Efficacy of the insecticide IMIDOR SL 200 (Neonicotinoid) against the mirids of cocoa (Theobroma cocoa Variety Amelonado) in center Côte D'Ivoire

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Mirids
Cocoa tree

ABSTRACT
The aim of this study was to test the efficacy of new kinds of insecticides i.e. Neonicotinoids on cocoa mirids to confirm the minimum effective dose of IMIDOR SL 200 and to determine the number of treatments applied per year following the development of the population over time after spraying the insecticide. Study was conducted in the center of Ivory Coast in state owned plantations in Tournokro near Yamoussoukro. Results of the study revealed that mirids have found generally very sensitive to various level of insecticide used. The efficacy of IMIDOR SL 200 substance proved best @ doses of 0.175 L/ha and 0.150 L/ha, and it is showing effectiveness just like CABOSSE PLUS 50 EC and CONFIDOR. These substances effectively control mirids. The recommended minimum dose that controls at least 90% of mirids was 0.150 L/ha or 30 g.ai/ha. From the results of the study it can be concluded that two times per year application are sufficient to protect cocoa trees against mirids.

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1 Introduction

The cocoa tree (Theobroma cocoa L.) is an important crop worldwide (Thresh et al., 1988). In 2013, the cocoa production in Africa was estimated 2.813 million tons, i.e. 71%, for a global production (Anonymous, 2013). Côte d’Ivoire alone has produced 37 to 40% of the total world production, i.e. a production of around 1.4 million tons (Anonymous, 2013). This crop contributes total 15% in GDP of Côte d’Ivoire (ICCO, 2006; Anonymous 2014) and thus stands as one of the most important pillars for the Ivorian economy. Above mentioned facts are enough to prove the importance the this crop in Côte d’Ivoire, but recently cocoa growing regions are now facing several constraints such as ageing plantations and the pressure of the pests on the crops. Among these mirids, represent a major scourge harmful to cocoa growing in the world (Lavabre, 1977; Wheeler, 2000; Cassis & Shuch, 2012).

The mirids grubs feeds on the sap of young twigs and pods that they sting. Their bites create black spots on pods that eventually make them to rot in case of recurrent attacks. Then, young twigs and suckers become dry. This results in low yields of the cocoa crops and poor quality of cocoa beans. The solution that has always been considered as the most affective to fight against cocoa mirids is to use of insecticides (Sonwa et al., 2008). However, it was found that regular use of these insecticides developed resistance against organophosphates in target organisms (Bisseleua et al., 2011). Now, most of products used against cocoa mirids are of the neonicotinoid family and cause a systemic action. Aim of the present work was to assess the efficacy of IMIDOR SL 200, minimum effective dose, number of treatment required every year and to evaluate the efficacy of this products on other cocoa pests.

2 Materials and Methods

2.1 The study site

The studies were conducted from August 2010 to January 2011 in the state owned plantations in Toumokro (7 ° 15'N - 5 ° 28' W) near Yamoussoukro in the center of Côte d’Ivoire. The local climate is called “baouléen” and is characterized by a humid tropical seasonal variation (Ardoin-Bardin, 2004) with two seasons viz rainy season (April to October) and dry season (November to March). The average annual rainfall is below 1100 mm. The average monthly temperature ranges between 22 - 31°C. The relative humidity varies between 75 and 85% (Ardoin-Bardin, 2004).

The plant material used was the cocoa tree Theobroma cocoa, variety Amelonado (Malvaceae). This variety widely cultivated in industrial and local plantations for high yield. The plantation of cocoa surveyed hasn’t been treated for last ten years.

2.2 Insecticides

The insecticides tested were IMIDOR, CONFIDOR, and CABOSSE PLUS. With regard IMIDOR, three doses were used (0.125 L/ha, 0.150 L/ha and 0.175 L/ha). The formulations and active ingredient of insecticides are given in table 1.

2.3 Experimental design

The experimental was designed in randomized complete block design with 5 treatments with 3 repetitions. Three insecticides were tested: IMIDOR, CONFIDOR and CABOSSE PLUS.

A basic plot covering 300 m2 (20 x 15 m) with 40 trees. The basic plots are separated from each other by a strip of at least 10 m wide. Six treatments were performed and compared with the control trees.

2.4 Application of Insecticides and monitoring of insect’s populations

Before applying insecticides, trees were observed to determine the initial population of mirids present. For this study, the treatments were started from the threshold of two mirid per tree. The cocoao trees were treated two times viz the first treatment has given in the month of July and August while the second treatments has been given in the month of December and January. These periods correspond to the peaks of pullulations of mirids.

After giving treatments, the insect’s population was monitored every month. For this purpose five different mirids host trees were selected from each of the treated plots. The day before treatment, tarpaulins 16 m2 (4m x 4m) were plated directly above the marked trees. Insecticides were applied by using a SOLO based spray; total 40 liters of insecticide were sprayed per hectare.

Table 1 Different formulation of insecticides, chemical group and their concentrations used.

<table>
<thead>
<tr>
<th>Entry Name</th>
<th>Formulation</th>
<th>Active ingredient</th>
<th>Chemical group</th>
<th>Tested doses</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMIDOR</td>
<td>200 SL</td>
<td>Imidacloprid</td>
<td>Neonicotinoids</td>
<td>0.125 L/ha, 0.150 L/ha and 0.175 L/ha</td>
</tr>
<tr>
<td>CONFIDOR</td>
<td>200 SL</td>
<td>Imidacloprid</td>
<td>Neonicotinoids</td>
<td>0.125 L/ha</td>
</tr>
<tr>
<td>CABOSSE PLUS</td>
<td>50 EC</td>
<td>Imidacloprid (30 g/l) and Bifenthrine (20 g/l)</td>
<td>Neonicotinoids</td>
<td>0.500 L/ha</td>
</tr>
</tbody>
</table>

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http://www.jebas.org
The treatment was done at early morning between 6 am and 9 am, according to the standard method. The counting of dead mirids has been done after 5 h, 24 h, 48 h, 96 h and 120 h of treatments applying. The counting of insects killed by leaching was done 5 h after these treatments. Insects are collected and stored in pill alcohol 70°C and grouped by type of treatment. After 120 h, the PROTEUS 170 O-TEQ (double dose) was applied to the same five trees sheeted, with goal to kill insects spared.

2.5 Assessing the efficacy of different chemicals

After each sampling, the efficacy rate of each product has been calculated by the below mentioned formulas:

\[
\% \text{ Efficacy} = \left( \frac{M_k}{M_k + M_I} \right) \times 100
\]

Where,

- \(M_k\) = number of mirids killed by the chemicals applied
- \(M_I\) = number of mirids killed by leaching
- \(M_k + M_I\) = total number of mirids killed

2.6 Data Analysis

The collected data have been analyzed by the “Statistica” software (version 7.0) by one way analysis of variance (ANOVA), was performed. They made it possible by separate the various averages obtained using Duncan and the Newman-Keuls tests at the selected threshold probability of \(p < 0.05\).

3 Results

3.1 Initial population of mirids

The level of mirids infestation in basic plots was assessed on monthly basis. Thus, from the third month, the population of mirids started increasing in the plots treated with IMIDOR SL 200 @ 0.125 L/ha. While the Plots treated by IMIDOR SL 200 @ 0.175 L/ha and reference products (CONFIDOR 200 SL @ 0.125 L/ha and “CABOSSE PLUS 50 EC” @ a dose of 0.500 L/ha) have less than 2 mirids per tree (Figure 1). From the fourth month, the mirids thresholds per tree were started increasing and reached more than two in all the treated plots. While in case of untreated plots, the mirids damage threshold was continually increased till fifth month. Based on the information generated, needs of the insecticide application was felt and it can be recommended that insecticides should be used as per the threshold levels. The number of mirids per tree remained within the damage threshold for all the treatment except for IMIDOR SL 200 @ 0.125 L/ha for this treatment threshold value was above the reference value. Thus, treatments with IMIDOR SL 200 @ 0.150 L/ha and IMIDOR SL 200 @ 0.175 L/ha in the month of “July-August” helps in protected the cocoa against mirids’ attacks until the second treatment that was performed in “December-January”. Two treatments per year were enough to protect trees when the IMIDOR @ 0.150 L/ha or 0.175 L/ha is used. The CONFIDOR 200 SL @ 0.125 L/ha and CABOSSE PLUS 50 EC @ 0.500 L/ha are good reference.

![Figure 1 Number of mirids (grubs + adults) at each leaching in order to induce the treatment.](http://www.jebas.org)
3.2 Development of mirids populations after initiating the treatment

The Student Newman Keuls (SNK) multiple comparisons test at the 5% threshold indicates that highest reduction (p <0.0049) in the average numbers of mirids was reported in the treatment of IMIDOR SL 200 @ 0.150 L/ha, this reduction was followed by the IMIDOR SL 200 @ 0.175 L/ha treatment from the third month, which reflecting a resurgence of mirids (Table 2). Mirids outbreaks continued within the fourth and fifth months, indicating that “IMIDOR SL 200” based products at 0.150 L/ha and 0.175 L/ha have a persistence of three months. Products CONFIDOR 200 SL, 0.125 L/ha and CABOSSE PLUS 50 EC at 0.500 L/ha proved their effective control over mirids (Table 1). Significant differences (P <0.0001) were observed between the untreated control and all the insecticides treatments, since the first month of leaching until the end of the experiment (5 months). The only significant differences between the various treatments by insecticides were observed between the 4th and 5th month.

3.3 Mirids’ mortality (grubs + adults) during the different treatments over time

An analysis of variance based on the combined populations of mirids and grubs in treated and untreated plots revealed that mortality rates were low during the early hours for all treatment with IMIDOR SL 200, irrespective of the dose. In contrast, the mortality rate was quite high for treatment containing CONFIDOR 200 SL @ 0.125 L/ha and CABOSSE PLUS 50 EC @ 0.500 L/ha with respective values of 36% and 41% (Table 3). After 72 hours, all treatment reached over 55% cumulative mortality for treatment containing IMIDOR SL 200 and the mortality rate reached 100% for the reference products i.e. CONFIDOR 200 SL @ 0.125 L/ha and CABOSSE PLUS 50 EC @ 0.500 L/ha. The active ingredient of IMIDOR SL 200 indisputably performs effectively on mirids after 48 h. These observations would suggest that the selected doses of IMIDOR SL 200 were quite effective against the mirids.

3.4 Assessment of the efficacy of different chemicals on mirids

All the treatments containing insecticides except IMIDOR SL 200 at 0.125 L/ha were performed effectively against mirids. Indeed, the efficacy percentages obtained were higher than reference value (90%). Treatment with IMIDOR SL 200 @ 0.125 L/ha and CONFIDOR @ 0.125 L/ha were the most effective and owing the percentages of 94% (Figure 2). These treatments are followed by CABOSSE PLUS 50 EC @ 0.5 L/ha and IMIDOR SL 200 @ 0.150 L/ha with efficiencies of 92% on the mirids.

Table 2 Effect of various treatments on the development of mirids populations (grubs + adults).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>1st month</th>
<th>2nd month</th>
<th>3rd month</th>
<th>4th month</th>
<th>5th month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated control tree</td>
<td>15</td>
<td>12</td>
<td>14</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>IMIDOR SL 200 @ 0.125 L/ha</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>IMIDOR SL 200 @ 0.150 L/ha</td>
<td>0</td>
<td>1</td>
<td>9</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>IMIDOR SL 200 @ 0.175 L/ha</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>10</td>
<td>17</td>
</tr>
<tr>
<td>CONFIDOR 200 SL @ 0.125 L/ha</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>CABOSSE PLUS 50 EC @ 0.5 L/ha</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.66</td>
<td>1.11</td>
<td>2.06</td>
<td>1.74</td>
<td>2.98</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>24.69</td>
<td>39.2</td>
<td>22.37</td>
<td>14.35</td>
<td>17.48</td>
</tr>
<tr>
<td>Associated probability with repetitions</td>
<td>0.3541</td>
<td>0.6772</td>
<td>0.2126</td>
<td>0.417</td>
<td>0.9057</td>
</tr>
<tr>
<td>Associated probability to products (p)</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0049</td>
<td>0.0001</td>
<td>0.0118</td>
</tr>
</tbody>
</table>

The value given in tables are the mean of three replicates, averages followed by the same letter in the same column are not significantly different. The averages comparisons are performed only when the associated probability is less than or equal to 0.05

Table 3 Percentage mortality of mirids with different insecticides per time slots (h).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>5h – 24 h</th>
<th>48h – 72h</th>
<th>96h – 120h</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMIDOR SL 200 @ 0.125 L/ha</td>
<td>4%</td>
<td>55%</td>
<td>100%</td>
</tr>
<tr>
<td>IMIDOR SL 200 @ 0.150 L/ha</td>
<td>10%</td>
<td>61%</td>
<td>100%</td>
</tr>
<tr>
<td>IMIDOR SL 200 @ 0.175 L/ha</td>
<td>7%</td>
<td>59%</td>
<td>100%</td>
</tr>
<tr>
<td>CONFIDOR 200 SL @ 0.125 L/ha</td>
<td>36%</td>
<td>100%</td>
<td>-</td>
</tr>
<tr>
<td>CABOSSE PLUS 50 EC @ 0.5 L/ha</td>
<td>41%</td>
<td>100%</td>
<td>-</td>
</tr>
</tbody>
</table>
Discussion

The results of the study suggested that IMIDOR SL 200 was highly effective as the CONFIDOR 200 SL and CABOSSE PLUS 50 EC against Mirids, only few exceptions was reported. Similar types of results were obtained at field level plantation and at laboratory level by many authors in previous studies on the same active ingredient, but at varying doses (NGuessan & Coulibaly, 2000; Gerken et al., 2001; Asogwa et al., 2004, Asogwa et al., 2006; Anikwé et al., 2009). A total of 238 mirids were collected when the plots were treated by IMIDOR SL 200 with three different doses while this number was only 125 in the plots treated by two reference products. These results are in agreement with Anikwé et al. (2009). The only difference being that these authors conducted four successive treatments compared to our study in which only two treatments were performed. Furthermore, results of the present study confirmed that two treatments per year would be sufficient to protect cocoa trees against mirids. The efficacy of IMIDOR SL 200 would decrease over time and this would be a good reference chemical against mirids. Previous tests performed with neonicotinoids and imidacloprid on mirids and other Hemipteras highlight the Knockdown effect of these chemicals (Biney, 2005; Asogwa et al., 2006; Anikwé & Okelana, 2009). It is well established that efficacy of these chemicals decreased with the time.

These insecticides caused mortality rate of over 95%, after 24 hours of the treatment (Biney, 2005; Asogwa et al., 2006; Dwomoh et al., 2007; Anikwé et al., 2009). According to Anikwé et al., (2009), the insecticide ‘Actara 25 W/G’ would perform effectively on adult mirids than on nymphs. The neonicotinoids act on acetylcholine receptors, resulting in paralysis of the nervous system of the insect leading to the death (NRA, 2001; Dwomoh & Boakye, 2003). The applied doses of insecticides also played a very significant role in the efficacy of a product. Results of this study suggest the required dose of IMIDOR SL 200 @ 0.175 L/ha compared to 6g/L in the work of Anikwé et al., (2009), in Nigeria. The vegetative state of the plots treated with IMIDOR SL 200 suggests that this product could be considered in the fight against this complex pest of young cocoa trees and saplings in the nursery. These same remarks were made for the chemicals such as CONFIDOR 200 SL and Proteus 170 O-TEQ (Kenne et al., 2003; Dormon et al., 2007; Asogwa & Dongoh, 2009). The synthetic pyrethroids generally proved less effective than carbamates and organophosphates and they are not generally used in the “anti-mirid” fight (Ojoladé et al., 2005; Anikwé et al., 2009).

From past few years, the active ingredients of the neonicotinoids family including thiamethoxam and imidacloprid, entered the chemical pesticides market intended for the cocoa cultivation. These active materials have the advantage of being less toxic and highly systemic thereby making them fit for use with hand pressure sprayer (Opokou et al., 2006; Babin, 2009). All the products used, as well as the reference a substance seems to perform very effectively on the cocoa pests; namely mirids populations.

The second treatment provides 100% mortality of mirids because the spreading was heavy. Insects are especially intoxicated by inhalation or contact, so that re-infection might be due to migrant adults or molting insects at the time of

Figure 2 Efficacy of tested insecticides on the mirid populations (in percentage) after 120 h of application.
applying the treatment. Poisoning by ingestion seldom occurs, but we still don’t know about the behavior of the insect in the presence of dew drops that may contain suspension or emulsion of lethal doses. So, it makes sense to eliminate all grubs turned into females before they become able to lay eggs.

Conclusions

The use of insecticides has always been and is still the most widely used method in the fight against cocoa mirids. Indeed, these pests proved to be generally very sensitive to the different active ingredients used. The efficacy of chemical ingredients IMIDOR SL 200-based was reported highest at doses of 0.175 L/ha and 0.150 L/ha, just like those of ‘CABOSSE PLUS 50 EC’ and CONFIDOR 200 SL. These substances effectively control mirids. The recommended dose that can controls at least 90% of mirids is 0.150 L/ha, i.e. 30 g.m²/ha. Two treatments per year are sufficient to protect cocoa trees against mirids. Pest control should be conducted according to treatment schedules based on a thorough knowledge of seasonal variations in populations of mirids. Thus, the most widely recommended schedule, suggests a treatment during the populations’ growing period (June-July) and another application of insecticide after the harvest (November-December) so as to limit attacks on the foliage of cocoa trees, which are the most damaging to culture. It is recommended that each insecticide application includes two separated treatments of one month interval; the second treatment is meant to remove grubs emerging from eggs that survived the first treatment.

References


