Sainmatika: Jurnal Ilmiah Matematika dan Ilmu Pengetahuan Alam
Volume 22 No. 1, June 2025 DOI 10.31851/sainmatika.v22i1.17167
https://jurnal.univpgri-palembang.ac.id/index.php/sainmatika

Effect of *Curcuma Zanthorrhiza* on Population and Infectivity of *Pentalonia Nigronervosa* as A Vector of Banana Bunchy Top Virus Disease

Arsi[1,2*], Suparman[1], Yulia Pujiastuti[1], Chandra Irsan[1], Rahmatul Khaira[1], Harman Hamidson[1], Arinafril[1], Titi Tricahyati[1]
*e-mail: arsi@fp.unsri.ac.id

[1]*Program Study of Plant Protection, Faculty of Agriculture, Sriwijaya University, Palembang, Indonesia*
[2]*Student Program Study of Agricultural Science, Faculty of Agriculture, Sriwijaya University, Palembang, Indonesia*

ABSTRACT

BBTV (Banana Bunchy Top Virus) is a viral disease that attacks cultivated banana plants and can cause stunting. The symptoms of BBTV disease attack on banana plants are narrowed, piled up leaves and stunted plants. The disease is caused by an insect vector. *Pentalonia nigronervosa* is the vector insect that transmits BBTV disease. The purpose of the research was to see the java turmeric plant as an alternative host for population growth and BBTV disease vector. The method in the study used a Randomized Group Design. This treatment consists of two treatments with 10 replications. Based on the results of research conducted on the population of *P. nigronervosa* experienced fluctuations, but high growth in water media. BBTV disease that attacks banana plants in each treatment has the highest incidence in the control treatment, namely, 73.33% dan the lowest disease incidence the turmeric treatment was 6.67%. The highest intensity of BBTV disease attack in the control treatment was 42.06%, while the lowest in the Javanese turmeric treatment was 1.50%. *P. nigronervosa* inoculated on Javanese turmeric for 72 days can suppress BBTV disease transmission. However, based on the analysis of each treatment, no significant differences were found. P. nigronervosa has the highest population in the soil medium 95.4 individuals and water medium 86.7 individuals. The population of *P. nigronervosa* has a good development in turmeric plants.

Keywords: *Pentalonia nigronervosa*, Alternative host, Disease vectors, Rate of attack

INTRODUCTION

Indonesia is a tropical country that is rich in fruits. Indonesia's geographical location around the equator allows Indonesia to have various types of tropical fruits, one of which is bananas. Bananas are among the fruit commodities with the largest production in Indonesia. (Hapsari et al. 2017; Hastuti et al. 2019; Rai et al. 2018; Sunaryo et al. 2020). Various banana genetics are spread throughout Indonesia, making Indonesia the country with the largest banana production in Asia (Sunaryo et al. 2020). Consumer demand for bananas is increasing over time. Bananas contain vitamins, minerals, fiber, and fat that are useful for the body in terms of health. Bananas also contain caratenoids, which in fruits and vegetables can prevent diseases such as cardiovascular disease, cancer, and other serious diseases (Hapsari and Lestari 2016; Phillips et al. 2021; Rai et al. 2023). Public interest in bananas is getting higher because bananas are easily available and the price is fairly cheap and spread throughout Indonesia (Yudi et al. 2024).

Banana cultivation requires no special skills and is easy to do, but it is not free from pests and diseases. Certain cases have been found that indicate that pest and disease attacks can cause banana crop failure. The main pests that attack banana plants are leaf roller caterpillars, fruit flies, root nematodes, and stem borers, while diseases such as fusarium wilt, bacterial wilt, dwarf disease, and blood disease (Blood Disease Bacterium) (Shankar, 2016).

Banana Bunchy Top Virus (BBTV) is a banana dwarf disease that attacks bananas during the vegetative phase. The most important and costly disease of banana crops worldwide is banana dwarfism. BBTV is distributed in almost all parts of Indonesia. BBTV disease affects all cultivars of banana plants. (Hamim et al. 2017; Irwansyah et al. 2019). BBTV disease is transmitted by the insect vector *P. nigronervosa* aphids. Banana aphids are the only known vector of BBTV disease and are widely distributed in tropical and subtropical regions around the world (Arsi et al. 2024; N. et al. 2020). These insects are found on young banana tissue. Aphids are economically important plant pests that cause damage to crops and ornamental plant species through parasitic feeding on plant sap and through transmission of plant viruses. *P. nigronervosa* sucks the cellular fluid of young plants and can transmit viruses to the plants it sucks from (Efendi et al. 2022; Suparman et al. 2023). *P. nigronervosa* is persistent, meaning that once the pentalonia takes food from plants containing dwarf virus, it will continue to transmit dwarf virus throughout its life (Poorani et al. 2023; Tricahyati et al. 2022).

BBTV disease generally attacks young banana plants. The bunchy top virus causes plants to be fruitless and stunted. Bunchy Top virus causes the plant to be fruitless and stunted. Symptoms of Banana Bunchy Top disease on banana plants are stunted bananas, narrowed leaves, more upright, the edges of the leaves curl upwards and appear yellowed, and lines of chlorosis are visible on the edges of the mother leaf bone. Symptoms of banana dwarfism virus infection are also seen in the roots, namely the inhibition of root elongation in addition to the stem and leaves of the banana (Arsi et al. 2024; Irwansyah et al. 2019).

Javanese turmeric, a plant from the Zingiberaceae tribe, is an alternative host for *P. nigronervosa*. Javanese turmeric is commonly found in banana plantations. The presence of Javanese turmeric as a host plant of *P. nigronervosa* will affect virus transmission to the main plant, alternative hosts of BBTV vectors such as taro plants, galangal, and weeds, and the highest BBTV infestation was found in banana plantations with a lot of shade from large trees, and mixed with other plants (Bagariang et al. 2019; Rahmah et al. 2021).

Control of banana dwarf disease caused by the Bunchy Top virus can be done by suppressing the vector insects that spread BBTV. Generally, insect pest control uses chemical control. This control has been widely abandoned because it can damage the environmental ecosystem and is harmful to human health if used improperly (Poorani et al. 2023; Tricahyati et al. 2022). New methods are needed to control pests and diseases. This is done to avoid environmental damage by chemical residues. As one of the species of the Zingiberaceae family, Javanese turmeric grows around banana plantations. It is known that *P. nigornervosa* can live and develop on several Zingiberaceae species. This study aims to determine the population growth rate of *P. nigronervosa* on temulawak plants as an alternative host. To determine whether infective (virus-containing) *P. nigronervosa* vectors can still transmit the virus after spending 48 hours in the Temulawak alternative host. What is the efficiency of BBTV virus transmission by *P. nigronervosa* that has been passed on to Javanese turmeric.

MATERIALS AND METHODS

This research was conducted in the Entomology Laboratory and Department of Plant Pests and Diseases, Faculty of Agriculture, Sriwijaya University.

The tools used during the research were small shovels, machetes, buckets, and sprayers. While the materials used were plantain seedlings, *Pentalonia nigronervosa*, Javanese turmeric, kendang fertilizer, mineral soil, polybags, and gauze masks.

The method to be used in this research is a group randomized design with 2 treatments, repeated 10 times and each replicate consists of 3 plant units. The total number of plants is 60 plants with the following treatments:

P1 = infective *P. nigronervosa* directly transferred to healthy plants.

P2 = *P. nigronervosa* was transferred to temulawak plants.

This research consisted of two sub-researches, namely research to study the growth and development of the *P. nigronervosa* population and research to determine the role of temu lawak plants in influencing the infectivity of *P. nigronervosa* in transmitting Banana Bunchy Top Virus.

P. nigronervosa aphids were obtained from diseased banana plants. They were then reared on shoots of healthy banana and taro plants. Once the aphid population had increased, the aphid nymphs were transferred back to new taro plants or banana shoots. The nymphs will become imago and produce offspring that will be used as insect vectors for BBTV transmission. In addition, banana aphids were also reared on temu lawak plants to determine their population growth rate.

Rooted temu lawak shoots were planted in a 1.5-litre mineral water bottle, the top was cut off and the bottom was given soil then the temu lawak shoots were planted in the soil. Five *P. nigronervosa* were infested on the temu lawak shoots. Then the top of the bottle was covered with a mosquito net and tied with a rubber band. This work was repeated 10 times so that there were 10 bottles with temu lawak buds infested with *P. nigronervosa* in them. Observations were made every day to see the increase in the number of ticks on each temulawak bud.

Insect vectors of *P. nironervosa* were propagated by rearing on taro plants. Taro plants were put into a 1.5-litre mineral water bottle and filled with 100 ml of water. Insects were transferred by bringing parts of the taro plant to a new bottle and adding fresh taro plants.

The banana plants used in this study were seedlings of the princess banana species aged between 1-2 months. Banana propagation was carried out by chopping banana stumps that contained bud eyes and then planting until new shoots appeared so that they were ready for use.

The plant container used was a 40x40 cm polybag filled with mineral soil mixed with 15% kendang fertilizer. Bananas were transferred to the polybags after 2 months of age. Bananas that have shown active growth were pruned to leave 25 cm from the soil surface. Banana maintenance was carried out by watering the banana plants in the morning and evening and cleaning them of weeds The infested *P. nironervosa* is the third instar with the characteristic brown color with a length of approximately 0.9 mm and at this instar, the eyes begin to be visible and the antennae are five segments. Aphids were transferred to temulawak plants for 3 days. The infective *P. nironervosa* was transferred to the temulawak plant for 72 hours and then inoculated on a healthy plantain plant. Some. *P. nironervosa* was directly inoculated on healthy banana plants with 3 individuals per plant.

Observations were divided into two, namely observations of the pentalonia population on temulawak plants and observations of disease symptoms that appeared on healthy banana plants that had been inoculated with *P. nigronervosa*. Observations of the test insect population were carried out every day for 2 weeks and observations of disease symptoms were carried out every day starting from 2 weeks after inoculation to see the symptoms that appeared on banana plants. Percentage of pest infestation attacking plants using the formula (Prabaningrum dan Moekasan, 2016):

$$I = \frac{n}{N} 100\%$$

Notes:
I = Attack Intensity (%)
n = Number of Plants Affected by Pests
N = Number of Plants Observed

Observations of incidence were made to observe the incidence of disease caused by Banana Bunchy Top virus attacking banana plants observed per group of plants.

Observations of the level of attack on plants used a modified scoring based on the morphological appearance of diseased plants and the level of symptoms of attack caused by BBTV on each clump (Prabaningrum dan Moekasan, 2016):, as in the following table.

Table 1. Attack intensity score and symptom criteria

Score	Symptoms of Attack
0	Healthy plants and no visible symptoms of dwarfism
1	Slight dwarf disease infection i.e. slight yellowing of leaf margins and narrowing of leaves
2	Moderate dwarf disease infection: moderate yellowing of leaf margins, narrowing of leaves, shortening, and dwarfing.
3	Dwarf disease infection is severe, with severe yellowing of leaf margins, narrowing of leaves, twisting, distortion, dwarfing, and necrosis.

Incidence Formulas (Prabaningrum dan Moekasan, 2016):

$$IS = \frac{\sum (n \times v)}{N \times Z} \times 100\%$$

Notes :
IS : Attack Intensity (%)
n : Number of plants or plant parts on scale-iv
N : number of plants or plant parts of the sample observed
v : Scale value of plant damage
z : Highest damage scale value

Population counting of *P. nigronervosa* was done by manually counting the number of all aphids that had been photographed previously using a mobile phone camera.

Data Analysis

Data on population and disease attacks will be analyzed using Analysis of Variance (ANOVA) with R-Studio Application. If the data has a significant effect, further tests are carried out using the BNT test at the 5% level.

RESULTS AND DISCUSSION

The incidence of disease caused by the BBTV virus was measured by the number of symptoms or new cases that appeared on banana plants per plant block. The incidence was observed in two groups of banana plants with different treatments: the first treatment (control) was the infective *P. nigronervosa* vector directly inoculated on healthy banana plants and the second treatment was the infective *P. nigronervosa* vector transferred on Javanese turmeric for three days after which it was inoculated on healthy plants. Observations were made eight times and started two weeks after virus vector inoculation (Table 2).

Table 2. Banana Bunchy Top Virus Incidence on Banana Plants

Treatment	BBTV Virus Incidence at Observation							
	1	2	3	4	5	6	7	8
Control	0	0	13,33	30,00	63,33	66,67	73,33	73,33
Javanese turmeric	6,67	6,67	20,00	43,33	56,67	63,33	63,33	63,33
F count	$2,25^{ns}$	$2,25^{ns}$	$0,42^{ns}$	$1,47^{ns}$	$0,13^{ns}$	$0,01^{ns}$	$0,21^{ns}$	$0,21^{ns}$
F Table	5,11	5,11	5,11	5,11	5,11	5,11	5,11	5,11
BNJ 5%	-	-	-	-	-	-	-	-

Notes: *) significantly different, ^{ns}) Not significantly different at the test level of P < 0.05.

The results of statistical analysis of the percentage of incidence of control banana plants and banana plants treated with *P. nigronervosa* which was first placed on temulawak plants, obtained F count in the first and second observations of 2.25. The third observation was 0.42, the fourth observation was 1.47 and the fifth observation was 0.13, 0.009, 0.21, and 0.21 respectively. The F table value obtained is 5.11 and the P value from observation one to observation eight is 0.16, 0.16, 0.52, 0.25, 0.71, 0.97, 0.65, and 0.65 (Figure 1)

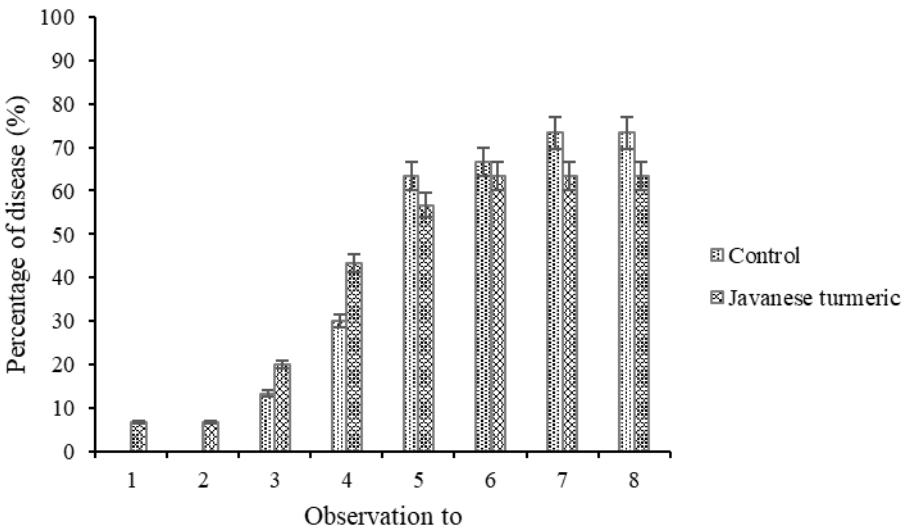

Figure 1. Banana Bunchy Top Virus Disease Incidence on Banana Plants

Based on the data from the observation of the incidence of bbtv virus on banana plants treated with *P. nigronervosa* which was first placed on temulawak plants, it is known that there is an increase in the percentage of incidence value at each observation. The highest percentage of attacks occurred in the sixth, seventh, and eighth observations, with an incidence of 63.33%. The highest percentage of incidence for the control treatment was found in the seventh and eighth observations, with a percentage of 73.33%. The control treatment only caused symptoms in the third observation, but the overall incidence rate of the control was higher than that of banana plants treated with *P. nigronervosa* which was first placed on Javanese turmeric (Figure 2)

Figure 2: Block of healthy banana plants (A) and Block of banana plants infected with Bunchy Top virus (B).

The intensity of virus attack on banana plants by dwarf virus with control treatment and treatment using temulawak plants obtained data on the percentage of attack as in the following (Table 3)

Table 3. The intensity of Banana Bunchy Top Virus Attack on Banana Plants

Treatment	Intensity of BBTV Virus at Observation to							
	1	2	3	4	5	6	7	8
Kontrol	0	0	7,03	7,87	19,00	26,90	39,27	42,06
Javanese turmeric	1,50	2,33	4,83	11,03	15,97	18,40	33,15	38,24
F count	2,24^{ns}	2,18^{ns}	0,18^{ns}	0,95^{ns}	0,79^{ns}	2,58^{ns}	0,84^{ns}	0,45^{ns}
F table	5,11	5,11	5,11	5,11	5,11	5,11	5,11	5,11
BNJ 5%	-	-	-	-	-	-	-	-

Notes: *) significantly different, tn) Not significantly different at the test level of P < 0.05.

Statistical analysis of the intensity of the BBTV virus on bananas with Javanese turmeric plant passers obtained the calculated F value for observation one was 2.24, observation two 2.18, observation three 0.18, observation four 0.95, observation five 0.79, observation six 2.58, observation seven 0.844, and observation eight the calculated f value was 0.457. F table of all observations of

Bunchy Top disease intensity in eight observations is 5.11. The P value in each observation showed different numbers, from the first observation to the eighth observation were 0.16, 0.17, 0.67, 0.35, 0.38, 0.14, 0.38, and 0.51, respectively. Based on the P value, the virus intensity did not affect both treatments (Figure 3)
.

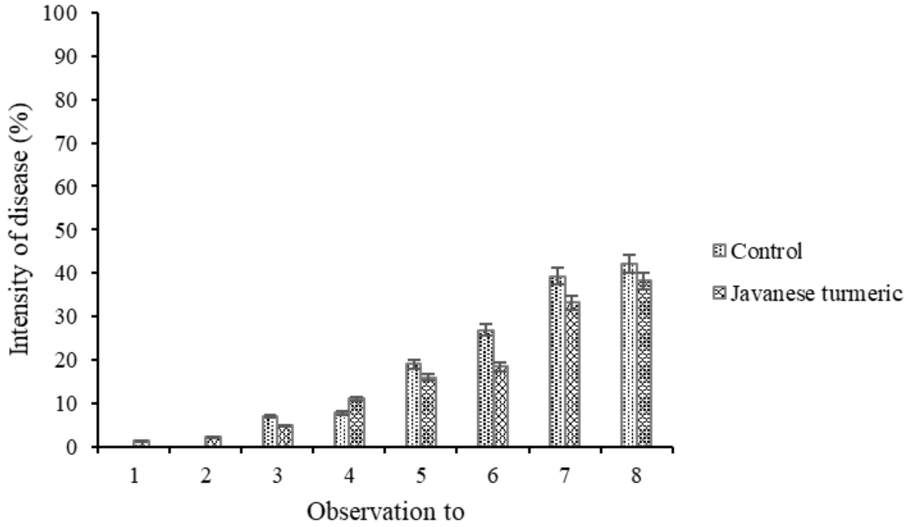

Figure 3. The Intensity of Banana Bunchy Top Virus Attack on Banana Plants

The intensity of the Banana Bunchy Top virus attack in eight observations can be seen in Figure 4.2 and the treatment using Javanese turmeric plants experienced an increase in percentage during the eight observations. In the control treatment, there was an increase from week three to week eight but the intensity of the attack began to appear in week three for the control treatment. The highest intensity for both treatments occurred in week eight and the lowest was in week three for the control treatment and week one for the Javanese turmeric treatment. The lowest intensity value for the control treatment was 7.03% and the highest was 42.06%. Treatment two using Javanese turmeric plants had the lowest intensity with a value of 1.50 and the highest was 38.24% (Figure 4)
.

Figure 4 Healthy banana plants (A) and banana plants infested with Banana Bunchy Top virus (B).

p-ISSN 1829 586X
e-ISSN 2581-0170

The population of *P. nigronervosa* was observed on Javanese turmeric plants in two media to compare the development of *P. nigronervosa* populations in both media. The media used are soil media and water media. In soil media, Javanese turmeric plants are planted directly from the plant buds while in water media Javanese turmeric cuttings are put into bottles and filled with enough water. The number of plants used was 10 plants observed every day. The difference between the two populations in different media can be seen in Figure 4.5. Based on the results of observations, the population of *P. nigronervosa* in soil media is more than the population of *P. nigronervosa* in water media (figure 5)

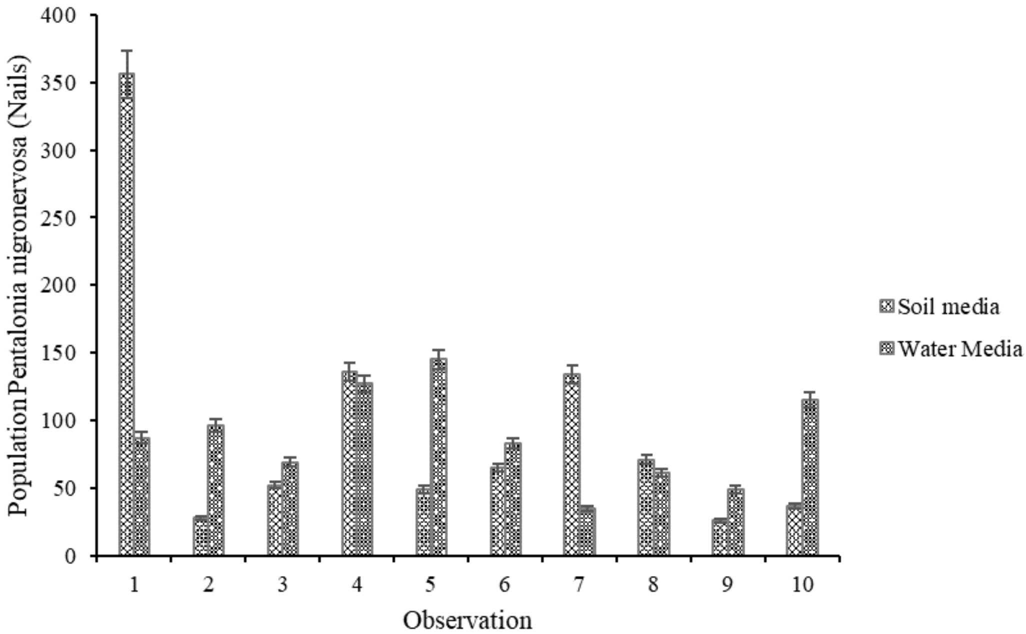

Figure 5. The population of *Pentalonia nigronervosa* in Soil and Water Media

Based on the results of research on the population of *P. nigronervosa* on soil media, it can be seen that in the first observation, the population of *P. nigronervosa* had a high population of 356 individuals, but decreased in the second observation, in the third observation the population of *P. nigronervosa* in soil media increased, in the fourth and seventh observations there was an increase in the population of *P. nigronervosa*, but the decline in the population of *P. nigronervosa* also occurred in the fifth, eighth, ninth and tenth observations. But overall the number of *P. nigronervosa* populations in the soil is more than *P. nigronervosa* in the water.

Observations of the *P. nigronervosa* population in water media for the first and second observations had relatively the same number of populations, in the fourth and fifth observations there was an increase in the number of *P. nigronervosa* populations. The sixth and seventh observations decreased the population of *P. nigronervosa*. In general, the decrease and increase in the population of *P. nigronervosa* in water media is not as significant and not as much as the population of *P. nigronervosa* in soil media (Figure 6).

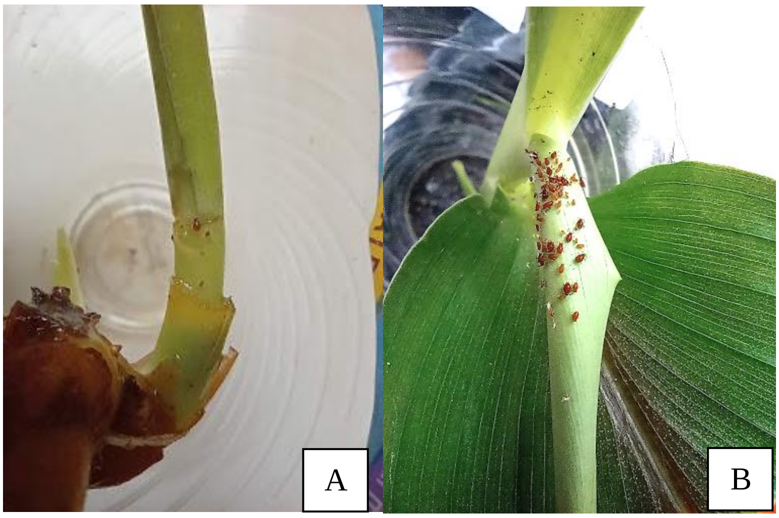

Figure 6. Population of *Pentalonia nigronervosa* in (A) Soil Media and (B) Water Media

Based on the research conducted on the effect of temu lawak plants on Banana Bunchy Top Virus, it is known that the incidence of disease that occurs in each block of plants observed eight times has increased and some are fixed. The incidence for the control treatment is the infective *P. nigronervosa* virus vector transferred directly to healthy banana plants. Treatment two infective *P. nigronervosa* was transferred first to temu lawak plants and then inoculated on banana plants. After inoculation, the first observation was made after 14 days to record symptoms early so that no data were missed.

The first observation of incidence in the treatment of one control plant has not yet appeared symptoms but in the treatment using two Javanese turmeric symptoms have appeared in the second observation with an average incidence of 6.67%. The second observation of disease incidence has not appeared in the control treatment and the treatment of javanese turmeric plants still shows the same number. This shows that the incubation period of the virus is longer in the control treatment than in the treatment using temu lawak plants.

The incidence continued to increase for the dick treatment from observation three to observation seven. In the treatment using Javanese turmeric, the incidence continued to increase from week three to week six but stagnated from week six to week eight. Based on statistical analysis, the calculated F value is smaller than the F table so the treatment has no effect and this is supported by the P value of each treatment from eight observations none with a value below 0.05. The treatment of *P. nigronervosa* transferred to temu lawak plants before inoculation on banana plants had no statistical effect in reducing the incidence of the Banana Bunchy Top virus on banana plants.

The intensity of the banana dwarf virus attack, also known as the Bunchy Top virus, was observed on healthy banana plants with two treatments: treatment one was the control treatment, infective *P. nigronervosa* was inoculated directly on healthy banana plants, and treatment two was the infective *P. nigronervosa* vector transferred to temu lawak plants before being inoculated on healthy banana plants. Observations were made two weeks after vector inoculation. The total days of observation counted 2 weeks after inoculation amounted to 23 days. Symptoms began to increase significantly starting from the 5th observation or 27 days after inoculation. The highest percent intensity of the control treatment was 42.06% and the highest percent in the Javanese turmeric plant treatment was 38.24. The average results of the two treatments were not significantly different in both treatments.

The results obtained that the intensity of dwarf virus attack according to statistical tests did not significantly affect. This means that the treatment of infective *P. nigronervosa* transferred to Javanese turmeric plants has no real effect in reducing the intensity of dwarf virus attacks on banana plants. This treatment is the same as the control treatment where the infective *P. nigronervosa* is directly inoculated. This could be because Javanese turmeric is a suitable host plant for the development of *P. nigronervosa*. According to research, the Zingiberaceae tribe is an alternative host for *P. nigronervosa*. The Javanese turmeric is one of the plants of the Zingiberaceae tribe. The virus persists in the body of its host as long as the host is alive. Although in treatment two the infective aphid vector was transferred first to temu lawak plants, due to the nature of the aphid will carry the virus during its life, the virus will still be in the body of the vector even though it was transferred first to javanese turmeric. Attacks will still occur on banana plants with the treatment of vectors transferred first to Javanese turmeric. Observations of the population of *P. nigronervosa* on Javanese turmeric plants were carried out on two different media to see the host suitability of *P. nigronervosa* aphids. Observations were made on 10 plants which were observed every day for 10 days. Based on the data obtained, some plants have high populations in soil media. In one plant, the population of banana aphids reached a population of 350 individuals. This can occur because of the appropriate host, and sufficient food sources for the development of its population. *P. nigronervosa* will look for soft plant parts to take nutrients for its population development.

The population of *P. nigronervosa* in both media is almost the same. The distribution of population in both media is quite even. In water media, the number of populations per plant was almost similar, and in soil media, only one plant showed a high population. *P. nigronervosa* can live on temu lawak plants as its host in both water and soil media and in live plants or cuttings of Javanese turmeric plants.

CONCLUSION

Based on the research conducted on the population growth of *Pentalonia nigronervosa* in Javanese turmeric and the effect of Javanese turmeric (Curcuma zanthorrhiza) on the efficiency of P. nigronervosa as a vector of BBTV disease. Pentalonia nigronervosa can reproduce well in temu lawak plants either in water or soil media. Javanese turmeric plants could not reduce the infectivity and transmission efficiency of BBTV by its vector, *P. nigronervosa* to healthy banana plants

REFERENCES

Arsi, Pujiastuti, Y., Suparman, & Irsan, C. 2024. The role of insect vector *Pentalonia nigronervosa* in spreading banana bunchy top disease in South Sumatera. *IOP Conference Series: Earth and Environmental Science* 1346(1). DOI: 10.1088/1755-1315/1346/1/012004

Bagariang, W., Hidayat, P., & Hidayat, S. H. 2019. Morphometric analysis and host range of the genus *Pentalonia* Coquerel (Hemiptera: Aphididae) Infesting Banana in Java. *Jurnal Perlindungan Tanaman Indonesia* 23(2): 171. DOI: 10.22146/jpti.38220

Efendi, R. A., SHK, S., & Hamidson, H. 2022. Biology of *Pentalonia nigronervosa* COQUEREL ON

VARIOUS ZINGIBERACEOUS CROPS. *BIOVALENTIA: Biological Research Journal* 8(2): 118–129. DOI: 10.24233/biov.8.2.2022.308

Hamim, I., Green, J. C., Borth, W. B., Melzer, M. J., Wang, Y. N., & Hu, J. S. 2017. First Report of Banana bunchy top virus in Heliconia spp. on Hawaii. *Plant Disease* 101(12): 1–2.

Hapsari, L., Kennedy, J., Lestari, D. A., Masrum, A., & Lestarini, W. 2017. Ethnobotanical survey of bananas (Musaceae) in Six districts of East Java, Indonesia. *Biodiversitas* 18(1): 160–174. DOI: 10.13057/biodiv/d180123

Hapsari, L., & Lestari, D. A. 2016. Fruit characteristic and nutrient values of four Indonesian banana cultivars (Musa spp.) at different genomic groups. *Agrivita* 38(3): 303–311. DOI: 10.17503/agrivita.v38i3.696

Hastuti, Purnomo, Sumardi, I., & Daryono, B. S. 2019. Diversity wild banana species (Musa spp.) in Sulawesi, Indonesia. *Biodiversitas* 20(3): 824–832. DOI: 10.13057/biodiv/d200328

Irwansyah, I., Sofian, S., & Akhsan, N. 2019. Identification of characteristics of banana Bunchy Top Virus (BBTV) symptoms and intensity on banana plants in several Districts in Kutai Kartanegara Regency. *Jurnal Agroekoteknologi Tropika Lembab* 2(1): 55. DOI: 10.35941/jatl.2.1.2019.2536.55-60

N., B. J. T., N., I., G., A., O., O., R., S., & D., D. 2020. Production of banana bunchy top virus (BBTV)-free plantain plants by in vitro culture. *African Journal of Agricultural Research* 15(3): 361–366. DOI: 10.5897/ajar2019.14522

Phillips, K. M., McGinty, R. C., Couture, G., Pehrsson, P. R., McKillop, K., & Fukagawa, N. K. 2021. Dietary fiber, starch, and sugars in bananas at different stages of ripeness in the retail market. *PLoS ONE* 16(7 July): 1–21. DOI: 10.1371/journal.pone.0253366

Poorani, J., Mohanasundaram, A., & Thanigairaj, R. 2023. Natural enemies of *Pentalonia nigronervosa* Coquerel, a Vector of Bunchy Top of banana and biology of its most effective predator *Scymnus nubilus* Mulsant. *Indian Journal of Entomology* 85(2): 381–384. DOI: 10.55446/IJE.2021.377

Prabaningrum, L., & Moekasan, T. K. 2016. Pengelolaan organisme pengganggu tumbuhan utama pada budidaya cabai merah di dataran tinggi. *Jurnal Hortikultura* 24(2): 179. DOI: 10.21082/jhort.v24n2.2014.p179-188

Rahmah, S., Maryana, N., & Hidayat, P. 2021. Host preference of *Pentalonia nigronervosa* Coquerel and *P. caladii* van der Goot (Hemiptera: Aphididae) on various host plants. *IOP Conference Series: Earth and Environmental Science* 694(1). DOI: 10.1088/1755-1315/694/1/012050

Rai, I. N., Dwivany, F. M., Sutanto, A., Meitha, K., Sukewijaya, I. M., & Ustriyana, I. N. G. 2018. Biodiversity of bali banana (Musaceae) and its usefulness. *HAYATI Journal of Biosciences* 25(2): 47–53. DOI: 10.4308/hjb.25.2.47

Rai, I. N., Mayadewi, N. N. A., Wiraatmaja, I. W., & Astiari, N. K. A. 2023. Fruit morphology and nutritional composition of different genome groups of six bananas cultivars from Bali Island. *Caraka Tani: Journal of Sustainable Agriculture* 38(2): 421–432. DOI: 10.20961/carakatani.v38i2.74941

Shankar, U. 2016. Integrated Pest Management in Banana. *Research Gate* (January): 328–350.

Sunaryo, W., Wahida, Idris, S. D., Pratama, A. N., Ratanasut, K., & Nurhasanah. 2020. Genetic relationships among cultivated and wild bananas from east Kalimantan, Indonesia based on ISSR markers. *Biodiversitas* 21(2): 824–832. DOI: 10.13057/biodiv/d210250

Suparman, S., Oktarida, R., Hamidson, H., & Arsi, A. 2023. Morphometrics and biological characteristics of *Pentalonia nigronervosa*, the vector of Banana bunchy top virus, living on various Araceous plants species. *Jurnal Hama dan Penyakit Tumbuhan Tropika* 23(1): 77–87. DOI: 10.23960/jhptt.12377-87

Tricahyati, T., Suparman, & Irsan, C. 2022. Natural enemies of *Pentalonia nigronervosa*, vector of Banana Bunchy Top Virus. *Biodiversitas* 23(7): 3675–3684. DOI: 10.13057/biodiv/d230745

Yudi Ariadi, B., Relawati, R., Agustina, Y., In Haryanto, L., Fauzi Kamarudin, M., & Muhammadiyah Malang, U. 2024. The promising prospect of banana production and marketing in Indonesia. *SOCA: Jurnal Sosial Ekonomi Pertanian* 18(1): 59–76.