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# Effectiveness of Different Spay Timing Methods for the Control of Lepidopteron Pests in Cotton

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*Keywords:* *helicoverpa armigera, diparopsis castanea, threshold, pest, spraying, predators.*

*GJSFR-D Classification:* *FOR Code: 070199*


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# Effectiveness of Different Spay Timing Methods for the Control of Lepidopteron Pests in Cotton

Mapuranga Rangarirai [α], Jimu Francis [σ] & Mubvekeri Washington [ρ]

*Abstract- Background:* Application of chemicals for the control of *Helicoverpa armigera* and *Diparopsis castanea* is based on egg threshold, while for *Erias insulana* and *E. biplaga* larval counts are used. In Zimbabwe the traditional farmer practice involves use of weekly spraying, fortnightly spraying and spraying at first sight of damaged squares. The methods may be less effective, costly, damaging to the environment and labour intensive. Experiments were conducted for three consecutive seasons from 2010/11 season up to 2012/13 season to evaluate the spray timing methods. Spraying at bollworm egg threshold level was the standard. The trial was laid as a randomised complete block design replicated four times at Cotton Research Institute, Dande and Umguza.

*Results:* Analysis of variance was done on bollworm larval counts and seed cotton yield using Genstat 14th version of 2011. The standard method and weekly spraying produced comparably reduced larval counts. Fortnightly spraying and spraying at first sight of damaged squares was less effective in control of bollworms. The standard method significantly spared predators at most sites over the three seasons in contrast with weekly spraying. However predator counts for standard and the other methods were comparable. Results of cost-benefit analysis done only in 2012/13 showed that weekly spraying was most expensive than other methods.

*Conclusion:* The standard method continued to be the best spray timing method for farmers.

*Keywords: helicoverpa armigera, diparopsis castanea, threshold, pest, spraying, predators.*

## I. Introduction

A good scouting programme is still the first line of defence against insect pests in cotton (Greene, 2012). Sucking pests, spiny bollworm larvae (*Erias insulana* and *E. biplaga*), leaf eaters, soil pests and many other pests of cotton are easily identified by smallholder farmers, making it easier for them to make a decision to spray or not. However problems arise with bollworms (African bollworm, *Helicoverpa armigera* Hub. and red bollworm, *Diparopsis castanea*), where the recommended method is to scout for bollworm eggs (Cotton Growers Association, 1998), and these bollworm eggs are very small, usually the size of a pin head (ANR-0409, 2012) and difficult to identify. A survey which was carried out in 1994 showed that 38% and 36% of farmers could not recognise red and heliothis bollworm eggs yet 94% and 75% of the same group of farmers can easily identify the larval stages (Jowah, 1994). In seasons with above normal rainfall bollworm eggs change from their usual blue and creamish white colour to greyish for red and heliothis bollworms respectively. For most farmers who are elderly and with poor eye sight they can`t recognise these eggs. The small bollworm eggs are also deposited singly (Greene, 2012) further increasing problems to farmers during scouting.

The difficulties experienced by farmers in trying to identify bollworm eggs have led them to stop basing decisions of when to spray on economic threshold data as recommended but they now do routine sprays based on their own perceptions. Some farmers have resorted to weekly sprays, others apply fortnightly sprays, and the majority spray after observing a fallen damaged square which is a sign of the presence of the 1st instar larva. This method has been recommended in various countries such as South and North Carolina, Virginia, Columbia (Greene, 2012; Boyd *et al*, 2004). Only a small fraction of farmers use the recommendations of the Zimbabwe Cotton Handbook where one should make use of bollworm eggs threshold scouted on 24 plants over an area on not more than 24 hectares. However, all these methods employed by farmers may be less effective and costly which would increase total production costs for these farmers. It is therefore essential to find an alternative, effective and cost saving spray timing method for use by these small-holder farmers among the different methods they are using.

The aim of this study was to evaluate the effectiveness of the different spray timing methods used by smallholder farmers with the following specific objectives

- To determine the method which can maintain low bollworm larval counts
- To determine the method which can spare a high population of predators
- To determine the method which can preserve high seed cotton yield
- To determine which spray timing method is economical

## II. Materials and Methods

This study, which began in 2010-2011 season, was repeated in 2011-12 and 2012-2013 season at Cotton Research Institute, (CRI). In the first season the experiment was established at CRI and Chisumbanje

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and at Dande, CRI and Mvuma in the second season and in the final season it was laid at Dande, CRI and Umguza. The experiment was laid out in a randomized complete block design with five treatments replicated 4 times at all sites. The treatments evaluated in this study are described on Table 1 below.

Cotton variety used across all sites in all seasons was SZ9314, it was hand planted. Seeds were spaced at 0.3m in rows which were 1m apart in plots measuring 22m by 14 rows. Compound L (5:18:10) was used as basal treatment applied at 200kg/ha at planting and Ammonium nitrate (34.5%N) at 100kg/ha was applied at flowering.

*Table 1:* Description of different spray timing methods and control treatments evaluated

| No. | Treatment name | Treatment description |
|---|---|---|
| 1 | Control | No chemical control of major bollworms (African, spiny and red bollworms) |
| 2 | Standard or threshold control | Spray when egg/larval counts reaches or exceed the recommended threshold levels ( 6 or 12 eggs/24 scouted plants red and African bollworm respectively and 6 larvae/24 scouted plants for spiny bollworm) |
| 3 | Weekly spraying | Weekly spraying against major bollworms |
| 4 | Fortnightly spraying | Fortnightly spraying against major bollworms |
| 5 | Damaged square | Spraying at first sight of at least three fallen and damaged squares/ buds on 24 scouted plants |

Planting was done at the start of every farming season at all sites, usually late November to mid December of each season. Four weeks after emergence seedlings were thinned to one plant per station. Scouting for red, spiny and African bollworms and other pests started soon after thinning. Scouting was done once weekly.

Six plants were scouted per plot which translates to 24 plants per treatment. All plants were scouted using the stepped traverse method in each plot. Other pests, sucking pests and leaf eaters were controlled when they reached or exceeded their recommended economic thresholds on 24 scouted plants selected randomly over the whole trial area. Weekly egg and larval counts of African, red and spiny bollworms and predators (larva and adult ladybird beetle, crysopa and spiders) were recorded. An analysis of variance (ANOVA) on the data were done using Genstat 14.1 version. ANOVA was also carried out on combined data for all sites by each season (across site analysis). Larval counts were transformed using the square root of count plus ⅜ (i.e. $\sqrt{(\beta + ⅜)}$), where $\beta$ is equal to observed parameter.

## III. Results

*a) Effects of different spray timing methods on bollworms in 2010 – 11 season*

There were significant differences among treatment means on red, African and spiny bollworm larval counts ($p < 0.05$, Table 2). The results show that the weekly, fortnightly and spraying at first sight of damaged squares were not significantly different from the standard method but they were however significantly different from the control which had the highest population of red, African and spiny bollworm larvae.

*Table 2:* Effect of different spray timing methods on number of Red and African bollworm larval stages at CRI in 2010/11 cropping season

| | Dande | | | CRI | | |
|---|---|---|---|---|---|---|
| Treatment | African | Red | Spiny | African | red | Spiny |
| No control of bollworms | | | | 1.1b | 1.7b | 1.3b |
| Threshold method | | | | 0.6a | 0.8a | 0.6a |
| Weekly spray | | | | 0.6a | 0.6a | 0.6a |
| Fortnightly spray | | | | 0.6a | 1.0a | 0.6a |
| Damaged square | | | | 0.9ab | 1.3ab | 0.6a |
| Mean | | | | 0.8 | 1.1 | 0.7 |
| P-value | | | | 0.032 | 0.046 | <.001 |
| LSD (0.05) | | | | 0.3 | 0.9 | 0.2 |
| CV (%) | | | | 17 | 23 | 5 |

*Means within a column not followed by a common letter are significantly different at 5% level by LSD comparison*

*b) Effects of different spray timing methods on bollworms in 2011 – 12 season*

There were significant differences ($p \leq 0.05$) for larval counts for African and red bollworms at CRI, Dande and Mvuma (Table 3). Weekly spraying kept bollworm larvae at CRI below the level of the standard method ($p < .001$) whereas fortnightly spraying and spraying after first sight of damaged squares, bolls or



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buds had lower control as compared to the standard method. Dande results show significant differences for African bollworm larvae ($p < .001$) and red bollworm larvae ($p = 0.003$). Weekly spraying managed to check African bollworm larvae below, but comparable to the threshold method. Fortnightly spraying had poor control than weekly spraying and threshold method. The lowest red bollworm count was recorded in the threshold method and was comparable to all test treatments. The no spray recorded the highest count in all cases.

*Table 3:* Effect of different spray timing methods on number of Red and African bollworm larvae stages at Dande, CRI and Mvuma in 2011/12 cropping season

| | Dande | | CRI | | Mvuma | |
|---|---|---|---|---|---|---|
| Treatment | African | Red | African | Red | African | Red |
| No control of bollworms | 14.58a | 3.83a | 2.18a | 1.08a | 0.65a | 0.35a |
| Threshold method | 3.5c | 0.83b | 0.80c | 0.40b | 0.29b | 0.10b |
| Weekly spray | 2.67c | 0.92b | 0.61c | 0.25c | 0.15b | 0.02b |
| Fortnightly spray | 5.17b | 1.00b | 1.25b | 0.60b | 0.13b | 0.08b |
| Damaged square | 4.04bc | 1.62b | 0.98bc | 0.45b | 0.19b | 0.17b |
| Grand mean | 5.99 | 1.64 | 1.16 | 0.56 | 0.28 | 0.15 |
| P-value | <.001 | 0.003 | <.001 | <.001 | 0.006 | 0.020 |
| LSD (0.05) | 1.40 | 1.48 | 0.45 | 0.29 | 0.27 | 0.18 |
| CV (%) | 4.4 | 9.3 | 3.3 | 2.7 | 2.6 | 35.9 |

*Means within a column not followed by a common letter are significantly different at 5% level by LSD comparison*

At Mvuma the no spray had a significantly higher count of African ($p = 0.006$) and red ($p = 0.020$) bollworm larvae. The alternative spray timing methods were comparable to the recommended threshold method in both cases.

c) *Effects of different spray timing methods on bollworms in 2012-13 season*

The 2012 – 13 season results showed significant differences for egg and larval counts for heliothis, red and spiny bollworms at CRI, Dande and Umguza ($p \leq 0.05$). Results at CRI showed significant differences for both heliothis ($p = 0.038$) and spiny ($p = 0.011$) bollworm larvae among treatment means (Table 4).

Weekly spraying kept African bollworm larvae at CRI below the level of the recommended threshold method whereas fortnightly spraying and spraying after first sight of damaged squares, bolls or buds had poor control as compared to the threshold method. Spiny bollworm larvae were highest in the weekly spraying and it was comparable to damaged squares. Significantly low spiny bollworm larvae were recorded in the threshold method and it was comparable with the no spray and fortnightly spraying.

Dande results show significant differences for African ($p < 0.001$) and red ($p = 0.045$) bollworm larvae ($p \leq 0.05$). The weekly spraying, fortnightly spraying and spraying at first sight of damaged plant part were not significantly different from the recommended threshold method. They all maintained a lower level of African bollworm larvae and red bollworm larvae when compared to the no control. Fortnightly spraying had poor control, but with no statistical differences, than weekly spraying and threshold method. The control recorded the highest count in all cases. At Umguza there were no significant differences ($p = 0.033$) among treatment means with regards to red bollworm larvae while all test treatments were comparable to the recommended method but had lower larval counts than the control. There were no significant differences among treatment means for African bollworm larvae.

*Table 4:* Effect of different spray timing methods on number of red, African and spiny bollworms larvae at Dande, CRI and Umguza during 2012/13 cropping season

| | Dande | | CRI | | | Umguza | |
|---|---|---|---|---|---|---|---|
| Treatment | African | Red | African | Red | Spiny | African | Red |
| No control of bollworms | 6.12 b | 1.82 b | 1.88 b | 1.06 | 0.42 ab | 0.79 | 0.54 b |
| Threshold method | 1.54 a | 1.21 a | 1.33 a | 0.88 | 0.17 a | 0.21 | 0.36 ab |
| Weekly spray | 1.79 a | 0.93 a | 1.30 a | 1.56 | 1.00 c | 0.21 | 0.14 a |
| Fortnightly spray | 1.61 a | 1.07 a | 1.58 ab | 1.06 | 0.50 ab | 0.58 | 0.21 a |
| Damaged square | 1.82 a | 1.25 ab | 1.75 b | 1.00 | 0.75bc | 0.33 | 0.11 a |
| Mean | 2.57 | 1.26 | 1.57 | 1.11 | 0.56 | 0.43 | 0.27 |
| P-value | <.001 | 0.045 | 0.038 | NS | 0.011 | NS | 0.033 |
| LSD (0.05) | 1.14 | 1.48 | 0.413 | 0.647 | 0.401 | 0.50 | 0.29 |
| CV (%) | 10.7 | 12.4 | 17.1 | 13.7 | 15.5 | 19.0 | 13.6 |

*Means within a column not followed by a common letter are significantly different at 5% level by LSD comparison*



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*d) Across site analysis by seasons on accumulated bollworm larval counts*

Across site analysis for all the sites for 2011 – 12 and 2012 – 13 seasons revealed significant differences among treatment means (Table 5). In 2012 – 13 season there were significant differences among treatment means with regards to African bollworm larvae ($p < 0.001$). The lowest larval count was recorded in the threshold method and was comparable to all experimental treatments while the no spray had significantly high larval counts. Spiny bollworm larvae was significantly high ($p = 0.007$) in weekly spraying and was comparable with damaged squares. The threshold method had the lowest spiny larval count which was comparable with fortnightly spray and no control. Red bollworm larvae had no significant differences.

The 2011 – 12 season had significant differences in African ($p < 0.001$) and red ($p < 0.001$) bollworm larval counts. The lowest African bollworm larval count was in weekly spraying and was comparable with the threshold method while the highest count was in no control. The highest red bollworm larvae were recorded in the no spray and all other treatments were not significantly different from each other.

*e) Effects on different spray timing methods on beneficial organisms*

Significance differences among treatment means regarding crysopa eggs ($p < 0.001$) and ladybird larvae ($p = 0.005$) were recorded for 2012/13 season (Table 6). Crysopa eggs were significantly high in the untreated control. The standard method of spray timing spared crysopa eggs and was comparable to the use of damaged square while weekly and fortnightly spraying did not preserve predators and were comparable to each other.

There were significant ($p = 0.005$) differences among treatment means on ladybird beetle larvae. The untreated control had the highest count of larvae and was statistically different with all other treatments. All the other treatments were comparable to each other.

*Table 5:* Mean accumulated bollworm larval counts across three sites

| | 2012 – 2013 season | | | 2011-2012 season | | |
|---|---|---|---|---|---|---|
| Treatment | African | Red | Spiny | African | Red | Spiny |
| No control of bollworms | 22.08b | 6.92 | 0.42ab | 31.06c | 9.63b | 0.56 |
| Threshold method | 8.42a | 4.83 | 0.17a | 9.75ab | 2.63a | 0.13 |
| Weekly spray | 8.92a | 4.58 | 1.00c | 7.13a | 2.06a | 0.13 |
| Fortnightly spray | 10.17a | 4.42 | 0.50ab | 12.63b | 3.44a | 0.06 |
| Damaged square | 10.75a | 4.50 | 0.75bc | 10.88b | 4.13a | 0.56 |
| Grand mean | 12.07 | 5.05 | 0.56 | 14.29 | 4.38 | 0.287 |
| P-value | <.001 | 0.069 | 0.007 | <.001 | <.001 | 0.054 |
| LSD (0.05) | 2.971 | 2.258 | 0.4040 | 3.336 | 2.173 | 0.453 |
| CV (%) | 14.7 | 24.1 | 23.6 | 15.5 | 28.4 | 37.9 |

*Means within a column not followed by a common letter are significantly different at 5% level by LSD comparison*

*Table 6 :* Effect of different spray timing methods on number of predators in 2010/11 season

| Treatment | Crysopa eggs | Crysopa larvae | Ladybird larvae | Ladybird adult | Spiders |
|---|---|---|---|---|---|
| No control of bollworms | 17.25c | 1.75 | 5.50b | 0.50 | 7.00 |
| Threshold method | 10.25b | 0.25 | 2.50a | 0.50 | 6.25 |
| Weekly spray | 4.25a | 0.25 | 0.25a | 0.25 | 3.75 |
| Fortnightly spray | 5.50a | 0.25 | 1.25a | 0.25 | 2.75 |
| Damaged square | 8.50ab | 0.00 | 1.25a | 0.25 | 3.75 |
| Mean | 9.15 | 0.50 | 2.15 | 0.35 | 4.7 |
| P-value | <.001 | NS | 0.005 | NS | NS |
| LSD (0.05) | 4.467 | NS | 2.44 | NS | NS |
| CV (%) | 27.7 | 17 | 10 | 11 | 9.5 |

*Means within a column not followed by a common letter are significantly different at 5% level by LSD comparison*

Across site analysis with regards to beneficial organisms for 2012 – 13 season shows that significant differences among treatment means were only recorded for crysopa eggs ($p = 0.003$) and spiders ($p < .001$) (Table 7). The highest count of crysopa eggs was in the threshold method and was comparable with the no spray and damaged squares. Fortnightly spraying had the lowest egg count and was statistically not different from weekly spraying. The no control had the highest spider count. The lowest spider count was recorded in

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the weekly spraying and was comparable with fortnightly spraying and the threshold method. For 2011 – 12 season significantly (p = 0.006) high crysopa egg count was recorded in the no spray and all other treatments were comparable (Table 8). The no control also recorded the highest crysopa larval count and also with the threshold method but significantly (p = 0.049) different weekly and fortnightly spraying. Ladybird beetle adult counts were highest in the no spray and were comparable with damaged squares. The threshold method, weekly and fortnightly spraying were comparable. The significantly (p = 0.006) low spider counts were recorded in fortnightly spraying and were statistically similar to weekly spraying and threshold method. The no control had the highest spider count and was comparable with damaged squares and threshold method.

*Table 7:* Mean accumulated count of predators 2012 -13 season on three sites

| Treatment | Crysopa eggs | Crysopa larvae | Ladybird larvae | Ladybird adult | Spiders |
|---|---|---|---|---|---|
| No control of bollworms | 5.75c | 1.08 | 1.17 | 1.08 | 6.67c |
| Threshold method | 6.25c | 0.50 | 1.33 | 1.08 | 4.08ab |
| Weekly spray | 4.00ab | 0.75 | 0.83 | 0.58 | 2.58a |
| Fortnightly spray | 3.333a | 1.33 | 0.50 | 1.33 | 3.58ab |
| Damaged square | 5.08bc | 0.75 | 1.00 | 0.67 | 5.08b |
| Mean | 4.88 | 0.88 | 0.97 | 0.95 | 4.40 |
| P-value | 0.003 | 0.410 | 0.171 | 0.196 | <.001 |
| LSD (0.05) | 1.620 | 0.796 | 0.683 | 0.728 | 1.527 |
| CV (%) | 20.8 | 38.3 | 26.2 | 29.1 | 21.7 |

*Means within a column not followed by a common letter are significantly different at 5% level by DMRT comparison*

*Table 8:* Mean accumulated count of predators 2011 -12 season on four sites

| Treatment | Crysopa eggs | Crysopa larvae | Ladybird larvae | Ladybird adult | Spiders |
|---|---|---|---|---|---|
| No control of bollworms | 11.50b | 2.13b | 4.50 | 4.56b | 7.25b |
| Threshold method | 8.69a | 1.56ab | 2.69 | 2.44a | 5.69ab |
| Weekly spray | 8.81a | 0.81a | 2.50 | 2.50a | 4.56a |
| Fortnightly spray | 7.63a | 1.00a | 3.31 | 2.38a | 4.50a |
| Damaged square | 8.81a | 1.31ab | 4.50 | 4.19b | 6.44b |
| Mean | 9.09 | 1.36 | 3.50 | 3.21 | 5.69 |
| P-value | 0.006 | 0.049 | 0.205 | 0.003 | 0.006 |
| LSD (0.05) | 2.207 | 0.912 | 1.822 | 1.351 | 1.681 |
| CV (%) | 18.2 | 37.8 | 39.1 | 28.2 | 21.6 |

*Means within a column not followed by a common letter are significantly different at 5% level by LSD comparison*



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*f) Effects of different spray timing methods on seed cotton yield*

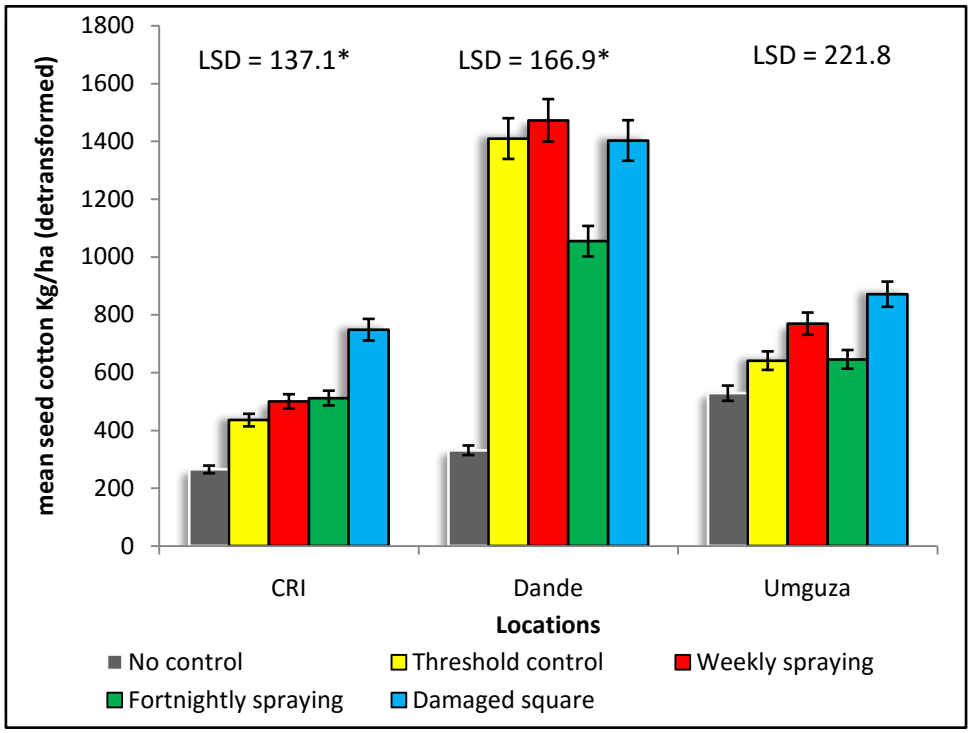


*Figure 1:* Mean seed cotton yield Kg/ha for 2012 – 13

Figure 1 displays seed cotton yield per hectare for CRI, Dande and Umguza. At Dande yield for control was significantly lower than all the other treatments, fortnightly spraying had intermediate yield while the threshold control, weekly spraying and spraying at first sight of damaged square had high seed cotton yields which were not significantly different from each other.

Comparison of seed cotton yield at CRI shows significant differences among treatment means with the control having the lowest yield. The intermediate yield was recorded for weekly spraying, fortnightly spraying and the threshold method. Significantly high yield was recorded in spraying at first sight of damaged squares or buds.

At Umguza the highest yield was recorded in spraying at first sight of damaged squares which was not significantly different from the threshold method, weekly and fortnightly spraying. The last three were also comparable to the control which recorded the lowest yield per hectare.



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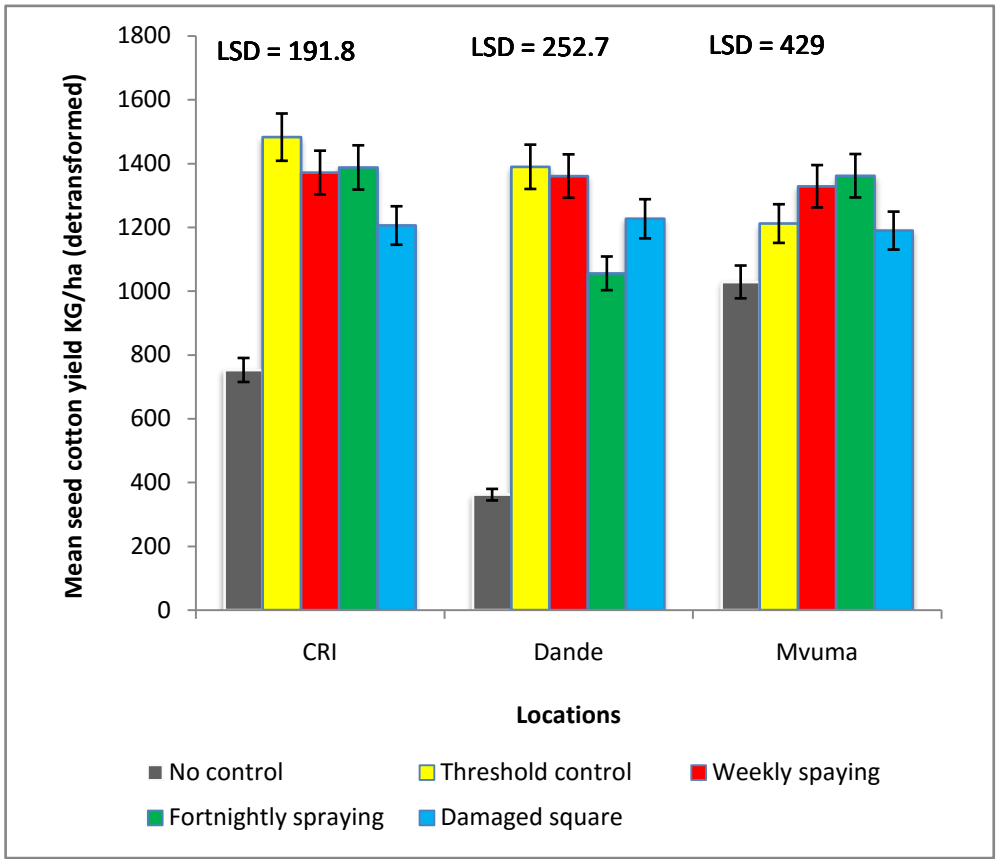


*Figure 2:* Mean seed cotton yield Kg/ha for 2011 – 12

Figure 2 displays seed cotton yield per hectare for Dande, CRI and Mvuma for 2011 to 2012 cropping season. At Dande yield for control was significantly lower than all the other treatments, fortnightly spraying had intermediate yield while the threshold control, weekly spraying and spraying at first sight of damaged square had high and comparable seed cotton yields. Comparison of seed cotton yield at CRI shows significant differences among treatment means with the control having the lowest yield. The intermediate yield was recorded for weekly spraying, fortnightly spraying and spraying at first sight of damaged squares whilst the highest yield was achieved in the threshold spraying but it was comparable to weekly and fortnightly spraying. Different spray timing methods did not produce significant differences for seed cotton yield at Mvuma. However biological differences were recorded; the order of yield was: no control of bollworms, spraying after noticing at least three damaged squares, threshold spraying, weekly spraying and fortnightly spraying, lowest to highest yield respectively. Generally, weekly and fortnightly spraying produced yields which were comparable to threshold method and sometimes higher. These spray timing methods were also effective in keeping lower counts of bollworm eggs and larvae when compared to the threshold method.

*g) Cost benefit analysis of weekly and fortnightly spraying*

An economic analysis of the weekly and fortnightly spraying shows that the two methods were more expensive than the standard method but the weekly spraying method was most expensive than both the methods (Table 6).

*Table 6:* Total variable costs (US$) associated with spray timing methods for 2012 – 13 season at CRI, Dande and Umguza

| Site/Treatment | ET | Weekly | Fortnightly | Difference with ET | |
|---|---|---|---|---|---|
| | | | | Weekly | Fortnightly |
| CRI | 1050.59 | 1202.94 | 1109.10 | (152.35) | (58.51) |
| Dande | 1139.02 | 1318.09 | 1143.19 | (179.05) | (4.17) |
| Umguza | 1071.00 | 1208.74 | 1088.83 | (137.74) | (17.83) |



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## IV. Discussion

The weekly spraying generally performed comparable to the recommended threshold method in keeping low counts of red and heliothis bollworm larvae. Red and African bollworm counts were low indicating good performance of pesticides. Fortnightly spraying had poor control of bollworms in most incidences owing to the fact that pest populations may rise significantly before sprays are applied. This finding is similar to that established in Zambia (Javaid, 2008). It was found out that routine spraying (such weekly and fortnightly) always gave low yields than scouting based sprays. *H. armigera* thresholds of 0.5 eggs per plant in Zambia are the same with those in Zimbabwe often described as 12 eggs per 24 plants (Cotton Growers Association, 1998; Javaid, 2008). Fortnightly spraying at Dande and Umguza had low yield owing to the fact that bollworm incidence, especially African bollworm were very high and thus the crop was exposed to pest damage for long before sprays could be applied. Routine sprays are not suitable because they increase the risks of environmental contamination because less than 1% of applied insecticides actually reach the target (Daka, 2003). A considerable proportion of the poison is deposited in water and soil bodies.

## V. Conclusion

The use of economic threshold for spray timing was the most effective in controlling bollworms, cheapest and spared more predators; it thus continues to be the best spray timing method for use by cotton farmers in Zimbabwe. The method is effective and cheap as compared to other methods.

## VI. Recommendation

Scouting for red and African bollworm eggs and spiny bollworm larvae should be done before any pesticide sprays can be done in cotton. Cotton growers should continue scouting their fields to determine bollworm infestation levels before applying pesticides.

*Competing interests*

The authors declare no competing interests

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## III. Acknowledgements

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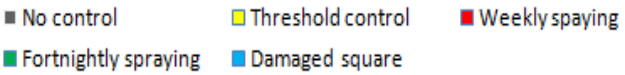
## References Références Referencias

1. ANR-0409 (2012) Cotton Scouting Handbook, Alabama Cooperative Extension System.
2. Boyd MI, Phipps BJ, Wrather AJ (2004) Integrated pest management Cotton pests scouting and management, MU Extension, University of Missouri-Columbia.
3. Cotton Growers Association (CGA). (1998) Cotton handbook, Zimbabwe. Revised Edition. *European Union.* Harare, Zimbabwe.
4. Daka PS (2003). A study of Deltamethrin in sediment from the Okavango delta - Botswana. Unpublished Masters Dissertation. University of Botswana.
5. Greene JK (2012) Cotton Insect Management, South Carolina Pest Management Handbook for field crops.
6. Javaid I (2008) Application of insecticides on cotton in Zambia: Timing of spray applications. *Tropical Pest Management.* Vol. 36 (1). DOI: 10.1080/09670879009371425
7. Jowah P (1994) Studies on timing of insecticide applications on small scale cotton farmers. A thesis submitted in partial fulfilment of the degree of Doctor of Philosophy of Crop Science. Faculty of Agriculture, University of Zimbabwe.

*Legend for seed cotton yield graphs (for Figure 1 and 2)*

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