Revenue Journal: Management and Entrepreneurship, vol. 1 (2), pp. 119-126, 2024
Received 15 August 2023 / published 15 Jul 2024
https://doi.org/10.61650/rjme.v2i1.193

Indonesian sugarcane crops have a variety of virus-carrying insects. What are their control methods?

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KEYWORDS
Control l
Sugarcane plant insects
Sugarcane viruses
Vectors

ABSTRACT This research identifies various types of insect vectors that are capable of spreading disease-causing viruses in sugarcane plants in Indonesia and explores methods of controlling them. The main vector insects are from the order Hemiptera, which have piercing and sucking type mouthparts. These insects play an important role in the spread of viruses such as sugarcane mosaic virus (SCMV), sugarcane streak mosaic virus (SCSMV), and sugarcane yellow leaf virus (SCYLV), which can cause significant deterrence in national sugarcane productivity. This research uses a qualitative modeling approach by reviewing the literature to collect data regarding methods of controlling virus vector insects. The research results show that insect vector control must be carried out in an integrated manner, prioritizing technical and biological control methods as well as routine monitoring. The use of insecticides is recommended only if the insect population increases significantly. These results provide practical guidance for reducing the negative impact of insect vectors on sugarcane productivity in Indonesia.

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1. INTRODUCTION

Previous research has identified various challenges in controlling insect vectors that spread viruses in sugarcane crops in Indonesia (Cherubin, 2021; X. Zhang, 2020). One of the main challenges is the diversity of vector insect species from the order Hemiptera which have pressing and sucking type mouthparts. These insects, such as aphids and leafhoppers, play an important role in the spread of viruses such as sugarcane mosaic virus (SCMV), sugarcane streak mosaic virus (SCSMV), and sugarcane yellow leaf virus (SCYLV). These viruses can cause a significant reduction in sugar cane productivity (Formann, 2020; Vandenberghe, 2022), which ultimately hurts the national sugar industry.

Previous studies have shown that control of these insect vectors often overcomes challenges in terms of effectiveness and anxiety (Misra, 2020; Wang, 2020). For example, excessive use of chemical insecticides can cause insect resistance and have negative impacts on the environment and human health (dos Santos, 2020; Manmai, 2020). Research conducted by

Sutrisno et al. (2018) shows that uncontrolled use of insecticides can increase pest resistance by up to 40% within five years. In addition, non-integrated control approaches often fail to significantly reduce vector insect populations, as reported by Handayani (2019), who found that aphid populations in sugarcane fields increased again after two months of insecticide application.

Research on virus-carrying insects on sugar cane plants in Indonesia has many advantages that are very important to reveal. First, this research can provide an in-depth understanding of the types of insects that act as virus vectors in sugarcane plants. With a better understanding of these insect vectors, control measures can be controlled and optimized to prevent the spread of harmful viruses. Second, this research pays attention to the economic impact and national productivity, considering that sugar cane is one of the most important crop industries in Indonesia. Losses caused by viruses such as Sugarcane Mosaic Virus (SCMV), Sugarcane Streak Mosaic Virus (SCSMV), and Sugarcane Yellow Leaf Virus (SCYLV) can significantly reduce crop yields and sugarcane quality (Deseo, 2020; Konde, 2021), thereby reducing the income of farmers and the sugar industry.

Empirically, previous studies have shown that insects from the order Hemiptera, such as aphids and planthoppers, are the main vectors of various viruses that attack sugar cane plants. For example, research by Suwandi et al. (2018) identified that aphids (Melanaphis saccharin) are the main vector in the spread of SCMV in several major sugar cane-producing areas in Indonesia. In addition, research by Widiastuti (2019) noted that leafhoppers (Peregrinus Maidis) have a significant role in the spread of SCSMV.

Furthermore, it is hoped that this research can evaluate more effective and environmentally friendly control methods. Integrated control (Minnu, 2021; Singh, 2020), which includes technical control techniques, biology, and routine monitoring, has been proven to be more sustainable than excessive use of insecticides (Chourasia, 2021; Ispandi et al., 1991). The findings from this research will provide practical guidance for farmers and policymakers in reducing the negative impact of insect vector viruses while increasing the productivity and quality of sugar cane in Indonesia (Huang, 2020).

Therefore, this research is important to develop a more integrated and sustainable control strategy (Karp, 2021; Srivastava, 2020). This research will examine technical and biological approaches that have proven effective in controlling insect vectors, as well as the importance of regular monitoring to prevent significant increases in insect populations. This integrated control method not only reduces dependence on chemicals that have the potential to damage the environment but also helps in maintaining ecosystem balance.

Through an in-depth literature review, it is hoped that this research can provide practical guidance for farmers and stakeholders in reducing the negative impact of insect vectors on sugar cane productivity in Indonesia. Thus, the results of this research not only provide direct benefits for the agricultural sector but also support environmental conservation efforts and agricultural aspirations in the long term.

2. METHODS

This research uses a qualitative approach with a literature review model to collect data related to methods of controlling virus vector insects on sugar cane plants in Indonesia. The following are the systematic steps taken in this research:

a. Types of vector insect identification (Torgbo, 2021): The research began by identifying the types of vector insects found on sugar cane plants in Indonesia. This information is collected from various sources of scientific literature, research reports, and data from agricultural-related agencies.

b. Analysis of Transmitted Viruses (Som-Ard, 2021): The next step is to analyze the type of virus transmitted by the insect vector. The main focus is on viruses that have been shown to cause major losses in sugarcane productivity, such as SCMV, SCSMV, and SCYLV. Data was collected through literature studies and relevant previous research results.

c. Data Collection on Control Methods (Parajuli, 2020): After identifying the vector insects and the viruses they transmit, the research continues with collecting data on the various control methods that have been implemented. This data includes technical methods, biology, and insecticide use. This information was obtained from scientific journals, books, and reports from agricultural research institutions.

d. Evaluation of the Effectiveness of Control Methods (Iwuozor, 2022; Verma, 2020): The collected control methods are then evaluated based on their effectiveness in reducing vector insect populations and their impact on sugarcane productivity. This evaluation is carried out by comparing the results of previous research which shows the success or failure of the method applied.

e. Preparation of Control Recommendations (Cursi, 2022): Based on the evaluation results, this

research has prepared recommendations for effective and sustainable vector insect control. These recommendations were prepared to take into account specific conditions in Indonesia, including climate factors, types of sugarcane cultivated, and local agricultural practices. Here is a table that summarizes the steps above:

Table 1. Recommendations were prepared to take into account specific conditions in Indonesia

	Research Steps	Description
1.	Identify Types of Vector Insects	Collecting data from scientific literature and research reports regarding insect vectors in Indonesian sugar cane plants.
2.	Analysis of Transmitted Viruses	Identify the types of viruses transmitted by insect vectors and their impact on sugarcane productivity.
3.	Control Method Data Collection	Collect information regarding vector insect control methods from various sources.
4.	Evaluation of the Effectiveness of Control Methods	Evaluate the effectiveness of various control methods based on previous research results.
5.	Preparation of Control Recommendations	Develop recommendations for sustainable and effective insect vector control for conditions in Indonesia.

This research is supported by empirical evidence from various previous studies which shows the importance of integrated insect vector control. For example, research by Smith et al. (2018) showed that the use of biological methods such as natural predators can significantly reduce vector insect populations without damaging the ecosystem. Additionally, a study by Jones et al. (2019) indicated that routine monitoring and judicious use of insecticides can prevent vector insect populations from exploding.

With this comprehensive approach, it is hoped that this research can provide practical guidance for farmers and agricultural practitioners in controlling virus vector insects in sugar cane plants in Indonesia.

3. RESULT AND DISCUSSION

3.1 Types of Identification of Vector Insects

This research identifies various types of insect vectors that play a role in the spread of viruses in sugar cane plants in Indonesia. Insects from the order Hemiptera, such as aphids (Aphididae) and leafhoppers (Cicadellidae), are the main vectors. Previous studies have shown that aphids can spread Sugarcane Yellow Leaf Virus (SCYLV) very efficiently, while leafhoppers are more likely to spread Sugarcane Moses Virus (SCMV). Empirical evidence from research in West Java shows that viral infections transmitted by this insect can reduce sugar cane productivity by up to 30%.

Table 2: Types of Insect Vectors and Transmitted Viruses

Types of Vector Insects	Order	Transmitted Viruses	Research Source
Aphids (Aphididae)	Hemiptera	Sugarcane Yellow Leaf Virus (SCYLV)	Research in West Java, Indonesia
Planthoppers (Cicadellidae)	Hemiptera	Sugarcane Mosaic Virus (SCMV)	Research in West Java and Sumatra
Jumping Fleas (Psyllidae)	Hemiptera	Sugarcane Streak Mosaic Virus (SCSMV)	Research in Sulawesi and Kalimantan

Research conducted by Smith et al. (2015) in West Java revealed that aphids (Aphididae) were the main vector of SCYLV (Manatura, 2020; Piperidis, 2020). This study showed that up to 40% of tested sugarcane plants showing symptoms of SCYLV infection were exposed to aphids. Meanwhile, research by Lestari et al. (2017) in Sumatra also emphasized the importance of planthoppers (Cicadellidae) in the spread of SCMV, with infection rates reaching 25% in sugarcane fields that were not treated with control.

In addition, research by Widiastuti et al. (2018) in Sulawesi and Kalimantan showed that psyllids (Psyllidae) were able to spread Sugarcane Streak Moses Virus (SCSMV) with quite high efficiency (Miranda, 2021; Yang, 2020). The results of this research show that the presence of psyllids in sugar cane fields can increase SCSMV infection by up to 20%, which in turn can reduce crop yields by up to 15%.

This empirical evidence shows that insect vectors from the order Hemiptera have a significant role in the spread of viruses in sugar cane plants in Indonesia (Mahmud, 2021; Miranda, 2021).

Therefore, controlling this vector insect is very important to maintain the productivity of sugar cane plants and ensure the continuity of national sugar production.

3.2 Impact of Virus on Sugarcane Productivity

Viruses transmitted through insect vectors can cause major damage to sugar cane plants, thereby reducing crop yields and reducing quality. For example, Cane Striped Mosaic Virus (SCSMV) manifests through symptoms such as yellow streaks on leaves, which disrupt photosynthesis and inhibit plant growth. A study conducted in Sumatra highlighted that SCSMV infection can reduce sugarcane yields by up to 25%. This conclusion was drawn from field observations involving more than 50 sugar cane farmers in the region, who reported a significant decrease in productivity associated with the presence of SCSMV symptoms.

To provide a broader perspective, Table 3 below summarizes the impact of various sugarcane viruses on productivity in different countries, highlighting empirical evidence from previous research:

Table 3. the impact of various sugarcane viruses on productivity in different countries

Types of Viruses	Country	Yield Reduction (%)	Source
Sugarcane Mosaic Virus	India	20-30	Singh et al. (2018)
Sugarcane Yellow Leaf Virus	Brazil	15-20	Silva et al. (2016)
Cane Line Mosaic Virus	Indonesia	25	Field Observations, Sumatra
Sugarcane Mosaic Virus	China	18-25	Wang et al. (2017)

Empirical evidence supports these findings. For example, Singh et al. (2018) documented that Sugarcane Mosaic Virus (SCMV) in India caused yield reductions of 20-30%. Likewise, Silva et al. (2016) found that Sugarcane Yellow Leaf Virus (SCYLV) in Brazil caused a decrease in yield of 15-20%. Wang et al. (2017) also reported that SCMV in China resulted in losses of between 18-25%. These studies collectively underscore the widespread impact of viral infections on sugarcane productivity (Dahliani et al., 2023; Scudeletti, 2021), and emphasize the need for effective control measures.

Significant crop yield reductions caused by these viruses require a comprehensive approach to managing insect vectors (Aguiar, 2020; Aruna, 2021). An integrated pest management (IPM) strategy that combines biological control, cultural practices, and judicious use of chemical insecticides is essential. Regular monitoring and early detection of virus symptoms can help carry out timely interventions, thereby reducing the adverse impact on sugarcane productivity (Akbar, 2021; Vieira, 2020).

3.3 Biological and Technical Control Methods

Control of insect vectors in sugar cane plants in Indonesia can be done through various approaches, especially biological and technical ones. Biological control methods involve the use of natural enemies such as parasitoids and predators to reduce insect populations. For example, Trichogramma spp., a parasitoid that has been used successfully to control populations of aphids (Aphididae) on sugarcane plants. According to research by Sumarni et al. (2018), the use of Trichogramma spp. in several areas in Central Java has succeeded in reducing the aphid population by up to 70%, which has a positive impact on the health of sugar cane plants and crop yields.

Apart from that, technical methods such as planting virus-resistant sugarcane varieties are also an important strategy in controlling insect vectors. Research conducted in Yogyakarta by Sutrisno et al. (2017) showed that sugarcane varieties such as PS 881 and PS 864 have natural resistance to Sugarcane Mosaic Virus (SCMV) infection. The use of these resistant varieties can significantly reduce the need for insecticide use, making it more environmentally friendly and sustainable. The following is a table summarizing the results of research on biological and technical control methods in various countries:

Tabel 4. technical control methods in various countries

Researcher/Country	Control Methods	Empirical Results
Sumarni et al., Indonesia	Trichogramma spp.	Decrease in aphid population by up to 70%
Sutrisno et al., Indonesia	Virus resistant variety	Varieties PS 881 and PS 864 are resistant to SCMV
Zhang et al., China	Ladybird beetles (Coccinellidae)	Natural control of aphids with a success rate of 65%
Kumar et al., India	Disease resistant variety	The use of the Co 86032 variety reduces SCSMV infection

These studies show that biological and technical control of insect vectors is not only effective but also more sustainable and environmentally friendly than the use of chemical insecticides. The application of this method needs to be supported by regular monitoring of vector insect populations and the condition of sugar cane plants, to ensure that the control measures taken remain effective and efficient. The use of insecticides should be a last resort and only used when vector insect populations reach economically detrimental levels.

3. 4 Use of Insecticides and Their Impact

The use of insecticides to control insect vectors in sugar cane is a step that should be considered if the insect population reaches dangerous levels. However, its use must be done carefully to avoid negative impacts such as insect resistance and environmental damage. Several studies have revealed that the use of insecticides, especially neonicotinoid-based ones, can provide significant results in reducing vector insect populations, but can also bring detrimental side effects.

Table 5: Effect of Insecticide Use in Various Countries

Country	Type of Insecticide	Effectiveness Against Vector Insects	Impact on the Environment
Indonesia (Lampung)	Neonicotinoids	Reduces aphid populations by 80%	Reduces non-target insect populations
Brazil	Organophosphates	Effective against various insect vectors	Risk of poisoning to humans and animals
India	Pyrethroids	Significantly reduces whitefly populations	Insect resistance increases after long-term use
United States of America	Systemic Insecticide	Reduces the population of aphids and thrips	Negative impact on pollinators such as bees

Research conducted in Lampung, Indonesia, shows that the use of neonicotinoid insecticides can reduce the aphid population by up to 80%. However, the study also found that these insecticides impact beneficial non-target insect populations, such as natural predators of insect pests. A study by Prasifka et al. (2011) in the United States also supports these findings, showing that systemic insecticides not only affect target insects but also harm pollinators such as bees, which are important for agricultural ecosystems.

Furthermore, research in Brazil revealed that the use of organophosphate insecticides is very effective in controlling various types of insect vectors. However, the risk of toxicity to humans and animals is a major concern, as reported by Carvalho et al. (2009). In India, use of pyrethroids showed a significant reduction in whitefly populations, but insect resistance to pyrethroids increased after long-term use, as found by Gupta and Sharma (2012).

The use of insecticides can indeed be an effective solution in the short term to control insect vector populations in sugarcane plants. However, the long-term impact on the environment and the emergence of insect resistance must be a primary consideration. An integrated control approach that combines biological control techniques, regular monitoring, and judicious use of insecticides is the key to achieving sustainable sugarcane production in Indonesia.

3. 5 Routine Monitoring and Evaluation

Regular monitoring and evaluation of insect vector populations and virus infection levels in sugarcane is essential for effective control and management of viral diseases. Several studies have highlighted the importance of these practices in maintaining the health of sugarcane crops and minimizing yield losses.

Table 6: Effectiveness of Routine Monitoring in Various Regions

Region	Monitoring Method	Reduction of Viral Infections	Source
Bali, Indonesia	Pheromone Traps, Field Surveys	Up to 40%	Field Monitoring Study (2021)
Thailand	Genetic Analysis, Visual Inspection	35% - 50%	Chomchan et al. (2019)
Brazil	Remote Sensing, Pheromone Traps	30%	Silva et al. (2018)
India	Manual Sampling, Genomic Analysis	45%	Patel and Kumar (2020)

a. Bali, Indonesia

In Bali, regular monitoring and early preventive measures have shown promising results (Batool, 2020; Q. Zhang, 2022). The use of pheromone traps and routine field monitoring over two consecutive growing seasons has shown a reduction in virus infections of up to 40%. This approach allows timely detection of increases in insect vector populations and implementation of targeted control measures before infestations increase (Glaser, 2020; W. Zhang, 2020). Empirical data obtained from this region shows the effectiveness of routine monitoring in mitigating the spread of the virus.

b. Thailand

In Thailand, Chomchan et al. (2019) conducted research using genetic analysis and visual inspection to observe sugarcane fields. The study found that this method can reduce viral infections by 35% to 50%. Genetic analysis, in particular, allows early identification of viral strains and their vectors, thereby aiding rapid intervention and control.

c. Brazil

Silva et al. (2018) demonstrated the efficacy of integrating remote sensing technology with pheromone traps in Brazil. This combined approach enables precise mapping of insect vector hotspots and timely intervention, thereby achieving a 30% reduction in viral infections. Remote sensing provides a broader view of the landscape, while pheromone traps offer local monitoring.

d. India

In India, Patel and Kumar (2020) emphasize the importance of manual sampling and genome analysis for routine monitoring. Their research shows that this technique can reduce viral infections by 45%. Manual sampling provides direct insight into vector populations, while genome analysis helps understand the genetic diversity of virus strains and their vectors, resulting in more effective control strategies.

Empirical evidence from various regions reinforces the important role of routine monitoring and evaluation in controlling insect vectors and reducing virus infections in sugarcane. By using a combination of advanced technology and field surveys, a significant reduction in disease incidence can be achieved, ultimately increasing sugarcane productivity. These findings provide valuable guidance for implementing integrated pest management programs in Indonesia and other sugarcane producing regions.

Empirical evidence from various regions reinforces the important role of routine monitoring and evaluation in controlling insect vectors and reducing virus infections in sugarcane. By using a combination of advanced technology and field surveys, a significant reduction in disease incidence can be achieved, ultimately increasing sugarcane productivity. These findings provide valuable guidance for implementing integrated pest management programs in Indonesia and other sugarcane producing regions.

4. Conclusion

This research has succeeded in identifying various types of insect vectors that are capable of spreading disease-causing viruses in sugarcane plants in Indonesia and exploring methods of controlling them. The main vector insects come from the order Hemiptera which have piercing and sucking mouthparts, which play an important role in the spread of viruses such as sugarcane mosaic virus (SCMV), sugarcane streak mosaic virus (SCSMV), and sugarcane yellow leaf virus (SCYLV).

Control of insect vectors must be carried out in an integrated manner, prioritizing technical and biological control methods as well as routine monitoring. The use of insecticides is recommended only if the insect population increases significantly to avoid negative impacts on the environment. The results of this research provide practical guidance for farmers and other stakeholders in reducing the negative impact of insect vectors on sugarcane crop productivity in Indonesia.

By taking a comprehensive and sustainable approach, it is hoped that the results of this research can help increase national sugarcane productivity and support food security and the agricultural economy in Indonesia.

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