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Management of Thrips (Thysanoptera: Thripidae) on French Beans (Fabaceae) in Kenya: Economics of Insecticide Applications

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Abstract: This study was conducted to measure economic benefit of using different spray schedules to control thrips on French beans. It was done using different spray regime scenarios of two insecticides: Lambda cyhalothrin (Karate 1.75% EC) and Methiocarb (Mesurol 500 SC). It is shown that increasing the number of sprays results to lower thrips infestations, explaining why local farmers practice calendar spraying. However, this lowers the net returns obtained from French bean sales. In contrast, application of one to two sprays maintains thrips below economic damage and provides the highest net returns. It is suggested that farmers should only use the effective insecticide after noting a density of three thrips per flower. This is possible if farmers embrace monitoring of thrips buildup on French beans.

Key words: Action threshold, economic damage, economic injury level, economic returns, *Frankliniella*, *Megalurothrips*

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) production in Kenya is mainly for export market, especially to European Union. More than 80% of French bean production is carried out by small-scale farmers, who have to maintain high quality standards of their produce to continue accessing the EU market. Among the main French bean pests, thrips cause the highest damage. Losses of more than 40% are reported at farm level due to abscission of buds and flower abortion and a further 20% at collection points due to blemishes and lesions formed by rasping feeding of thrips. Such losses make farmers rely heavily on insecticides to eliminate the thrips (Nderitu *et al*., 2001), similar to other areas in the world where French bean production is a major enterprise (Cardona and Corrales, 1992). Chemical insecticides offer the most effective control strategy of thrips and as such, it may be difficult to eradicate their use in thrips management. Farmers use them oblivion of the danger they pose on themselves, produce (residues), as well as environment. The available and suitable alternative of reducing high use of insecticides in agriculture is to advocate for their correct use and only when required, achieved by a shift from calendar sprays to a 'spray when necessary' regime. This can be achieved within a suitable integrated management strategy developed for thrips on French beans. Most

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studies in Africa report on the management of the legume flower thrips (*Megalurothrips sjostedti* Trybom) on wide range of crops, e.g., dry common beans (*P. vulgaris* L.) and cowpeas (*Vigna unguiculata* Walp.). While these crops are grown on seasonal basis (once or twice in a year), French beans are grown all year round, sometimes using irrigation to supplement rains. In addition, *M. sjostedti* is easily controlled by insecticides unlike *Frankliniella occidentalis* (Pergande), which is a new thrips pest in Kenya and is known to develop resistance against most insecticides (Jensen, 2000; Pablo *et al*., 2007). It is, therefore, imperative to determine the Action Threshold (AT) of these thrips pest on French beans for guiding farmers on when to apply insecticides. Action threshold of a pest is defined as the pest density that would warrant initiation of a control strategy, usually insecticide application (Dent, 2000). Measurement of AT requires knowledge of the economic injury level of the pest, which is the lowest number of the pest that would cause economic damage. Economic damage begins to occur when the cost (in terms of money) of suppressing the injury caused by the pest is equal to the potential monetary loss from the pest population (Larson, 2005). The aim of this study was to determine the spray regime that would provide a farmer the highest economic returns when controlling thrips on French beans. Such information would be an incentive to farmers to use insecticides wisely. This action, attained mainly through precision timing of sprays, is expected to improve their net income and ensure their produce meet export requirements and having assurance of continued market access.

MATERIALS AND METHODS

Crop Establishment

This field experiment was conducted at Mwea-Tebere, which is one of the major French bean growing areas in Kenya. In the research area, French beans are grown in the dry seasons to avoid flooding in rainy seasons. Farmers stagger plantings such that they have prolonged harvesting in a season. This study was established twice in the first dry season of 2002 (4 February and another set on 18 February). Seeds of Amy, the most grown variety in the research area, were hand-sown in plots of 5×5 m within a complete randomized block design layout with four replicates for each treatment. An alley of 2 m was maintained between plots and 5 m between blocks. Local agronomic practices were followed other than application of insecticides. Six treatments were applied to assess insecticide spray regime that a farmer would derive maximum net returns in a season and enable determination of the action threshold of thrips that would aid in deciding when to initiate the spray. Two insecticides were chosen from the local market: Methiocarb (Mesurol 500 SC; Carbamate) that was being advocated for use against thrips and Lambda (L) cyhalothrin (Karate 1.75% EC; Organophosphate) that was popular among farmers due to its low cost. The six spray regime included: Twelve, six, three, two applications of methiocarb, four applications of L-cyhalothrin and untreated French beans as control. Methiocarb was applied at the rate of 200 g ai ha^{-1} (40 mL/20 L water) while L-cyhalothrin was applied at the rate of 1 kg ha^{-1} (50 mL/20 L water) using different lever operated knapsack sprayer fitted with a cone nozzle 35 days after beans emergence.

Sampling

Thrips infesting French beans were randomly collected on 30 flowers and 30 leaves from inner rows of each plot and at the same time. This was done at an interval of three days after first treatment applications and continued throughout the flowering period. To compare the impact of the two insecticides on thrips, similar number of samples was collected just before applying insecticide and 24 h after. Samples were preserved with 70% ethyl alcohol solution for processing. In the laboratory, leaves and flowers were washed thoroughly with 70% ethyl alcohol solution to ensure no thrips were discarded. The content of each sample was poured on a petri dish with square grids engraved on the bottom to facilitate thrips counting under a dissecting microscope. Adult thrips were separated to

F. occidentalis and *M. sjostedti* species, but larvae were not identified to species level, they were grouped together (as immatures) for analysis. After attaining the required size and age, French bean pods were harvest from each plot and separated to two grades: marketable (export market) and non marketable (reject).

The value of the commodity was used to determine economic damage of thrips. This was important in determining the economic injury level and the action threshold of thrips on French beans. The ordinary linear regression analysis was employed for these analyses. First the gross Marginal Rates of Return (MRR) that would explain the profitability of each spray regime were measured. The net returns were then calculated by subtracting the cost incurred for each spray regime used from the corresponding gross returns obtained from selling French bean pods. The farm gate price of French beans fresh pods at the time of the experiment was Kenya shillings (Ksh.) 30.00 per kg. The cost of 1 L Mesurol 500 SC was Ksh. 3, 000.00 and 1 L Karate 1.75% EC was Ksh. 2,500.00. Marginal rate of returns was calculated as the change in returns as a result of a small change in the cost incurred for insecticide spray regime. Those MRR less than unity (1) were considered unprofitable (Mukankusi *et al*., 1999).

Economic Damage (ED) due to thrips was calculated as, ED (kg ha^{-1}) = cost of chemical control (Ksh ha^{-1}) divided by the wholesale value of French beans (Ksh kg^{-1}). The Economic Injury Level (EIL) of thrips was determined from the equation, $Y = a+bx$ (or $x = -(a-y)/b$), where a is the expected yield at zero infestation level and Y is the yield below which the value of crop loss is greater than the cost of chemical control (Stewart and Khattat, 1980). The value (a-Y) in real terms is the economic damage. Therefore EIL, x, = -(ED/b (negative term)) or x = ED/slope of regression line (which is taken as a positive term). Finally, AT calculations were aided by use of guidelines laid out by Reichelderfer *et al*. (1984). It is the point where the curve of EIL against cost of pesticide control (positively sloping) meets the curve of EIL against the net returns (negatively sloping).

Data were analyzed using Genstat statistical package version 7.1. Analysis of variance was done and F-test was used to test significance at 95% level. Means were separated by use of Standard Error (SE) of means.

RESULTS

The effects of the insecticides in the two plantings sessions was not significantly different although more thrips were recorded in the first planting. However, this was only so for *F. occidentalis* and immatures, as *M. sjostedti* were more in the second planting (Table 1). Methiocarb sprays resulted to a decline in the populations of all the thrips compared with sprays of L-cyhalothrin, which had no significant effects, with the number of thrips recorded being similar to those collected in the unsprayed plots. However, L-cyhalothrin was able to significantly reduce infestations of *M. sjostedti*. It was also clearly observed that fewer thrips were present in flowers of French beans that received higher frequency of methiocarb application. As expected, thrips declined significantly and drastically 24 h

Table 1: Mean number of thrips infesting French bean flowers in two planting sessions at Mwea-Tebere, Central Kenya in 2002 under different insecticide application regimes

		Planting 1				Planting 2			
Treatments	No. of sprays	*F. occidentalis*	*M. sjostedti*	Immatures	Total thrips	*F. occidentalis*	*M. sjostedti*	Immatures	Total thrips
Methiocarb	12	8.8	0.3	4.7	13.8	10.9	1.0	8.3	20.2
Methiocarb	6	17.5	1.2	10.0	28.7	27.0	3.5	24.3	54.8
Methiocarb	3	34.6	2.0	28.3	64.9	31.6	6.8	34.7	73.1
Methiocarb	2	37.7	2.4	24.9	65.0	33.6	6.9	29.4	69.9
L-cyhalothrin	4	64.1	1.9	77.2	143.3	37.3	4.8	32.7	74.8
No spray	-	53.3	9.5	60.1	122.9	38.7	5.6	35.2	79.5
P		***	***	***	***	***	***	***	***
SED		4.6	0.2	0.6	10.9	2.9	0.2	4.5	7.2

***: Significant at 99% level

Table 2: Mean number of thrips on leaves of French beans in two planting sessions at Mwea-Tebere, Central Kenya, 2002 under different treatments

Treatments	No. of sprays	Planting 1 *F. occidentalis*	*M. sjostedti*	Immatures	Total thrips	Planting 2 *F. occidentalis*	*M. sjostedti*	Immatures	Total thrips
Methiocarb	12	0.8	0.00	1.0	1.8	0.5	0.00	1.10	1.7
Methiocarb	6	2.1	0.30	3.1	5.6	2.0	0.00	2.40	4.4
Methiocarb	3	3.4	0.04	5.8	9.3	3.7	0.20	4.60	8.4
Methiocarb	2	3.6	0.20	5.0	8.8	4.3	0.00	4.40	8.7
L-cyhalothrin	4	4.6	0.10	6.7	11.3	4.5	0.00	4.90	9.3
No spray	-	4.7	0.30	5.1	10.0	3.6	0.08	4.10	7.8
P		***	**	***	***	***	***	***	***
SED		0.5	0.05	0.6	1.0	0.5	0.03	0.60	0.9

,*: Significant at 95 and 99% level, respectively

Table 3: Mean number of French bean pods/10 plants in a plot and their weight (g) from different treatments in two planting sessions at Mwea-Tebere, Central Kenya, 2002

Treatments	No. of sprays	Planting 1 No. of pods	Marketable weight (g)	Unmarketable weight (g)	Planting 2 No. of pods	Marketable weight (g)	Unmarketable weight (g)
Methiocarb	12.0	94.1	1068.0	275.0	63.8	267.0	42.5
Methiocarb	6.0	83.4	922.0	331.0	86.2	544.0	64.4
Methiocarb	3.0	96.1	907.0	308.0	105.4	783.0	111.6
Methiocarb	2.0	79.0	949.0	331.0	115.9	714.0	67.0
Lambda cyhalothrin	4.0	83.0	766.0	283.0	96.9	641.0	74.5
No spray	-	89.0	806.0	317.0	81.1	425.0	50.2
P		**	**	NS	**	**	NS
SE	6.5		98.4	46.5	180.7	3.3	25.2

**: Significant at 95% level; NS: Not Significant

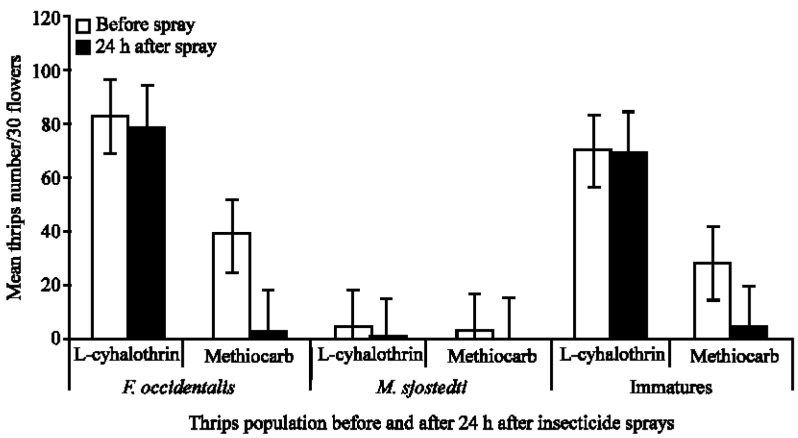

Fig. 1: Mean number of flower thrips (± SE) on French bean flowers just before and 24 h after application of insecticide sprays, at Mwea-Tebere, Central Kenya

after spray application (Fig. 1). However, this was only observed in Methiocarb-treated plots. Treatment of L-cyhalothrin was only effective against *M. sjostedti*.

Thrips infestation on French bean leaves was lower than in flowers, as expected a priori (Table 2). The density of *M. sjostedti* on leaves was lower than those of *F. occidentalis,* similar to observations in flowers. However, the number of immatures was higher than the adult thrips in both plantings. It was observed that the number of thrips collected in leaves reduced with increased number of methiocarb sprays similar to the trend in flowers.

In terms of yield, there was significant difference ($p<0.05$) on the mean number of pods harvested from ten random plants per plot under different treatments in both plantings (Table 3). Similarly, the weight of marketable pods (fit for export market) was significantly different among the treatments. Although plots treated with L-cyhalothrin had similar number of pods as plots that received six sprays

Table 4: Mean yield of French beans, cost of sprays and marginal rate of return for different chemical spray schedules, at Mwea-Tebere, Central Kenya

Treatments	No. of sprays	Total ai (kg)	Yield (kg ha^{-1})	Gross return (Ksh ha^{-1})	Cost of sprays	Net return	Marginal rate of return
Methiocarb	12	2.40	427.2	12, 816.00	14,400.00	-1,584.00	-0.1
Methiocarb	6	1.20	368.8	11,064.00	7,200.00	3,864.00	0.5
Methiocarb	3	0.60	362.8	10,884.00	3,600.00	7,2884.00	2.0
Methiocarb	2	0.40	379.6	11,388.00	2,400.00	8,988.00	3.8
Lambda cyhalothrin	4	0.26	306.4	9,192.00	6,500.00	2,692.00	0.4

- = Negative

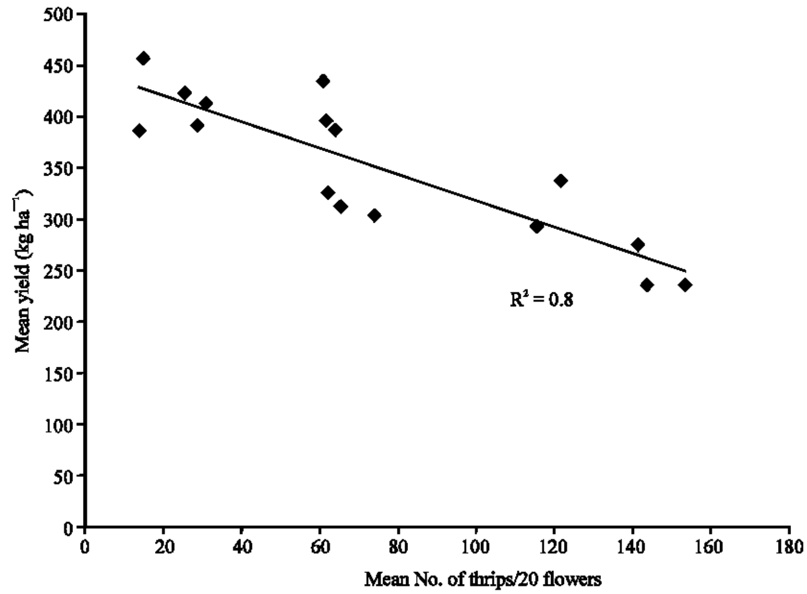

Fig. 2: Regression of French bean yield against mean number of thrips on French bean flowers at Mwea-Tebere, Central Kenya

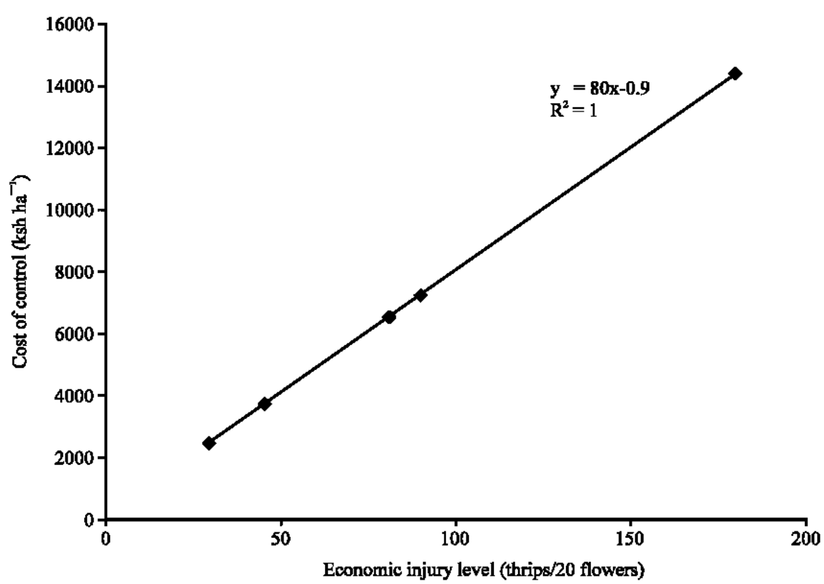

Fig. 3: Economic injury levels of flower thrips infesting French beans against the cost of thrips control, at Mwea-Tebere, Central Kenya

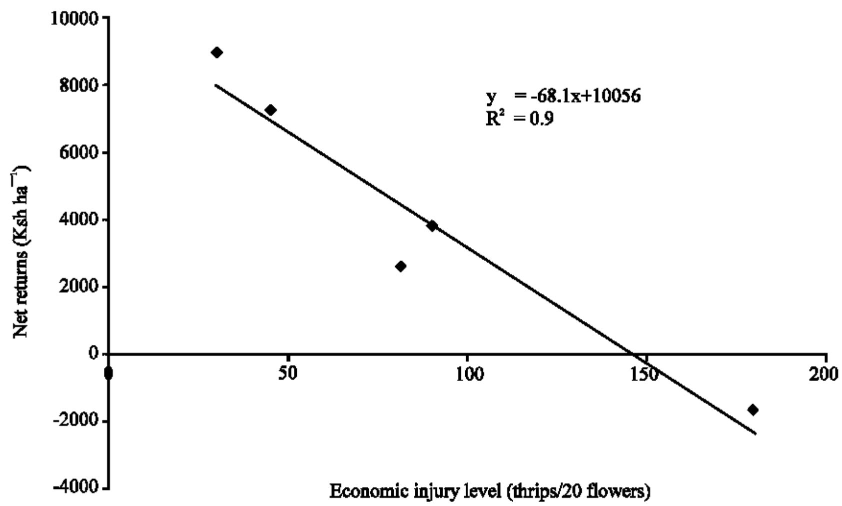

Fig. 4: Economic injury levels of flower thrips infesting French beans against the net returns from French bean yield, at Mwea-Tebere, Central Kenya

of methiocarb, they had the least weight of the marketable grade. Plots that received 12 sprays of methiocarb recorded the highest weight of marketable pods among the treatments. However, there was no significant difference among the treatments in the weight of the non marketable grade.

The number of sprays influenced thrips density differently and in effect resulted to significant French bean yield differences (Table 4). Although higher yields were recorded on plots that received many sprays, net returns from such plots were lower due to the increased cost of the insecticides. It is shown that two sprays of methiocarb were the most economical as they resulted to the highest marginal rate of return. Figure 2 expresses the linear function of French bean yield against thrips population. It shows declining yields of French beans as the number of thrips density increased, as expected.

The cost of thrips control using insecticides was linearly and positively related to the economic injury levels (EILs) of thrips infesting French bean flowers (Fig. 3). It was observed that the higher the EILs, the higher the cost of thrips control. In contrast, the net returns of French bean yield had linear and negative relationship with the EILs of flower thrips (Fig. 4). Using the equations of Fig. 3 and 4, it was possible to estimate the AT of thrips on French beans. At the point where they meet, the cost of the action taken to control thrips is equal to the net returns realized from French bean sales, i.e., $80x-0.9 = -68.1x+10056$. Solving this equation, $x = 0$, which is the number of thrips/flower of French beans that should warrant chemical application to minimize their population increase.

DISCUSSION

The results showed that methiocarb was effective in controlling all thrips compared with L-cyhalothrin, which was only capable of reducing *M. sjostedti* density. The effectiveness of L-cyhalothrin on *M. sjostedti* has been known for sometime now, especially on dry common beans and cowpeas (Amatobi, 1994; Kibata and Anyango, 1996; Marquini *et al*., 2002) and has been one of the reasons why this insecticide is popular among farmers for general control of thrips pests although some recent findings have shown it is not worth to use it in French beans (Kasina *et al*., 2006; Nderitu *et al*., 2007). The appearance of *F. occidentalis* in Kenya late 1980s challenged prevailing control options that were mainly based on insecticides. Most insecticides available locally were ineffective or too expensive for farmers to purchase. They resulted to calendar and many sprays in a season hoping to eliminate the pest (Nderitu *et al*., 2001) but this has been impossible as *F. occidentalis* builds resistance fast (Amatobi, 1995; Herron and Gullick, 2001). The findings from this present study confirm effectiveness of methiocarb against *F. occidentalis* on different crops (Robb *et al*., 1995; Denholm *et al*., 1998; Jensen, 2000). This study also showed that high number of methiocarb sprays lowers thrips population on French beans. For example, twelve sprays of methiocarb reduced thrips population to almost zero compared with its two applications, which recorded some thrips number. This provides some justifications why farmers opt for many sprays in a season although they do not consider the insecticide effectiveness, potential of resistance build up by pest, as well as the economic returns. The current world-wide trend in pest control entails minimization of economic damage by the pest with low applications of pesticides. This would enable the farmer to reap maximum profits as the cost of insecticides is lowered. The results of this present study revealed that although thrips population on French beans sprayed twice in a season was higher than on French beans sprayed six and twelve times, the net benefit that would accrue to the farmer was the highest. This implies that if farmers consider economic returns, then they would be well off if they use fewer sprays. Likewise, they have to accept some level of thrips density on French beans and not to aspire for their total elimination. Some previous studies also recommended less than three sprays of the effective insecticide against *M. sjostedti* infesting cowpeas, suggesting that it would be more profitable to the farmer and would keep the pest below economic injury level (Bal, 1991; Alghali, 1992; Nabirye *et al*., 2003). Other than economic benefit, few applications of insecticides have health benefits. For example, the green pods of French beans are harvested as the crop continues to flower and as such few applications would not endanger pickers. Likewise, few sprays minimize likelihood of pesticide residues on the produce, ground water contamination, environmental pollution, as well as the effects on natural enemies. To achieve these few sprays, farmers should be guided by the thrips density. This present study found that three thrips per flower would warrant use of an effective insecticide to bring the number down. This implies that farmers should monitor thrips build up in the season and only use insecticide when thrips attain the AT level. About three thrips per flower have also been reported as AT of thrips on cowpeas and cucumber (Bal, 1991; Salifu, 1992; Shipp *et al*., 2000). This present study emphasizes monitoring of thrips on French beans so that farmers are guided by the population build up, unlike use of calendar sprays. This is possible as farmers know thrips pests, which they can easily identify (Nderitu *et al*., 2001). It is emphasized that only the effective insecticide should be used when thrips reach AT level, so that one application will be enough. Therefore, French bean farmers can gain from the industry economically if they reduce the number of sprays, achieved through use of AT levels of thrips.

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