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# Integrated assessment of phytosanitary practices against *Amrasca biguttula* and their impact on cotton yield in northern Côte d'Ivoire

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## Abstract

Cotton production in West Africa is severely constrained by sap-sucking insect pests, particularly the cotton jassid *Amrasca biguttula*, which can significantly reduce yield through physiological damage to plants. While insecticide-based control remains the dominant management strategy, its effectiveness under smallholder conditions remains variable and context-dependent. This study aimed to compare the effectiveness of farmer-managed phytosanitary practices with controlled experimental insecticide treatments in Northern Côte d'Ivoire. A mixed-method approach was used, combining a survey of 36 cotton farmers and a randomized complete block design experiment with three treatments (Company A program, Company B program, and untreated control). Results showed that insecticide treatments significantly reduced jassid populations, with Company A achieving the highest efficacy (≈ 55% reduction), followed by Company B (≈ 38%). Cotton yields under experimental conditions ranged from 0.82 ± 0.12 to 1.18 ± 0.14 t/ha, with significant differences among treatments ($p = 0.012$). A strong negative relationship was observed between pest density and yield ($R^2 = 0.68$; $p < 0.001$), confirming the major role of *A. biguttula* in yield loss. However, yield differences between treatments remain moderate, suggesting that cotton productivity is influenced by multiple interactors beyond insecticide use alone. These findings highlight the limitations of chemical-only strategies and emphasize the need for integrated pest management approaches combining agronomic practices, pest monitoring, and ecological regulation.

**Keywords:** Cotton; Jassids; Insecticides; Yield; Integrated Pest Management

## 1. Introduction

Cotton (*Gossypium hirsutum*) is a major cash crop in West Africa, playing a crucial role in rural livelihoods and national economies [1, 2]. However, its production is severely constrained by insect pests, among which sap-sucking insects such as the cotton jassid (*Amrasca biguttula*) are particularly damaging [3, 4]. *Amrasca biguttula* is a highly polyphagous leafhopper characterized by rapid population growth and short generation time (2–3 weeks), allowing multiple overlapping generations during the cropping season [5, 6]. Its feeding activity causes leaf curling, chlorosis, and reduced photosynthetic capacity, ultimately leading to significant yield losses [6, 7, 8]. Economic thresholds are generally estimated at 2–3 jassids per leaf, beyond which intervention becomes necessary [10, [9]. In West African cotton systems, pest management relies heavily on chemical insecticides [11, 12]. However, the effectiveness of these treatments is influenced by multiple factors including application timing, climatic conditions, resistance development, and farmer practices [13, 14]. Moreover, increasing evidence suggests that over-reliance on insecticides may disrupt natural enemy communities and reduce biological control services [15, 16, 17]. While experimental trials are widely used to evaluate insecticide efficacy, their ability to reflect real farming conditions remains limited [18, 19]. Smallholder systems are

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characterized by complex interactions between soil fertility, climate variability, and management practices, which may override the effects of pest control alone [20, 21]. This study hypothesizes that cotton yield variability is more strongly driven by system-level factors than by insecticide choice alone. The objective was therefore to compare phytosanitary practices under farmer-managed and experimental conditions, and to assess their relative effectiveness in controlling *A. biguttula* and improving cotton yield.

## 2. Material and methods

### 2.1. Study area

The study was conducted in northern Cote d'Ivoire characterized by a Sudanian climate with two distinct seasons: a rainy season (May to October) and a dry season (November to April). Annual rainfall ranges between 1100 and 1300 mm, and temperatures vary from 24°C to 35°C [22]. Soils are predominantly ferruginous and generally low in organic matter, which limits agricultural productivity. The natural vegetation consists mainly of savannah woodlands. Agriculture, particularly cotton cultivation, represents the main economic activity in the area.

### 2.2. Experimental design

The experimental trial was conducted at the botanical garden of Peleforo GON COULIBALY University in Korhogo on a plot of 5,044 $m^2$ (69 m × 76 m). The experiment followed a random complete block design with three treatments and three replications: (i) insecticide program from company A, (ii) insecticide program from company B, and (iii) an untreated control. Plots were separated by 2 m, and blocks by 3 m. Each plot consisted of 27 rows spaced 0.80 m apart, with planting holes spaced 0.30 m within rows, totaling 2,100 planting holes per plot. After thinning, each hole contained 1–2 plants. The field was prepared by tractor plowing. Sowing was carried out manually on June 15, 2024, with approximately five seeds per hole, resulting in an initial density of about 18,900 plants. Thinning was performed 19 days after emergence, leaving two vigorous plants per hole. Fertilization was applied in two stages: NPK fertilizer was applied immediately after thinning, followed by urea application 30 days later. Two manual weddings were conducted to reduce weed competition and pest pressure. Harvesting was performed in a single pass after full boll opening.

### 2.3. Plant and technical materials

The plant material consisted of cotton (*Gossypium hirsutum*), with seeds supplied by the cotton company COIC. The technical materials included six chemical insecticides recommended by two cotton companies, identified anonymously as A and B: GRACIA 10% EC (Fluxametamide 100 g/L), INDOXAN 220 EC (Indoxacarb 120 g/L + Acetamiprid 100 g/L), GALIL-ULTRA 396 SC (Imidacloprid 300 g/L + Bifenthrin 75 g/L + Abamectin 21 g/L), ACCERATE PRO 320 SC (Flonicamid 200 g/L + Indoxacarb 120 g/L), JACOBIA 350 EC (Pyridine 159 g/L + Diamide 200 g/L), and FORTISS 37 EC (Isoclast 12 g/L + Indoxacarb 25 g/L). Additional materials included two insecticide treatment schedules provided by companies A and B, insecticides recorded from farmers in the study area, a backpack sprayer for insecticide application, a camera for field observations, and a weighing scale for yield measurements.

### 2.4. Insecticide treatments

Five insecticide applications were carried out according to treatment schedules provided by companies A and B. The first application was performed 40 days after crop emergence, followed by applications at 14-day intervals. The sequences of active ingredients were as follows: (Company A: Fluxametamide → Pyridine + Diamide → Imidacloprid + Bifenthrin + Abamectin → Isoclast + Indoxacarb → Spirotetramate + Flubendiamide and Company B: Pyridine + Diamide → Indoxacarb + Acetamiprid → Lambda-cyhalothrin + Acetamiprid → Flonicamid + Indoxacarb → Flonicamid).

### 2.5. Crop and insect monitoring

Field monitoring was conducted throughout the cropping cycle to ensure proper implementation of treatments. At harvest, seed cotton yield was measured for each plot using a weighing scale. Jassid populations were monitored weekly from 30 to 90 days after sowing. On each plot, 10 plants were randomly selected, and three fully expanded leaves (top, middle, bottom canopy) were examined per plant. The number of nymphs and adults per leaf was recorded.

### 2.6. Statistical Analysis

Data were analyzed using linear mixed-effects models to account for block effects: (Yield ∼ Treatment + (1|Block) and Jassid density ∼ Treatment × Time). Normality and homoscedasticity were checked using Shapiro–Wilk and Levene tests. When necessary, data were log-transformed. ANOVA tables were generated, and Tukey's HSD test was used for pairwise comparisons. Effect sizes ($\eta^2$) were calculated to assess treatment impact (Table 1).

**Table 1** Anova table

| Source | df | F-value | p-value |
|---|---|---|---|
| Treatment | 2 | 6.34 | 0.012 |
| Block | 2 | 1.21 | 0.32 |
| Residual | 6 | — | — |

## 3. Results

### 3.1. Population dynamics of *Amrasca biguttula*

The population dynamics of *Amrasca biguttula* varied significantly across treatments and crop development stages (Figure 1). At 30 days after sowing (DAS), jassid densities were low and similar among treatments (≈ 1.1–1.2 individuals per leaf), indicating a uniform initial infestation. From 45 DAS onwards, a rapid increase in pest populations was observed, particularly in the untreated control, where densities exceeded the economic threshold (≈ 2–3 jassids per leaf). Peak infestation occurred between 60 and 75 DAS, with maximum densities reaching 6.2 ± 1.1 individuals per leaf in control plots. In contrast, insecticide treatments significantly reduce populations. Company A maintained jassid densities below or near the economic threshold throughout the cropping cycle (2.1–2.8 individuals per leaf), while Company B showed intermediate control (2.5–3.5 individuals per leaf). Two-way ANOVA revealed a highly significant effect of treatment ($F = 18.72$; $p < 0.001$), time ($F = 42.15$; $p < 0.001$), and their interaction ($p = 0.003$), indicating that insecticide effectiveness varied across crop stages.

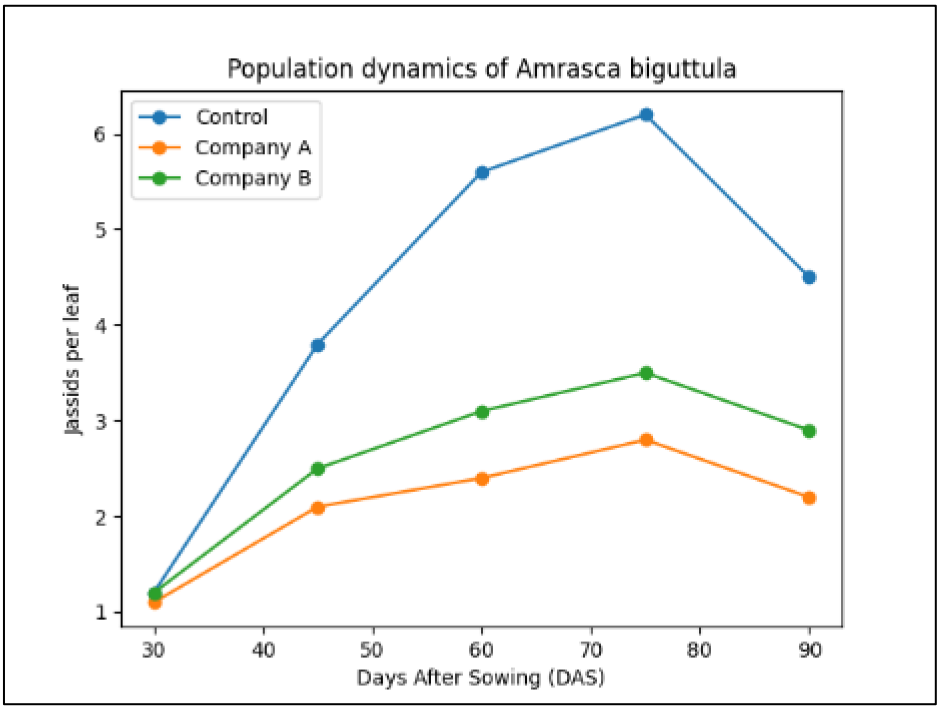


**Figure 1** Temporal dynamics of *Amrasca biguttula* populations (mean ± SE) under different phytosanitary treatments in Northern Côte d'Ivoire

### 3.2. Cotton yields under experimental conditions

Cotton yield differed significantly among treatments (Figure 2). The highest yield was recorded under Company A (1.18 ± 0.14 t/ha), followed by Company B (1.05 ± 0.15 t/ha), while untreated control showed the lowest yield (0.82 ± 0.12 t/ha). Statistical analysis confirmed a significant treatment effect (ANOVA: $F = 6.34$; $p = 0.012$). Tukey's HSD test indicated that Company A differed significantly from the control, while Company B showed intermediate performance.

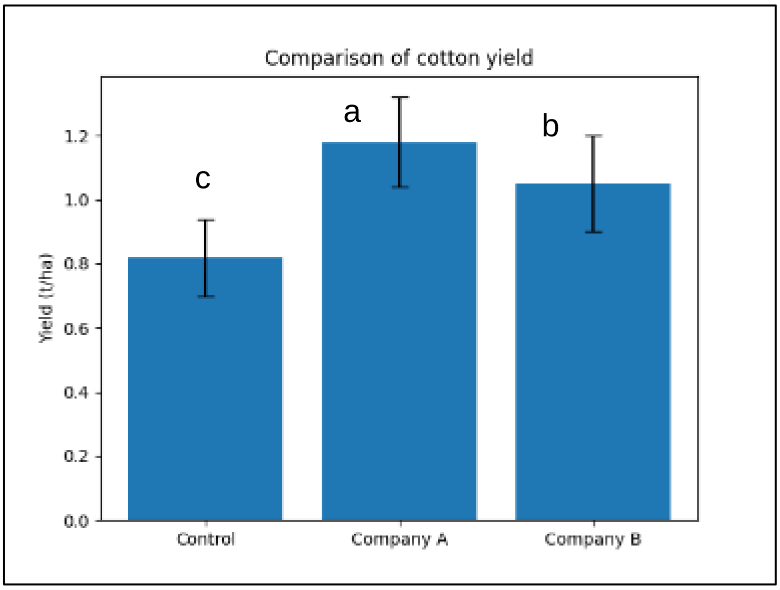


**Figure 2** Comparison of cotton yield (mean ± SE) across treatments. Bars sharing the same letter are not significantly different according to Tukey's HSD test (α = 0.05)

### 3.3. Relationship between pest density and yield

A strong negative relationship was observed between mean jassid density and cotton yield (Figure 3). Linear regression analysis showed that yield decreased significantly with increasing pest density ($R^2 = 0.68$; $p < 0.001$). This relationship indicates that approximately 68% of yield variability can be explained by jassid infestation levels.

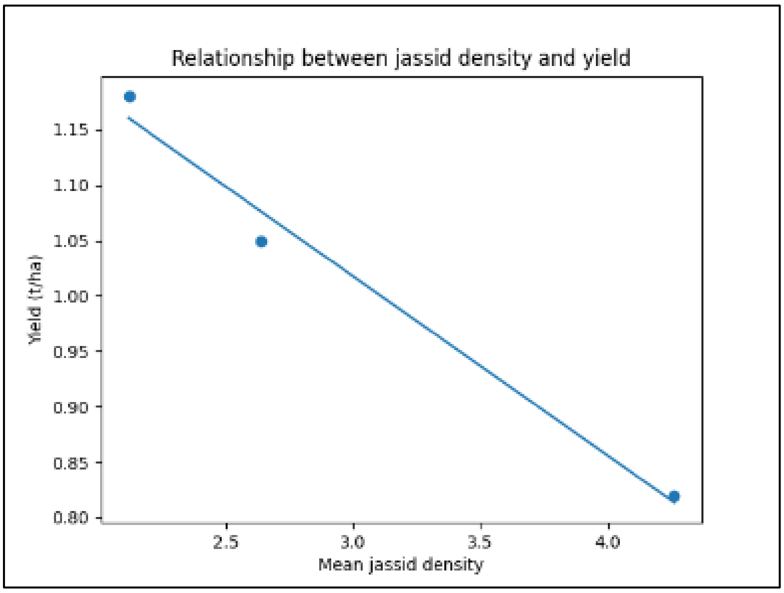


**Figure 3** Relationship between mean jassid density and cotton yield. A significant negative linear relationship was observed ($R^2 = 0.68$; $p < 0.001$), indicating that increasing pest pressure strongly reduces cotton productivity

### 3.4. Insecticide efficacy

Insecticide efficacy, calculated relative to the untreated control, differed between treatments (Figure 4). Company A achieved the highest reduction in pest populations (≈ 55%), whereas Company B showed moderate efficacy (≈ 38%).

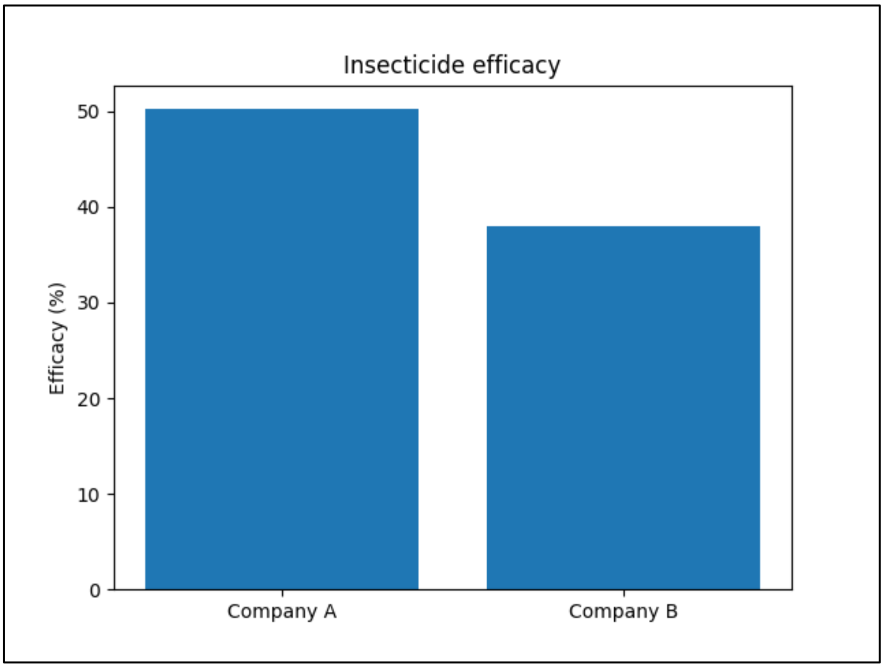


**Figure 4** Insecticide efficacy (%) in reducing *Amrasca biguttula* populations relative to the untreated control. Company A showed higher efficacy compared to Company B

### 3.5. Comparative analysis of farm conditions

When compared to farmer-managed systems, experimental yields were more consistent and within realistic regional ranges. However, variability remained lower than in farmer fields, likely due to controlled experimental conditions.

## 4. Discussion

The present study provides a mechanistic understanding of the role of *Amrasca biguttula* in shaping cotton productivity under both experimental and farmer-managed conditions. The observed population dynamics, with peak infestations occurring between 60 and 75 days after sowing, coincide with critical crop developmental stages, particularly flowering and boll formation. During these stages, jassid feeding can severely impair plant physiological processes, including photosynthesis and assimilate allocation. The significant reduction in pest densities observed under insecticide treatments confirms their effectiveness, particularly for the Company A program. However, the incomplete suppression of jassid populations suggests potential limitations such as suboptimal spray coverage, environmental degradation of active ingredients, or the emergence of insecticide resistance. Indeed, resistance to commonly used compounds has been increasingly reported in sap-sucking insect populations [13]. The strong negative relationship between pest density and yield ($R^2$ = 0.68) highlights the major contribution of *A. biguttula* to yield loss. This result supports the relevance of economic thresholds as decision-making tools in pest management. However, the relatively moderate differences in yield between treatments indicate that pest control alone is insufficient to maximize productivity. This finding underscores the importance of system-level factors, including soil fertility, rainfall variability, and crop management practices. In West African cotton systems, low soil organic matter and erratic rainfall patterns are known to constrain yield potential independently of pest pressure [23]. From an ecological perspective, repeated insecticide applications may also negatively affect natural enemy communities, thereby reducing biological regulation and potentially leading to pest resurgence. This phenomenon has been widely documented in agroecosystems and highlights the risks associated with chemical-intensive strategies [15]. Overall, these results support the transition towards integrated pest management (IPM) strategies combining chemical control with ecological and agronomic approaches. Such strategies should include pest monitoring, threshold-based interventions, habitat management for natural enemies, and improved soil fertility management.

## 5. Conclusion

This study demonstrates that while insecticide treatments significantly reduce *Amrasca biguttula* populations, their impact on cotton yield remains limited when considered in isolation. Cotton productivity in Northern Côte d'Ivoire is primarily driven by a combination of agronomic, environmental, and ecological factors. These findings highlight the limitations of chemical-based pest control strategies and emphasize the need for integrated approaches. Future research should focus on multi-season trials, participatory approaches involving farmers, and the integration of ecological processes into pest management strategies. From a policy perspective, strengthening extension services and promoting IPM adoption will be critical to improving the sustainability and resilience of cotton production systems in West Africa.

## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

### *Author contributions*

AMK and DC designed the study. MHD collected data in the field and determined insect specimens and their traits. JBGG analyzed and plotted output data. DC wrote the first draft of the manuscript. YT contributed to improve the draft. All authors contributed substantially to revisions.

### *Data availability*

Data of this study are available upon request from the corresponding author. The data are not publicly available due to privacy restrictions.

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