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Sustainable Management of *Bacterial Fruit Blotch* in Watermelon Using Biocontrol Agents at Tella, Taraba State

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Abstract

Bacterial fruit blotch (BFB), caused by *Acidovorax citrulli*, represents a significant challenge to watermelon cultivation in Nigeria, frequently resulting in substantial yield losses under conducive climatic conditions. This study aimed to evaluate the effectiveness of selected plant-based biocontrol agents in managing BFB and improving the growth and yield performance of three watermelon varieties: Sweet Sangaria, Kaolack, and a local landrace. A two-year field trial (2020–2021) was conducted in Tella, Taraba State, using a randomized complete block design with three replications. Treatments consisted of neem oil, garlic oil, jatropha oil, and their binary combinations, alongside streptomycin as a standard control and an untreated control plot. Results revealed that the plant-based treatments significantly reduced BFB incidence compared to the control, with some combinations performing comparably to streptomycin. Additionally, improvements were observed in plant growth parameters and fruit yield across all treated plots. The findings underscore the potential of botanical biocontrol agents as sustainable alternatives to synthetic antibiotics for managing BFB in watermelon cultivation, contributing to environmentally friendly disease management strategies suitable for smallholder farming systems.

Keywords: Watermelon; *Acidovorax citrulli*; Bacterial Fruit Blotch; Biocontrol Agents; Sustainable Agriculture

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INTRODUCTION

Watermelon (*Citrullus lanatus*) is an economically important fruit crop widely cultivated in tropical and subtropical regions due to its high nutritional and market value. In Nigeria, watermelon cultivation has expanded considerably in recent years as both a source of income for farmers and a means of addressing food security (Aji *et al.,* 2024). However, production is constrained by several diseases, among which bacterial fruit blotch (BFB), caused by *Acidovorax citrulli*, is the most destructive. The disease affects seedlings, foliage, and fruits, resulting in severe pre- and post-harvest losses, sometimes reaching 100% under favorable conditions (Burdman and Walcott, 2012; Latin and Hopkins, 1995).

BFB is seedborne and easily disseminated through contaminated seed lots and planting materials. It thrives under warm, humid, and rainy conditions, which are common in many watermelon-growing areas of Nigeria (Olatinwo and Adegbite, 2014). Climate variability, including changes in rainfall patterns and relative humidity, has been shown to intensify the severity of BFB and complicate its management (Zheng *et al.,* 2024). With climate change predicted to increase disease outbreaks in tropical agroecosystems, sustainable and environmentally friendly management practices are urgently required.

Although chemical control using antibiotics such as streptomycin has been applied, reliance on synthetic inputs is discouraged due to health risks, environmental hazards, and the emergence of resistant strains of pathogens (Hopkins *et al*., 2003; Zhang *et al.,* 2025). Biocontrol using plant-derived extracts offers an eco-friendly alternative. Extracts from neem (*Azadirachta indica*), garlic (*Allium sativum*), and jatropha (*Jatropha curcas*) possess antimicrobial compounds that can suppress phytopathogens while promoting plant growth (Isman, 2006; Xu *et al.,* 2024). Their effectiveness against bacterial diseases has been demonstrated in several crops, making them promising candidates for watermelon disease management (Sundaramoorthy et al., 2014).

Given the rising incidence of BFB in Nigeria and the need for sustainable strategies, this study was undertaken to assess the efficacy of neem, garlic, jatropha, and their combinations as bioextract-based emulsions for managing BFB in watermelon varieties at Tella during the 2020–2021 cropping seasons. The study also examined varietal responses and the interaction of climatic conditions with disease incidence, growth, and yield parameters.

MATERIALS AND METHODS

Study Area

The field trials were conducted during the 2020 and 2021 rainy seasons at Tella, Taraba State, Nigeria. The site is located within the Guinea savanna agroecological zone, characterized by a unimodal rainfall pattern (May–October) and mean annual rainfall of 1,200–1,600 mm. The mean temperature ranges between 24–32 °C, with relative humidity peaking during August and September. Climatic data (rainfall and humidity) were collected monthly from the Nigerian Meteorological Agency (NIMET) station at Tella to assess environmental influences on disease incidence.

Experimental Design and Treatments

The experiment was laid out in a Randomized Complete Block Design (RCBD**)** with a factorial arrangement, consisting of: Factor A (Varieties): Sweet Sangaria, Kaolack, and Local landrace. Factor B (Biocontrol treatments): Neem oil emulsion (5% Garlic oil emulsion (5%), Jatropha oil emulsion (5%). Neem + Garlic (1:1), Neem + Jatropha (1:1), Garlic + Jatropha (1:1), Streptomycin (standard check, 200 ppm) and Untreated control Each treatment was replicated three times, giving a total of 72 experimental plots.

Preparation of Plant Bioextracts

Fresh leaves of neem (*Azadirachta indica*), cloves of garlic (*Allium sativum*), and seeds of jatropha (*Jatropha curcas*) were collected from the Tella farming community. Extracts were prepared following the method of *Aji et al.* (2024) with modifications. Plant materials were washed, air-dried, ground, and soaked in distilled water (1:5 w/v) for 48 hr. The filtrates were emulsified with 0.1% Tween-20 to ensure uniform foliar application.

Field Management and Application

Watermelon seeds of each variety were sown on ridges spaced 1.5 m apart, with an intra-row spacing of 0.6 m, giving a plant population density of ~11,000 plants/ha. Standard agronomic practices (weeding and fertilizer application at 120 kg N, 60 kg P, and 60 kg K ha^{-1}) were applied uniformly across plots. Bioextracts and streptomycin were applied as foliar sprays at 3-week intervals beginning at 3 weeks after sowing (WAS). Control plots received only water spray.

Data Collection

Disease incidence (%): was recorded at 6 and 9 WAS as the percentage of plants showing typical BFB symptoms per plot.

Growth traits: included number of leaves, vine length, and number of branches per plant (average of 10 tagged plants).

Yield traits: included number of fruits per plant, mean fruit weight, and total fruit yield (t/ha).

Climatic variables: (rainfall, humidity) were used to correlate weather conditions with disease development.

Data Analysis

Data were subjected to Analysis of Variance (ANOVA) using SAS 9.4. Treatment means were separated using Least Significant Difference (LSD) at 5% probability level (Steel & Torrie, 1980). Interaction effects between varieties and biocontrol treatments were also examined.

RESULTS

Climatic Conditions at Tella (2020–2021)

Rainfall and relative humidity followed the expected unimodal pattern for the Guinea savanna. Peak rainfall occurred in July–August (240–260 mm), with relative humidity reaching 79–83%. The 2021 season recorded slightly higher rainfall but lower humidity compared to 2020, conditions that favored better crop growth and reduced BFB incidence (Fig. 1 and Fig. 2).

Effect of Biocontrol Agents on Disease Incidence

Significant ($p < 0.05$) differences were observed among treatments. Neem oil, garlic oil, and their combinations reduced BFB incidence compared to untreated controls. Streptomycin remained the most effective, but neem + garlic was comparable in reducing disease severity across both years.

Table 1. Effect of biocontrol agents on BFB incidence (%) in watermelon varieties at Tella (2020–2021).

Treatment	Sweet Sangaria	Kaolack	Local Variety	Mean ± SE	LSD (0.05)
Neem oil	14.6	18.2	21.5	18.1 ± 1.2	3.5
Garlic oil	15.3	19.0	22.1	18.8 ± 1.4	
Jatropha oil	20.1	23.5	27.0	23.5 ± 1.7	
Neem + Garlic	12.5	16.4	19.2	16.0 ± 1.1	

Treatment	Sweet Sangaria	Kaolack	Local Variety	Mean ± SE	LSD (0.05)
Neem + Jatropha	16.9	20.6	24.0	20.5 ± 1.3	
Garlic + Jatropha	17.4	21.2	25.2	21.3 ± 1.5	
Streptomycin (check)	8.7	10.2	12.0	10.3 ± 0.9	
Control (untreated)	32.4	38.7	42.6	37.9 ± 2.2	

Effect on Growth Parameters

Biocontrol treatments improved vegetative growth compared to the control. Neem + garlic significantly increased vine length and number of leaves, nearly matching streptomycin in performance.

Table 2. Effect of biocontrol agents on vegetative growth of watermelon at Tella (2020–2021).

Treatment	Vine length (cm)	No. of leaves	No. of branches	LSD (0.05)
Neem oil	168.2	52.4	10.5	5.6
Garlic oil	165.7	51.0	10.1	
Jatropha oil	150.3	47.2	9.3	
Neem + Garlic	175.6	56.8	11.2	
Neem + Jatropha	160.8	50.6	9.9	
Garlic + Jatropha	158.2	49.8	9.7	
Streptomycin (check)	182.5	58.6	11.6	
Control (untreated)	135.4	42.5	8.1	

Effect on Yield Parameters

Significant improvements in yield traits were recorded in treated plots. Streptomycin gave the highest fruit yield, closely followed by neem + garlic. The untreated control had the lowest yield across both years.

Table 3. Effect of biocontrol agents on yield traits of watermelon at Tella (2020–2021).

Treatment	Fruits/plant	Fruit weight (kg)	Yield (t/ha)	LSD (0.05)
Neem oil	3.4	4.8	28.6	2.4
Garlic oil	3.2	4.7	27.4	
Jatropha oil	2.9	4.3	24.8	
Neem + Garlic	3.8	5.1	31.5	
Neem + Jatropha	3.3	4.6	26.9	
Garlic + Jatropha	3.2	4.5	26.1	
Streptomycin (check)	4.0	5.3	33.2	
Control (untreated)	2.4	3.8	19.7	

DISCUSSION

The findings from this study demonstrate that bioextract-based treatments can significantly reduce bacterial fruit blotch (BFB) incidence and enhance the growth and yield of watermelon under field conditions at Tella. Neem, garlic, and jatropha extracts showed varying degrees of effectiveness, with neem + garlic combination performing almost at par with streptomycin. This supports earlier reports that plant-derived extracts possess antimicrobial properties capable of suppressing bacterial pathogens (Isman, 2006; Xu *et al.,* 2024).

The significant reduction in disease incidence observed in neem- and garlic-based treatments can be attributed to the presence of bioactive compounds such as azadirachtin in neem and allicin in garlic, which disrupt microbial cell membranes and interfere with pathogen metabolism (Aji *et al.,* 2024; Sundaramoorthy *et al.,* 2014). Jatropha oil, though less effective when used alone, improved disease control when combined with neem or garlic, suggesting a synergistic effect.

The improvement in vine length, leaf number, and branching across treated plots indicates that bioextracts not only reduced disease pressure but may have enhanced physiological processes by lowering pathogen load and stress on plants. Similar observations were reported in cucurbits where organic amendments and biocontrol agents promoted vigor and tolerance to biotic stress (Sundaramoorthy *et al.,* 2014).

Yield improvements were consistent with reductions in disease incidence. The highest yields were recorded under streptomycin and neem + garlic, which indicates that these treatments effectively balanced disease suppression with agronomic performance. This aligns with previous findings that sustainable disease management strategies integrating plant extracts can be comparable to synthetic chemical control in effectiveness (Hopkins *et al.,* 2003; Zhang *et al.,* 2025).

Climatic data further revealed that BFB severity was higher in 2020 when relative humidity was higher, whereas 2021, with slightly lower humidity and more evenly distributed rainfall, favored reduced disease pressure and higher yields. This corroborates reports that climate variability, particularly humidity and rainfall intensity, strongly influences the epidemiology of BFB (Olatinwo amd Adegbite, 2014; Zheng *et al.,* 2024).

Overall, the study provides evidence that biocontrol agents, especially neem + garlic extract, can serve as a sustainable alternative to synthetic antibiotics in managing BFB under tropical field conditions.

CONCLUSION

The study demonstrated that plant-based bioextracts are effective in reducing bacterial fruit blotch incidence and improving the growth and yield of watermelon varieties at Tella. Neem + garlic extract emerged as the most promising treatment, providing disease suppression and yield benefits comparable to streptomycin. Climatic factors, particularly rainfall and relative humidity, significantly influenced disease pressure, with higher humidity associated with increased BFB incidence.

Adopting neem and garlic bioextracts offers an eco-friendly, cost-effective, and sustainable management strategy for watermelon farmers in Nigeria. Further research is recommended to refine formulations, optimize dosages, and integrate these extracts into broader integrated pest management (IPM) frameworks.

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