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SAFEGUARDING INDONESIA'S CASSAVA INDUSTRY: CRITICAL RESPONSE TO SLCMV'S ADVANCE IN SOUTHEAST ASIA

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ABSTRACT

Sri Lankan Cassava Mosaic Virus (SLCMV) has emerged as a significant threat to cassava production in Southeast Asia since its initial detection in Cambodia in 2015, with recent outbreaks in Vietnam and Thailand and its first detection in Australia in 2024. This viral disease, transmitted by the whitefly Bemisia tabaci and infected planting materials, poses a substantial risk to Indonesia's cassava industry. Studies from affected countries demonstrate yield losses of 16-33% and starch content reductions of 22-38% in infected plants. This review analyzes SLCMV's current status and potential impacts on Indonesian cassava production and proposes management strategies based on regional experiences. We identify critical risk factors, including widespread vector presence and informal planting material exchange networks. Recommended preventive measures include strengthening quarantine systems, implementing enhanced surveillance programs, developing rapid diagnostic capabilities, and establishing clean seed certification systems. Our findings emphasize the urgent need for coordinated action to protect Indonesia's cassava industry from this emerging pathogen.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) plays a vital role in global food security and industrial applications, with Southeast Asia contributing over 95 percent of global exports. In recent years, the emergence of the Sri Lankan cassava mosaic virus (SLCMV) has become a significant threat to cassava production in this region. First detected in Ratanakiri, Cambodia, in 2015, SLCMV has demonstrated an alarming capacity for rapid geographical expansion, spreading to Vietnam (2017), China (2018), Thailand (2019), Laos (2020), and most recently, Australia (2024).

For Indonesia, as Southeast Asia's largest cassava producer with approximately 700,000 hectares under cultivation, SLCMV represents an emerging biosecurity threat requiring immediate attention. Several risk factors make Indonesia particularly vulnerable to SLCMV introduction: (1) the widespread presence of *B. tabaci* populations throughout the archipelago, (2) extensive informal trade networks for cassava planting materials across the region, and (3) shared borders with countries where SLCMV is already established.

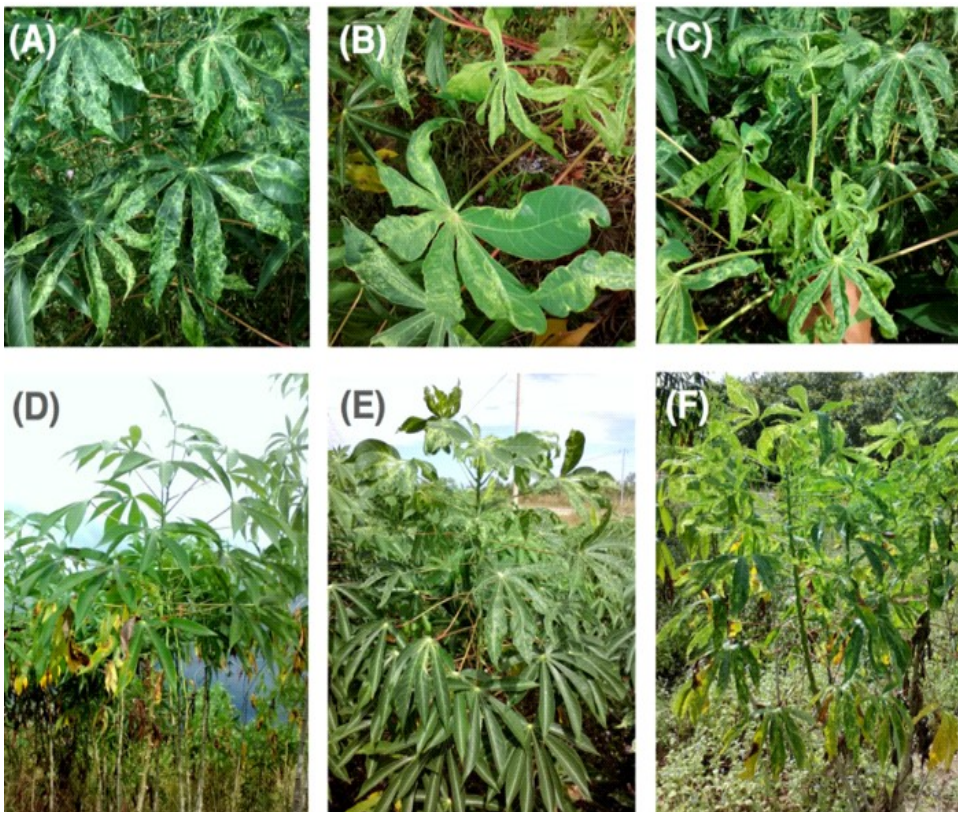


Figure 1. Symptoms observed on SLCMV-positive plants identified in Cambodia (Minato et al., 2019)**.** (A)-(C) Typical CMD symptoms on leaves, (A) mosaic, (B) deformation, and (C) curl. (D) Asymptomatic plant testing positive by PCR for SLCMV infection. (E) Plants with mosaic symptoms only on upper leaves and (F) plants with systemic mosaic symptoms.

Table 1. SLCMV's structural components and characteristics (Chaowongdee et al., 2023; He et al., 2024; Saokham et al., 2021)

Component	Feature	Details	Function/Characteristics
Virus Morphology			
Particle Structure	Twinned icosahedral	Geminate particles	Distinctive morphology of geminiviruses
Particle Size	~2.7-3.0 kb	Each DNA component	Typical size for begomoviruses
Genome Organization			
DNA-A Component	~2.7-3.0 kb	It contains six genes:	Master component for virus replication
	AV1 (CP)	Capsid Protein	• Viral encapsidation • Essential for whitefly transmission • Key structural protein
	AV2	Pre-coat protein	Movement and pathogenicity
	AC1 (Rep)	Replication protein	• Essential for viral replication • Species-specific binding
	AC2	Transcriptional activator	Gene regulation
	AC3	Replication enhancer	Enhances viral replication
	AC4	Symptom determinant	Pathogenicity factor
DNA-B Component	~2.7-3.0 kb	It contains two genes:	Movement functions
	BC1	Movement protein	Cell-to-cell movement
	BV1	Nuclear shuttle protein	Nuclear transport
SLCMV-HN7	Chinese isolate	Found in Hainan	Specific virulence pattern
SLCMV-Col	Original strain	Reference strain	Different virulence from HN7
Regulatory Elements			
Common Region	~200 nucleotides	Shared between DNA-A/B	• Contains regulatory elements • Replication origin • Promoter sequences
Protein Features			
Capsid Protein (CP)	30 kDa	Structural protein Immunogenic	Vector transmission Used for virus detection
Rep Protein	Variable	Contains 7-aa motif Some strains lack motifs.	Essential for replication Affects virulence
Associated Molecules			
Satellites	Not reported	Unlike some begomoviruses	No satellite DNAs were found
DI DNAs	Can occur	Defective interfering DNAs	May affect symptoms

This paper aims to evaluate the current status of SLCMV, assess its potential impact on Indonesian cassava production, and propose management strategies based on experiences from affected countries. Understanding these aspects is crucial for developing effective preventive measures and response protocols before the virus potentially reaches Indonesian shores. The findings will be valuable for policymakers, agricultural researchers, and stakeholders in Indonesia's cassava industry to prepare for and mitigate this emerging threat.

MATERIALS AND METHODS

This study synthesized and analyzed comprehensive data on SLCMV publication, collected between 2015 and 2024 from SCOPUS and Google Scholar databases, focusing on its emergence and spread across Southeast Asia and Australia. We use mixed methods to systematically reviewed peer-reviewed research articles, surveillance reports from national agricultural agencies, technical bulletins, official disease notifications, and regional workshop proceedings on cassava diseases. Recent molecular characterization studies of SLCMV were particularly emphasized to understand virus evolution and spread patterns.

Our epidemiological analysis examined the geographical progression of SLCMV since its first detection, including transmission dynamics, vector population distribution, and environmental factors influencing disease spread. Economic impact assessments from affected countries were analyzed to project potential consequences for Indonesian agriculture. Special attention was given to the recent Australian detection in 2024, as it represents a significant expansion of the virus's geographical range and has important implications for regional biosecurity.

We mapped potential entry pathways and evaluated existing biosecurity measures to assess Indonesia's risk exposure. This included an analysis of cassava cultivation patterns, an assessment of vector presence in major growing areas, and a review of current diagnostic capabilities. The effectiveness of management strategies implemented in Cambodia, Vietnam, and Thailand was evaluated to identify approaches that could be successfully adapted to Indonesian conditions.

Data validation was achieved by cross-referencing multiple research publications on cassava virus diseases. Standardized criteria were applied to analyze disease incidence and severity, quantify economic impacts, assess management strategy effectiveness, and determine implementation feasibility in the Indonesian context. This methodological approach enabled a comprehensive understanding of the SLCMV threat and informed the development of targeted recommendations for Indonesia's cassava industry.

RESULTS AND DISCUSSION

The analysis of SLCMV's emergence and spread across Southeast Asia provides critical insights into Indonesia's cassava industry. Since its initial detection in Cambodia in 2015, SLCMV has demonstrated a remarkable capacity for geographical expansion, moving at an estimated 100-150 kilometers per year. The virus's progression through Vietnam (2017), Thailand (2019), and Laos (2020), culminating in its recent detection in Darwin, Australia (2024), highlights its capacity for both gradual expansion and long-distance jumps through

human-mediated movement of infected planting materials.

Our examination of field survey data from affected countries (Table 2) reveals infection rates ranging from 6% to 80%, with severity strongly correlated to using infected planting materials. Molecular analysis of virus isolates shows 96-98% sequence similarity across geographical locations, suggesting recent spread from a common source. This finding (Table 3) has particular significance for Indonesia, given the highly efficient vector species *Bemisia tabaci* Asia II 1 biotype's presence throughout its cassava-growing regions.

The economic implications for Indonesia's cassava sector are concerning. Data from Vietnamese studies showing yield losses of 16-33% and starch content reductions of 22-38% in infected plants suggest potential annual losses of 3.3-6.6 million tonnes if SLCMV becomes established across Indonesia's production areas (Collavino et al., 2022; Uke et al., 2018; Wang et al., 2020). The impact

Table 2. Geographic distribution of SLCMVs in South Asia and Southeast Asia

Country/ Region	Year First Detected	Location Details	Key Findings/ Notes
Cambodia (Carvajal-Yepes et al., 2016; Hareesh et al., 2023; Minato et al., 2019; Saokham et al., 2021; Wang et al., 2016)	2015	Ratanakiri Province (first detection)	First report in Southeast Asia
	2016-2017	Stung Treng Province	Higher incidence than Ratanakiri (6.3-56.3% within-field incidence
Vietnam (Chaowongdee et al., 2023; Hareesh et al., 2023; Minato et al., 2019; Saokham et al., 2021; Uke et al., 2022)	2017	Tay Ninh Province	Damaged >1200 ha of an established crop
		Southern regions	Spread through infected planting materials.
China (Hareesh et al., 2023; Wang et al., 2020)	2018	Hainan Province Fujian Province	7 out of 32 samples positive • 3 out of 11 samples positive • Two strains identified: SLCM HN7 and SLCMV-Col • Some plants showed coinfection with both strain
Thailand (Chaowongdee et al., 2023; Hareesh et al., 2023; Hemniam et al., 2022; Saokham et al., 2021; Uke et al., 2022)	2018-2019	Five provinces along Cambodia's border Prachinburi Sakaeo Burium Surin Sisaket	The overall incidence of 40% Highest incidence (80%) 43% incidence 37% incidence 25% incidence 19% incidence
Laos (Chittarath et al., 2021; Hareesh et al., 2023)	2020	Kong District, Champassack Province	• 18.3% PCR positive • Only 6.7% showed visible symptoms
Australia (Fan et al., 2024; Vala et al., 2024)	2024	Darwin, Northern Territory Jingili community garden	• First detection outside of As • First report in Australia • 96.38% nucleotide identity with Asian SLCMV

extends beyond direct yield reduction, affecting root quality parameters crucial for industrial processing. This is particularly significant given that approximately 70% of Indonesia's cassava production serves industrial markets.

Secondary economic impacts include increased production costs, potential loss of export markets due to quarantine restrictions, and disruption of traditional seed systems. The industrial starch sector appears particularly vulnerable, as reduced starch content in infected plants directly affects processing efficiency and product quality.

Our analysis of management strategies from affected countries indicates that successful SLCMV control requires integrated approaches combining enhanced surveillance, strict quarantine measures, vector management, and capacity building. Experience from Thailand demonstrates that delayed response can lead to rapid disease establishment and difficult containment situations. Therefore, immediate implementation of enhanced

Table 3. SLCMV's transmission mechanisms and characteristics (Chaowongdee et al., 2023; Hareesh et al., 2023; Malik et al., 2022; Saokham et al., 2021; Siriwan et al., 2020; Vannatim et al., 2024)

Transmission Type	Details	Characteristics	Impact/Notes
Vector Transmission			
Vector Species	Bemisia tabaci	Whitefly species complex	Primary insect vector
Whitefly Biotypes	Asia II 1	Most efficient vector	Predominant in SE Asia
	Mediterranean (MED)	Less efficient	Insecticide resistant
	MEAM1	Poor transmission	Lower concern
Vector Transmission Process			
Mechanism	Non-propagative	The virus doesn't replicate in vector	Circulative transmission
	Circulative	The virus moves through insect bodies.	
Acquisition Time	Multiple feeds	Vector feeds on infected plant	Minutes to hours
Transmission Distance	Short range	Up to 20m typically	Local spread
	Wind-assisted	Can travel longer distances	Weather dependent
Efficiency	Variable	Depends on whitefly biotype	Asia II 1 most efficient
Vegetative Transmission			
Stem Cuttings	Primary route	Main long-distance spread	Major concern
Infection Rate	High	55-77% yield loss	More severe than whitefly
Spread Distance	Unlimited	Through trade/exchange	International spread
Transmission Patterns			
Field Patterns	Edge effect	Initial infection at field edges	From external sources
	Progressive spread	Moves inward from edges	Through whitefly
Seasonal Patterns	Weather dependent	Higher in the dry season	Whitefly population linked
	Temperature sensitive	< 35°C optimal	Affects vector activity
Environmental Factors			
Temperature	Optimal range	Below 35°C	Affects vector survival
Humidity	Moderate	65-73% relative humidity	Influences vector activity
Rainfall	Negative correlation	Heavy rain reduces vectors	Seasonal effects
Wind	Variable impact	Assists vector movement	Spread factor

surveillance programs in Indonesian border regions and major cassava-producing areas is crucial.

Key management recommendations (Table 5) include establishing systematic surveys in high-risk areas, developing rapid diagnostic capabilities, strengthening border controls, and implementing clean seed certification systems. Vector management through integrated pest management strategies and

Table 4. Disease impact of SLCMV's (Hareesh et al., 2023; Nomura et al., 2024; Siriwan et al., 2020; Uke et al., 2022)

Category Direct Crop Impacts	Impact Type	Details	Severity/Notes
Yield Loss	Production Reduction	16-33% loss from infected cuttings	Severe economic impact
	Starch Content	22-38% reduction	Affects industrial use
	Root Weight	Significant reduction	Impacts marketable product
Symptoms			
Leaf Symptoms	Mosaic Pattern	Green/yellow mosaic	Primary diagnostic feature
	Leaf Curling	Upward/downward curling	Varies by strain
	Distortion	Abnormal leaf shape	Affects photosynthesis
	Chlorosis	Yellow patterns	Variable severity
Growth Impact	Stunting	Reduced plant height	Affects overall yield
	Reduced Leaf Size	Smaller leaf area	Reduces photosynthetic capacity
	Twig Stunting	Affects branch development	More severe in susceptible varieties
Transmission Effects			
Cutting-borne	High Impact	55-77% yield loss	The most severe transmission route
	Systemic Infection	Affects entire plant	Long-term impact
Whitefly-borne	Moderate Impact	35-60% yield loss	Secondary transmission route
	Localized Symptoms	Initially affects upper leaves	Progressive infection
Varietal Response			
Tolerant Varieties	TME3, KU50	Mild symptoms Recovery possible	Better yield maintenance Recommended for planting
Susceptible Varieties	R11, Others	Severe symptoms No recovery	Major yield losses Not recommended in affected areas
Economic Impact			
Direct Losses	Crop Value	Reduced market value	Significant economic loss
	Quality Impact	Lower starch content	Affects industrial use
Indirect Costs	Management Costs	Disease control expenses	Additional production costs
	Prevention Measures	Clean planting material costs	Increased input costs
Regional Impact			
Southeast Asia	Major Impact	Widespread occurrence	Affects multiple countries
Thailand	Significant	40% overall incidence	Major cassava producer
Vietnam	Severe	>1200 ha affected	Economic importance
Cambodia	First Affected	Expanding impact	Source of spread
Industry Impact			
Starch Industry	Quality Effects	Reduced starch content	Industrial processing impact
Biofuel Sector	Yield Impact	Reduced biomass	Affects biofuel production
Food Security	Supply Chain	Reduced availability	Social impact

Table 5. SLCMV's management strategies and controls (Deepthi and Makeshkumar, 2016; Graziosi et al., 2016; Hareesh et al., 2023; Raju et al., 2023; Uke et al., 2022)

Management Category Prevention & Quarantine	Strategy	Implementation Details	Effectiveness/Notes
Clean Planting Material	Virus-free stems	Tissue culture propagation	Highly effective
	Certification systems	Testing before distribution	Primary prevention
	Aeroponic culture	Rapid multiplication	New technology
Quarantine Measures	Border control	Import restrictions	International level
	Movement restrictions	Between affected regions	Regional level
	Testing protocols	PCR and ELISA screening	Essential screening
Breeding & Resistance			
Genetic Resistance	CMD2 gene	Single dominant resistance	Most effective source
	TME3 cultivar	African germplasm	Proven resistance
	KU50 cultivar	Asian adapted variety	Regional tolerance
Breeding Programs	Conventional breeding	Cross-breeding	Long-term solution
	Molecular breeding	Marker-assisted selection	More precise
	Genetic engineering	Transgenic approaches	Under development
Vector Management			
Chemical Control	Insecticides	Against whitefly	Short-term solution
	Rotation strategies	Resistance management	Prevent resistance
Cultural Control	Physical barriers	Nets/screens	Effective but costly
	Trap crops	Vector diversion	Supplementary method
Biological Control	Natural enemies	Predators/parasitoids	Sustainable approach
Field Management			
Cultural Practices	Roguing	Remove infected plants	Essential practice
	Field isolation	Distance from sources	Preventive measure
	Timing of planting	Avoid peak vector periods	Strategic planning
Monitoring	Regular inspection	Symptom observation	Early detection
	Disease mapping	Track spread patterns	Management tool
Education & Training			
Farmer Training	Disease recognition	Symptom identification	Basic knowledge
	Management practices	Control methods	Implementation
	Clean seed use	Importance of health material	Prevention

protection of nursery facilities with insect-proof screening has proven effective in containing spread in affected areas.

Establishing a national task force combining expertise in virology, entomology, and extension services would provide the coordinated response necessary for effective disease prevention and management. Regional cooperation and information-sharing networks have proven valuable in affected countries and should be prioritized in Indonesia's preparedness strategy.

Current evidence suggests that Indonesia's window for preventive action remains open, but immediate, coordinated effort is required to establish practical barriers against SLCMV introduction and spread. Success will depend on combining robust quarantine measures, enhanced surveillance systems, and rapid response capabilities, supported by strong regional cooperation and stakeholder engagement across the cassava value chain.

CONCLUSION

Sri Lankan Cassava Mosaic Virus (SLCMV) represents an immediate and significant threat to Indonesia's cassava industry, as demonstrated by its rapid spread across Southeast Asia and recent detection in Australia. The virus's potential impact on Indonesia's cassava production, with projected yield losses of 16-33% and starch content reductions of 22-38%, necessitates urgent preventive action.

Our analysis indicates that effective SLCMV management in Indonesia requires a comprehensive approach combining enhanced surveillance, strict quarantine measures, and robust vector management strategies. Establishing early detection systems, developing rapid diagnostic capabilities, and implementing clean seed certification programs are critical priorities. Success in preventing SLCMV establishment in Indonesia will depend on the immediate implementation of these measures, supported by strong regional cooperation and stake-holder engagement.

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