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BIOEFFICACY OFMAHOGANY SEED EXTRACT (KHAYA SENEGALENSIS (DESR.) A. JUSS.) IN THE MANAGEMENT OF BOLLWORM DAMAGE ON COTTON IN NORTHERN GUINEA SAVANNA ZONE OF NIGERIA

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ABSTRACT

The pest pressure particularly from bollworms becomes very high and drives cotton growers to adopt all tactics to combat or at least reduce the effect by using chemical combinations which are not readily available, and when available the cost is beyond the reach of an average cotton farmers, and if left on control it will lead to total loss for the farmer. Field trials were conducted at two locations in Samaru and Maigana both in Northern Guinea Savannah agrological zone of Nigeria during the 2016 wet season to determine the effects of three concentrations of aqueous *Khaya* seed extract (KSE) (20%w/v, 30%w/v and 40%w/v) on the damage on cotton (SAMCOT 9) by bollworms. The experimental design used was Randomized Complete Block Design with four replications. Four (4) sprays at two-week interval beginning from 9weeks after sowing (WAS) were applied. Data were recorded on the number of terminal shoot damage, number of damaged shed squares, number of damaged shed cotton bolls and number of damaged matured green bolls. There was no significant difference ($P \geq 0.05$) in the number of terminal shoot damaged by spiny bollworm (*Earias spp.*) from spray application of Lambda cyhalothrin, KSE and untreated control. Aqueous KSE and Lambda cyhalothrin significantly ($P \leq 0.05$) reduce the number of damaged shed cotton squares, shed cotton bolls and matured green bolls than untreated control. Thus, aqueous KSE at (40%w/v) significantly reduce bollworms damage on cotton plants compared to the synthetic insecticide, and the efficacies demonstrated shows the potential of the material as being a good alternative for managing bollworms damage on cotton. It can be concluded from this study that aqueous KSE can be effectively used for managing bollworms damage on planted cotton. Higher concentration of 40% gives optimum result although, lower rates between 20-30% is also effective than no treatment at all.

Keywords: KSE, shed cotton squares, shed cotton bolls, matured green bolls, damage.

Introduction

Cotton is an important cash crop of considerable social and economic importance in Nigeria, cultivated for its fibre and oil. It is mainly grown in the Savanna region of the Northern States in the areas extending from latitude 7°N to 13°N under rain-fed (Poswal, 1988). In cotton production, there are many factors that can reduce yield. Arthropod pests are one of the most important organisms that causes significant yield losses to cotton plant, with those that attack fruit being more destructive than those that cause damage on leaf, stem, and root (Mapuranga *et al.*, 2015). Total annual losses in the world are estimated at about U.S. $300 billion, and average yield loss range from 30 to 40% and are generally much higher in many tropical and subtropical countries (Greenberg *et al.,* 2012) The pest pressure particularly from bollworms becomes very high and drives growers to adopt all tactics which may not be really suitable to the given situation and would ensure failure of such efforts (Jothi, 2007).In intensive agriculture, insecticides have been look upon as potent weapons for modern pest management, but excessive and indiscriminate use has led to problems of pest resistance, pest resurgence, accumulation of harmful residue in the environment and toxicity to non-target organisms and man (Matthews 1989; Ahmad 2007; Mapuranga *et al.,* 2015). Cotton receives more pesticide protection per season than any other crop (Matthews,1989) and accounts for more than 25 percent of all agricultural insecticides used worldwide (Pimentel *et al.*, 1993 and Greenberg *et al.*,2012).

This has prompted necessity for the development of plant bioactive compounds that could be viable and effective for insect pest management, while also being compatible with the environment (Kranthi, 2016). Hence, a current shift in the desire for biopesticides from botanical sources rather than synthetic chemicals using the extract of plants having pesticidal properties. Botanical insecticides have more advantages than synthetic mainly upon their quick degradation and lack of persistence and bioaccumulation in the ecosystem, which have been key problems in chemical pesticide uses (Senthil-Nathan, 2013). Plant extracts also have the advantage of containing a mixture of compounds which may significantly reduce the chances of tolerance or resistance build-up by insect pests (Thacker, 2012). These plant extracts have a wide range of anti-insect properties including insecticidal, repellent, antifeedant, and insect growth inhibitory activities (Ahmad, 2007; Dhaliwal and koul, 2011; Senthil-Nathan, 2013). One of such tree plant is African mahogany (*Khaya senegalensis*) a member of the timber tree species of the family *Meliaceae* with rich source for limonoids (Paritala *et al.*,2015) with no real exploitation recognized regarding its rich phytochemical constituents (Satti and Elamin, 2012). The limonoids have been found to give effective control against cotton bollworms (Abdelgalei *et al*., 2001; Abdelgalei and Nakatani, 2003; Abdelgalei *et al.,* 2004). Hence, this study was conducted to determine the effect of different concentrations of KSE on the damage by bollworms on SAMCOT-9 cotton variety.

Materials and Methods

Experimental sites and Experimental lay-out

The study took place during the 2016 wet season at two different locations situated at Institute for Agricultural Research (I.A.R) farm Samaru, (Latitude$12^{o}13'$and$11^{o}11'$ N / Longitude$8^{o}39'$ and $7^{o}38'$E and 686m above sea level) and Kaduna State Agricultural Development Agency (K.A.D.A) research farm in Maigana (Latitude $12^{o}12'$and 11^{o} $10'$ N/ Longitude $8^{o}38'$/ 7^{o} $37'$ E and 675m above sea level) in Northern Guinea Savannah ecological zone of Nigeria. The study areas have a mean annual rainfall of 1016mm and mean maximum and minimum temperatures of 32.2^{o}C and 23.5^{o}C respectively. The treatments consisted of 3 concentrations of Khaya seed extracts (KSE) of 20% w/v, 30% w/v and 40% w/v (200g, 300g and 400g/L of water), an insecticidal check (Lambda-cyhalothrin 25gai/litre EC) and untreated control replicated four (4) times in randomized complete block design (RCBD).

Land preparation

The cotton variety used was SAMCOT-9, an erect and medium staple cultivated commercial variety adapted to the North-West cotton growing zone of Nigeria under rain-fed conditions. The seeds were treated with Dress Force 42WS (Imidacloprid 20% + Metalaxyl-M 20% + Tebuconazole 2%) 8g/Kg, and sown at 4 seeds per hole at a depth of 3cm, 90cm inter-row spacing and 45cm intra-row spacing on the ridges. Emerged seedlings were thinned to two plants per stand 3WAS. A mixture of Paraquat and Butachlor as Pre-emergence herbicide at the rate of 1 litre/ha was applied. Supplementary hoe weeding was done throughout especially at the critical periods of weeds interference. Fertilizer was applied at the recommended rate of 60: 13: 25 Kg/ha using NPK 15:15:15 at 3WAS, and Urea was used for top dressing at 8WAS. Aqueous Khaya seed extract were prepared from matured, air-dried and pounded Khaya seeds. The pounded seeds were weighed into lots of 200g, 300g and 400g separately and soaked in 1000ml of tap water inside plastic buckets and allowed to stand for 48hrs and continuously stirred at 24hrs interval.

The content of each bucket was filtered with 500ml of water with the aid of a double-layer muslin cloth, and 300ml of 5% w/v starch and flaked soap (50g each/1000ml of water) was added. The crude seed extracts were applied at the rate of 100ml/L of water (10% v/v) per KSE treatments while the insecticidal check (Lambda cyhalothrin 2.5EC) was applied at the rate of 10ml/L of water (1%v/v) per plot with knapsack sprayer. Application commenced from 9WAS which corresponded to the period of formation of First Square to the detection of first flower. Four applications were carried out at 2weeks interval at different phenological stages of the crop. Data were collected from five randomly selected plants from the net plot and observations were recorded on number of plants with bored/damaged terminal growing points, number of damaged shed flowers/cotton squares, number of damaged shed cotton bolls, and number of matured cotton bolls damaged by bollworms.

Data Analysis

All data were transformed using square root transformation, and were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS) software (version 9.0), and mean differences among treatments were separated using Students Newman's Keul test (SNK) at *P=0.05*.

Results and Discussion

The results of the effects of KSE and Lambda cyhalothrin on bollworm damage on cotton are discussed below.

Effect of aqueous *Khaya* seed extract on terminal shoot damage on Cotton caused by Earias spp. at Samaru and Maigana in 2016 wet season.

There was no significant difference ($P \geq 0.05$) in the number of terminal shoot damaged by *Earias spp*. both in Samaru and Maigana with the application of different rates of KSE at 24hrs and 10days post spray application (PSA) (Table 1). The results of the two locations combined also follow similar trends at 24hrs and 10days PSA. The result indicated that similar number of terminal shoot were damaged by *Earias spp* among different rates of KSE in both locations, even though the untreated control recorded higher terminal shoot damage. This finding could be attributed to low pest pressure of spiny bollworms at the early stage of the crop development. This agrees with the report that Spiny bollworm usually appear late in September and reaching peak pest population by the end of October especially in Northern Nigeria (Lyon, 1971). *E. insulana* has also been reported as a serious pest of cotton late in the summer in USA, when most of the plants have already started producing bolls (Klein *et.al.*,1982). Absence of diapause, presence of alternative host plants, length of growing season, and time of sowing and presence of ratoon cotton are also among the factors that can influence the prevalence of *Earias* on cotton (Matthews, 1989). Infestation by *Earias spp.*have also been reported principally in areas where alternative host plant (*Abutilon spp.*, *Hibiscus spp.* and *Waltheria indica*) are common. Similarly, *Earias* population build up have been reported to be more during the boll development phase of the crop causing damage to all fruiting forms (Vennila *et. al.*,2007).

Table 1:Effect of *Khaya* seed extract on terminal shoot damaged by bollworms 9weeks after sowing at Samaru and Maigana.

Mean number of damaged terminal shoot 24hrs and 10days post spray application						
	Samaru		Maigana		Combined	
Treatment	24hrs	10days	24hrs	10days	24hrs	10days
KSE (%w/v)						
20	0.71	0.71	0.71	0.71	0.71	0.71
30	0.71	0.71	0.71	0.71	0.71	0.71
40	0.71	0.75	0.71	0.71	0.71	0.73
Lambda cyhalothrin	0.71	0.71	0.71	0.71	0.71	0.71
Untreated control	0.71	0.75	0.71	0.71	0.71	0.73
SE$\pm$	0.000	0.024	0.000	0.000	0.000	0.013
Significance	NS	NS	NS	NS	NS	NS

NS=Not significant.

Effect of aqueous *Khaya* seed extract on shed cotton squares damage by bollworms at Samaru and Maigana in 2016 wet season.

There was significant difference in the number of shed cotton squares damaged by bollworms with KSE at Maigana 24hrs and 10days post spray applications but not in Samaru (Table 2). At 24hrs PSA in Samaru, all the KSE and Lambda cyhalothrin treatments resulted in less shed cotton squares damaged by bollworms which were similar ($P \geq 0.05$), but were found to be significantly ($P \leq 0.05$) lower than the untreated control which had higher number of shed cotton squares. However, at 10days PSA, all the treatments resulted in similar ($P \geq 0.05$) number of damaged shed squares. At 24hrs PSA in Maigana, Lambda cyhalothrin resulted in significantly ($P \leq 0.05$) lower number of damaged shed squares than all the three KSE and the untreated control. All the KSE (30%w/v, 40%w/v, and 20%w/v) were found to have similar ($P \geq 0.05$) numbers of damaged shed cotton squares which were significantly ($P \leq 0.01$) lower than the untreated control. At 10days PSA, Lambda cyhalothrin resulted in similar ($P \geq 0.05$) number of damaged shed squares with 40%w/v KSE, but significantly ($P \leq 0.05$) lower than 30%w/v, 20%w/v and untreated control. Although, the number of damaged shed cotton squares from 30%w/v was similar ($P \geq 0.05$) to 20%w/v but significantly ($P \leq 0.05$) lower than untreated control which was found to be similar ($P \geq 0.05$) to 20%w/v, and gave the highest number of damaged shed cotton squares. The result of the combined analysis from the two locations 24hrs PSA, Lambda cyhalothrin had the lowest number of damaged shed cotton squares which was significantly (P≤0.05) lower than all the KSE and the untreated control.

However, all the KSE treatments resulted in similar (P≥0.05) number of damaged shed cotton squares which were significantly (P≤0.05) lower than the untreated control. At 10days PSA, both Lambda cyhalothrin and 40%w/v resulted in similar (P≥0.05) number of damaged shed cotton squares that were significantly (P≤0.05) lower than all the other KSE and the untreated control. Although 30%w/v was similar (P≥0.05) to 20%w/v but significantly (P≤0.05) lower than the untreated control which was found to be similar (P≥0.05) to 20%w/v on the number of damaged shed cotton squares.

The result indicated that the number of shed cotton squares damaged by bollworms was affected by different rates of KSE and this vary with location. In Samaru, all KSE rates and Lambda cyhalothrin treated plots were observed to have similar effect in reducing the number of shed squares damaged by bollworms and their effects were found to be better than the untreated plots. At Maigana, similar trend was observed among all the KSE which were effective in reducing the number of shed squares damaged by bollworms when compared with untreated plot. However, it was only Lambda cyhalothrin that was more effective in reducing the number of damaged shed cotton squares. Similarly, the damaged shed squares recorded for the two locations indicated an increasing effect of KSE from 20%w/v to 40%w/v in reducing the number of shed squares damaged by bollworms, although only 40%w/v KSE was comparable to Lambda cyhalothrin.

Hence this result could suggest that the use of KSE at rate as high as 40%w/v could compete with Lambda cyhalothrin in reducing the number of shed squares damaged by bollworms. The significant reduction on the number of damaged shed squares could be as a result of differential concentration of the active ingredient liminoids present in KSE which is known to possess potent anti-insect properties (Paritala *et al.*, 2015) as well as antimicrobial properties (Govindachar and Krishma, 1989; Roy and Saraf, 2006). It could also be that the highest rate of 40% w/v KSE has more of the concentration of the limonoids and hence the better efficacy. This is further corroborated by the report that significantly lower number of cotton squares were damaged by the larvae of African bollworm when high concentration of NSKE was used as compared to the control (Wondafrash *et al.*, 2012).

Table 2: Effect of *Khaya* seed extract on shed cotton squares damaged by bollworms 9weeks after sowing in Samaru and Maigana.

Mean number of damaged shed cotton squares 24hrs and 10days post spray application						
	Samaru		**Maigana**		**Combined**	
Treatment	24hrs	10days	24hrs	10days	24hrs	10days
KSE (%w/v)						
20	0.71b	0.83	1.63b	1.71ab	1.17b	1.27ab
30	0.78b	0.71	1.41b	1.46b	1.10b	1.08b
40	0.71b	0.71	1.41b	1.04c	1.06b	0.88c

Lambda cyhalothrin	0.71b	0.71	1.13c	0.94c	0.92c	0.83c
Untreated control	1.12a	0.83	1.97a	1.95a	1.54a	1.39a
SE+	0.038	0.047	0.172	0.155	0.085	0.078
Significance	*	NS	*	*	*	*

NS=Not significant *= (P≤0.05). Means followed by same letter(s) within the same column are not different statistically at *P=0.05* using SNK.

Effect of *Khaya* seed extract on shed cotton bolls damaged by bollworms at Samaru and Maigana in 2016 wet season.

The results show that effect of different rates of KSE in Samaru and Maigana resulted in a significant difference on number of damaged shed cotton bolls at 24hrs and 10days post spray application (Table 3). At 24hrs PSA in Samaru, all KSE and Lambda cyhalothrin had similar (P≥0.05) number of damaged shed cotton bolls which were significantly (P≤0.05) lower than untreated control. At 10days PSA, similar trend was observed with Lambda cyhalothrin, 40%w/v and 20%w/v having similar (P≥0.05) number of damaged shed cotton bolls which were significantly (P≤0.05) lower than 30%w/v and untreated control. The 30%w/v was also significantly (P≤0.05) lower than untreated control. At 24hrs PSA in Maigana, Lambda cyhalothrin recorded significantly (P≤0.05) lower number of damaged shed cotton bolls than all KSE treatments and untreated control. Also, 40%w/v was found to be similar (P≥0.05) to 30%w/v but significantly (P≤0.05) lower than 20%w/v and untreated control. However, both 30%w/v and 20%w/v had similar (P≥0.05) number of damaged shed cotton bolls which were significantly (P≤0.05) lower than untreated control. At 10days PSA, Lambda cyhalothrin and 40%w/v had similar (P≥0.05) number of damaged shed cotton bolls which were significantly (P≤0.05) lower than other KSE and untreated control. Both 30%w/v and 20%w/v also recorded similar (P≥0.05) number of damaged shed cotton bolls that were significantly (P≤0.05) lower than untreated control during the period.

The result of the 24hrs PSA for the two locations combined shows a significant difference among treatments with Lambda cyhalothrin having significantly (P≤0.05) lower number of damaged shed cotton bolls than all KSE and untreated control. More so, 40%w/v also recorded significantly (P≤0.05) lower number of damaged shed cotton bolls than other KSE and untreated control. Likewise, 30%w/v and 200%w/v had similar (P≥0.05) numbers of damaged shed cotton bolls which were significantly (P≤0.05) lower than untreated control. At 10days PSA, similar observation was made on result of the two location combined with Lambda cyhalothrin and 40%w/v having similar (P≥0.05) number of damaged shed cotton bolls which were significantly (P≤0.05) lower than other KSE and untreated control. More so, 20%w/v and 30%w/v were also significantly (P≤0.05) lower than untreated control. Application of different rates of KSE spray in Samaru were found to have similar effects with Lambda cyhalothrin which are better than untreated plots in reducing number of damaged shed cotton bolls.

However, at Maigana, it was observed that only 40%w/v KSE had similar effect with Lambda cyhalothrin in reducing number of shed cotton bolls damaged by bollworms, although other KSE rates were better than the untreated plots. The combined results for both locations also shows similar effects of 40%w/v KSE and Lambda cyhalothrin which were better than other rates of KSE and untreated plots. The observed reduction in number of damaged shed cotton bolls by KSE indicates potential of the extract to have effect on the insect. This finding is in line with the reports that Khaya seed contains various types of secondary metabolites such as limonoid with wide range of anti-insect properties (Ahmad, 2007; Dhaliwal and Koul, 2011; Senthil-Nathan, 2013).Application of Neem kernel seed extracts with this source of limonoids has also been found to suppress bollworms and whiteflies without affecting the natural balance of cotton ecosystem (Jothi, 2007).

Table 3: Effect of aqueous *Khaya* seed extract on shed cotton bolls damaged by bollworms 11weeks after sowing in Samaru and Maigana.

	Mean number of damaged shed cotton bolls 24 hours and 10 days post spray application					
	Samaru		Maigana		Combined	
Treatment	24hrs	10days	24hrs	10days	24hrs	10days
KSE (%w/v)						
20	0.80b	1.08c	1.62b	2.02b	1.21b	1.55b
30	0.84b	1.39b	1.48bc	1.78b	1.16b	1.59b
40	0.75b	1.00c	1.29c	1.31c	1.02c	1.15c
Lambda cyhalothrin	0.71b	0.84c	0.97d	1.27c	0.84d	1.05c
Untreated control	1.44a	2.18a	2.56a	2.58a	2.00a	2.38a
SE±	0.066	0.222	0.198	0.163	0.105	0.132
Significance	*	*	*	*	*	*

*= ($P \leq 0.05$). Means followed by same letter(s) within the same column are not different statistically at *P=0.05* using SNK.

Effect of *Khaya* seed extract on bollworm damage to Matured cotton bolls on plants at Samaru and Maigana in 2016 wet season.

Spray application of different rates of KSE in Samaru and Maigana resulted in a highly significant difference on the number of damaged matured cotton bolls at 13weeks and 15weeks post spraying (Table 4). At 13weeks PSA in Samaru, both Lambda cyhalothrin and all the KSE treatments recorded similar ($P \geq 0.05$) numbers of damaged matured cotton bolls that were significantly ($P \leq 0.05$) lower than untreated control which recorded highest damage. At 15weeks PSA, Lambda cyhalothrin recorded significantly ($P \leq 0.05$) lower number of damaged matured cotton bolls than all KSE and untreated control. Likewise, the 40%w/v was similar ($P \geq 0.05$) to 20%w/v but significantly ($P \leq 0.05$) lower than 30%w/v and the untreated control. However, the 20%w/v and 30%w/v recoded similar ($P \geq 0.05$) number of damaged matured cotton bolls which were significantly ($P \leq 0.05$) lower than the untreated control.

At 13weeks PSA in Maigana, Lambda cyhalothrin (1.40) recorded significantly ($P \leq 0.05$) lower number of damaged matured cotton bolls than all KSE and the untreated control. Similarly, 40%w/v KSE also recorded significantly ($P \leq 0.05$) lower number of damaged matured cotton bolls than the other KSE and the untreated control. Likewise, 30%w/v also had significantly ($P \leq 0.05$) lower number of damaged matured cotton bolls than 20%w/v and the untreated control. And the 20%w/v was also significantly ($P \leq 0.05$) lower than untreated control which recorded highest number of damaged matured cotton bolls during the period. At 15weeks PSA, similar trend was observed with Lambda cyhalothrin having significantly ($P \leq 0.05$) lower number of damaged matured cotton bolls than all KSE and the untreated control. The 40%w/v also recorded significantly ($P \leq 0.05$) lower number of damaged matured cotton bolls than the other two KSE and the untreated control. However, both 30%w/v and 20%w/v were similar ($P \geq 0.05$) but significantly ($P \leq 0.05$) lower than untreated control that recorded higher number of damaged matured cotton bolls. The combined result of the two location at 13weeks PSA showed that Lambda cyhalothrin had significantly ($P \leq 0.05$) lower number of damaged matured cotton bolls than all KSE and untreated control. The 40%w/v also recorded significantly ($P \leq 0.05$) lower number of damaged matured cotton bolls than the other two KSE and the untreated control.

The 30%w/v also recorded significantly lower ($P \leq 0.05$) number of damaged matured cotton bolls than 20%w/v and the untreated control. Likewise, the 20%w/v had significantly ($P \leq 0.05$) lower number of damaged matured cotton bolls than the untreated control. At 15weeks PSA, Lambda cyhalothrin recorded significantly ($P \leq 0.05$) lower number of damaged matured cotton bolls than all the KSE and the untreated control. The 40%w/v also recorded significantly ($P \leq 0.05$) lower number of damaged matured cotton bolls than the other KSE and the untreated control. Similar numbers of damaged matured cotton bolls ($P \geq 0.05$) were recorded on 30%w/v and 20%w/v which were significantly ($P \leq 0.05$) lower than untreated control. The result indicated that the number of matured green bolls damaged by bollworms was affected by different concentrations of KSE and this vary with locations. The results of the two locations combined also indicated an increasing effect of the KSE from 20%w/v to 40%w/v in reducing the number of damaged matured green bolls with only 40%w/v KSE found to be similar to Lambda cyhalothrin. This finding suggests a comparable effect of KSE at 40%w/v concentration with Lambda cyhalothrin in reducing the number of matured green bolls damaged by bollworms.

The efficacy of the KSE in reducing level of damage to matured green bolls on cotton plants in this study could be attributed to the insecticidal action of the secondary metabolites found in KSE which could interferes with the feeding and repelling large number of the bollworms that could have caused substantial damage to the developing bolls. This corroborates the findings that mahogany seed is rich in phytochemical constituent (Satti and Elamin, 2012) which have been found to give effective control against cotton bollworms (Abdelgalei *et. al.*, 2001; Abdelgalei and Nakatani, 2003; Abdelgalei *et. al.*, 2004) as well as some storage pests of cowpea and sorghum (Bamaiyi and Bolanta, 2006; Bamaiyi *et al.*,2006). Similarly, aqueous NKSE which is also a rich source of limonoids at higher concentrations have been reported to adversely affect the attack of pink bollworms up to 12 days after spray (Khattak *et al.*,1982)

Table 4: Effect of aqueous *Khaya* seed extract on matured bolls damaged by bollworms in Samaru and Maigana.

Mean number of damaged matured bolls 13 weeks and 15 weeks post spray application						
	Samaru		**Maigana**		**Combined**	
Treatment	13wks	15wks	13wks	15wks	13wks	15wks
KSE (%w/v)						
20	1.13b	1.44bc	3.23b	1.91b	2.18^{b}	1.68b
30	1.15b	1.55b	2.79c	1.70b	1.97c	1.62b
40	0.88b	1.26c	1.77d	1.10c	1.33d	1.18c
Lambda cyhalothrin	0.88b	0.96d	1.40e	0.84d	1.14e	0.90d
Untreated control	2.02a	2.40a	3.80a	2.63a	2.91a	2.52a
SE$\pm$	0.075	0.113	0.117	0.072	0.076	0.063
Significance	*	*	*	*	*	*

*= ($P \leq 0.05$). Means followed by same letter(s) within the same column are not different statistically at $P=0.05$ using SNK.

Conclusion and Recommendation

Conclusion

Application of aqueous KSE at (40%w/v) can significantly reduce bollworms damage on cotton plants and was as good as the synthetic insecticidal check. The efficacies demonstrated by aqueous KSE in this study, shows the potential of the material as being a good alternative for managing bollworms damage on cotton.

Recommendation

It is therefore recommended that cotton farmers should use aqueous KSE for the management of bollworms damaged on cotton. Furthermore, farmers that could not use higher concentration of 40% can opt for lower rates between 20-30% than no treatment at all.

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