Research Article

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Comparative Efficiency Of Abamectin, Cropping Seasons And Yellow Sticky Trap On *Bemisia Tabaci* Gennadius, Biotope B (Hemiptera: Aleyrodidae) Infestation Of Tomato (*Solanum Lycopersicum l.*) In The Highlands Of Cameroon

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Efficience comparée d'abamectine, de saisons culturales et de piège collante jaune sur l'infestation de Bemisia Tabaci Gennadius, Biotope B (Hemiptera: Aleyrodidae) sur la Tomate (Solanum Lycopersicum l.) dans les hautes terres de l'Ouest Cameroun

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ABSTRACT

This study was conducted in the field at the University of Dschang Research and Application Farm from November 2019 to February 2020 and March to June 2020 to tests the effects of combining sticky traps with the bioinsecticide treatment abamectin on whitefly populations. The randomized complete block design with three replications was used. Treatments were abamectin 2.5 ml; 3.5 ml; 4.5 ml; 5.5ml and positive control (IMIDACHLOPRID and LAMBDACYHALOTHRIN). Two weeks after transplanting, the number of adults caught by the yellow sticky trap was collected every four days. The number of eggs and adults on the plants, the total number of leaflets and rolled leaflets were taken every week on five plants. Collection of fresh weight of harvested fruits was done once a week from the 49^{th} Day After Transplanting. The results showed that the whitefly was present in the field, with capture by the yellow sticky trap being more important in the dry season than in the rainy season, with a peak at 42 and 54 DAT respectively. The dry season and the plot without traps were more infested (44%), with the highest numbers of eggs and adults, respectively 58% and 45%. The average yield in $t.ha^{-1}$ is low, that is 1.07 $t.ha^{-1}$ in the wet season and 0.89 $t.ha^{-1}$ in the dry season; with a higher average in the plots with traps. The 2.5 ml Abamectin dose recorded more eggs. The 3.5-4.5ml dose recorded more *Bemisia tabaci* adults, less leaflet infestation and more yield. The used of sticky yellow trap in the field combine with abamectin can be recommend as an effective method for control of whiteflies.

Key words: Abamectin, yellow sticky trap, whitefly (*Bemisia tabaci*), tomato (*Solanum lycopersicum L.*), cultural season

Résumé

Cette étude vise à évaluer l'efficience d'abamectine et du piège jaune collant sur la mouche blanche de la tomate. L'essai a été implanté sur deux parcelles distantes de 20 m à Dschang en saison sèche et pluvieuse avec une équipée de pièges collantes. Le dispositif a été en blocks complets randomisés avec trois répétitions et cinq traitements (abamectine 2,5 ml ; 3,5 ml; 4,5 ml ; 5,5ml et l'IMIDACHLOPRIDE et LAMBDACYHALOTHRINE). Deux semaines après repiquage, le nombre d'adultes capturés par le piège a été collecté tous les quatre jours. L'effectif d'œufs et d'adultes sur les plants, le nombre total de folioles et celles enroulées ont été prises chaque semaine sur cinq plants. Le poids frais des fruits récoltés a été faite une fois par semaine à partir du 49^{e} Jour Après Repiquage. Les résultats ont montré que la mouche blanche a été présente, leur capture par le piège jaune collant étant plus importante en saison sèche qu'en saison humide, avec un pic à 42 et à 54 Jours Après Repiquage respectivement. La saison sèche et la parcelle sans pièges ont été plus infestées (44%), avec un effectif d'œufs et d'adultes plus important, respectivement 58% et 45%. Le rendement moyen en $t.ha^{-1}$ est faible, il est de 1,07 $t.ha^{-1}$ en saison humide et de 0,89 $t.ha^{-1}$ en saison sèche; avec les parcelles avec pièges plus productives. La dose d'Abamectine 2,5 ml a enregistré plus d'œufs. Celles 3,5-4,5 ml plus d'adultes de *Bemisia tabaci*, moins d'infestation des folioles et plus de rendement. L'emploi des pièges collants jaune combiné à l'application d'abamectine est recommandé comme moyen de lutte efficace contre la mouche blanche en champ.

Mots clés : Abamectine, piège collant jaune, mouche blanche (*Bemisia tabaci*), tomate (*Solanum lycopersicum L.*), saison culturale.

Introduction

The agricultural sector is one of the pillars of the economy in almost every country in the world, as it employs 70% of the working population in Cameroon and contributes to the growth of other economic sectors (Sonkwa, 2016). It has much strength and is both traditional and modern, despite many problems. In addition to cash crops, there are also food crops, including market garden produce, which play an important role (Blancard, 2009).

The tomato (*Solanum lycopersicum L.*) is a herbaceous plant, widely cultivated for its fruit, consumed in the household in fresh or processed form (Boa, 2016). It is the second most consumed vegetable in the world after the potato (Fondio *et al.*, 2013). Its global production has increased rapidly over the last decade, from 141.4 million tonnes in 2009 to 177 million tonnes in 2016 (FAO, 2018). It is distributed as follows: Asia: 45%, Europe: 22%, Africa: 12%, North America: 11%, South and Central America: 8% (Planetoscope, 2012). Its global average yield is estimated at 37.6 $t.ha^{-1}$ (FAOSTAT, 2017) and thus 20.4 $t.ha^{-1}$ in Africa (Planetoscope, 2016). It is in fact an important vegetable crop, as it is not only considered a source of vitamins, but also a source of income and a major contributor to food security (Qessaoui et *al.*, 2020). In Cameroon, fresh tomato production is estimated at about 1.3 million tonnes in 2017, for a total cultivated area of 105561 ha, or a yield of 12.1 $t.ha^{-1}$ (FAOSTAT, 2017). It is therefore an important fruiting vegetable in Cameroonian agriculture.

There are many constraints to tomato production, including the whitefly *Bemisia tabaci* (Gennadius, 1889), an insect of the order Hemiptera and family Aleyrodidae (Qessaoui *et al.*, 2020). This pest can cause damage by feeding, causing honeydew, transmitting more than 111 species of plant pathogenic viruses and inducing physiological disorders in plants. Global losses caused by this pest exceed US$ 300 million per year or about CFAF 170 billion (Qessaoui *et al.*, 2020). The actual number of biotypes of this pest is unknown, but 24 different biotypes have been identified, of which biotype B is the most severe and widespread (Perring, 2001; Magali, 2011). *B. tabaci*, especially biotype B, is difficult to control because of its high resistance to many commercially available insecticides, its wide host range and its rapid development and reproduction (He and Huang, 2005). In China, as in most African countries, the control of *B. tabaci* is mainly based on chemical insecticides, which has caused many serious problems, including environmental pollution (Ren *et al.*, 2001). There is a need to explore some non-chemical methods to effectively control this pest and to significantly reduce the spraying of chemical insecticides. Integrated Pest Management (IPM) is traditionally discussed in this perspective. This concept proposes chemical, biological and even physical management strategies to solve specific phytosanitary problems in a given socioeconomic and environmental context (Vuillaume, 2007). Thus, the University of Dschang (UDs) via the Faculty of Agronomy and Agricultural Sciences (FAAS) in partnership with RUSSEL IPM, has included in its training programme experimental research of agronomic interest, specifically Integrated Pest Management (IPM). Indeed, RUSSEL IPM, a British company, is a developer of Integrated Pest Management technologies, that manufactures and markets biopesticide products and chromatic and/or pheromone traps throughout the world and particularly in Cameroon.

Yellow sticky traps are a commonly used method for monitoring and controlling certain pests, particularly whiteflies. They can significantly reduce the density of *B. tabaci* in the field. The combination of yellow sticky traps and parasitoids has proven to be an effective method to control *B. tabaci* (Yaobin *et al.*, 2012). Here we test the efficiency of another control strategy: the combination of yellow sticky traps with bioinsecticides that include abamectin. The overall objective of this study is to contribute to the increase of tomato productivity in Cameroon. More specifically, to determine the impact of sticky traps on the whitefly population and also to evaluate the effect of abamectin as an alternative bioinsecticide to chemical insecticide on the *B. tabaci* population.

1. Materials and methods

1.1. Material

The trial was conducted in the field at the Research and Application Farm (RAF) of the Faculty of Agronomy and Agricultural Sciences (FAAS) of the University of Dschang (UDs); located at an altitude of about 1380 m and situated between 10006'329" East longitude and 5044'524" North latitude. It has a tropical, humid monsoon climate (Figure 1).

The tomato variety, Cobra F1 hybrid, was the only plant material for this trial. The agricultural inputs were organic manure (chicken droppings) and chemical fertilizer (NPK 20-10-10 and 12-14-19) at

5 $t.ha^{-1}$ and 240 $kg.ha^{-1}$ respectively; a chemical insecticide (Parastar; Imidacloprid and Lambdacyhalothrin) and a bioinsecticide (Abac; Abamectin); yellow sticky trap; and small tools for plant maintenance. Parastar is the most used chemical insecticide by producers against white flies.

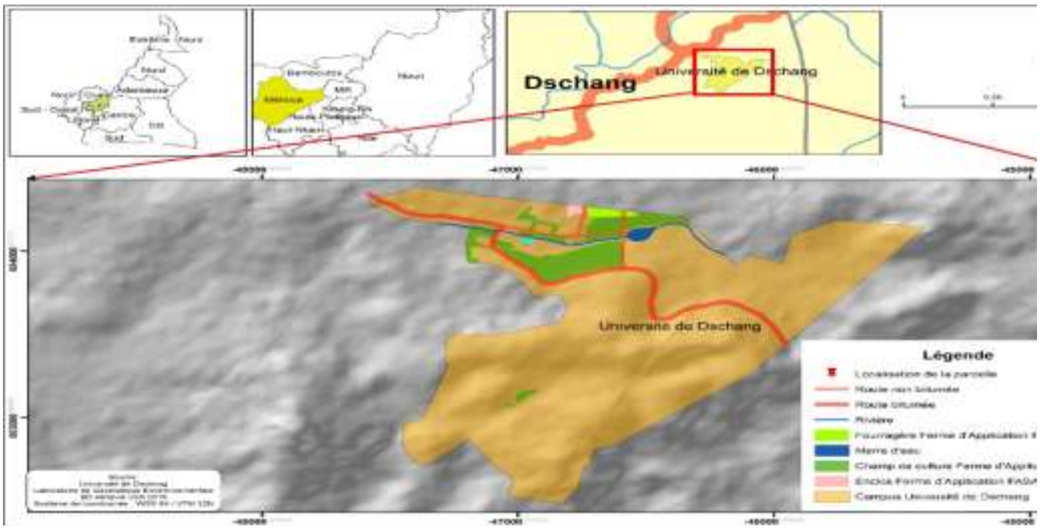


Figure 1: Map of the Application and Research Farm of the University of Dschang

1.2. Methods

Experimental setup

The trial was conducted in the field over two seasons: from November 2019 to February 2020 (dry season) and from March to June 2020 (wet season). The randomised complete block design with 3 replicates was choose. Five treatments including four different doses of bioinsecticide:

- T_1 =2.5 ml,
- T_2 =3.5 ml,
- T_3 =4.5 ml,
- T_4 =5.5 ml and
- T_5 =50 g/15 l H20, one dose of chemical insecticide (control plot, producers insecticide) were tested.

The total area of 264 m^2 subdivided into two plots of 132 m^2 each and at least 20 m apart was used. On one of them, yellow traps were installed for comparison purpose.

Conduct of the trial

For each trial, a nursery (1 m wide by 2 m long) was installed and amended (with 5 t.ha of chicken droppings^{-1}) on specially prepared areas. Sowing was done in rows and then covered with a thin layer of soil. Twenty to thirty days after sowing, the plants were ready to be transplanted. For plant protection, the plants were treated twice with a chemical insecticide (Parastar 40Wettable Powder, WP) and a fungicide (Monchamp 720WP). A mosquito net was used to completely cover the nursery to avoid attacks by certain pests.

The experimental plot was carried out in several operations: site preparation (weeding, ploughing, staking, making the beds and forming the pits); transplanting; fertilisation; phytosanitary protection (insecticide and fungicide treatments; as well as the installation of a trapping device); maintenance; irrigation and harvesting.

Data collection

On each plot, observations and measurements were made on the total number of *B. tabaci* adults caught by the yellow sticky trap; the abundance of *B. tabaci* eggs and adults; the total number of leaflets per plant as well as the rolled ones; and the fresh weight of the harvested fruits (Figure 2).

The assessment of adults caught by yellow sticky traps of 3.6 m^2 each, was done every four days, starting at 14 Days After Transplanting (DAT).

The abundance of *B. tabaci* on the experimental site was determined once a week from 21st DAT, by counting whitefly eggs and adults on the sampled plants between 7:00 and 9:00 am. Whiteflies were almost always found on the underside of the leaves.

The determination of the rate of infestation of leaflets by *B. tabaci* was done by counting the total leaflets and those showing symptoms of leaf blade rolling upwards. This was done throughout the development cycle of the plant, once a week from 21 DAT. The infestation was characterised by a general reduction in plant growth, with reduced leaf blades curled upwards.

The production evaluation consisted of harvesting ripe fruit per treatment from 49 DAT and weighing them with a 0.05 g precision scale during the four harvests.

The data obtained were processed in Microsoft Office Excel 2007 programs, as well as in JMP 8.0.2 Software. Statistical analyses based on the descriptive statistics (mean, standard deviation) of each of the variables were performed. An analysis of variance was performed to detect whether there was a significant difference or not between the treatments tested during the experiment for a measured or observed parameter. For significant variables, the Student or HSD Tukey test was used to separate the means into homogeneous groups at the 5% level.

Figure 2: *Bemisia tabaci* adults on sticky trap (a); Bemisia *tabaci* eggs (b); *Bemisia tabaci* adults underside of leaflets (c); Curled leaflets (d) and weighing of fresh weight of harvested fruits (e).

3. Results

3.1 Total number of *Bemisia tabaci* adults caught by the yellow sticky trap as a function of time.

The catches of *B. tabaci* adults (Figure 3) change in a sawtooth pattern over time during both seasons, with a higher number of individuals in the dry season than in the wet season. In the dry season, the first capture (14^{th} DAT) is about 1400 individuals on a total surface of 28.8 m^2. From the 14^{th} to the 18^{th} DAT, the number of adults caught dropped considerably (about 1000 individuals less). Thereafter, the number of adults caught increased continuously until it reached a peak at the 42^{nd} DAT; then it decreased successively after this peak. Whereas in the rainy season, the number of catches gradually increases to reach the peak at the 54^{th} DAT and then decreases.

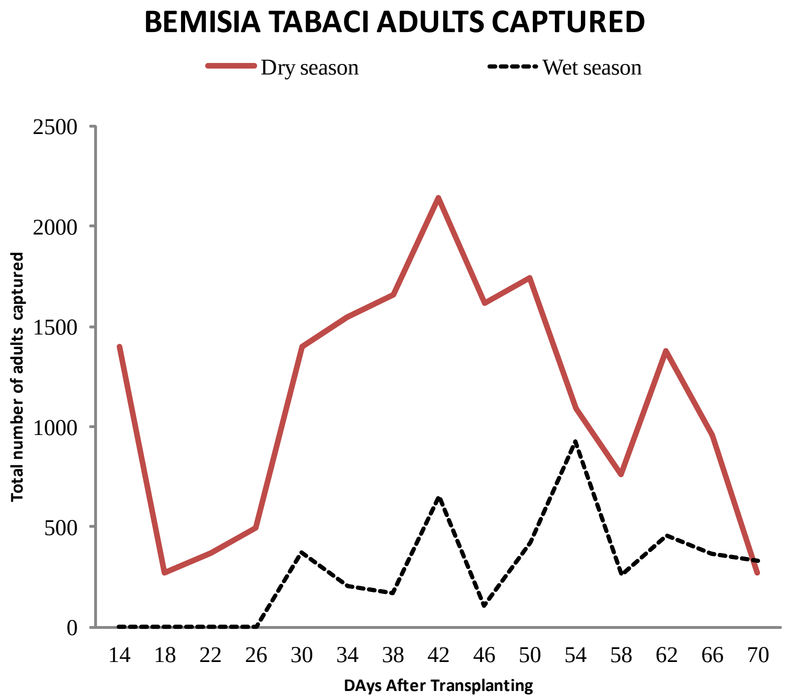
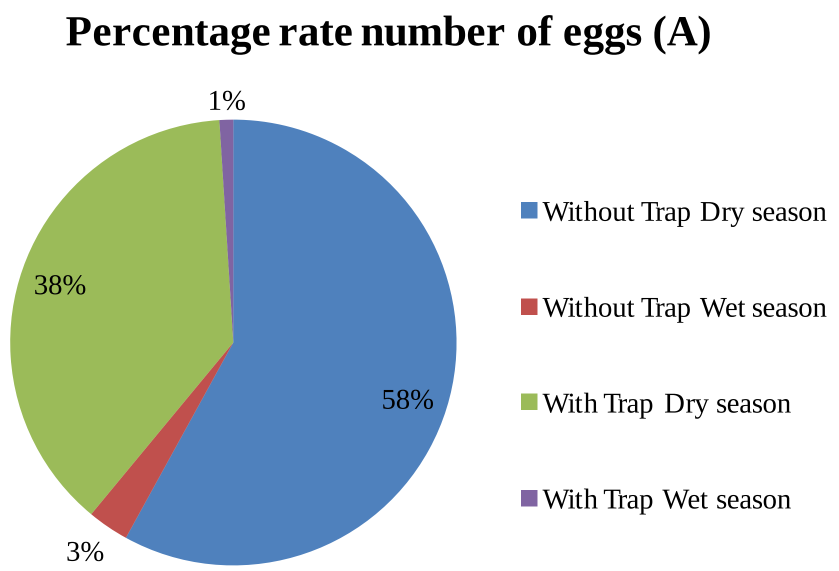


Figure 3: Evolution of the total number of *Bemisia tabaci* adults caught over time.

3.2 Effect of seasons and traps

3.2.1. Average abundance of eggs and adults of *Bemisia tabaci* according to seasons and traps

The number of eggs and adults (Figure 4) was higher in the dry season (on average 96% and 69% respectively) than in the wet season (4% eggs and 31% adults) and higher in the plot without traps (62% eggs and 65% adults) than in the plot with traps (39% and 44%). The analysis of variance of the egg results reveals that the average number of *B. tabaci* eggs varies significantly according to the seasons (degree of freedom=2; F=298.59; P<.0001*). On the other hand, the effect of the seasons*traps interaction was not significant. Concerning adults, the results of the statistical test indicate that the number of mobile *B. tabaci* adults differed by season and trap (degree of freedom=1; F=5.0612; P=0.0246*).



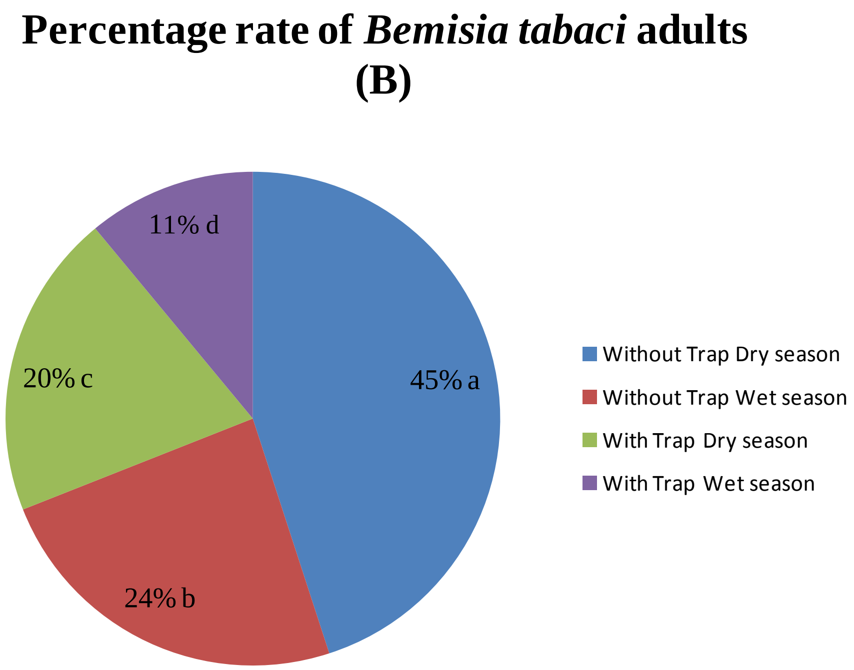
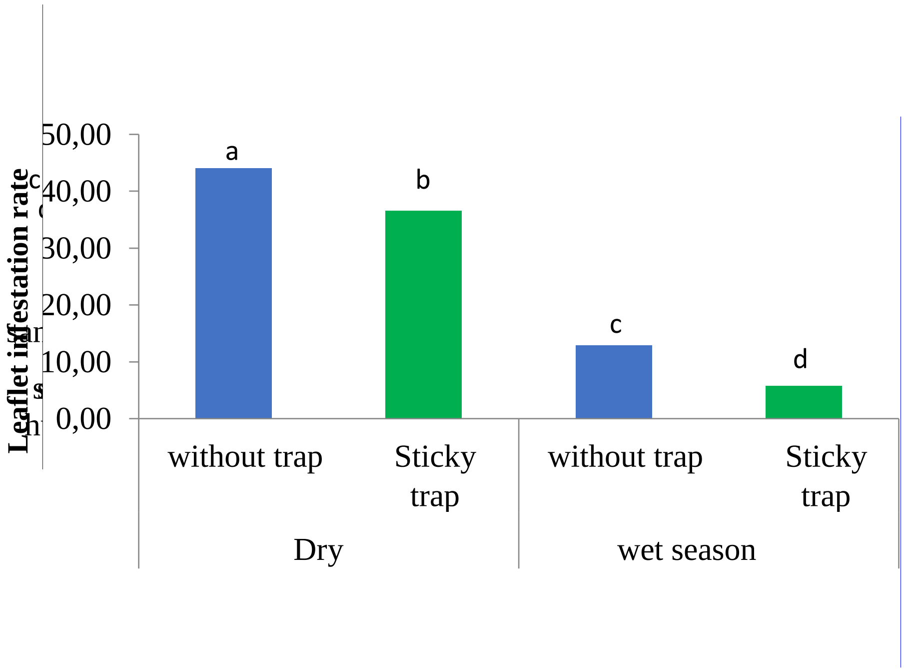


Figure 4: Average number of eggs (A) and adults of *Bemisia tabaci* (B) according to seasons and traps

3.2.2. Average leaflet infestation rate according to seasons and traps

The average leaflet infestation rate (Figure 5) was higher in the dry season than in the wet season, with a higher average on the plots without yellow traps. In the dry season, the average infestation rate was 44% in the plot without traps and 37% in the plot with traps. In the wet season, this rate decreased to 13% on the plot without traps and 6% on the plot with traps. The results of the analysis of variance show that the infestation rate varies significantly according to the seasons (degree of freedom=1; F=1018.143; P<.0001*) and the traps (degree of freedom=1; F=43.1735; P<.0001*). However, the interaction seasons and traps is not significant.



Means followed by the same letter are not significantly different in the HSD (Honestly Significant Difference) Tukey test ($P \leq 0.05$).

Figure 5: Average leaflet infestation rate according to seasons and traps.

3.2.3. Increase of the leaflet infestation rate by *Bemisia tabaci* as the function of time.

The infestation rate in function of time (Figure 6) shows a gradual increase during the dry season; with a stabilisation at 60 DAT on the plot with traps, compared to a jagged evolution in the wet season, and a cancellation around 63 DAT on the plot with traps. For both plots with and without yellow sticky traps, , the maximum infestation rate is about 77% in the dry season; in the wet season it is 35% in the plot without traps and 18% in the plot with traps. In fact, in the dry season on the plot without traps, from the 21st to 25th DAT the infestation rate decreases, then increases continuously; contrary to a linear increase on the plot with traps. In the wet season, on the other hand, the same pattern is observed regardless of the traps: a first peak at 42 DAT and a second at 56 DAT.

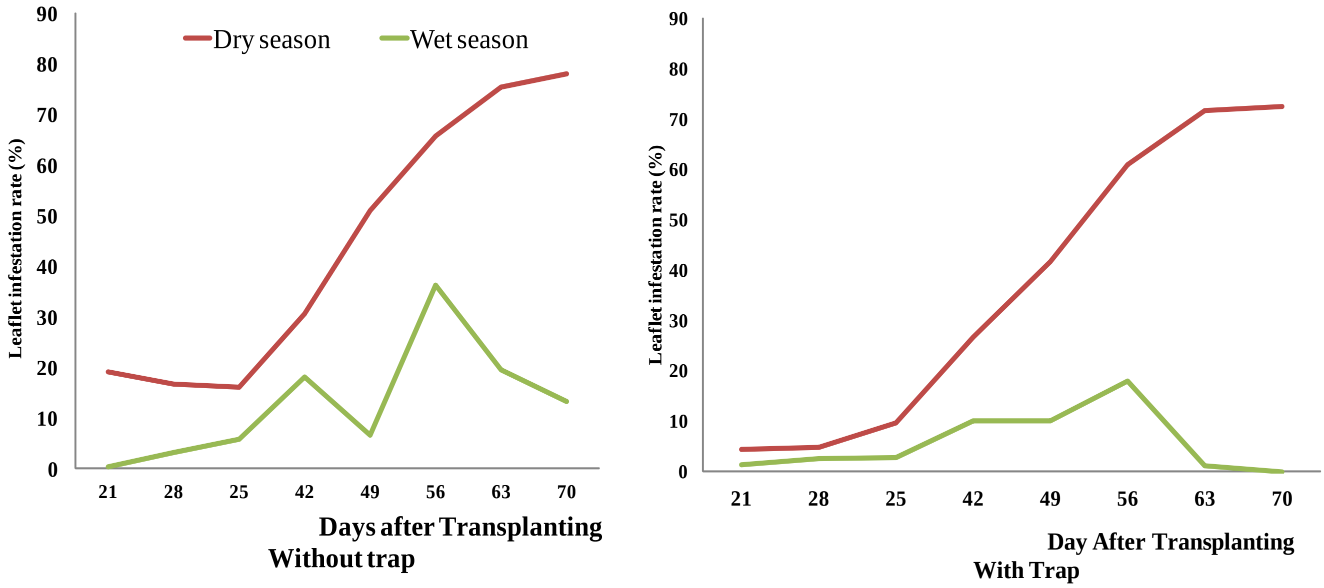


Figure 6: Change in the leaflet infestation rate as a function of the Days After Transplanting.

3.2.4. Average yields according to seasons and traps

The average yield in $t.ha^{-1}$ (Table 1) is low, at 1.07 $t.ha^{-1}$ in the wet season and 0.89 $t.ha^{-1}$ in the dry season, with a higher average in the plot with traps. The analysis of variance indicates a significant difference between the average fruit yield (degree of freedom=3; F=29.35779; P=0.0039*) by season and trap.

Table 1: Average fruit yield ($t.ha^{-1}$) according to seasons, traps and harvests.

Average yield ($t.ha^{-1}$)	Dry season		Wet season	
	Without traps	With traps	Without traps	With traps
First Harvest	0.24±0.10	0.36±0.11	0.37±0.05	0.36±0.12
Secund harvest	0.19±0.06	0.32±0.09	0.88±0.21	0.96±0.23
Thrid harvest	0.66±0.15	2.07±0.27	0.58±0.09	2.32±0.25
Forth harvest	0.13±0.09	3.21±0.35	0.59±0.18	2.57±0.30
Average	**0.30±0.10^b**	**1.49±0.21^a**	**0.60±0.13^b**	**1.55±0.26^a**

*Means followed by the same letter in the column are not significantly different in the HSD Tukey test ($P \leq 0.05$).

3.3 Effect of seasons, yellow sticky traps and treatments

3.3.1. Average abundance of eggs and adults of *Bemisia tabaci*, and average leaflet infestation rate according to seasons, traps and treatments.

With the exception of the 2.5 ml Abamectin (T1), all other treatments did not allow egg development (Figure 7). In the dry season the 3.5 ml Abac and 4.5 ml Abac treatments had more *B. tabaci* adults. These same treatments resulted in less leaflet infestation rate by *B. tabaci* adults. The analysis of variance of these results shows that the effect of the interaction seasons*traps*treatments is not significant on the number of eggs. On the other hand, the number of mobile adults of *Bemisia tabaci*, varied significantly according to the seasons*traps*treatments (degree of freedom=4; F=2.6736; P=0.0305*). The infestation rate differed by season and trap but the interaction of season*trap*treatment was not statistically significant.

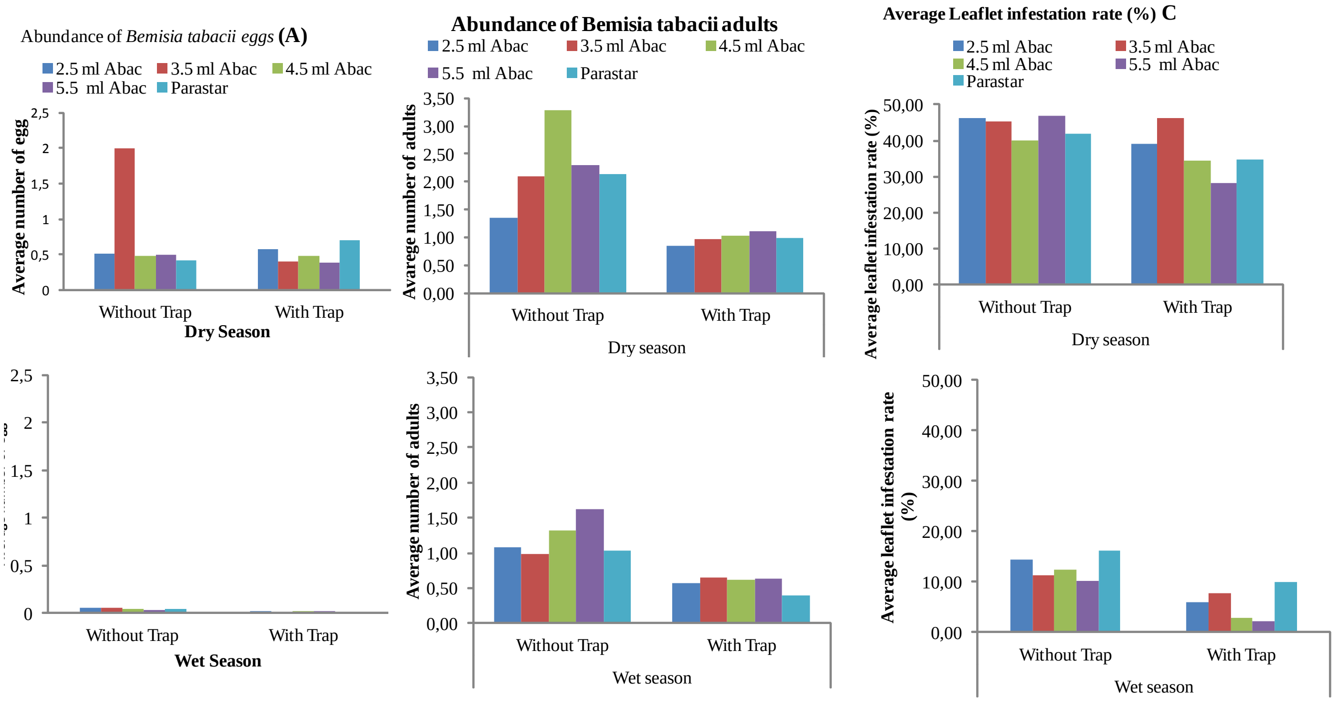


Figure 7: Average abundance of eggs (A), adults of *Bemisia tabaci* (B) and average leaflet infestation per season (C) per trap and per treatments

3.3.2. Fruit yields in relation to seasons, traps and insecticide treatments

In the dry season and on the plot without traps, the T3 insecticide treatment has the highest fruit yield and T1 the lowest; in contrast to the T3 and T5 insecticide treatments respectively on the plot with traps (Table 2). In the wet season, the treatments T2 and T3 were used on the plot without traps and the treatments 3.5 ml and 5.5 ml on the plot with traps. Thus the dose of abamectin that gives the best fruit yields is 3.5-4.5 ml. The analysis of variance indicates that the average total fruit yield differs between seasons and traps.

Table 2: Average total yield by season, trap and treatment

Season	Trap	Average total yield (t/ha) by insecticide treatments				
		2.5 ml (T1)	3.5 ml (T2)	4.5 ml (T3)	5.5 ml (T4)	Parastar (T5)
Dry season	**Without traps**	0.00 ±0.00	0.32±0.15[ab]	0.43±0.18[a]	0.35±0.12[ab]	0.42±0.10[a]
	With traps	1.16±0.34[a]	1.66±0.45[a]	1.85±0.55[a]	1.72±0.53[a]	1.06±0.27[a]
Average		**0.58±0.17[a]**	**0.99±0.27[a]**	**1.14±0.32[a]**	**1.03±0.30[a]**	**0.74±0.16[a]**
Wet season	**Without traps**	0.50±0.14[a]	0.80±0.21[a]	0.45±0.10[a]	0.48±0.14[a]	0.79±0.22[a]
	With traps	1.57±0.35[a]	1.75±0.40[a]	1.48±0.35[a]	1.37±0.39[a]	1.59±0.42[a]
Average		**1.03±0.22[a]**	**1.27±0.24[a]**	**0.97±0.21[a]**	**0.92±0.22[a]**	**1.19±0.25[a]**

*Means followed by the same letter on the line are not significantly different in the HSD Tukey test ($P \leq 0.05$).

4. Discussion

The total number of whitefly adults caught is greater in the dry season than in the wet season. This could be explained by two main reasons. The first is that in the dry season, the insects multiply by parthenogenesis, which considerably increases the population. The second reason is that in the wet season the populations of *B. tabaci* decrease due to the high mortality caused by the rains. This corroborates with the results obtained on cotton in Ivory Coast by Didi *et al*. (2018). In the dry season, the first capture (14th Day After Transplanting) is about 1400 individuals on a total area of 28.8 m^2; and drops suddenly from the 14th to the 18th DAT. This could be due to the fact that the trap captured the majority of whitefly in the surrounding area, especially in the maize plot (whitefly trap plant) located near the experimental site. In the wet season the number of captures was zero from the 14th to the 26th day. This could be justified by the global health situation (Corona Virus) which prevented the collection of whitefly. The increase in the number of captures thereafter could be justified by the physiological age of the plant. Soro *et al.* (2017) demonstrated that mobile forms of *B. tabaci* are numerous when the vegetation of tomato plants is dense. Peak captures are at the 42nd and the 54th respectively in the dry and wet seasons. These results are close to those of N'zi *et al*. (2019) on tomato in Ivory Coast. According to these authors, during fruiting of the plants, the quantity of essential amino acids is important, thus offering a better nutritional quality towards insects. The decrease in catches after these peaks could be justified by the effect of the trap. Park *et al* (2010) demonstrated that yellow sticky traps significantly reduce the density of *B. tabaci* in the field and in the greenhouse.

The number of eggs and adults, as well as the average infestation rate on leaflets is higher in the dry season than in the wet season, with a higher average on the plots without yellow traps. It is therefore possible that, although some adults were caught by the yellow sticky traps, others landed on the plants and caused infestations on the leaflets. Yaobin *et al* (2012) had similar results on Eggplant in China.

The leaflet infestation rate increases progressively during the dry season with a stabilisation at the 63rd DAT on the plot with traps, compared to a jagged evolution in the wet season, and a cancellation around the 63rd DAT on the plot with traps. The shape of these curves could be justified by theses reasons: the effectiveness of the trap, which stabilized the fly population at the end of the crop in the dry season; the rains interrupted the insect's life cycle (suppressing oviposition, increasing adult mortality) and consequently slowed down the evolution of leaf infestation. The increase in the rate of leaflet infestation over time may be due to the growth stage of the plant. In other words, the size of the plant translated by more leaves and leaflets, also the flowering and fruiting period. These results are similar to those obtained by Scharma *et al*. (2017) on tomato in India. Helden & Halder (1986) and Bokombola & Balomba (2019) also thought that, when climatic conditions are not too bad, the whitefly population increases until the third month after sowing, after which the number of flies decreases.

The yield is low, although in the wet season it is a bit higher and the average higher on the plots with traps. This could be justified by the high infestation of whitefly. Soro *et al* (2007) have shown that if the whitefly infestation reaches 75%, the yield of the plants will be zero.

With the exception of the 2.5 ml Abac insecticide treatment, all other treatments induced the development of fewer eggs. In the dry season, the 3.5 ml Abac and 4.5 ml Abac treatments had more *B. tabaci* adults. It would appear that these two previous treatments resulted in less infestation of leaflets by *B. tabaci* adults, and resulted in the highest fruit yields. This confirms the efficacy of the insecticide abamectin in managing sucking insects compared to the positive control. These results are similar to those of Kumer *et al*. (2017) on ornamentals in Florida and Sharma *et al.* (2017) on tomato in India, who showed that the Avermectin insecticides in general and abacmectin in particular control 85 and 95% of these insects.

Yields are low no matter the treatments. This could be justified by the fact that all treatments were infested by other pests, notably *Tuta absoluta* and fruit fly, in the dry season; and downy mildew, in the wet season; which led to rotting and fruit drop overall.

5. Conclusion

The objective of this study was to determine the combined effect of yellow sticky traps on the whitefly population and the efficacy of different doses of abamectin on whiteflies. At the end of the investigations, it was found that yellow sticky traps significantly reduced the white fly population in the field during both cropping seasons. Plots that received yellow sticky traps were less infested than those that were not trapped. Abamectin doses of 3.5 ml and 4.5 ml had a significant effect on eggs and adults of *Bemisia tabaci*. This was reflected in a low leaflet infestation rate and a high fresh weight yield of fruit as well as parastar the insecticide used by the growers. At the end of the investigations, we can recommend Abamectin at its two doses as bioinsecticide against the white fly during the two growing seasons. It is important to specify that the applications must begin before 25 days after the transplantation and continue during the flowering and the fruiting. Thus, in an IPM program, the chemical insecticide parastar can be used before flowering and abamectin during and after flowering until harvest.

Thanks

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