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BIODIVERSITAS
Volume 26, Number 3, March 2025
Pages: 1303-1309

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d260329

Utilization of medicinal plant extracts to reduce the mosaic disease complex of chili plant

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Manuscript received: 23 December 2024. Revision accepted: 13 March 2025.

Abstract. *Damiri N, Fenton AR, Irsan C, Oktaviani, Fadli R, Pratama R, Mulawarman, Arinafril, Rahim SE. 2025. Utilization of medicinal plant extracts to reduce the mosaic disease complex of chili plant. Biodiversitas 26: 1303-1309.* Viral diseases lead to substantial yield losses in chili cultivation, with the mosaic disease complex being one the most serious effects. The aim of this study was to investigate the effect of medicinal plant extracts in protecting chili plants against mosaic disease complex in the field. This research was conducted at the experimental field of the Faculty of Agriculture, Universitas Sriwijaya, Indralaya, Ogan Ilir District, South Sumatra, Indonesia. The research was desgined in a factorial randomized block. The first factor was medicinal plant extracts: A. *Annona muricata* leaf extract; B. *Datura metel* leaf extract; C. *Jatropha curcas* leaf extract; D. *Pachyrhizus erosus* leaf extract; E. *Azadirachta indica* leaf extract; J. control. The second factor was the interval of application time: one week (W1), two weeks (W2), and three weeks (W3). Each treatment was repeated 3 times. The extracts were sprayed at 2% concentration on chili plants. Results showed that the application of medicinal plant leaf extracts, combined with different application intervals, effectively suppresses the mosaic disease complex in chili plants. Among the treatments, extracts of *D. metel* and *A. indica* applied at two-week intervals resulted in the lowest incidence and severity of mosaic disease, both in terms of percentage and intensity. Additionally, treated plants exhibited greater fruit yield and increased plant height compared to the control group. The effectiveness of *D. metel* and *A. indica* as biopesticides is attributed to their potent bioactive compounds. Notably, applying these extracts at two-week intervals reduced mosaic disease complex attacks to just 12.02%. Further research should be conducted to optimize application methods and assess long-term effects on crop productivity.

Keywords: *Azadirachta indica*, chili, *Datura metel*, medicinal plants, mosaic disease, viruses

INTRODUCTION

Chili (*Capsicum annuum*) is the most important vegetable and spice plant or crop because of its unique color, taste, spiciness and aroma characteristics (Oney et al. 2021; Rahman et al. 2023). Chili is threatened by several pathogens causing significant yield losses. An important problem in increasing chili production is the emergence of disease-causing attacks originating from viruses (Damiri 2014; Hamidson et al. 2017). Diseases caused by plant viruses are predominantly spread through planting materials and insect vectors, such as *Aphis gossypii*, thrips, whiteflies, planthoppers and leafhoppers, posing significant risk to crop and causing substantial economic losses (Niraula and Fondong 2021; Wang et al. 2023).

Viral diseases are endemic and responsible for large yield losses in chili cultivation. Mosaic disease in chilies is generally caused by multiple viral infections (Suwandi et al. 2020). In Indonesia, mosaic disease is reported to be associated with many types of viruses, such as Cucumber Mosaic Virus (CMV), Pepper Yellow Leaf Curl Virus (PYLCV), Tobacco Mosaic Virus (TMV), Chile Veinal Mottle Virus (ChiVMV), and Pepper Vein Yellowing Virus (PeVYV). Mosaic virus disease can attack chili plants both in the lowlands, medium and highlands and cause reduction in production (Sukada et al. 2014; Damiri 2014, et al. 2018). Chili plants can be infected by many economically important viruses including the mosaic virus which can be a serious threat in chili cultivation because it has a very wide host range (Zehra et al. 2017; Meena and Manivel 2018; Zohoungbogbo et al. 2024). Currently, almost 75 viruses are known to infect chili plants worldwide, of which 37 species recognized by the International Committee on Taxonomy of Viruses (ICTV), while six species are tentative species (Thomas et al. 2021).

Infected plants generally show symptoms of deformed and stunted leaves with reduced internode extension and smaller leaves. Infection in the early growth stages can cause total loss due to flower drop and fruit set. Diseased cause abnormal fruits are not marketable. It was reported that yield loss due to mosaic disease on chili peppers ranged from 54-80% (Sukada et al. 2014). The yield loss caused by mosaic disease complex in chili is substantially large, because this virus can quickly spread to the plantations around the source of the virus according to the activity of aphids (aphids) which serve as vectors. Infection with mosaic disease complex in chili can reduce the number of fruits and fruit weight and in severe case can lead to 100 percent losses of marketable fruits (Damiri et al. 2018; Chakraborty and Ghosh 2022). Many efforts have been made so far to control the mosaic virus in chili plants but have not yielded the expected results. Plant viral diseases are generally difficult to control because so far, no agrochemicals have been developed to directly target viruses. Moreover they raise concern regarding environmental harm, safety issues and potential for insect population that efficiently transmit viruses to develop resistance (Krenz et al. 2014; Sukada et al. 2014). Generally farmers use synthetic chemicals to control insect vectors to reduce the incidence of viral diseases. Pesticides are chemical compounds used to eradicate insects, pests and plant pathogens, which are classified as insecticides, herbicides, nematicides, fungicides, bactericides (Zhan et al. 2020; Zhang et al. 2020).

The continuous use of chemical pesticides can cause serious environmental problems, such as rapid pest resurgence, pest resistance, negative impact on non-target organisms and health-related issues (Marasinghe and Karunarathe 2021; Ngegba et al. 2022; Anikina et al. 2023). Botanical pesticides, sourced from plants, are increasingly viewed as a leading alternative and promising solution to these challenges. They can inhibit viral pathogen development through the manipulation of the host by producing antiviral proteins that induce inhibition of viral replication, including controlling pests and other plant diseases (Lengai et al. 2020; Gelaye and Negash 2023). Their efficacy has been substantiated, and they are gaining attention primarily due to their effectiveness and rapid environmental degradation after use (Mandanayake et al. 2023). Many medicinal plants have the potential to be used as botanical pesticide for integrated pest management, providing environmental preservation benefit, low toxicity to mammals and a reduced risk of pest developing resistance. The aim of this study was to investigate the effect of medicinal plant extracts in protecting chili plants against mosaic disease complex in the field.

MATERIALS AND METHODS

Study area

This research was conducted at the experimental field of the Faculty of Agriculture, Universitas Sriwijaya, Indralaya, Ogan Ilir District, South Sumatra, Indonesia. This study used a factorial randomized block design. The first factor was crude extract of of plant leaves of soursop (*Annona muricata*), amethyst (*Datura metel*), jatropha plant (*Jatropha curcas*), jicama (*Pachyrhizus erosus*), neem (*Azadirachta indica*), and control/water without plants extracts. The second factor was the application interval, namely: once a week (W1), once every 2 weeks (W2) and once every 3 weeks (W3). Each treatment was repeated three times.

Preparation of host plants and medicinal plant extracts

The land was cleared of sediment and filled with a tractor. After cleaning, 48 plots measuring 3x3 meters each were prepared. Subsequently, each plot was enriched with 1.3 kg of manure and 90 gr of NPK fertilizer, in accordance with recommended chili cultivation practice. Local chili cultivar F1 Lado (*cabai keriting*) seedling (15 days old) were planted in prepared soil. Each leaf of the *A. muricata*, *D. metel*, *J. curcas*, *P. erosus* and *A. indica* plants was weighed as much as 500 gr. Leaves were then washed, dried, cut and mashed using a blender. The refined material was then mixed with 1 L of distilled water and incubated at room temperature for 24 hours. Then the suspension was filtered using gauze and filter paper. The obtain extract was placed in an Erlenmeyer and exposed to UV light for 15 minutes. Each leaf was extracted separately. The extract was stored in a refrigerator at temperature of 5°C. The concentration of each extract used for the experiment was 2% (Shiberu and Getu 2017).

Application of medicinal plant extracts

The plant extracts were applied two weeks after the seedlings were transferred to the field, with each plant extract being sprayed on chili plants at a concentration of 2% per treatment until the first harvest. Mosaic virus inoculation was allowed to occur naturally.

Plant maintenance

The plants were watered twice a day, morning and evening, using water pipes designed for this purpose. Weeding was done when necessary. Fertilization was given according to chili cultivation recommendations. Parameters observed were the percentage of mosaic disease complex incidence, disease severity, plant height, wet and dry weight, number of fruit and total fruit yield of each plant. Percentage, severity of mosaic disease, plant height, wet weight and dry weight of chili plants were calculated at the end of the research. The number and weight of fruit were calculated at the time of first harvest.

Percentage of mosaic disease complex was calculated using the formula (Kurnia et al. 2022):

$$DI = \frac{n}{N} \times 100\% \text{............ (1)}$$

Where,
DI : Percentage of mosaic disease complex incidence
n : Number of infected plants
N : Number of plants observed

Disease severity was calculated as follows: 0: no visible symptoms; 1: very slightly yellowing of leaflet margin on a pical leaf; 2: some yellowing and minor curling of leaflet ends; 3: a wide range of leaf yellowing, curling and cupping; 4: severe leaf yellowing and pronounced leaf curling (Yadav et al. 2022). The severity was calculated using the following formula:

$$DS = \frac{\Sigma n x v}{Z x N} \times 100\% \text{ ……….. (2)}$$

Where,
DS : Disease Severity
v : Disease score (0 to 4)
n : Number of plants showing disease score

Z : The highest disease score
N : Total number of plants observed

Data analysis

The data were the percentage of mosaic disease complex incidence, disease severity, plant height, plants wet and dry weight, number and total fruit yield of each plant were analyzed using the Analysis of Variance (ANOVA) method and further tested with the Least Significant Difference (LSD) of 5%.

RESULTS AND DISCUSSION

Symptoms of mosaic disease complex

The results showed that the leaves of chili plants that were attacked by mosaic disease became discolored. Chili plants infected with mosaic disease had yellow-green leaf patterns and curled leaves with chlorosis (wrinkled), an uneven leaf surface leading to malformations of leaves, stunted and delayed flowering (Figure 1), while chili plants that were not attacked by mosaic disease remain green.

Percentage of mosaic disease complex

The results of statistical analysis showed significant differences in the effect of medicinal plant extracts on the percentage of viral mosaic disease complex incidence in chili plants, While there was no significant difference in the interval of extract application. The Honestly Significant Difference (HSD) test at the 5% level revealed that the effect of various extracts on the percentage of mosaic disease complex in chili plants is presented in Table 1.

Table 1 shows that the application of medicinal plant leaf extracts and application time intervals can suppress mosaic virus attacks in the field and were significantly different from the control. The lowest percentage of mosaic virus attack was shown by *A. indica* treatment. In the application of *A. indica* extract at intervals of once a week, the incidence of mosaic disease in chilies was 17.41%, significantly different from the control and *A. muricata* extract. Application of *A. indica* extract at intervals of 2 and 3 weeks showed that the percentage of mosaic virus attacks reduced by 12.07% and 8.93%, respectively, which was significantly different from the control. It is suggested that *A. indica* extract can suppress yellow virus vector attacks, such as aphids and mealybugs. *Azadirachta indica* leaf extract is known to cause death in *Aphis craccivora* on long beans, which is a pest and also a vector for viruses that cause mosaic disease complex (Javandira et al. 2022). *Azadirachta indica* contains alkoids, flavonoids, triterpenoids, phenolic compounds, carotenoids, steroids and ketones which can function as vegetable insecticides (Rami et al. 2021; Javandira et al. 2022). Its leaves contain bioactive compounds, including azadirachtin, meliantriol, salanin and nimbin which can suppress attacks by insect vectors of mosaic complex diseases such as aphids by reducing their appetite and inhibiting their growth and reproduction (Ervinatun et al. 2018). *Azadirachta indica* leaf extract also contains terpenoids, flavonoids, saponins, tannins and alkanoids which can act as antibacterial (Andhiarto et al. 2019; Soraya et al. 2019). The limonoid tetranotriterpenoid complex compound contained in neem is an active compound is an antifungal and antifeedant against insect vectors (Romao et al. 2023).

Table 1 also shows that *D. metel* extract also has the potential to suppress complex viruses in chilies, although not as good as *A. indica*. It is rich in alkaloids, flavonoid, phenolic, saponin, and tannins which exhibit properties such antimicrobial, insecticidal, antioxidant, cytotoxix, and antifertility effects (Al-Snafi 2017). Atropine derived from *D. metel*, inhibits the growth of virus by afecting the glycosylation of viral proteins, which shows effectiveness againt Tomato Mosaic Virus (TMV). It plays an active defense role against viruses and triggers programmed cell death to protect plants from this virus (Al-Huqail et al. 2017).

Severity of mosaic disease complex

The result of statistical analysis showed significant differences in the impact of medicinal plants extract application on the percentages of mosaic disease complex severity on chili plants, whereas there was no significant difference in the time interval factor of application of the extracts. The Honestly Significant Difference (HSD) follow-up test at the 5% level, the effect of the application of several extracts on the severity of mosaic disease complex in chili plants is presented in Table 2.

Treatment using medicinal plant extracts as a whole yielded positive results and showed a significantly different from the control. The lowest disease severity was found in chili planting areas that were applied with *A. indica* extract. In areas where *A. indica* extract was applied once a week, the severity of mosaic virus diseases was 10.95%. The severity of disease in the second week was less (9.71%) than in the first week and in the third week it was only 66.8%, significantly different from the control. In relation to the severity of the mosaic virus complex transmitted by aphids, it affects the incidence and severity of mosaic disease in chili plants.

Figure 1. Symptoms of mosaic disease complex on chili

Table 1. Effect of application of medicinal plant extracts and application time interval on the percentage mosaic disease complex incidence in chili plants

Medicinal plant extracts (2%)	Application time intervals (weeks)		
	1	2	3
Annona muricata	45.49abc	23.31de	31.81bcd
Datura metel	24.05de	12.02de	19.48de
Azadirachta indica	17.41de	12.07de	8.93f
Jatropha curcas	26.39cde	24.96cde	26.86cde
Pachyrhizus erosus	15.47de	23.49de	30.16bcde
Control (without medicinal extract)	48.16ab	53.03a	55.51a

Note: Numbers followed by the same letter in the same column are significantly different based on least significant difference test at 5% level

Table 2. Effect of application of medicinal plant extracts and application time intervals on severity mosaic virus disease of chili plants

Medicinal plant extracts (2%)	Application time intervals (weeks)		
	1	2	3
Annona muricata	17.35ab	10.94b	16.17b
Datura metel	16.37b	8.56b	12.86ab
Azadirachta indica	10.95b	9.71b	6.68b
Jatropha curcas	12.29b	14.47b	16.84b
Pachyrhizus erosus	9.48b	12.54b	16.57b
Control (without medicinal extract)	31.11a	33.06a	34.47a

Note: Numbers followed by the same letter in the same column are significantly different based on least significant difference test at 5% level

Viruses in chili can be carried by insect vectors, such as *Bemisia tabaci* and *A. gossypii*. *Aphis* and *B. tabaci* are pests that attack chilies from the nymphal stage to adults. In addition, these pests have the potential to spread mosaic viruses and reduce chili production (Sani et al. 2020). Insect growth regulatory properties, it is most effective against the immature stages of the insect. The immature larvae of many species in the Lepidoptera family (moths and butterflies) are highly sensitive to azadirachtin. *Azadirachta indica* as a biopesticide that is easily accessible, environmentally friendly, biodegradable, inexpensive, and non-toxic to control pests and target vector insects such as *A. gossypii* (Ferdenache et al. 2019).

Azadirachta indica is effective against insect pests and plant disease vectors such as yellow virus and mosaic on chili plants. All parts of this plant, especially the leaves, bark, and root extracts have biopesticidal activity. Azadirachtin, a biopesticide obtained from neem extract, can be used to control various pests and disease vectors. These compounds work by repelling pests and vectors, inhibiting feeding, and by interfering with the growth and reproduction of these insects. Neem-based formulations do not kill insects directly, but by changing their behavior thereby reducing pest damage to plants and reducing their reproductive potential (Adhikari et al. 2020).

Datura metel can also suppress severity of complex virus disease, alhthough not as well as *A. indica*. Many plant extracts from *Datura* possess insecticidal properties that aid in controlling pest and vector infestation. *Datura metel* contain alkaloids like scopolamine, artropine, and hyoscyamine, which act as nuerotoxin, paralyzing or killing the vector of mosaic virus by distrupting their nervous system (Al-Snafi 2017). According to Al-Huqail et al. (2017), its extract can used as biocontrol of plants virus, activated oxygen species, which are effective againts Tomato Mosaic Virus (TMV), play a protective role by inducing programmed cell death to hep protect the plant from virus.

Number and weight of fruits

It was observed that flowering started after 6 weeks of planting. The first harvesting was done when the chili plants were three months old after planting. The effect of the application of several medicinal plant extracts on plant fruits number and weight is presented in the Table 3.

Table 3 shows that the treatment with *A. indica* and *A. muricata* extracts produced the highest number of fruits and fruit weight. The number of fruits produce by chilies applied with *A. indica* extract with a concentration of 2% range from 18.33-19.33 fruits/plant with a weight of between 30.81-40.21 gr. While the number of fruits produced by chilies plants treated with *A. muricata* ranged from 15.67-1911 fruits/plant with a weight of between 30.22-34.46 gr.

Table 3. Effect of application of medicinal plant extracts and application time interval on the amount chili fruit (fruit/plant)

Medicinal plant extracts (2%)	Application time intervals (weeks)					
	1		2		3	
	Number of fruits	Fruit weight (g)	Number of fruits	Fruit weight (g)	Number of fruits	Fruit weight (g)
Annona muricata	19.11ab	34.46ab	15.67ab	30.22abc	16.00ab	30.95abc
Datura metel	12.99ab	29.85abc	16.33ab	29.85abc	13.22ab	28.36abc
Azadirachta indica	19.33ab	40.21a	18.33ab	33.16abc	19.33ab	30.81abc
Jatropha curcas	16.89ab	35.87ab	16.11ab	32.76abc	19.78a	40.83a
Pachyrhizus erosus	14.00ab	30.81abc	15.89ab	24.46abc	13.11ab	27.60abc
Control (without Medicinal extract)	11.11ab	21.39bc	10.55b	17.23c	11.33ab	19.65bc

Note: Numbers followed by the same letter in the same column are significantly different based on least significant difference test at 5% level

The use of *A. indica* and *A. muricata* as a fertilizer has been proven, the organic and inorganic compounds present in the plant material acting to improve soil quality and increase crop quality and quantity. The waste that remains after oil extraction from *A. indica* can be used as a biofertilizer, providing macro-nutrients essential for plant growth. The content of secondary compounds from plant extracts such as flavonoids, terphenoids and flavonoids is thought to increase plant height, fresh weight and dry weight of plants (Kabera et al. 2014). Neem compound is becoming more popular. These compounds also help to raise the soil's concentrations of nitrogen and phosphorus, because it contains a lot of nitrogen, potassium, calcium, and other nutrients. Neem cake, which has no adverse effects on plants, soil, or other living things, is used to make high grade organic or natural manure (Faisal et al. 2023). Factors that encourage the use of neem-based products for pest control in agriculture are ecological and toxicological aspects (low toxicity and high efficacy), as well as economic aspects (Adusei and Azupio 2022).

Chili plant height

The effect of the application of several medicinal plant extracts on plant height is presented in Table 4. The study results indicated that plant height in chili plants was significantly influenced by the application of plants extracts. The highest plant height (66.27 cm) was observe in plants treated with *J. curcas* extract, followed by *A. indica* (56.07 cm), *P. erosus* (48.2 cm), *D. metel* (45.2 cm), and *A. muricata* (43.8 cm) at 3 weeks of interval. Results showed that plant extracts can increase the height of chili plants and it was significantly different from the control. These findings suggest that the application of plants extracts can enhance plant growth, possibly due to their bioactive components affecting physiological processes related to plant development.

Plants extract of *A. muricata*, *D. metel*, *A. indica*, *J. curcas* and *P. erosus* contained secondary metabolic compounds may be responsible to suppress of the diseases and might have a role to promote plant growth. The result aligns with previous studies that demonstrated the positive effect of plant-based treatments on plant growth. According to Mendez et al. (2021), plants extract has been showed to improve plant height in various crop. Similarly, Sudhashini et al. (2023), found that the use of natural plant-based treatments contributed to increased vegetative growth. In addition, Kabera et al. (2014) and Ummah et al. (2017) reported that leaf extracts from *Gentiana linearis* and *Centela asiatica* positively influence plant growth parameters, including height. Saha et al. (2010) also observed improved plant height in maize and rice following the application of natural plant extracts.

These results highlight the potential of plant extracts as growth enhancers in agricultural systems. Further research is needed to explore the underlying mechanisms through which plant extract contribute to plant height improvement and to determine their long-term effects on crop yield and productivity.

Wet and dry weight of chili plants

Table 5 shows that the application of medicinal plant extracts and application time intervals significantly affected the increase in fresh weight and dry weight of chili plants. Table 5 shows that application of medicinal plant extracts can increase the wet and dry weight of chili plants, with *P. erosus* and *A. indica* being the two most effective treatments in increasing chili plant productivity. Organic fertilizers can come from plants or animals, green manure, residues from processing plants, waste, compost, and forest litter which have positive values both in terms of soil fertility and quality, plant fertility, environmental health, and the economy (Haruna et al. 2020).

Table 4. Effect of application of medicinal plant extracts and application time intervals on height of chili plants (cm)

Medicinal plant extracts (2%)	Application time (weeks) 1	2	3
Annona muricata	57.33abc	36.53d	43.8bcd
Datura metel	61.07ab	45.67bcd	45.2bcd
Azadirachta indica	56.07abcd	57.93abc	56.67abc
Jatropha curcas	50.67abcd	50abcd	66.27a
Pachyrhizus erosus	67.87a	57.07abc	48.2abcd
Control (without medicinal extract)	38.51cd	38.63cd	41.59bcd

Note: Numbers followed by the same letter in the same column are significantly different based on least significant difference test at 5% level

Table 5. Effect of application of medicinal plant extracts and application time intervals on wet weight and dry chili plant (g/plant)

Medicinal plant extracts (2%)	Application time interval (weeks) 1		2		3	
	Wet weight	Dry weight	Wet weight	Dry weight	Wet weight	Dry weight
Annona muricata	197.67abc	162.00abc	179.00abc	168.67abc	129.67bc	102abc
Datura metel	248.00abc	223.33abc	137.00bc	105.33abc	124.67bc	93.33bc
Azadirachta indica	153.67abc	122.67abc	172.67abc	135.67abc	248.67abc	219.67abc
Jatropha curcas	118.67bc	88.33c	133.67bc	104.67abc	227.67abc	198.67abc
Pachyrhizus erosus	194abc	164.67abc	291.67a	249.00a	269.67ab	238.33ab
Control (without medicinal extract)	108.33c	95.00bc	106.67c	95.00bc	116.00c	108.33abc

Note: Numbers followed by the same letter in the same column are significantly different based on least significant difference test at 5% level

The content of secondary compounds from plant extracts, such as flavonoids, terpenoids, and saponins, is thought to influence plant growth, including plant height, fresh weight, and dry weight of chili plants. Some secondary compounds can promote growth, while others may inhibit it, depending on the type of plant extract used. For instance, *Alstonia scholaris* stem bark extract contains steroids, terpenoids, and saponins, which have been associated with increased plant growth. In contrast, cassava leaf extract contains terpenoids, flavonoids, and phenolics, which may be toxic. Flavonoids can inhibit auxin transport, leading to a reduction in plant height and stem diameter (Saha et al. 2010; Ummah et al. 2017).

Based on results, it can be concluded that applying *D. metel* and *A. indica* extracts at two-week intervals is an effective strategy for reducing the incidence and severity of mosaic disease complex in chili plants. This treatment also enhances plant height and fruit yield, making these plant extracts promising natural biopesticides for sustainable chili cultivation. Further research should be done to optimize application methods and assess long-term effects on crop productivity.

ACKNOWLEDGEMENTS

The authors would like to thank the leadership of the Faculty of Agriculture, Universitas Sriwijaya, Indonesia, who has given permission to use the laboratory and its equipment.

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