin 2.5 E.C	Deltamethrin 25 g/L	Contact	10.000	7

Statistical analysis

Insect count raw data were tested for normality using box and whiskers plots and found to be skewed, which necessitated data transformation using the logarithm function to normalize the data.

$\log 10(x+1)$

With (x) = Number of observed insects pest; 1 = Constant when all other factors are assumed to be variable. Data set were analysed using one-way ANOVA and presented as mean ± S.E.M (Standard Error of means). Means comparison was done using Fisher LSD. A GEN-Stat software 10th Edition (VSN International 2014) was used to analyse and compare the efficacy of five insecticides against unsprayed check.

Results

Commonly used insecticides against cotton pest in the WCGA of Tanzania

It was established that, common used insecticides are Banofos 720EC (Profenofos Agromethrin (Alfa-Cypermethrin 5% E.C) Bamethrin (Deltamethrin 2.5% E.C), Duduall (Cypermethrin 150g/L + Chorpyrifos 300g/L E.C), Ninja (Lambdacyhalothrin 50g/L E.C) and Zetabestox (Zeta-Cypermethrin 5% E.C). Follow up to research stations with national mandate on cotton research (ARI-Ukiriguru and ARI-Ilonga) indicated that Banofos unregistered insecticide despite being traded on and used by farmers in cotton production but fruits, vegetables, tobacco and coffee but not cotton (Fig. 1).

The Source of insecticides used by cotton farmers in selected Districts of WCGA

The survey revealed that almost all recommended insecticides were available at both CDTF outlets and agro shops. However, accessing insecticides from CDTF was the problem (Fig. 2).

User's perception of effectiveness of insecticides

Based on farmers' perception all insecticides were fairly effective against the key pests, *H. armigera* and *A. gossypii* despite the limited variation on knock down time and residual effect and some products being used but not tested and approved for the control of cotton pests, Collected data suggest that most cotton farmers had no understanding on when spraying should, which insecticide to use, against which pest, at what stage of cotton growth stage and how to spray correctly and effectively. Other irregularities included limited knowledge on scouting, spraying interval, frequency of insecticide application and dosage in all five districts covered.

Availability and accessibility of insecticides by cotton farmers in selected Districts of WCGA

The survey revealed that almost all recommended insecticides were available at both CDTF outlets and agro shops. However, accessing insecticides from CDTF was the problem. Apart from bureaucratic procedures, access to information by growers was a big setback.

Authenticity of the used insecticides:

Laboratory analysis of the active ingredient (a.i) showed that the composition and quantities of all the active ingredients of the five insecticides were similar to what was indicated on the label (Table 2) and as per what was registered by TPRI for tolerance limits jointly stipulated by WHO and FAO (Costa, 1997).

Table 2: Authenticity of the used insecticides based on Active Ingredient (a.i)

Lab No	Batch No.	Trade Name	Compound Name	Official Declared a.i	Lab Analytical Results of a.i	Emulsion Stability (physical test)	Solvent for extraction	Remarks
1	KR 14-0043	Ninja 5EC	Lambdacyhalothrin 50g/l	Lambdacyhalothrin	5.5% w/v	Uniform	Acetone	Conforms to requirements
2a	201210	Bamethrin 2.5EC	Deltamethrin 25g/l	Deltamethrin	2.4% w/v	Uniform	Acetone	Conforms to requirements
2b	AS 20111030	Bamethrin 2.5EC	Deltamethrin 25g/l	Deltamethrin	2.458% w/v	Uniform	Acetone	Conforms to requirements
3	S 20131218	Zetabestox 10EC	Zeta-Cypermethrin 100g/l	Zetacypermethrin	Zetacypermethrin 10.32% w/v	Uniform	Acetone	Conforms to requirements
4	25112012	Duduall 450EC	Chloropyrifos 350g/l Cypermethrin 100g/l	Chloropyrifos Cypermethrin	Chloropyrifos 34.48% w/v Cypermethrin: 10.64% w/v	Uniform	Acetone & Chlorpyrifos	Conforms to requirements
5	SHQI 2011H1011	Agromethrin 10EC	Alphacypermethrin 100g/l	Alphacypermethrin	10.7% w/v	Uniform	Acetone	Conforms to requirements

Effectiveness of the commonly used insecticides against major cotton insets pests after 1st, 2nd, 3rd sprays 2015-2016

In the first season (2015-2016). The first round spray, all insecticides had no significant differences statistically against major cotton pests when sprayed at a 20% threshold except for *H. armigera* in the unsprayed check (3.63b) and *P. gossypiella* in the unsprayed check (4.22b) at P<0.05 (Table 2). In contrast, second spray when insects pests attack were heavier (30% threshold), Dudu all gave the best control for aphids (0.00a) and bollworms worms (0.00a) at P<0.05 (Table 2). There were no significant different between Ninja and Bamethrin treatments P<0.05. Zetabestox and Agromethrin were significantly effective against *A. gossypii* at P<0.05 despite the poor control of bollworms. In the third spray Dudu all (0.00a) surpassed all other insecticides for managing *A. gossypii.* All insecticide outperformed unsprayed check (5.24b, 4.96b, 2.92b and 5.91b) for management of *Dysdercus* spp, *P. gossypiella* and unidentified beetle and *Earias* spp.

Effectiveness of the commonly used insecticides against major cotton insets pests after 1st, 2nd, 3rd sprays 2016-2017

During the second season (2016-2017). The first round spray, there were significant difference between Agromethrin, Dudu all, Ninja and Zetabestox (4.115a, 1.695b, 1.476b and 1.945b) for the management of *Empoasca lybica* and *Pectinophora gossypiella* (0.4429a. 0.000b, 0.000b and 0.000b) All other treatments were not statistically different for the management of major cotton insects pest at the threshold of 30% and P<0.05. In the second spray, all insecticides had good management over *A. gossypii* than unsprayed check (10.750b). Dudu all (0.000a), Ninja (0.000a) and Zetabestox (0.000a) had best management over all insects pest than the rest of insecticides and the unsprayed check (7.250c) at P<0.05. In particular Zetabestox (0.000a) had best management over A. gossypii than all other insecticides at P<0.05. In the third spray, Zetabestox (1.368a) outperformed all insecticides and unsprayed check (1.911c) for the management of *A. gossypii*. The rest of insecticides outperformed unsprayed check though statically were not significant different for their efficacy at P<0.05. Dudu all (0.0000a) and Ninja (0.0753a) had good management of *Dysdercus* spp than other insecticides and outperformed unsprayed check (0.3891b). Bamethrin (0.2386ab) Agromethrin (0.1945ab), and Zetabestox (0.1945ab) were not statistically significant at P<0.05.

All insecticides had best management over *H. armigera* and *P. gossypiella* though were not different statistically but they all differed with the unsprayed check (0.7966b) significantly at P<0.05. In the fourth spray all treatment were not statistically significant for the management of *A. gosspii*, *Dysdercus* spp, *Earias* spp and *Empoasca lybica* at P<0.05. Dudu all (0.000a) and Ninja (0.0753a) had best management of *H. armigera* followed by Zetabestox, Agromethrin, Bamethrin though the three were statistically not significant different statistically but they outperformed unsprayed check (0.3891b) at P<0.05. Table. 3

Effectiveness of the commonly used insecticides against insects pest damage parameters after 1st, 2nd, 3rd sprays in 2015/2016 and 2016/2017

In the first round spray unsprayed check had more of the dead bolls than all other treatments, either there were no significant different between treatments for the number of live bolls, oozing bolls and perforated bolls at P<0.05. In the second spray all deployed insecticides were not different for dead bolls except with the unsprayed check (4.250b) indeed unsprayed check had fewer live bolls (21.25a) when compared to insecticides treated plots. Flipping to oozing and perforated bolls, all plots were not statistically significant different at P<0.005. During third spray, the number of dead bolls were same statistically between unsprayed check and Agromethrin, Bamethrin and Zetabestox. There were also no significant difference between Ninja (1.001b) and Duduall (1.000b) at P<0.05 but the two differ significantly with unsprayed check (3.750a) at P<0.05. Moreover unsprayed check had fewer live bolls (1.241a), more of the oozing bolls (0.8216c) and perforated bolls (0.8216c) than all other treatments at P<0.05. During the fourth spray, the plots sprayed with Agromethrin

Table 2: Effectiveness of the commonly used insecticides against major cotton insets pests after 1st, 2nd, 3rd sprays 2015-2016

Spray	Insect spp	Registered name					
		Control	**Zetabestox®**	**Ninja®**	**Duduall®**	**Bamethrin®**	**Agromethrin®**
	Aphis gossypii	7.19a	6.83ab	5.80a	6.97b	7.28c	7.51c
	Dysdercus spp	0.75a	0.33a	0.50a	0.33a	0.00a	0.25a
	Helcoverpa armigera	3.63b	0.00a	0.00a	0.00a	0.00a	0.00a
1st	*Earias* sp	0.00a	0.00a	0.25a	0.00a	0.00a	0.00a
	Pectinophora gossypiella	2.23b	0.00a	0.00a	0.00a	0.00a	0.00a
	Un identified beetle	2.82a	0.33a	0.00a	0.00a	0.25b	0.25b
	A.gossypii	3.59b	0.32a	4.11b	0.00a	0.61a	0.00a
2nd	*Dysdercus*. Spp	0.00a	0.00a	0.00a	0.00a	0.25a	0.00a
	Earias. Sp	0.32a	0.00a	0.00a	0.00a	0.25a	0.25a
	H. armigera	7.80b	0.37a	0.33a	0.00a	0.00a	0.25a
	P. gossypiella	4.22b	0.00a	0.25a	0.25a	0.25a	0.25a
	Un identified beetle	4.99b	0.00a	1.44a	0.00a	2.40ab	0.75a
	A. gossypii	4.89b	0.82a	4.75b	0.00a	5.89b	0.57a
	Dysdercus spp	5.24b	0.50ab	0.33a	0.58a	0.87a	2.00ab
	Earias spp	4.96b	0.83a	1.19a	0.25a	1.15a	1.37a
3rd	*H. armigera*	1.84a	0.46a	0.00a	0.00a	0.00a	0.00a
	P. gossypiella	2.91b	0.00a	0.00a	0.32a	0.00a	0.75a
	Un identified beetle	5.91b	0.83a	1.64ab	0.33a	4.25b	1.08a

Mean separation by LSD ($P<0.05$). Means followed by the same letter are not significantly differ

(0.22258ab) and Zetabestox (0.1945ab) had no significant difference with the unsprayed check (0.3253ab) for number of dead bolls, significant difference was observed between Bamethrin (0.1505a) and Duduall (0.3763b) and between Bamethrin (0.1505a) and Ninja (0.3763b). There was no significant difference between treatments for number of live bolls between Agromethrin (47.00b), Duduall (48.50b) and Ninja (48.25b) at P<0.05. However Duduall recorded a bit more bolls than all insecticides. As expected unsprayed check (30.25a) recorded fewer live bolls than all other treatments at P<0.05. Bamethrin, Agromethrin, Duduall and Ninja were statistically not significant different for the number of perforated and Oozing bolls. Unsprayed check had more of perforated bolls (14.0753b) and oozing bolls (14.0753b) at P<0.05 (Table 4).

Implication of each treatment on seed cotton average yield for first seasons 2015-2016 and 2016-2017

In the first season (2015-2016), all plots treated with insecticides gave significantly higher yield Agromethrin 1,063 kg/ha, Bamethrin 1,238 kg/ha, Dudu all 1,111 kg/ha, Ninja 1,306 kg/ha and Zetabestox 1,114 kg/ha than unsprayed checks 766 kg/ha at P<0.05. There were no significant differences between treatments. Control check had the lowest yield compared to all treatments. Nevertheless, Ninja gave relatively higher yields than the rest of the treatments (Table 5).

In the second season (2016-2017), just like the first season, all plots which received the insecticides had better cotton yield per hectare than unsprayed check (600 kg). Dudu all (1,275 kg) and Ninja (1,200) were not statically different for their yield. Likewise Agromethrin (947.5 kg) and Bamethrin (910 kg) were statistically the same at P<0.05 and with F <.001, CV 6.5% (Table 6).

Discussion

Agromethrin Bamethrin, Insectido Karate and Ninja were the most common insectides to the cotton growers in all five because they were supplied through CDTF, sold at a cheaper price of TZS 2,500/Acre pack as opposed to agro shops in which the same products were sold at TZS 3,000/Acre pack.Banofos was also common because it is mostly used by vegetable farmers, relatively cheaper compared to Supercron, Sume, Abamectin and Select plus. Most important Banofos was said to be very effective against bollworm complex and other insect pests of cotton. Cotton farmers use Banofos as substitute for other insecticides which could otherwise supplied by CDTF. However in most cases ginners and cooperative society leaders do not inform cotton farmers about the availability of insecticides in their respective villages. Misungwi, Maswa and Kwimba received most of insecticides from CDTF and suffice their demand as they have fewer cotton farmers compared to Itilima which were supplied insecticides which did not saturate their demand.

Poor synchrony between cotton growth and insecticide availability forces growers to look for alternative sources of insecticides from the agro-shops some of which are not tested and approved for use in cotton by TPRI. Such insecticides were in use and sourced from agro shops included Banofos, Mupacron, Supercron, Agrithiote, Duducyper, Sume dimethoate, Select plus, Twigathiote, Duduthrin and Akrimactin. Yet some products were found expired. The fact that cotton is highly valued crop in WCGA, the feared destruction of the crop by insect pests and the truth that high economic yield cannot be attained without effectively controlling the pest, cotton growers seek to buy insecticides from any available source including open markets regardless of the authenticity.

The delays in dispensing insecticides to farmers was due to poor planning of the ginners for the transport, selling points and lack of dedicated personnel to sell the insecticides to cotton growers. Most ginners remit insecticides to cotton growers in small quantities as they worry of losing their money. On the other hand, the District councils inclusive of Ward and village executive and agricultural extension officers do not play their part in informing cotton growers about the availability of insecticides supplied through CDTF. by the CDTF and therefore cotton farmers resorted to purchase insecticide from Agro shops, this accounts as

Table 3: Effectiveness of the commonly used insecticides against major cotton insets pests after 1st, 2nd, 3rd sprays 2016-2017

		Registered name					
Spray	**Insect spp**	**Agromethrin®**	**Bamethrin®**	**Duduall®**	**Ninja®**	**Unsprayed check**	**Zetabestox®**
1st	*Aphis gossypii*	0.7373a	0.61137a	0.7664a	0.6790a	0.4905a	0.8668a
	Dysdercus spp	0.0000a	0.07526a	0.07526a	0.07526a	0.15051a	0.07526a
	Earias spp	0.8291a	0.5726a	0.7997a	0.5642a	0.4542a	0.7038a
	Empoasca lybica	4.115a	2.170ab	1.695b	1.476b	2.250ab	1.945b
	Helcoverpa armigera	0.2397a	0.0000a	0.0753a	0.0000a	0.2698a	0.0753a
	Pectinophora gossypiella	0.4429a	0.0985b	0.0000b	0.0000b	0.1945ab	0.0000b
	Taylorilygus Vosseli	0.3688a	0.3811a	0.3759a	0.3646a	0.3617a	0.3639a
	Un identified beetle	0.6003a	0.6003a	0.5866a	0.6560a	0.5566a	0.4956a
2nd	*A.gossypii*	3.591a	1.663a	0.325a	3.071a	10.750b	0.000a
	Dysdercus. Spp	0.0000a	0.0000a	0.0752a	0.0752a	0.1505a	0.0742a
	Earias. Spp	0.0905a	0.0753a	0.000a	0.000a	0.5084b	0.000a
	Empoasca lybica	5.179bc	0.575ab	0.000a	0.000a	7.250c	0.250a
	H. armigera	5.869b	0.000a	0.369a	0.325a	7.500b	0.000a
	P. gossypiella	4.215b	0.500b	0.000a	0.000a	2.750b	0.250a
	Taylorilygus Vosseli	0.6977b	0.0985a	0.0000a	0.0000a	0.7719b	0.0000a
	Un identified beetle	4.987b	2.195a	0.000a	1.651a	1.750a	0.000a

Mean separation by LSD ($P< 0.05$). Means followed by the same letter are not significantly different

Table 3: Effectiveness of the commonly used insecticides against major cotton insets pests after 1st, 2nd, 3rd sprays 2016-2017

Spray	Insect spp	Registered name					
		Agromethrin®	Bamethrin®	Duduall®	Ninja®	Unsprayed check	Zetabestox®
3rd	*A.gossypii*	1.715bc	1.687abc	1.621abc	1.536ab	1.911c	1.368a
	Dysdercus spp	0.1945ab	0.2386ab	0.0000a	0.0753a	0.3891b	0.1945ab
	Earias spp	0.0000a	0.07526a	0.07526a	0.075226a	0.15051a	0.07526a
	Empoasca lybica	0.5850b	0.5162ab	0.3138a	0.3891ab	0.6061b	0.5236ab
	H.armigera	0.3495a	0.0753a	0.0753a	0.0753a	0.7966b	0.1193a
	P.gossypiella	0.7500a	0.2500a	0.2500a	0.5000a	2.7500b	0.7500a
	Taylorilygus Vosseli	0.5108a	0.3451a	0.3451a	0.4370a	0.5708a	0.4203a
	Un identified beetle	0.3763b	0.1945ab	0.1505ab	0.3451ab	0.8063c	0.0000a
4th	*A.gossypii*	1.922a	1.793a	1.887a	1.904a	1.974a	1.942a
	Dysdercus spp	0.0000a	0.07526a	0.07526a	0.07526a	0.15051a	0.07526a
	Earias spp	0.3010a	0.222258a	0.3451a	0.3010a	0.3763a	0.4203a
	Empoasca lybica	0.3214a	0.2500a	0.0000a	0.1193a	0.1193a	0.0000a
	H.armigera	0.1945ab	0.2386ab	0.000a	0.0753a	0.3891b	0.1945ab
	P. gossypiella	0.6840ab	0.6733ab	0.4727a	0.6137ab	0.6432ab	0.7576b
	Taylorilygus Vosseli	0.7995a	0.9505b	0.9607b	0.9271ab	0.9528b	0.8153ab
	Un identified beetle	0.5994a	0.6003a	0.5866a	0.6560a	0.5566a	0.4956a

Mean separation by LSD ($P < 0.05$). Means followed by the same letter are not significantly different

Table 4: Effectiveness of the commonly used insecticides against insects pest damage parameters after 1st, 2nd, 3rd sprays 2016-2017

		Registered name					
Spray	Insect spp	Agromethrin(R)	Bamethrin(R)	Duduall(R)	Ninja(R)	Unsprayed check	Zetabestox(R)
	Dead bolls	0.0000b	0.5000ab	0.2500ab	0.0000b	1.2500a	0.0000b
1st	Live bolls	1.343a	1.410a	1.381a	1.322a	1.300a	1.322a
	Oozing bolls	0.2940a	0.2098a	0.2940a	0.2543a	0.0753a	0.2258a
	Perforated bolls	0.4365b	0.1945ab	0.2802ab	0.3448ab	0.0753a	0.1505ab
	Dead bolls	2.250ab	2.000a	0.750a	0.750a	4.250b	1.500a
2nd	Live bolls	27.00b	26,50ab	28.50b	28.25b	21.25a	26.75ab
	Oozing bolls	0.2940a	0.2098a	0.2802a	0.2543a	0.0753a	0.2258a
	Perforated bolls	0.00000a	0.00000a	0.07526a	0.11928a	0.00000a	0.00000a
	Dead bolls	3.250a	2.750a	1.000b	1.001b.	3.750a	3.250a
3rd	Live bolls	34.00b	33,50ab	35.50b	34.21b	23.25a	33.75ab
	Oozing bolls	0.3451b	0.0753ab	0.0000a	0.0753ab	0.8216c	0.2258ab
	Perforated bolls	0.3451b	0.0753ab	0.000a	0.0753ab	0.8216c	0.2258ab
	Dead bolls	0.22258ab	0.1505a	0.3763b	0.3763b	0.3253ab	0.1945ab
4th	Live bolls	47.00b	46,50ab	49.50b	48.25b	30.25a	46.75ab
	Oozing bolls	0.2940a	0.2098a	0.2002a	0.2009a	14.0753b	0.2258a
	Perforated bolls	0.4365a	0.4945a	0.2802a	0.3448a	14.0753b	0.4505a

Table 5: Implication of each treatment on seed cotton average yield for first seasons 2015-2016

Experiment seasons	Treatments	Scouting Frequency	Indicative threshold (%)	No of sprays	Seed cotton Yield (Kg/ha)
2015-2016	Agromethrin	6	30	3	1,063a
	Bamethrin	6	30	3	1,238bc
	Unprayed Check	6	30	3	766a
	Duduall	6	30	3	1,111ab
	Ninja	6	30	3	1,306c
	Zetabestox	6	30	3	1,114ab
F probability					<0.05
CV					8.6
LSD					1.46

Table 6: Implication of each treatment on seed cotton average yield for first seasons 2016-2017

Experiment seasons	Treatments	Scouting Frequency	Indicative threshold (%)	No of sprays	Seed cotton Yield (Kg/ha)
2016-2017	Agromethrin	6	30	4	947.5b
	Bamethrin	6	30	4	910b
	Unsprayed Check	6	30	4	600a
	Duduall	6	30	4	1,275d
	Ninja	6	30	4	1,200d
	Zetabestox	6	30	4	1,065c
F probability					< .001
CV					6.5
LSD					0.985

to why Itilima had more insecticide purchases from?

The outcome of laboratory chemical analysis for active ingredients (a.i) showed that, the composition and quantities of all the active ingredients of the five commonly used insecticides samples were similar to what was indicated on the label and in accordance with the registrar's portfolio at TPRI. As such, the registered products were with respect to tolerance limits as stipulated jointly by WHO and FAO (Costa, 1997). Thus the findings suggest that insecticides sample brought by the manufacturer for testing and registration by the TPRI are indisputable, despite the fact that one of the products, (Zeatabestox) was found expired.

Aphis gossypii was most abundant because they are primarily residing on the adaxial side of the leaves and since most insecticides were in contact, they failed to provide satisfactory results. This was also reported by (Hardee and Herzog, 1992; Rummel *et al.,* 1995; Mrosso *et al.,* 2006; Vanemden and Harrington, 2007; Denholm and Devine, 2013). This could also be due to prolonged and evolutionary adaptation conferred by genes encoding modified receptor proteins or enzymes that detoxify insecticides, by this mechanism, cotton aphids may have developed high tolerance against several contact insecticides (Rummel *et al.,* 1995; Gong, Zhang & Zhou, 1964; Obrien *et al.,* 1992; Slosser *et al.,* 2001). However, this wasn't part of the study. Parajulee *et al.* (2003) buttressed the observation by adding that Parthenogenetic reproduction is observed in many aphid females species in which adult females give birth to live nymphs. Furthermore, off springs of this type of reproduction are clones of the mother and do not involve gene recombination. This accounts for their highest abundance than all other major insect pests (Robertson, 2004).

African bollworm, (*H. armigera*) ranked second in abundance. This could be related to their feeding habits enabling them to grow faster and rapid buildup in number of this pest due to its high fecundity (one female bollworm moth can lay 250-1500 eggs), mobility and multiple hosts (1stgeneration on legumes crops, 2nd generation on corn/maize and 3rd generation caterpillars generally are the first infestation of cotton), ability to enter facultative diapauses all allows the pest to adapt to different climate condition (Clearly *et al.,* 2006). Some setback has been reported on H. armigera success during the feeding larva bore into cotton bolls with the posterior part of the body exposed outside, which exposes the larva to the direct effects of the insecticides than that of the pink bollworm, which tunnels into its boll and remains entirely inside (Mathews, 1989; Hill & Weller, 1998) contributed to its population reduction. Spiny and pink bollworms, Jassids, Lygus and unidentified beetle were least abundant as they are kept under check by the regular destruction of crop residues and easily killed by insecticides (Mrosso and Temu, 2008).

All insecticides were efficacious in controlling sucking and chewing pest complex though with some variations due to their active ingredients. In the first year Dudu all 450 EC which had synergistic effect of both contact and systemic translocated poison through the plant sap was highly efficacy in controlling bollworms complex, aphids, unidentified beetle, and stainers because translocation of the poison delayed its degradation under field conditions. (Adebayo, 2003) Ninja (Lambdacyhalothrin) was also very effective for almost all insects pest due to its contact nature and immediately knockdown effect of most pyrethroids. Agromethrin (Alphacypermethrin) and Bamethrin (Deltamethrin) were not very effective for bollworms and aphids perhaps due their prolonged use. Several factors could also affect their efficacy on the cotton leaf surface, the most important being insecticides persistence, foliage growth and the prevailed weather condition during and after application (Mulrooney & Elmore, 2000). This wide variation in efficacy justifies the significance of the careful selection of insecticides for both chewing and sucking insect pest management.

In the first season 2015-2016 seed cotton yield from the control treatment was significantly lower than the rest of treatments suggesting that spraying insecticides improves the cotton yield. However, it might not offer similar achievements. A similar observation was made by Williams (2003), who reported that the bollworm/budworm complex retained the top ranking as the number one cotton pest by yield reduction of 21.31% in Egypt in the absence of appropriate control measures. Our present study revealed that the loss in seed cotton yield in the absence of chemical control program is >50%. That is to say economic yield would be almost impossible to achieve without the chemical control given the common tendency of cotton growers to trust and make use of one insecticide and the diverse nature of cotton pest species in the WCGA, it is imperative that insecticides with multiple active ingredients and varied uptake pathway should be encouraged and promoted.

Yields from all treated plots with insecticides were not significantly different. However, this could not be attributed to insects pest alone but rather a combination of more than one factor such as inadequate rains and the resultant drought spell that compromised realization of optimum yield. Most of the leaves and flowers were abscised during crop growth coupled with bolls abortion and premature boll opening that contributed to lower yields than the standard average is seldom severe enough to warrant more than just a few sprays for optimal yield Meetens, Ndege & Enserink (1992) observed that under inadequate rains, the leaves and flowers were abscised, bolls abortion became common and premature boll opening contributed to lower yields of cotton in Egypt.

Moreover it was observed that, Ninja (lambacyhalothrin)a contact insecticide had highest yield than Duduall (Chlorpyrifos + cypermethrin) which is both contact and systemic insecticide and indeed provided best control over boll worms and other insects could not be explained scientifically nevertheless, the good result of Ninja in particular conceded the finding of El-Metwally *et al* (2003) in Egypt who reported that the average reduction of Pink bollworm was 90.3, 83.6 and 73.5% for fenpropathrin, esfenvalerate and lambacyhalothrin respectively. In addition since lambacyhalothrin has the highest knockdown effects resulted in killing most of yield limiting insects quit fast in so doing the crop was almost free from insects pest infestation.

In the second season 2016-2017, yields from plots treated with Duduall and Ninja were statistically similar at $P<0.05$ though Duduall (Chlorpyrifos + cypermethrin) had relatively higher yield (1275 kg/ha) than Ninja (1200 kg/ha) The combination of two insecticides gave it increased potency to control insect pests. Chlorpyriphos translocation delayed its degradation under field conditions, this account for its high efficacy in controlling bollworms complex, aphids, unidentified beetle, and stainers (Adebayo, 2003) and hence good yields which is an advantage over Ninja, Bamethrin, Agromethrin and Zetabestox. Bamethrin, Agromethrin and Zetabestox had relatively lower yield, this could have resulted to their prolonged use in the WCGA though under different trade names may have reduced potency for managing insects pests under field condition

Conclusion

All the insectoids tested were pertinent to the required standards by TPRI and were effective in managing all cotton insects pest in nutshell. Inefficacy of the insecticides in the WCGA should not be blamed on pesticides but rather the user's illiteracy that contributes to misuse. Inappropriate choices of insecticides, wrong timing of application, poor dosages and limited knowledge on scouting pests and decision making largely contribute to the ineffectiveness of insecticides. Given the prolonged use of pyrethroids, Tanzania cotton body and agencies such as United Republic of Tanzania (URT), CDTF, Tanzania Cotton growers Association (TCA) and Tanzania Cotton Growers Association (TACOGA) should work through Research institutes (TARI -Ukiriguru and Ilonga and university like SUA to develop a better strategy of using insecticides in the IPM context for efficient control of insect pests in cotton.

Therefore, the blame raised by farmers hold the truth based on the followings; (a) farmers could apply insecticides coinciding with the rains hours and hence applied chemicals washed out. (b) farmers use underdoes of agrochemicals and hence less effectiveness of the products. (c) farmers could have applied once or twice the chemicals, hence not practical as this study depicted three to four application frequency. Access and availability of insecticides by cotton growers was one of greatest challenges in WCGA. Following market liberalization, pesticides are imported directly from manufacturers like Rentokil, Syngenta, DVA Agro GmbH and BAYER by different local chemicals trading companies such as MUKPAR, MERU AGRO, SUBA AGRO, POSITIVE, BASF Agro, BALTON, HANGZOU and BAJUTA ENTERPRISE. Under such a free trade, quality control becomes compromised. Unfortunately, unscrupulous traders use this void of free market and farmer's ignorance to sell outdated inauthentic pesticides. Moreover, lack of credit facilities or subsidies for inputs undermines farmers' ability to timely purchase insecticides as most of cotton farmers did not seem to have saving for next season's input purchases. The high price of cotton inputs and lack of subsidies meant that cotton famers often left their fields unsprayed at mercy of natural enemies alone.

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Conflict of Interest

The authors declare that they have no conflict of Interest.

Authors Contribution

Jeremiah Joe Kabissa; Developed a research idea, reviewed literature, conducted experiment, collected and analysed data and wrote a draft manuscript. Gration M. Rwegasira; supervised and guided the research work, developed the methodology, guided data collection and analyses and refined the manuscript.

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