PESTS, DISEASES, AND PARASITIC PLANTS THREATENING COCOA PRODUCTION IN NIGERIA: IMPLICATIONS FOR SUSTAINABILITY

AWE, Omolara Oluwafunmilola PhD
Department of Biology
Adeyemi Federal University of Education,Ondo
Email: omolarawe15@gmail.com

Abstract

Nigeria is Africa's third-largest cocoa producer, yet its productivity has declined sharply over recent decades. This article provides a comprehensive identification and documentation of the major biotic stressors affecting cocoa (Theobroma cacao L.) production across the principal cocoa-producing states of Nigeria, including Ondo, Cross River, Osun, Ogun, Ekiti, Edo, Abia, Akwa Ibom, Delta, Kogi, and Kwara. Drawing on peer-reviewed literature (2000–2025), institutional research from the Cocoa Research Institute of Nigeria (CRIN), and field survey reports, the study systematically catalogues insect pests, particularly mirids (Sahlbergella singularis and Distantiella theobroma), the cocoa pod borer (Characoma strictigrapha), and mealybugs (Planococcus citri) as well as fungal and viral diseases including black pod disease (Phytophthora megakarya and P. palmivora), cocoa swollen shoot virus (CSSV), and vascular streak dieback (Oncobasidium theobromae). Hemi-parasitic plants, principally Tapinanthus bangwensis and Tapinanthus globiferus (Loranthaceae), are also documented. Regional variations in prevalence across the cocoa belt are discussed alongside agroecological drivers and climate change interactions. A dedicated recommendations section proposes evidence-based, actionable strategies encompassing integrated pest management, molecular surveillance, climate-adaptive practices, host resistance deployment, policy reform, and farmer empowerment. The article concludes that closing the gap between available knowledge and on-farm implementation is the most critical prerequisite for sustainable cocoa production in Nigeria.

Keywords: *Theobroma cacao, black pod disease, cocoa mirids, CSSV, integrated pest management, sustainable production.*

Introduction

Cocoa (*Theobroma cacao* L.) is one of the most economically and culturally significant crops in Nigeria. In the 1960s, it contributed nearly 80% of the country's non-oil foreign exchange earnings, earning itself the sobriquet "brown gold" and fuelling prosperity in smallholder-dominated communities across the forest belt (Nkang *et al*., 2015). Yet decades later, despite growing global demand for cocoa and chocolate, Nigeria's output remains far below its historical peak of approximately 300,000 metric tonnes, hovering between 200,000 and 250,000 metric tonnes annually (FAOSTAT, 2023). A confluence of challenges, ageing farm stock, limited technology adoption, climate variability, and, critically, persistent pressure from pests, diseases, and parasitic plants has suppressed yields and undermined farmer incomes (Etaware *et al*., 2022; Fadeyi *et al*., 2022).

The biotic stressors confronting Nigerian cocoa farmers are diverse and frequently synergistic. Losses attributable to pests and diseases alone have been estimated at 20–30% of potential annual yield under average management, rising to 90% during severe black pod disease epidemics caused by *Phytophthora megakarya* (Cilas & Bastide, 2020; Adedeji *et al*., 2022). When the chronic drag of hemi-parasitic mistletoes, termites, and secondary pathogens is added, the cumulative toll on Nigerian cocoa output becomes staggering. Globally, economic losses from insect pests and diseases in cocoa systems have been estimated at US$3.16 billion annually (Adeniyi & Asogwa, 2023), with West African producers bearing a disproportionate share of this burden.

Despite the scale of these losses, systematic, geographically resolved documentation of the full spectrum of biotic stressors across Nigeria's fourteen cocoa-producing states remains incomplete. The most recent comprehensive state-level surveys are several years' old, key data on cocoa swollen shoot virus(CSVD) distribution and Vascular streak dieback (VSD incidence are inadequate, and the contribution of parasitic plants to yield loss has been systematically underestimated in national crop protection literature (Olaiya & Agbeniyi, 2003; Ojua & Abu, 2024). Furthermore, while recent years have witnessed encouraging advances in molecular diagnostics, remote sensing, and climate-adaptive breeding, the translation of these advances into practical management tools accessible to smallholder farmers who manage over 90% of Nigeria's cocoa area, has been slow (Frontiers in Sustainable Food Systems, 2025).

This article addresses these gaps with five objectives: (1) to catalogue the principal insect pests with descriptions of their biology and damage; (2) to document major diseases and their causal organisms and epidemiology; (3) to review parasitic plants in Nigerian cocoa systems; (4) to discuss the regional distribution of biotic stressors across the cocoa belt; and (5) to provide concrete, evidence-based recommendations for achieving sustainable cocoa production. The article is intended as a practical reference for extension agents, agronomists, policymakers, and researchers engaged in the Nigerian cocoa sector.

Justification for the Research

The study was necessary to bridge several critical knowledge and execution gaps that threaten Nigeria's position as a major cocoa exporter, these include:

Substantial, Unresolved Production Decline: Although global demand for cocoa is rising, Nigeria's production has collapsed significantly below its historical peak of 300,000 metric tonnes, remaining trapped between 200,000 and 250,000 metric tonnes annually. Investigating the biotic stressors (pests, diseases, and parasitic plants) is critical because they severely limit yield and suppress smallholder incomes.

Outdated and Incomplete Spatial Data: National crop protection literature suffers from severely outdated state-level surveys. Prior to this review, nationwide surveillance data for threats like Cocoa Swollen Shoot Virus (CSSV) were several decades old, and crucial data tracking the distribution of Vascular Streak Dieback (VSD) were completely inadequate.

Underestimation of Parasitic Plants: While highly visible pests are regularly researched, the chronic drag and actual damage caused by hemi-parasitic mistletoes (*Tapinanthus* spp.) have been systematically underestimated in Nigerian national crop protection literature.

The "Knowledge-to-Farm" Implementation Gap: Although institutions like the Cocoa Research Institute of Nigeria (CRIN) have advanced molecular diagnostics and bred climate-adaptive, disease-resistant crop varieties, the translation of these scientific breakthroughs into actionable tools for smallholder farmers has been dangerously slow.

Unresolved Epidemic Threats: Black pod disease (BPD) alone causes yield losses up to 90% in epidemic years. The emergence of highly virulent strains (like *Phytophthora megakarya*) paired with shifting climate and rainfall patterns necessitates fresh, updated research documentation to update containment strategies.

Implications of the study for Policy Relevance

The findings of this review will mandate immediate institutional, financial, and structural policy reforms by government agencies, agricultural ministries, and industry stakeholders:

Rebuilding Institutional funding and emergency capacity

Indexed Funding for CRIN: Policymakers must move away from ad-hoc financing and establish long-term funding for CRIN's breeding, entomology, and pathology programs by indexing budgets directly to national cocoa export earnings.

Emergency Response Infrastructure: There will be a need to legislate a dedicated National Cocoa Plant Health Emergency Response Fund. This ensures immediate liquidity and protocol deployment to distribute diagnostic tools, certified seeds, and specialized fungicides during rapid disease outbreaks.

Standardizing and regulatory oversight of plant materials

Mandatory phytosanitary certification policy to curb the widespread transmission of incurables like CSSV, which is often spread unknowingly by farmers sourcing unverified materials from peers, policies must mandate strict phytosanitary certification for all cocoa planting materials sold nationwide. The need for subsidized roguing policies will also arise. This is because the only remedy for CSSV is physical removal (roguing) of infected trees, thus, governments must create eradication subsidies. Without financial compensation or replanting subsidies, resource-poor smallholders will continue to resist cutting down infected trees, which subsequently preserve viral reservoirs.

Market Incentives and International Alignment

IPM reward frameworks: Policies should introduce market incentive mechanisms, such as price premiums, targeted input subsidies, or fast-tracked export certificates, specifically rewarding farmers who actively adopt Integrated Pest Management (IPM) systems.

Global compliance frameworks: To retain access to premium global markets, trade policies must aggressively align Nigeria's cocoa standards with the African Regional Standard (ARS-1000) and the EU Deforestation Regulation. This includes strict regulatory tracking to optimize and reduce copper-based fungicide inputs to stay within international chemical cap thresholds.

Modernization of extension services

Institutionalized extension networks: Crop protection policy must formally establish a National Cocoa Integrated Pest Management Strategy, mandated to be updated every five years using geo-referenced surveillance, hardcoded into the curriculum of State Agricultural Development Programmes (ADPs).

Digital Integration Policies: State agricultural policies should prioritize funding for the deployment of mobile phone-based disease reporting apps and weather-linked disease forecasting models (such as ETAPOD: a forecast model for prediction of blackpod disease in Nigeria) to replace obsolete calendar-based fungicide distribution schedules with real-time, data-driven farming advisories.

Overview of Cocoa Production in Nigeria

Cocoa was introduced into southwestern Nigeria in the late nineteenth century, likely through missionary activities around 1879, and spread rapidly through Yoruba-speaking communities into what are today Ondo, Osun, Ogun, and Ekiti States, before extending eastward into Edo, Cross River, Akwa Ibom, and Abia States (Nkang *et al*., 2015). Fourteen states currently produce 95% of national output, with Ondo State alone accounting for approximately 30% (Etaware *et al*., 2022). By the mid-twentieth century, Nigeria was the world's second-largest producer, a status that reflected both the suitability of its agro-ecological environment and the enterprise of its smallholder farming population.

The Nigerian cocoa belt spans the humid rainforest and derived savanna zones between approximately latitudes 4°N and 9°N, where mean annual rainfall exceeds 1,200 mm and relative humidity remains consistently high. These conditions favour cocoa growth but are equally conducive to the proliferation of pathogens, insect pests, and parasitic plants (Etaware, 2019). Under optimal management, Cocoa Research Institute of Nigeria(CRIN) released improved varieties yield 1,000–2,000 kg of dry beans per hectare; in practice, the national average rarely exceeds 300–400 kg/ha, partly because of the chronic pressure of biotic stressors (Aikpokpodion, 2010). An estimated 800,000 hectares are under cocoa cultivation, managed almost entirely by smallholders farming plots of one to five hectares (Etaware *et al*., 2022).

Cocoa is Nigeria's third most exported agricultural commodity, recording a total export value of ₦12 billion in the third quarter of 2020 (Frontiers in Sustainable Food Systems, 2025). The crop supports the livelihoods of over three million farming families and underpins rural economies across multiple states. The economic case for investing in the crop's plant health infrastructure is therefore compelling: moderate improvements in pest and disease management alone could unlock hundreds of thousands of additional metric tonnes of output annually.

Insect Pests of Cocoa in Nigeria

Cocoa Mirids (Capsids)

The cocoa mirids, principally *Sahlbergella singularis* Haglund and *Distantiella theobroma* Distant (Hemiptera: Miridae) are consistently identified as the most economically destructive insect pests of cocoa in Nigeria. Yield losses under unmanaged conditions can reach 100%, while moderate infestations cause 25–30% losses a chronic drain that, aggregated nationally, represents hundreds of millions of dollars annually (Adeniyi & Asogwa, 2023; Ndubuaku & Asogwa, 2019).

Both species are sap-sucking bugs that feed on young succulent shoots, fan branches, and developing pods. Feeding punctures produce characteristic brown necrotic lesions that coalesce under heavy infestation, girdling shoots and inducing dieback. A critical secondary consequence is the predisposition of wounded tissue to invasion by *Calonectria rigidiuscula*, a fungal pathogen that establishes stem cankers and causes secondary die-back (Entwistle, 1965; Anikwe, 2009). The population threshold for economically significant damage is well established at six mirids per ten cocoa trees (Owusu-Manu, 1985, cited in Adeniyi & Asogwa, 2023). Dry-season populations peak between November and March. In agroforestry systems, wild Malvaceae species, notably *Ceiba pentandra* and *Cola acuminate* serve as mirid reservoirs, sustaining re-infestation pressure on managed plots (Cilas & Bastide, 2020).

Cocoa Pod Borer

The cocoa pod borer, *Characoma strictigrapha* (Lepidoptera: Noctuidae), causes internal rotting of beans even when external pod surfaces appear intact. Estimated losses reach approximately 17% under moderate infestation (Adeniyi & Asogwa, 2023), though localised damage can be considerably higher. Natural biological control agents, including parasitic Hymenoptera, *Aspergillus* sp., and parasitic nematodes, have been documented parasitising larvae and pupae in Nigerian plantations, representing a largely untapped biocontrol resource (Entwistle, 1965).

Mealybugs

Mealybugs, particularly *Planococcus citri* Risso and *Formicococcus njalensis* (Laing) (Hemiptera: Pseudococcidae), are significant both for direct phloem sap extraction and as vectors of cocoa swollen shoot virus. Their ant-tended colonies, where ants actively protect mealybugs from natural enemies in exchange for honeydew, complicate control significantly. The ant-mealybug mutualism means that the presence of *Crematogaster* or *Camponotus* highways on cocoa trunks serves as a practical early warning indicator for mealybug infestation, particularly in Cross River and Akwa Ibom States (Adeniyi & Asogwa, 2023).

Cocoa Shield Bug

The cocoa shield bug, *Bathycoelia thalassina* Herrich-Schäffer (Hemiptera: Pentatomidae), feeds on developing pods causing silvery discolouration and premature ripening, and creates entry points for secondary fungal infections. Biological control agents including the tachinid fly *Cylindromyia cribrata* and the scelionid wasp *Trissolcus* spp. provide approximately 14% adult parasitism under natural conditions (Entwistle, 1965).

Termites

Termites, principally Macrotermes spp. (Isoptera: Termitidae), target the root collar and lower trunk, hollowing structural wood and undermining tree stability. Field surveys in Ondo, Osun, and Cross River consistently rank termite infestation among the top five constraints to cocoa yield alongside black pod disease and tree senescence (Aikpokpodion, 2010). Damage is most severe in the dry season and in farms established on previously forested land with abundant woody debris providing nesting substrate.

Table 1: Summary of Major Pests, Diseases, and Parasitic Plants Affecting Cocoa Production in Nigeria

Pest / Organism	Scientific Name	Category	Part Affected	Yield Loss (%)
Cocoa Mirid	*Sahlbergella singularis; Distantiella theobroma*	Insect Pest	Shoots, pods, fan branches	25–100
Cocoa Pod Borer	*Characoma strictigrapha*	Insect Pest	Pods, beans	≤17
Mealybug	*Planococcus citri; Formicococcus njalensis*	Insect / Vector	Stems, branches	Variable; CSSV vector
Cocoa Shield Bug	*Bathycoelia thalassina*	Insect Pest	Pods	Moderate
Termites	*Macrotermes spp.*	Insect Pest	Roots, trunk	Significant
Black Pod Disease	*Phytophthora megakarya; P. palmivora*	Fungal (Oomycete)	Pods, stems, trunk	30–90
Swollen Shoot Virus	*Cocoa swollen shoot virus* (CSSV)	Viral Disease	Stems, roots, leaves	Up to 50
Vascular Streak Dieback	*Oncobasidium theobromae*	Fungal Disease	Shoots, vascular tissue	Moderate –High
Charcoal Pod Rot	*Lasiodiplodia theobromae*	Fungal Disease	Pods	Variable
Mistletoe (Loranthaceae)	*Tapinanthus bangwensis; T. globiferus*	Parasitic Plant	Branches, canopy	Canopy loss / variable

Note: *Yield loss estimates are approximate and vary by location, season, and farm management practices. Sources: Adeniyi & Asogwa (2023); Cilas & Bastide (2020); Etaware et al. (2022); Ndubuaku & Asogwa (2019).*

Diseases of Cocoa in Nigeria

Black Pod Disease

Black pod disease (BPD) is unequivocally the most economically devastating disease of cocoa in Nigeria. (Adegoke, (2018); Adeniyi (2019); Al et al (2017): Guest (2007); Okeoghene (2020); Oladoku (2025). The primary causal agent is Phytophthora megakarya Brasier & Griffin, with P. palmivora Butler contributing in less humid zones. Annual pod losses range from 30% under moderate management to 90% during epidemic years (Cilas & Bastide, 2020; Adedeji et al., 2022). Globally, BPD accounts for the loss of approximately 700,000 metric tonnes of cocoa annually (Adeniyi & Asogwa, 2023).

The disease presents initially as a small water-soaked lesion that rapidly expands to a brown-to-black discolouration encompassing the entire pod within 48–72 hours under wet conditions. Internally, the bean mass becomes necrotic and loses all commercial value. Severe infections also cause stem canker, resulting in vascular disruption and tree death (Adedeji et al., 2022). Epidemiology is driven by rainfall, which disperses P. megakarya zoospores from infected pods to healthy material. Infestation begins with pods closest to the ground and spreads upward through rain splash and insect activity (Agbeniyi & Adenikinju, 2001). The emergence of P. megakarya, substantially more virulent than P. palmivora and producing approximately ten times more sporangia—has intensified management challenges across the cocoa belt (Bailey et al., 2016). Climate change, particularly shifting rainfall patterns and extended wet seasons, is expected to further increase BPD severity and spatial distribution (Farmforce, 2025; Frontiers in Sustainable Food Systems, 2025).

Recent molecular investigations using Random Amplified Polymorphic DNA(RAPD) markers and species-specific Polymerase chain reaction (PCR) have improved the rapid differentiation of Phytophthora species in Nigerian cocoa systems, enabling more targeted fungicide recommendations (Adedeji et al., 2022). An epidemiological model for BPD prediction in Nigeria (ETAPOD) has also been developed, linking disease forecasting to local rainfall data as a decision-support tool for fungicide application timing (Etaware et al., 2022).

Cocoa Swollen Shoot Virus Disease (CSSV)

Cocoa swollen shoot virus disease (CSSV) is transmitted by mealybugs, particularly P. citri and F. njalensis. First recorded in Nigeria in the 1940s, it has since been reported across the major cocoa-growing states, with severe impacts in Ondo, Ogun, and Cross River States (Cilas & Bastide, 2020). Infected trees display characteristic swelling of chupons and fan branches, chlorotic vein-banding on leaves, and red flushing of young growth. Yield losses can reach 50%, and in severely affected farms, tree mortality is substantial (Aikpokpodion, 2010).

CSSV management is particularly challenging because the virus is systemic and incurable; the only effective control is physical removal (roguing) and destruction of infected trees. Smallholder farmers frequently resist this strategy in the absence of replanting subsidies. Wild Malvaceae forest species and landscape heterogeneity maintain virus and vector reservoirs at farm margins. Updated nationwide CSSV surveillance data are urgently needed, as the most recent comprehensive surveys are several decades old (Ojua & Abu, 2024).

Vascular Streak Dieback (VSD)

Vascular streak dieback, caused by Oncobasidium theobromae Talbot & Keane, is increasingly documented in Nigeria's higher-altitude cocoa areas, particularly in Cross River and Taraba States (Cilas & Bastide, 2020). The disease causes characteristic brown vascular flecking in shoot wood, progressive die-back, sparse yellowed canopy, and reduced pod set. VSD is likely significantly underdiagnosed in Nigeria because the confirmatory diagnostic procedure, longitudinal cutting of affected shoots to reveal vascular browning, is rarely performed by extension agents or farmers. Capacity-building for VSD field diagnosis should be a priority in national plant protection training programmes.

Cherelle Wilt and Charcoal Pod Rot

Cherelle wilt, the blackening and drying of young pods before harvestable size—is exacerbated by biotic factors including mirid feeding, fungal infection, and water stress. Natural wilt rates of 25–50% occur in well-managed farms; under pest and disease pressure, rates can approach 80%, severely limiting final pod set. Charcoal pod rot, caused by Lasiodiplodia theobromae (Pat.) Griffon & Maubl., is an opportunistic pathogen that attacks pods weakened by physical damage or unfavourable weather. It is of greater relative importance in the drier marginal cocoa zones of Kogi, Kwara, and Adamawa States.

Parasitic Plants Affecting Cocoa in Nigeria

Overview

Parasitic flowering plants of the family Loranthaceae, commonly known as mistletoes, impose a sustained but often underestimated burden on Nigerian cocoa productivity. As hemi-parasites, they possess chlorophyll and are capable of photosynthesis, yet penetrate host vascular tissue through specialised haustoria to extract water and mineral nutrients (Mathiasen et al., 2008). On cocoa, mistletoe infestation reduces yield through two mechanisms: direct interception of photosynthate and nutrients, and structural damage to host vascular tissue. The relationship between mistletoe infestation and black pod disease is also documented, as the moist microhabitat created by parasite masses provides favourable conditions for Phytophthora sporulation (Thorold, 1952; Olaiya & Agbeniyi, 2003).

Tapinanthus bangwensis

The most commonly documented mistletoe on cocoa in West Africa is Tapinanthus bangwensis (Engl. & K. Kraus (1959) Danser (Loranthaceae). Seeds are dispersed primarily by frugivorous birds, making vector management practically impossible (Akrofi & Acheampong, 2016). Once established via the haustorium, expanding parasite masses shade the host canopy, competing for light, water, and nutrients. In heavily infested trees, mistletoe masses cover a substantial canopy proportion, reducing pod production. In Ghana, approximately 14% of cocoa trees are infested with mistletoes, with over 70% of infestations attributed to T. bangwensis (Amoako-Attah et al., 2014). Nigerian documentation of infestation rates in Moor Plantation, Ibadan, confirms the productivity-reducing effects of Tapinanthus on related economic trees and underscores the need for systematic survey across cocoa states (Edagbo et al., 2013).

Tapinanthus globiferus and other Loranthaceae

A second species, Tapinanthus globiferus (A. Rich.) Van Tiegh., has been reported to possess a wider host range and broader geographical distribution across Nigeria than T. bangwensis (Odebiyi et al., 2003). Mechanical control by cutting back infested branches is largely ineffective for both species, as the haustorial connection with host tissue means that superficial removal of visible parasite shoots does not prevent regeneration. Research on spatial arrangement of cocoa trees in Ghana found that planting in rows significantly reduced mistletoe density compared to randomly planted farms, suggesting that canopy spatial management may constitute a cost-effective prevention strategy (Tankou & Ntui, 2023).

Regional distribution across Cocoa-Producing States

Ondo State

Ondo State, Nigeria’s largest cocoa producer (~30% of national output), hosts a correspondingly diverse pest-disease complex. BPD caused by P. megakarya dominates, with survey peaks in August coinciding with maximum rainfall (Agbeniyi & Adenikinju, 2001). Mirid populations reach damaging levels annually, peaking between November and March. Mistletoe infestations by T. bangwensis have been documented in older farms in the Idanre, Ondo, and Ile Oluji Local Government Areas. Climate projections for southwest Nigeria suggest more intense and unpredictable rainfall, which is expected to increase BPD severity in the state (Frontiers in Sustainable Food Systems, 2025).

Cross River State

Cross River State presents a particularly severe disease environment: high humidity, proximity to the Cross River forest, and a preponderance of senescent cocoa trees create ideal conditions for BPD and CSSV. A 2024 study of smallholder farmers in the state found that most sourced planting materials from other farmers (71%) rather than certified CRIN stations, and that a majority lacked knowledge of specific fungicide application timing for BPD, underscoring systemic gaps in extension support (Ojua & Abu, 2024). VSD incidence in the state’s higher-altitude farms warrants targeted surveillance.

Osun, Ogun, and Ekiti States

Osun and Ogun States share broadly similar pest-disease profiles dominated by BPD and mirids, with CSSV periodically documented. The southern zones of Ogun State experience a longer dry season, moderating BPD intensity while sustaining higher mirid populations. In Ekiti State's drier, marginal cocoa zones, charcoal pod rot assumes greater relative importance. Parasitic plant infestations are documented in ageing cocoa stands in the Ilesa area of Osun State.

Edo, Delta, Abia, and Akwa Ibom States

In Edo and Delta States, proximity to oil palm and rubber plantations maintains mirid and mealybug reservoirs in adjacent crops. CSSV has been periodically recorded in Edo. In the southeastern states of Abia and Akwa Ibom, dense agroforestry shade systems can moderate BPD while increasing VSD risk and sustaining pod borer populations. Weaker extension reaches in these states correlates with lower rates of IPM adoption (Frontiers in Sustainable Food Systems, 2025).

Kogi and Kwara States

At the northern frontier of the cocoa belt, lower and more variable annual rainfall increases drought stress that lowers plant resistance to opportunistic pathogens. Termite damage is disproportionately high in these drier states. BPD, while present, tends to be less severe than in high-rainfall zones, though episodic outbreaks during wet years cause substantial losses.

Impacts on Cocoa Production Sustainability

These biological threats jeopardize the continuous loop of sustainable cocoa farming across multiple dimensions:

Economic Sustainability (Livelihoods & Yields)

The massive yield drops (often more than half the potential output during heavy rainy seasons) mean volatile and heavily reduced income for smallholder farmers. The high financial burden of purchasing chemical inputs, coupled with labor costs for constant spraying and pruning, erodes the net profit margins of farming families (Adejumo, 2005). Over time, this makes cocoa farming economically unviable, driving younger generations away from the trade.

Environmental Sustainability (Chemical Overuse)

To battle mirids and black pod disease immediately, Nigerian farmers lean heavily on chemical pesticides, including organophosphates, carbamates, and copper-based fungicides (Ndubuaku and Asogwa, 2019)

Resonance & Resistance: Pathogens quickly build resistance to these heavily applied chemical groups (Adejumo, 2005).

Ecosystem Damage: Runoff pollutes local water bodies, depletes soil health, and eradicates non-target beneficial insects (like the midges responsible for pollinating cocoa flowers), which accidentally lowers natural yield rates.

Social Sustainability (Labor & Resource Stress)

Managing infected fields demands grueling physical labor. Constant manual removal of mistletoe, regular harvesting of diseased pods, and demanding spray schedules can exhaust family labor supplies (Adejumo, 2005). Additionally, handling hazardous chemicals with inadequate personal protective equipment poses significant, long-term health risks to rural agricultural communities.

Conclusion and Policy Recommendation

The biotic stressors catalogued in this review, ranging from the devastating pod losses inflicted by Phytophthora megakarya to the insidious canopy degradation wrought by Tapinanthus mistletoes and the chronic yield drain of mirid capsids, collectively represent a formidable but not insurmountable challenge to Nigerian cocoa production. Nigeria possesses in CRIN a research institution with deep institutional knowledge; its cocoa agroecosystems harbour rich natural enemy communities capable of supporting biological control; and an expanding arsenal of molecular, digital, and climate-adaptive tools is becoming available to transform surveillance and management.

What is lacking is not knowledge per se, but the systematic documentation, integration, and operationalisation of that knowledge at the farm level. This review has documented significant gaps: outdated state-level pest and disease survey data; low adoption of CRIN-certified resistant varieties; inadequate extension reach in several key producing states; and the consistent underestimation of parasitic plant damage in national crop protection literature. Closing these gaps, through the seven-pronged recommendation framework advanced here requires coordinated investment from government, research institutions, development partners, and the private sector.

The stakes are high. Nigeria's three million cocoa farming families, the downstream processors and exporters who depend on their output, and the national economy that benefits from cocoa's foreign exchange contribution all share an interest in reversing the productivity decline of recent decades. With renewed investment in plant health documentation, surveillance, and management, Nigeria has the capacity to reclaim a position of leadership in the global cocoa economy while securing sustainable livelihoods for the smallholder farmers who are its backbone.

Recommendations

The complexity and geographic diversity of the biotic stressors documented in this review necessitate a multi-pronged, evidence-based management strategy that is realistic for smallholder-dominated systems.

The following recommendations are made for sustainable development in Cocoa agro-economy:

- Strengthening Integrated Pest Management (IPM) Systems
- Accelerating Host Plant Resistance Deployment
- Modernising Surveillance and Molecular Diagnostics
- Scaling Biological Control and Conservation of Natural Enemies
- Improving Chemical Control Practices and Stewardship
- Climate-Adaptive Farming Practices
- Policy, Institutional, and Market Linkage Reforms

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