International Journal of Zoology Studies
www.zoologyjournals.com
ISSN: 2455-7269
Received: 05-05-2026, Accepted: 05-06-2026, Published: 20-06-2026
Volume 11, Issue 2, 2026, Page No. 149-154

Field evaluation of the efficacy of new chemical and biological molecules against *Amrasca biguttula* in the central cotton-growing region of Senegal

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DOI: https://doi.org/10.66856/ijzs.2026.11.2.11057

Abstract
The 2022/2023 cotton season was marked by severe and persistent infestations by a new species of leafhopper, *Amrasca biguttula* (Ishida), commonly known as the Indian cotton leafhopper. Production losses caused by this species are estimated at over 50% compared to the season's forecast. This study aimed to evaluate the biological efficacy of new chemical and biological compounds against infestations of *A. biguttula* in Senegal's cotton-growing region. Seven chemical insecticide formulations and one biological formulation based on Azadirachtin were tested using randomized complete block design with three replications. Field efficacy was of each formulation was evaluated by comparing leafhopper infestation following insecticide applications. The treatment effects were analyzed using an analysis of variance (ANOVA). The results show that the formulations Plinazolin 40 g/ha, Dinotefuran 110 g/l + Bifenthrin 27.5 g/ha; Nitenpyram 75 g/ha + Pyriproxyfen 75 g/ha + Indoxacarb 25 g/ha, Fluxamethamide 30 g/ha and Flonicamid 50 g/ha + Indoxacarb 30 g/ha, demonstrate a good level of control over *A. biguttula*. The best yields were also observed with these formulations. The insecticide combinations Acetamiprid 30 g/ha + Indoxacarb 25 g/ha, Sulfoxaflor 20 g/ha + Emamectin benzoate 10 g/ha and Azadirachtin-10 g/ha show a low efficacy against leafhoppers. The effective formulations could be used alternately in leafhopper control programmes to manage resistance in these pests in cotton-growing areas.

Keywords: *Amrasca biguttula*; yield losses, insecticide formulations, insecticide efficacy, cotton

Introduction

Cotton is one of the most important agricultural exports from Senegal. It is the third-largest source of agricultural export revenue after fish products and groundnuts (ANSD, 2020) and accounted for 1.4% of the national GDP in 2012 (Fall, 2013).

However, the recent impact of pest attacks on cotton production has severely affected the cotton sector. Indeed, during the 2022/2023 season, a new species of leafhopper, *Amrasca biguttula* (Ishida), was observed in Senegal's cotton-growing regions, causing crop losses estimated at 14,000 tons of seed cotton out of a forecast of 27,500 tons, representing a loss of income for producers of approximately four (4) billion two hundred (200) million CFA francs (Sarr *et al.*, 2026) [19]. The losses caused by this species have had a significant impact on the economy and producers' incomes.

In response to the emergence of *A. biguttula*, the main insecticides typically used in plant protection programmes have proved ineffective in controlling it. In light of this, it is therefore necessary to update and adapt the control methods and strategies used against pests, particularly against leafhoppers. It is within this context that this study is situated, the overall objective of which is to evaluate the efficacy of new chemical and biological compounds against *Amrasca biguttula*. Specifically, the aim is to identify insecticidal compounds that are effective against this species.

Material and Methods

Plant Material

The cotton variety used in this study was Stam 129A, one of the most widely cultivated varieties in Senegal. This variety has a seed cotton yield exceeding 2.5 t ha^{-1} under favorable conditions and a lint percentage of approximately 46% (CORAF/WECARD, 2013).

Study Site

The study was conducted during the 2024 and 2025 wet seasons at the Velingara Local Experimental Station (MES). This site is located in the central part of the cotton-growing basin and has a Sudanian climate, clay soil and annual rainfall varying between 700 and 800 mm, occurring between June and October. The MES of Velingara is situated between 13°9′ north latitude and 14°2′ west longitude.

Experimental treatments

A total of six formulations were evaluated against jassid attacks, including four chemical formulations (Nitenpyram 75 g/ha + Pyriproxyfen 75 g/ha + Indoxacarb 25 g/ha, Fluxamethamide 30 g/ha; Indoxacarb 30 g/ha + Flonicamid 50 g/ha, Bifenthrin 27.5 g/ha + Dinotefuran 110 g/ha, and Plinazolin 40 g/ha) and one biological formulation (Azadirachtin 10 g/ha). These formulations were compared with insecticides commonly used in Senegal's cotton-growing regions. These were Indoxacarb 30 g/ha +

Acetamiprid 25 g/ha and Emamectin benzoate 10 g/ha + Sulfoxaflor 20 g/ha. An untreated plot was also included in the trial to assess the efficacy of each formulation against leafhoppers (Table 1).

Table 1. Formulations used to carry out the test

Trade name	Formulation	Dose (g.m.a/ha)	Chemical family	Target insects
Non Traité (NT)	-			
Indoxan duo 220 ec	*Indoxacarbe 120g/l+ acetamipride 100g/l*	30+ 25	Oxadiazines+ Neonicotinoids	Lepidoptera + sucking insects
Jacobia super 350 ec	*Nitenpyrame 150 g/l + Pyriproxyfène 150 g/l + Indoxacarbe 50 g/l*	75+ 75+ 25	Neonicotinoids+ Pyridine derivatives+ oxadiazines	sucking insects+ sucking insects+ Lepidoptera
Graci 10 ec	*Fluxamétamide 100 g/l*	30	Isoxazolines	Lepidoptera & sucking insects
Calliflor 60 ec	Emamectine-benzoate 20g/l + Sulfoxaflor 40g/l	10+ 20	Avermectin+ sulfoximines	Lepidoptera + sucking insects
Azal m	Azadirachtine 50 g/l	10	Limonoids	Lepidoptera & sucking insects
Angel 320 sc	Indoxacarbe 120g/l+ Flonicamide 200 g/l	30+ 50	Oxadiazines+ Pyridine-carboxamides	Lepidoptera + sucking insects
Flyer plus 275 ec	Bifenthrine 55 g/l + Dinotefuran 220 g/l	27,5+ 110	Pyrethroids+ Neonicotinoids	Lepidoptera + sucking insects
Laudento 200 sc	Plinazolin 200 g/l	40	Isoxazolines	Lepidoptera & sucking insects

Experimental design

The treatments were arranged in a randomized complete block design with four replications. Each plot comprised 10 rows of cotton plants, each 10 meters long. Planting distances were 80 cm between rows and 20 cm between plants within the row. The blocks were separated by a 1-metre-wide aisle. The experimental area consisted of the four central rows.

Crop management of the trial

The trial was conducted over the two years in accordance with the standardized technical guidelines for the Senegalese cotton-growing region. Seed treatment was carried out using the formulation: Thiamethoxam 350 g/l + Fludioxonil 8.3 g/l + Metalaxyl 33 g/l. A pre-emergence herbicide (Promethrin 250 g/l + Fluometuron 250 g/l + Glyphosate 60 g/l) was applied to all the experimental plots. Fertilization was carried out using the formula 14-18-18+6S+1B+2.5 CaO, supplemented with urea (46% N).

Phytosanitary treatments

Pest surveys were carried out weekly (one day before treatment (T-1) and six days after treatment (T+6)), from the 30th to the 122nd day after emergence (DAE) of the cotton plants. Observations were made on 30 plants per plot, taken in groups of five plants consecutively from the six central rows, using the diagonal method(Vayssaire, 1982). The number of individuals and plants attacked by leafhoppers was counted by examining the five terminal leaves of each identified plant. A plant is considered infested if any of its leaves show damage or symptoms of jassid attack.

Quantitative yield assessment

This was carried out on the two central rows over an 8-metre section per plot. The weight of the seed cotton harvested from the two central rows of each plot was measured and the yield assessed in kg/ha.

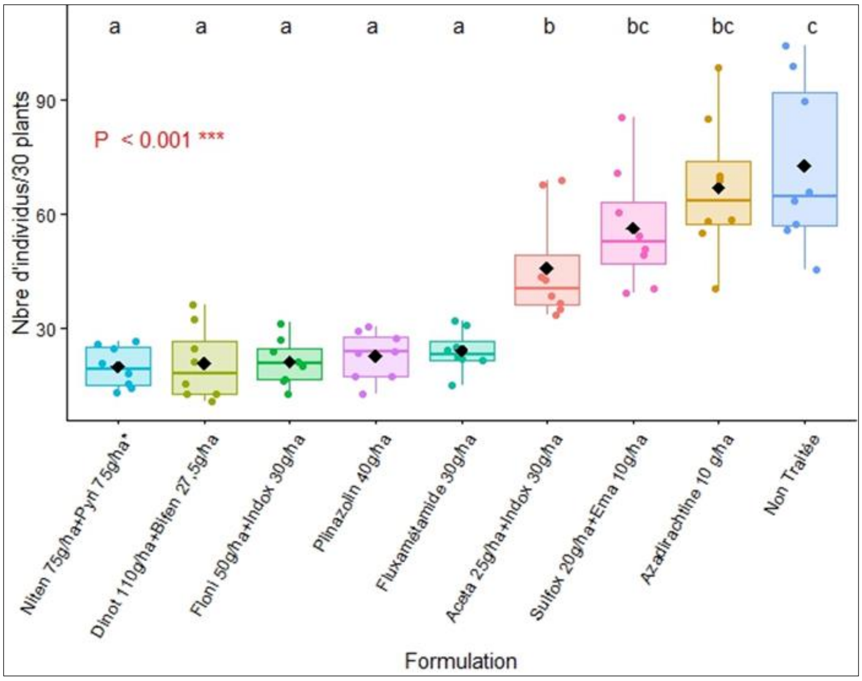
Statistical analysis

The collected data were subjected to an analysis of variance using the RStudio (2026 [19].01.0) development environment of the R software version 4.5.2-2025 [16](R Core Team, 2025) [16]. The generalized linear model (GLM) for count data, or Poisson regression, was used to analyse pest observations (number of individuals and plants attacked by leafhoppers). With regard to the assessment of yield, the categorical generalized linear model (ANOVA) was adopted and Tukey's post-hoc test (HSD test) was performed to identify levels of significant differences between treatments at the 5% significance level.

Results and discussion

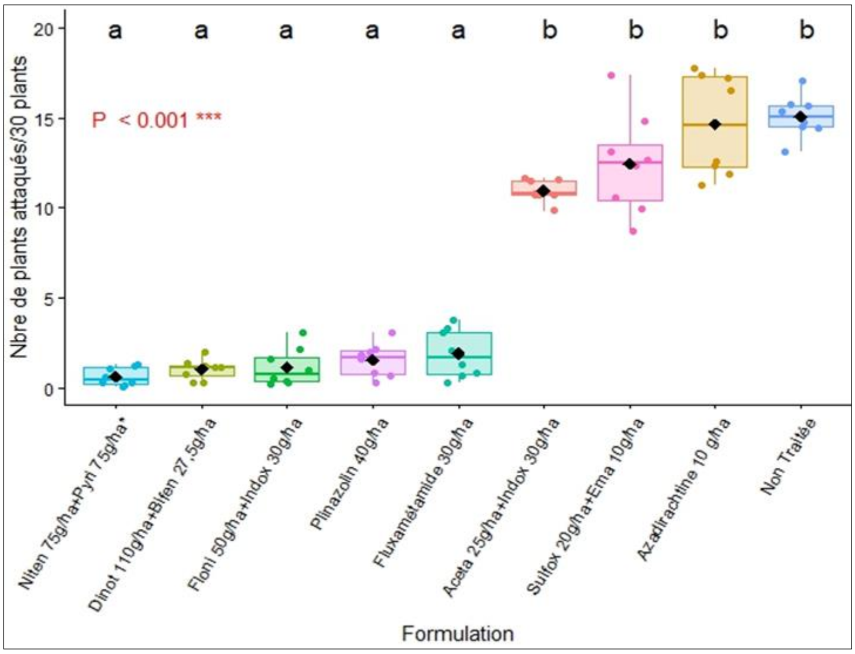
Effect of the tested formulations on leafhopper infestations

Analysis of variance of *Amrasca biguttula* infestation levels reveals that the insecticide formulations Plinazolin 40 g/ha, Dinotefuran 110 g/ha + Bifenthrin 27.5 g/ha; Nitenpyram 75 g/ha + Pyriproxyfen 75 g/ha + Indoxacarb 25 g/ha, Fluxamethamide 30 g/ha and Flonicamid 50 g/ha + Indoxacarb 30 g/ha significantly reduced ($P < 0.001$) the adult populations of *A. biguttula* (Figure 1) and the number of plants attacked by this species (Figure 2). No statistical variability was observed between these compounds in the control of *A. biguttula* infestations. The control efficacy of the combinations Acetamiprid 30 g/ha + Indoxacarb 25 g/ha, Sulfoxaflor 20 g/ha + Emamectin benzoate 10 g/ha and Azadirachtin 10 g/ha appears to be limited against attacks by this leafhopper.



P= Probabilité au seuil de 5% ; Les moyennes affectées de la même lettre constituent statistiquement un groupe homogène. Chaque groupe homogène présente une différence très hautement significative (***) avec les autres groupes
Aceta +Indox = Acetamipride+ Indoxacarbe ; Dinot + Bifen= Dinotefuran + Bifenthrine; Floni+Indox= Flonicamide +Indoxacarbe; Niten +Pyri= Nitenpyrame + Pyriproxyfène + Indoxacarbe ; Sulfox +Ema= Sulfoxaflor + Emamectine-benzoate*

Fig 1: Effect of formulations on the adult populations of *A. biguttula*



P= Probabilité au seuil de 5% ; Les moyennes affectées de la même lettre constituent statistiquement un groupe homogène. Chaque groupe homogène présente une différence très hautement significative (***) avec les autres groupes
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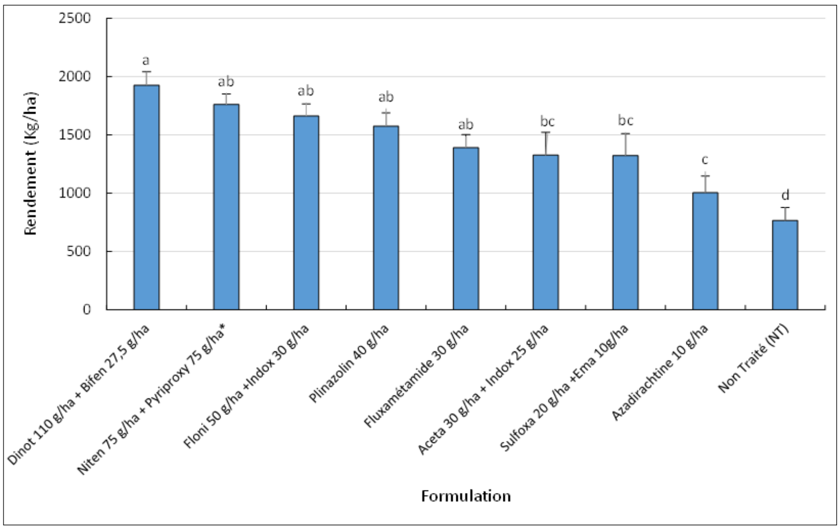
Fig 2: Effect of formulations on the damage caused by *A. biguttula*

Effect of the tested formulations on cotton yield

Analysis of variance of cotton yield levels for the various formulations tested revealed highly significant differences ($P < 0.001$) between the treatments (Figure 3). The formulations Dinotefuran 110 g/ha + Bifenthrin 27.5 g/ha, Flonicamid 50 g/ha + Indoxacarb 30 g/ha, Nitenpyram 75 g/ha + Pyriproxyfen 75 g/ha + Indoxacarb 25 g/ha, Plinazolin 40 g/ha and Fluxamethamide 30 g/ha, significantly recorded higher yields than the reference controls (Sulfoxaflor 20 g/ha + Emamectin benzoate 10 g/ha and Acetamiprid 30 g/ha + Indoxacarb 25 g/ha).

The average seed cotton yield (1,004 kg/ha) recorded in the plots treated with Azadirachtin was lower than the other yields.



P= Probabilité au seuil de 5% ; Les moyennes affectées de la même lettre constituent statistiquement un groupe homogène. Chaque groupe homogène présente une différence très hautement significative (***) avec les autres groupes
Aceta +Indox = Acetamipride+ Indoxacarbe ; Dinot + Bifen= Dinotefuran + Bifenthrine; Floni+Indox= Flonicamide +Indoxacarbe; Niten +Pyri= Nitenpyrame + Pyriproxyfène + Indoxacarbe ; Sulfox +Ema= Sulfoxaflor + Emamectine-benzoate.*

Fig 3: Average yield (kg/ha) obtained for the formulations tested

Discussion

The results regarding the biological efficacy of the tested molecules revealed that the insecticide formulations containing plinazolin, dinotefuran + bifenthrin; nitenpyram + pyriproxyfen + indoxacarb, fluxamethamide and flonicamid + indoxacarb significantly controlled infestations of *Amrasca biguttula* and the damage it causes in the central zone (Velingara) of the cotton-growing region. The efficacy of plinazolin and fluxamethamide against *A. biguttula* has been reported by several authors (Kouadio, 2025) [13],(Aniruddha *et al.,* 2025). This efficacy may be related to their mode of action. Indeed, the only commercially available insecticides acting on the *GABA* receptor were phenylpyrazoles (fipronil) and organochlorine cyclodienes (endosulfan), which share a similar mode of action. However, isoxazolines, to which plinazolin and fluxamethamide belong, constitute a distinct chemical class, known to inhibit the *GABA* receptor at a site different from that of fipronils and organochlorines. The widespread cyclodiene resistance mutation, A301S, would therefore not affect the susceptibility of these molecules (Blythe *et al*., 2022). This could explain their high levels of efficacy observed against leafhopper attacks. According to some authors (Sahito *et al.,* 2016) [18], (Dattarao & Po, 2020) [8], nitenpyram is highly effective against *A. biguttula*, whereas pyriproxyfen's efficacy against this species is moderate. However, combining these two compounds would create a synergistic effect against the pests, thereby significantly reducing their larval and adult populations. Indeed, nitenpyram, which belongs to the second-generation neonicotinoid family(Shah *et al.,* 2019) [20], acts on nicotinic acetylcholine receptors (nAChR), whereas pyriproxyfen is a growth regulator that acts as a juvenile hormone analogue in insects. The combined effect of these two molecules is believed to provide effective protection against leafhoppers.
The efficacy of flonicamid lies in its ability to rapidly halt feeding following application(Laurentie et Morita, 2005) [15]. It disrupts the insects' nervous system, causing a shock effect and consequently death by starvation (Morita *et al.*, 2000). This unique mode of action means it does not develop cross-resistance with other classes of molecules, notably neonicotinoids, organophosphates, carbamates, pyrethroids and others (Laurentie et Morita, 2005) [15]. These properties of flonicamid could therefore explain the high efficacy of the flonicamid + indoxacarb combination observed on *Amrasca biguttula*.
Dinotefuran belongs to the third generation of neonicotinoids. It acts as an agonist of nicotinic acetylcholine receptors in a manner distinct from other commonly used insecticides belonging to the same family(Vimala *et al.,* 2016) [22]. This characteristic gives it a faster systemic action and highly notable efficacy against sucking pests(Venkateshalu & Math, 2017) [21]. This could be related to the high levels of efficacy observed with the application of the dinotefuran + bifenthrin formulation.
According to some authors(Chaudhari *et al*., 2015),(Sahito *et al*., 2016) [18], acetamiprid has limited efficacy against *Amrasca biguttula*. Indeed, this species is thought to have developed resistance to most commonly used insecticides belonging to the first generation of neonicotinoids, including acetamiprid (Halappa & Patil, 2016) [10]. This may be linked to a resistance mechanism involving the detoxification enzyme glutathione S-transferase (GST) in certain populations of *A. biguttula* (Halappa & Patil, 2016) [10]. The overuse of neonicotinoid insecticides is thought to be the cause of this phenomenon (Kranthi, 2007) [14]. These observations could therefore explain the average control levels of the acetamiprid + indoxacarb formulation against infestations and damage caused by *A. biguttula* at the trial sites.
Like neonicotinoids, sulfoxaflor, a relatively new insecticide, acts on the nicotinic acetylcholine receptors (nAChR) of insects (Watson *et al.*, 2021) [23]. Thus, in their study on the baseline susceptibility of sulfoxaflor 24 SC against *Amrasca biguttula biguttula* in India, Kapasi *et al*. (Kapasi *et al.,* 2018) [12] were able to demonstrate that the susceptibility levels of this species to sulfoxaflor application are very low. This could be due to cross-resistance between different groups of neonicotinoids owing to the presence of similar active groups and modes of action (Halappa & Patil, 2016) [10]. Indeed, *Amrasca biguttula* is a polyphagous pest native to Asia that has recently spread to West Africa

(Azrag *et al.,* 2025) [3]. In Senegal, its first appearance was reported during the 2022 rainy season (Sarr *et al.,* 2026) [19]. These findings suggest that *A. biguttula* had already developed resistance to certain insecticides used in its area of origin in Asia prior to its arrival in Senegal's cotton-growing region. This pre-existing resistance would partly explain the ineffectiveness of certain conventional compounds during its invasion of West Africa.

Azadirachtin-based insecticides do not directly kill pests, but alter certain physiological processes (Sagar *et al*., 2022) [17]. They have repellent properties and often act as growth regulators in certain insect pests. However, due to their low persistence on cotton plants combined with rapid degradation in sunlight, their use requires frequent applications. Thus, given the high reproductive capacity, invasiveness and persistence of *Amrasca biguttula* in cotton fields (Cultivar Revista, 2026), the use of azadirachtin-based insecticides may prove insufficient. This would explain the low efficacy of this compound against *A. biguttula* at all trial sites.

The highest seed cotton yields were recorded with Plinazoline, Dinotefuran + Bifenthrin; Nitenpyram + Pyriproxyfen + Indoxacarb, Flonicamid + Indoxacarb and Fluxamethamide. The application of these insecticides ensured a good level of protection against leafhoppers, leading to significant yields. Thus, their inclusion in plant protection programmes will ensure the effectiveness of these programmes, whilst also allowing for the rotation of the modes of action of the products used to manage resistance in leafhoppers.

Conclusion

The aim of this study is to evaluate the biological efficacy of new chemical and biological compounds against infestations *of Amrasca biguttula* in the central region of the Senegalese cotton-growing area. Our results show that the insecticide formulations Plinazolin 40 g/ha, Dinotefuran 110 g/ha + Bifenthrin 27.5 g/ha; Nitenpyram 75 g/ha + Pyriproxyfen 75 g/ha + Indoxacarb 25 g/ha, Fluxamethamide 30 g/ha and Flonicamid 50 g/ha + Indoxacarb 30 g/ha provided good protection for cotton plants against jassid infestations and damage. The efficacy of insecticide combinations, Acetamiprid 30 g/ha + Indoxacarb 25 g/ha and Sulfoxaflor 20 g/ha + Emamectin benzoate 10 g/ha and azadirachtin 10 g/ha was very low. The active ingredients identified as effective against whitefly attacks will thus enable the range of insecticides used in protection programmes to be diversified and help prevent the development of resistance by *A. biguttula.*

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