

## Sustainable Management of Insect Pests and Diseases of Tomato Using *Adamfo Pa* (*Urtica* Spp.) Botanical Extract

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### ABSTRACT

Tomato production in Ghana is constrained by insect pests and diseases, leading to heavy pesticide use. *Adamfo Pa*, a *Urtica*-based botanical, offers a promising, eco-friendly alternative. Field experiments were conducted during the 2025 major cropping season to evaluate the efficacy of *Adamfo Pa* botanical for the management of insect pests and diseases of tomato (*Solanum lycopersicum* L.) under local conditions in Ghana. Trials were established at Fumesua (Forest ecozone) and Ejura (Savannah-Transition ecozone) using a split-plot design with application interval (weekly and bi-weekly) as the main plot factor and five dosage treatments (control, *Adamfo Pa* at 300 ml/100 L of water, 400 ml/100 L of water and 500 ml/100 L of water, and standard reference biopesticide and fungicide) as sub-plot factor. Data were collected on insect pest incidence, disease incidence and severity, crop growth, yield parameters, and phytotoxicity. *Adamfo Pa* significantly reduced whitefly (*Bemisia tabaci*) populations and African ear borer (*Helicoverpa armigera*) fruit damage compared to the untreated control, with the 400 and 500 ml/100 L of water rates performing comparably to the reference biopesticide (Bypel). Weekly applications consistently resulted in lower pest pressure than bi-weekly applications. *Adamfo Pa* also significantly reduced the incidence and severity of major tomato diseases, particularly wilt and Septoria leaf spot, across both locations, with disease severity reductions comparable to the reference fungicide (Mancozeb). Crop yield and fruit number increased significantly with increasing *Adamfo Pa* dosage, and the 500 ml/100 L of water rate under weekly application produced yields similar to the standard reference checks. No phytotoxic effects were observed. Overall, *Adamfo Pa* demonstrated strong potential as an effective and environmentally friendly botanical for integrated management of tomato pests and diseases in Ghana, with optimal performance achieved at 400–500 ml/100 L of water applied weekly.

### Keywords

Botanical, Biopesticide, Integrated pest management, Phytotoxicity, Sustainable agriculture, *Urtica* extracts.

nutritional importance, tomato production in Ghana is constrained by severe insect pest infestations and diseases, which significantly reduce yield and market quality [4,5].

### Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important horticultural crops in Ghana and across sub-Saharan Africa, contributing significantly to household nutrition, income generation, and food security [1,2]. It is a major source of vitamins A and C, minerals, and antioxidants, and play a central role in local diets and agro-based livelihoods [3]. Despite its economic and

Among the most destructive insect pests affecting tomato production are whiteflies (*Bemisia tabaci*), aphids (*Aphis gossypii*), thrips (*Thrips tabaci*), leaf miners (*Tuta absoluta*), and fruit borers (*Helicoverpa armigera*). These pests not only cause direct feeding damage but also act as vectors for viral and bacterial diseases, including tomato yellow leaf curl virus and bacterial wilt (*Ralstonia solanacearum*). Additionally, fungal diseases such as

damping-off (*Pythium* spp.) early blight (*Alternaria solani*), late blight (*Phytophthora infestans*), and powdery mildew further exacerbate production losses [6].

To combat these challenges, most smallholder farmers in Ghana rely heavily on synthetic chemical pesticides and fungicides. While these synthetic chemicals can provide short-term pest and disease suppression, their indiscriminate and excessive use has resulted in numerous adverse consequences, including pesticide resistance, environmental contamination, destruction of beneficial organisms, and increased risks to human health through occupational exposure and food residues [7,8]. These concerns have intensified calls for safer, and environmentally friendly alternatives that are effective, affordable, and compatible with sustainable agriculture.

Botanicals have emerged as promising tools in integrated pest and disease management systems. Derived from plant extracts, these products are biodegradable, generally less toxic to non-target organisms, and often possess multiple modes of action, reducing the likelihood of resistance development [9-12]. Among such botanicals, species of the genus *Urtica* (stinging nettle) have gained attention due to their documented insecticidal, fungicidal, and plant growth-promoting properties.

*Adamfo Pa* is a biopesticide formulated from extracts of *Urtica dioica* and *Urtica urens* at a concentration of 15 g/L. The product was developed by Naturnova as part of efforts to promote eco-friendly crop protection solutions tailored to Ghanaian agro-ecological conditions. Extracts from *Urtica* species contain a wide range of bioactive compounds, including acetic acid, formic acid, chlorogenic acid, rutin, lecithin, and L-prunasin. These compounds have been reported to exhibit antimicrobial, insecticidal, repellent, and plant growth-enhancing activities [13-16].

Previous studies have shown that *Urtica* extracts can suppress populations of aphids, mites, and caterpillars, while also inhibiting the growth of fungal pathogens responsible for leaf spot and blight diseases [17-20]. In addition, nettle-based formulations have been reported to improve plant vigour, enhance chlorophyll content, and stimulate natural plant defence mechanisms, suggesting potential triple benefits in pests and diseases management as well as crop productivity.

In this context, *Adamfo Pa* represents a promising botanical for sustainable tomato production in Ghana. However, scientific evaluation under local field conditions is necessary to validate its efficacy, determine optimal application rates, and assess potential phytotoxic effects. This study was therefore designed to evaluate the effectiveness of *Adamfo Pa* in managing insect pests and diseases of tomato, as well as its impact on plant growth and yield, in selected forest and transition ecozones of Ghana.

## Materials and Methods

### Study Sites and Experimental Setup

Field experiments were conducted during the 2025 major cropping season at two research stations of the Council for Scientific and

Industrial Research–Crops Research Institute (CSIR-CRI) in Ghana. The first site was located at Fumesua in the Forest ecozone, while the second site was at Ejura in the Savannah–Transition ecozone. These two locations were selected to represent contrasting climatic, edaphic, and biotic conditions commonly encountered in Ghanaian tomato production systems. The Fumesua site is characterized by a bimodal rainfall pattern, relatively high annual precipitation, moderate temperatures, and loamy soils with good organic matter content, conditions favourable for both crop growth and disease development. In contrast, the Ejura site experiences a unimodal rainfall regime, higher temperatures, lower relative humidity, and predominantly sandy loam soils, conditions that often favour insect pest outbreaks. The use of these contrasting environments allowed for a comprehensive evaluation of the performance and robustness of *Adamfo Pa* botanical under diverse agro-ecological conditions.

### Plant Material and Field Establishment

The study focused on tomato (*Solanum lycopersicum* L.), due to its high economic importance and susceptibility to insect pests and diseases. The tomato variety *Pectoneck*, commonly cultivated by farmers and known for its responsiveness to pests and disease pressure, was used for the trials. Tomato seedlings were raised in nursery beds and transplanted at four weeks after sowing. Field plots were prepared using conventional land preparation practices, including ploughing and harrowing. Transplanting was carried out at a spacing of 100 cm × 50 cm, consistent with recommended agronomic practices for tomato production in Ghana. The total land area at each location was approximately 826 m<sup>2</sup>. Standard cultural practices such as weeding, staking where necessary, and supplemental irrigation were uniformly applied across all treatments to minimize confounding effects.

### Experimental Design and Treatment Structure

The split-plot design was employed to evaluate the efficacy of *Adamfo Pa* under different application regimes. This design was selected to allow simultaneous assessment of two major factors: application frequency and dosage rate. The main plot factor consisted of two levels of application interval: weekly application and bi-weekly application. Within each main plot, five sub-plot treatments representing different dosage rates, control, and reference standard checks were randomly assigned. The treatments were Control (0 ml *Adamfo Pa* per 100 L of water), *Adamfo Pa* at 300 ml per 100 L of water, *Adamfo Pa* at 400 ml per 100 L of water, *Adamfo Pa* at 500 ml per 100 L of water, reference standard checks: biopesticides (Bypel) for insect pests and fungicide (Mancozeb WP) for fungal diseases. Each treatment combination was replicated three times at each location to enhance statistical reliability. One-meter-wide alleys were maintained between plots to reduce spray drift and cross-contamination.

### Treatment Application

Application of treatments commenced in late May 2025 at the Fumesua site, shortly after transplanting but at establishment of seedlings. At Ejura, applications began in mid-July 2025, reflecting the later onset of rains in the Savannah–Transition

ecozone. Weekly application plots received a total of eight (8) spray applications, while bi-weekly plots received four (4) applications over the cropping period. Treatments were applied using calibrated knapsack sprayers, ensuring uniform spray volume and coverage. Applications were carried out during early morning hours to minimize volatilization and drift. Reference standard checks (Bypel and Mancozeb WP) were applied according to manufacturer recommendations. All treatment pesticide handling and application followed established Good Agricultural Practices (GAPs), including the use of protective clothing and adherence to safety protocols.

### Data Collection

Data collection was carried out systematically throughout the cropping season, beginning one week after the first application of treatments and continued until harvest.

### Pest and Disease Incidence and Severity

Weekly visual assessments were conducted to monitor insect pest populations and diseases development. Standardized severity scales were used to rate pests damage and disease symptoms. Target insect pests included tomato leaf miner (*Tuta absoluta*), African ear borer (*Helicoverpa armigera*), and whiteflies (*Bemisia tabaci*).

**Whiteflies:** The under surface of three leaves of the tagged tomato plants were carefully examined and whiteflies count made to determine incidence.

**Leaf miners:** These were identified by the type of mines on the tomato leaves. The serpentine leaf miner, *Liriomyza* sp. creates slender tunneling mines on the leaves while the *T. absoluta* produces broader or sheet-like mines on the leaves. The incidence at the vegetative stage was determined by counting the number of tagged plants with mines per plot. The incidence was calculated as:

$$\text{Percent incidence (\%)} = \frac{\text{number of plants with mines} \times 100}{\text{Total plants sampled}}$$

The number of fruits on tagged trees and the number of the fruits that were infested were counted and the percent damage calculated as:

$$\text{Percent damage (\%)} = \frac{\text{number of fruits infested} \times 100}{\text{Total number of fruits}}$$

**Fruit borers:** Fruits and stems of the tomato were examined for holes created by the larvae of *H. armigera*. The number of fruits with bores out of total per plant were counted and percent damage calculated as in *T. absoluta*

Target diseases included wilts, damping-off, anthracnose, and leaf spot. Observations for abnormal symptoms such as leaf scorch, chlorosis, and plant stunting were done, and disease incidence and severity documented. For disease incidence, the total number of infected plants was expressed as a percentage of the total number of plants observed. Severity was done by using a scale of 0-5 as

reported by Cardoso [21].

### Phytotoxicity Assessment

Plants were regularly examined for signs of phytotoxicity, such as leaf burn, necrosis, deformation, or growth suppression, following *Adamfo Pa* application. Phytotoxic effects, if present, were rated using visual injury scales [22,23].

### Yield Parameters

Data taking on yield at harvest were number of fruits per plant, fresh fruit weight, and marketable fruit yield. Yield data were extrapolated to a per-hectare basis to facilitate comparison among treatments.

### Statistical Analysis

All collected data were subjected to Analysis of Variance (ANOVA) appropriate for a split-plot design to determine the effects of application frequency, dosage rate, and their interactions using Statistix 8.0 package. When significant differences were detected, treatment means were separated using Tukey's Honest Significant Difference (HSD) test at a 5% probability level ( $p \leq 0.05$ ). Prior to analysis, data were examined for normality and homogeneity of variances using the Shapiro-Wilk and Levene tests [24]. Count data were square-root ( $\sqrt{x+0.5}$ ) transformed to stabilize variance, while damage scores were arcsine-transformed [25].

## Results and Discussion

### Whitefly (*Bemisia tabaci*) Management

Whiteflies were the most prevalent insect pests observed on tomato during the vegetative growth stage at both experimental sites. Although leaf miners (*Liriomyza* spp.) were occasionally encountered, their incidence remained very low and did not warrant inclusion in the statistical analysis. This observation was consistent with reports that whiteflies are among the earliest and most destructive pests of tomato in tropical agro-ecosystems, particularly under warm and humid conditions [26-28].

Across both the Forest (Fumesua) and Savannah-Transition (Ejura) ecozones, all *Adamfo Pa* treatments significantly reduced whitefly populations compared to the untreated control (Table 1). The lowest whitefly densities were recorded in plots treated with the reference biopesticide (Bypel), followed closely by the high (500 ml/100 L of water) and mid (400 ml/100 L of water) *Adamfo Pa* rates. Importantly, whitefly populations under the 400 ml/100 L of water and 500 ml/100 L of water *Adamfo Pa* treatments were statistically comparable to those under Bypel, indicating strong insecticidal efficacy at these rates.

The effectiveness of *Adamfo Pa* against whiteflies can be attributed to the bioactive compounds present in *Urtica* spp. extracts, including organic acids and phenolic compounds, which have been reported to exhibit repellent, antifeedant, and contact toxicity effects on sap-sucking insects [9,18]. The progressive reduction in whitefly density with increasing dosage suggests a clear dose-response relationship, supporting the importance of adequate concentration for effective pest suppression.

**Table 1:** Whiteflies population density on tomato after application of treatments across ecozones.

Application interval	Mean whitefly / plant	
	FUMESUA	EJURA
Weekly	0.59b	0.47b
Bi-weekly	1.09a	0.67a
Application dose		
Control (0 ml/100 L of water)	3.01a	1.23a
Adamfo Pa at 300 ml/100 L of water	0.67b	0.47b
Adamfo Pa at 400 ml/100 L of water	0.51bc	0.42bc
Adamfo Pa at 500 ml/100 L of water	0.38bc	0.37c
Reference biopesticide (Bypel) of water	0.26c	0.34c

Treatments designated with different letters indicate statistically significant differences at  $p \leq 0.05$ .

Application interval also had a significant effect on whitefly populations. Weekly applications consistently resulted in lower whitefly densities than bi-weekly applications at both locations (Table 1). This finding highlights the importance of maintaining sufficient residue levels of the biopesticide on plant surfaces to disrupt whitefly population build-up, especially given the rapid reproductive cycle of *B. tabaci*. Similar observations have been reported for other botanical insecticides, where shorter spray intervals improved pest control efficacy [10]. Based on these results, *Adamfo Pa* applied at 400 ml/100 L of water on a weekly basis is recommended for effective whitefly management in tomato.

### African Ear Borer (*Helicoverpa armigera*) Incidence and Fruit Damage

The African ear borer was recorded mainly at the fruiting stage, but its overall population density was relatively low, particularly at the Ejura site where no infestation was observed (Table 2). At Fumesua, no African ear borer infestation was recorded on plots treated with mid (400 ml/100 L of water), high (500 ml/100 L of water) *Adamfo Pa* rates, or the reference biopesticide, while the low *Adamfo Pa* rate significantly reduced pest incidence compared to the control.

Although pest incidence was generally low, fruit damage differed significantly among treatments, underscoring the economic importance of even minimal infestations. The untreated control recorded the highest fruit damage, while Bypel and high-rate *Adamfo Pa* treatments resulted in the lowest damage levels.

**Table 2:** African ear borer incidence and damage on tomato fruits.

		No. African ear borer/ plant		Fruit damage (%)	
		FUMESUA	EJURA	FUMESUA	EJURA
Application interval	Weekly	0.74a	0.00	9.30b	0.00
	Bi-weekly	0.75a	0.00	14.71a	0.00
Application dose	Control (0 ml/100 L of water)	0.23a	0.00	74.09a	0.00
	Adamfo Pa at 300 ml/100 L	0.09b	0.00	23.09b	0.00
	Adamfo Pa at 400 ml/100 L	0.00a	0.00	0.00c	0.00
	Adamfo Pa at 500 ml/100 L	0.00a	0.00	0.00c	0.00
	Reference biopesticide (Bypel)	0.00a	0.00	0.00c	0.00

Treatments designated with different letters indicate statistically significant differences at  $p \leq 0.05$

Damage levels under the 400 ml/100L of water and 500 ml/100L of water *Adamfo Pa* treatments were statistically comparable to the reference biopesticide and substantially lower than those observed under the lower *Adamfo Pa* concentrations.

Weekly and bi-weekly application intervals resulted in similar pest incidence; however, weekly applications significantly reduced fruit damage compared to bi-weekly applications (Table 2). This apparent discrepancy between incidence and damage can be explained by the feeding behaviour of *H. armigera*, where a single larva may damage multiple fruits during its development. Frequent applications likely reduced larval survival or feeding activity, thereby limiting cumulative damage.

Given the low pest pressure observed during the study period, a dosage range of 400–500 ml/100 L of water applied weekly is recommended for effective management of African ear borer, particularly as a preventive strategy.

### Disease Incidence

*Adamfo Pa* applications significantly influenced the incidence of major tomato diseases, particularly wilt and *Septoria* leaf spot. For wilt disease, *Adamfo Pa* consistently reduced disease incidence at Ejura (Table 3). This suggests that *Adamfo Pa* may possess antimicrobial properties effective against soil- and vascular-borne pathogens, consistent with reports on *Urtica* spp. extracts inhibiting fungal and bacterial growth [14,29].

In contrast, the effect of *Adamfo Pa* on *Septoria* leaf spot incidence varied between locations. At Ejura, *Adamfo Pa* treatments resulted in reduced disease incidence, whereas reductions at Fumesua were not significantly different from the control. These inconsistency in disease incidence may be linked to environmental factors such as humidity, rainfall, and inoculum pressure, which strongly influence foliar disease development. Such location-specific responses have been reported in disease management studies involving botanical products [6].

Application interval significantly affected *Septoria* leaf spot incidence at Fumesua and wilt incidence at Ejura, with bi-weekly applications resulting in lower disease incidence than weekly applications. This may suggest that longer intervals allowed better plant recovery or reduced leaf wetness associated with frequent spraying, which can favour foliar pathogen infection.

### Disease Severity

Despite variability in incidence, disease severity for both *Septoria* leaf spot and wilt were consistently reduced by *Adamfo Pa* across all doses and locations (Table 4). All *Adamfo Pa* treatments significantly lowered severity scores compared to the untreated control and performed comparably to the reference fungicide (Mancozeb WP). This reduction in severity is particularly important, as disease severity is more closely linked to yield loss than incidence alone [30].

The ability of *Adamfo Pa* to suppress disease severity may be attributed to the combined fungistatic effects of phenolic acids and organic acids present in *Urtica* extracts, as well as possible induction of plant defense mechanisms [31]. These findings reinforce the potential of *Adamfo Pa* as a broad-spectrum biopesticide [32] for integrated disease management in tomato production systems.

### Crop Growth and Yield Response

Application of *Adamfo Pa* significantly influenced tomato productivity, as reflected in fruit number and fruit yield (Table 5). Weekly application intervals resulted in significantly higher fruit

numbers than bi-weekly applications at both locations, although total fruit yield did not differ significantly between application intervals. This suggests that more frequent applications may enhance flower retention and fruit set, even when final yield differences are modest.

Dosage effects were more pronounced. The 500 ml/100 L of water *Adamfo Pa* treatment produced fruit numbers and yields comparable to the reference fungicide, and significantly higher than the lower doses and the control. The control plots recorded the lowest productivity, reflecting the cumulative impact of unmanaged pests and diseases.

The improved yield under higher *Adamfo Pa* doses is likely a combined result of effective pest and disease suppression and the reported growth-promoting effects of *Urtica* extracts, which have been associated with enhanced nutrient uptake and physiological vigor. Overall, weekly application of *Adamfo Pa* at 500 ml/100 L of water emerged as the most effective non-synthetic chemical alternative to the reference fungicide for tomato production.

**Table 3:** Mean tomato disease incidence variations based on application interval and application dose at Fumesua and Ejura.

		Septoria leaf spot		Wilt	
		FUMESUA	EJURA	FUMESUA	EJURA
Application Interval	Weekly	40.30a	28.67a	51.30a	15.33a
	Biweekly	32.15b	29.33a	51.90a	3.33b
Application Dose	Control (0 ml/100 L of water)	43.25a	48.33a	51.00a	25.00a
	Adamfo Pa at 300 ml/100 L of water	35.00a	28.33b	55.63a	10.00b
	Adamfo Pa at 400 ml/100 L of water	28.13a	21.67b	60.38a	3.33b
	Adamfo Pa at 500 ml/100 L of water	34.00a	26.67b	52.38a	8.33b
	Reference chemical (Mancozeb WP)	40.75a	20.00b	38.63a	0.00b

Treatments designated with different letters indicate statistically significant differences at  $p \leq 0.05$

**Table 4:** Mean tomato disease severity variations based on application interval and application dose at Fumesua and Ejura.

		Septoria leaf spot		Wilt	
		FUMESUA	EJURA	FUMESUA	EJURA
Application Interval	Weekly	2.30a	2.13a	0.00a	2.40a
	Biweekly	2.10a	2.07a	0.00a	1.33a
Application Dose	Control (0 ml/100 L of water)	3.00a	3.5a	0.00a	4.00a
	Adamfo Pa at 300 ml/100 L of water	1.86b	1.83b	0.00a	2.00ab
	Adamfo Pa at 400 ml/100 L of water	2.00b	1.67b	0.00a	1.33ab
	Adamfo Pa at 500 ml/100 L of water	2.16b	2.00b	0.00a-	2.00ab
	Reference chemical (Mancozeb WP)	2.00b	1.50b	0.00a-	0.00c

Treatments designated with different letters indicate statistically significant differences at  $p \leq 0.05$

**Table 5:** Effect of *Adamfo Pa* on tomato productivity.

		Number of fruits (kg/ha)		Fruit yield (kg/ha)	
		FUMESUA	EJURA	FUMESUA	EJURA
Application Interval	Weekly	67520a	64572a	7278a	7123a
	Biweekly	57120b	55173b	6165a	5932a
Application Dose	Control (0 ml/100 L of water)	27800d	30855e	2839d	2748e
	Adamfo Pa at 300 ml/100 L of water	40800c	46852d	4428c	4337d
	Adamfo Pa at 400 ml/100 L of water	56600b	61652c	7148b	7057c
	Adamfo Pa at 500 ml/100 L of water	78400a	82452b	9399a	8791b
	Reference Chemical (Mancozeb WP)	82000a	90054a	9795a	9704a

Treatments designated with different letters indicate statistically significant differences at  $p \leq 0.05$

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## Conclusion

The results demonstrate that *Adamfo Pa* is an effective biopesticide and biofungicide for managing key insect pests and diseases of tomato, with performance comparable to standard biopesticides and fungicides. Optimal efficacy was achieved at 400–500 ml/100 L of water, particularly under weekly application regimes, supporting its potential integration into sustainable tomato production systems in Ghana.

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