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SHORT COMMUNICATION

Correlation of Mottle Disease Severity and Insect Vector Abundance on Black Pepper Yield

Korelasi Keparahan Penyakit Belang dan Kelimpahan Serangga Vektor Terhadap Hasil Panen Lada

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ABSTRACT

Insect-borne viral diseases epidemics are influenced by interaction among host plants, viruses, their vectors, and environment. Two species of mealybugs i.e. *Planococcus minor* and *Ferrisia virgata* are known as virus vectors that cause mottle disease on black pepper (*Piper nigrum*). Research was conducted to determine the main factors affecting mottle disease spread in the field. Study was conducted by observing 30 productive black pepper plants at the experimental field in Sukabumi, West Java. The parameters involved abundance of mealybugs, severity of mottle disease, and yield of black pepper plants. Disease severity and plant yield was assessed for three consecutive harvest seasons, while mealybug abundance was observed every two months for a year. The results showed that abundance of mealybugs did not have significant affect to disease severity and plant yield, indicating the vectors in the field does not play as a prominent role in disease spreading. Simple linear regression between disease severity and plant yield showed coefficient determination of R^2 value about 0.4351 with negative correlation, indicating opposite effect between severity and plant yield. Increasing disease severity affect moderately plant yield decrease. Therefore, planting virus free seed stocks and applying good cultivation practices in the field will inhibit disease development and spreading which in turn will affect continuous optimal plant yields.

Keywords: Linear regression, *Piper nigrum*, disease spread, mealybug

ABSTRAK

Epidemi penyakit virus tular serangga dipengaruhi oleh interaksi antara tanaman inang, virus dan vektornya serta kondisi lingkungan. Dua spesies kutuputih yaitu *Planococcus minor* dan *Ferrisia virgata* diketahui sebagai vektor virus belang pada tanaman lada (*Piper nigrum*). Penelitian dilakukan untuk menentukan faktor utama yang berpengaruh terhadap penyebaran penyakit belang di lapangan. Pengamatan dilakukan terhadap 30 tanaman lada umur produktif di kebun Sukabumi, Jawa Barat. Peubah yang diamati ialah kelimpahan kutuputih, keparahan penyakit, dan produksi lada. Keparahan penyakit dan produksi lada diamati selama tiga musim berturut-turut, sedangkan jumlah kutuputih dihitung

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selama satu tahun dengan interval dua bulan sekali. Hasil penelitian menunjukkan bahwa kelimpahan kutuputih tidak berpengaruh nyata terhadap tingkat keparahan penyakit dan produksi lada. Hal ini mengindikasikan bahwa serangga vektor bukan menjadi faktor utama yang terlibat dalam penyebaran penyakit. Regresi linear sederhana antara keparahan penyakit dan produksi lada menunjukkan korelasi negatif dengan koefisien determinasi R^2 sebesar 0.4351 mengindikasikan efek yang berlawanan antara keparahan penyakit dan produksi lada. Peningkatan keparahan penyakit akan menurunkan produksi lada dengan kategori sedang. Penggunaan bibit bebas virus dan praktik budi daya lada yang baik akan menghambat perkembangan dan penyebaran penyakit di lapangan yang akan berpengaruh terhadap produksi optimal yang berkesinambungan.

Kata kunci: kutuputih, *Piper nigrum*, penyebaran penyakit, regresi linear

Several factors influence the cultivation of black pepper in Indonesia, among others are climate change, pests and diseases, availability of superior varieties, and most farmers do not practice the appropriate cultivation because limited capital and mastering technology (Karmawati *et al.* 2020). Improper crop cultivation may cause nutrient deficiency and high intensity of pests and diseases. Yellowing of leaves may occur due to poor uptake of nitrogen, phosphorus, and potassium (Surendra *et al.* 2019). Three main insect pests, i.e. *Lophobaris piperis, Thrips* sp., and *Dasinus piperis* has been reported from black pepper field in Lampung and caused 38%, 23%, and 9% plant damage, respectively (Kardinan *et al.* 2022). As for disease problem, infection of *Phytophthora capsici*, nematodes, and viruses has been reported as important pathogens on black pepper plantation in Indonesia (Miftakhurohmah *et al.* 2020; Verma *et al.* 2022).

Mottle disease on black pepper is caused by two viruses, i.e. *Piper yellow mottle virus* (PYMoV) and *Cucumber mosaic virus* (CMV), with PYMoV as the dominant virus. Furthermore, two species of mealybugs, *Planococcus minor* and *Ferrisia virgata* has been identified as the vector of PYMoV (Miftakhurohmah *et al.* 2020; Miftakhurohmah *et al.* 2022). In general, epidemic of viral diseases is affected by the interaction among the virus, plant host, and environment condition including insect vector of the virus. It is necessary to conduct analyses on the relationship between several disease factors in order to study disease spread, effect of the disease to yield loss and its epidemic potential (Islam *et al.* 2019; Helina *et al.* 2020). No information is available up to now regarding the pathosystem of mottle disease of black pepper, especially in Indonesia. Therefore, this study was initiated to evaluate the interaction between abundance of PYMoV insect vector (*P. minor* and *F. virgata*), and disease severity to plant yield.

Research was carried out on black pepper plantations in the experimental field of Indonesian Spice and Medicinal Crops Research Institute (ISMCRI) Sukabumi, West Java. Plants were cultivated using *Glyricidia* sp. as live support and grasses as cover crop, with space between plants was 2.5 x 3 m. Disease severity and plant yield were observed in three successive harvest seasons from 2018 to 2020, started on plants aged about 3-4 years. In 2018, samples observed were 18 plants, and increased to 30 plants in 2019 and 2020. Infection of PYMoV has been confirmed by PCR detection method from plants showing mottle and stunting. Therefore, in this study it was assumed that plants with mottle systems and stunting is infected by PYMoV.

Disease severity was observed one month before harvesting, on June-July (annually), with a scoring system (Table 1). Harvesting of black pepper fruit was carried out by picking spikes directly by hand, and fresh spikes per plant were weighed. Yield data for each season is the cumulative of 2-3 times of spike picking, which were carried out between July-October (every year). Abundance of *P. minor* and *F. virgata* was observed every two months for one year, starting after the second season

of black pepper harvest until before the third of harvest (October 2019 to August 2020) following the procedure explained in Miftakhurohmah *et al.* (2022). Analysis correlation between disease severity and insect abundance to yield was conducted using multiple and simple linear regressions. Correlation categories was grouped based on coefficient of determination R^2 values as follows: very weak (0–20)%, weak (21–40)%, moderate (41–60)%, strong (61–80)%, and very strong (80–100)% (La Morte 2021).

As reported previously, common symptoms associated with infection of PYMoV involved mottling, mosaic, or curling of the leaves; while severe symptoms may cause shortened stem segments and smaller leaves (Miftakhurohmah *et al.* 2020; Che *et al.* 2021). During three consecutive years from 2018 to 2020 disease severity tends to increase, i.e. 25.92%, 68.89%, and 77.78%, respectively (Figure 1). Fresh spike yields decreased in the harvesting period on 2018 to 2019, from 1.050 to 0.806 kg per plant, but slightly increased on 2020 up to 0.813 kg per plant (Figure 1). Based on data from 2018 to 2019, disease severity increased by more than 50% and caused yields decreased up to 23%. During the observation period, fertilization and weeding activities was only conducted twice, i.e. after second harvest (September 2019) until third harvest (August 2020). These practices seem to affect disease severity and in turn causes yield increase up to 0.9%. This fact indicates that an appropriate cultural practices affect better plant health and inhibit disease development. Evizal and Prasmatiwi (2021) reported that black pepper yield cultivated in optimal conditions increased from the first to second harvest period after 2–3 years of harvest (6–7 years olds after planting), although the production will decline gradually as the plants get older. Minimal fertilizer input may cause nutrient deficiency, and increase plants susceptibility against

Table 1 Disease severity scores of *Pepper yellow mottle virus*

Score	Description and proportion of symptoms in individual plant
0	No symptom
1	Mottle, mosaic, curly of leaves on ≤ 1/3 of plant
2	Mottle, mosaic, curly of leaves on > 1/3 - ≤ 2/3 of plant
3	Mottle, mosaic, curly of leaves on > 2/3 of plant
4	Mottle, mosaic, curly of leaves and stunted ≤ 1/3 of plant
5	Mottle, mosaic, curly of leaves and stunted > 1/3 - ≤ 2/3 of plant
6	Mottle, mosaic, curly of leaves and stunted > 2/3 of plant

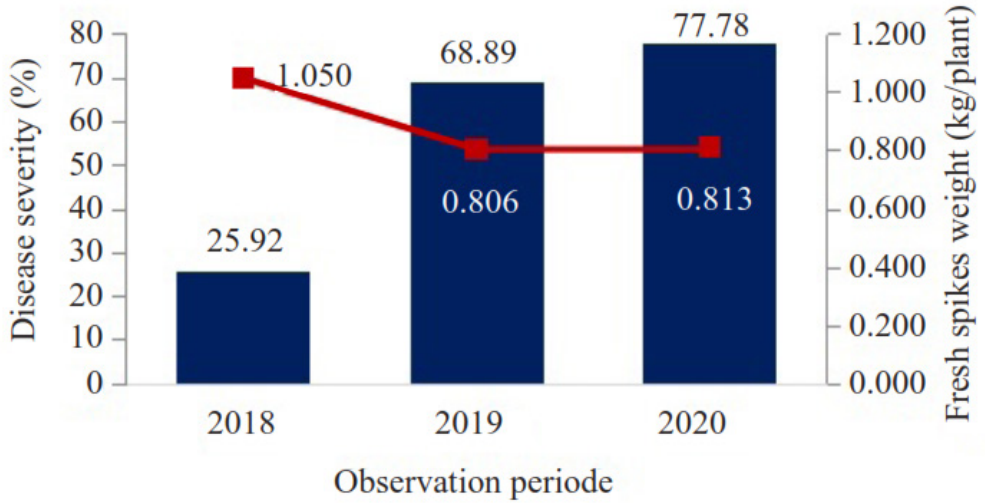

Figure 1 Severity of mottle disease and black pepper yield during three consecutive years 2018, 2019, and 2020.

pathogen infection. Fertilizer application according to the recommendation has been reported to increase plant resistance to mealybugs, promote better plant performance, and significantly increase yield and crop quality (Tien *et al.* 2020; Hartono *et al.* 2022).

Multiple linear regression analysis on interaction between plant yield, disease severity, and insect abundance resulted in F value of < 0.05, indicating a significantly different interaction. Factors that affect plant yields are concluded based on p value. Disease severity had a p value of 0.0002 (< 0.0250), indicating that this factor had a significant effect on plant yield; while insect abundance had no significant effect (p value > 0.0250) (Table 2). The interaction between disease severity and plant yield were determined by simple regression analysis of two factors with regression equation is $Y = -0.529X + 3.282$. Value of $a = -0.529$ indicates that there was a negative correlation between disease severity and plant yield, the increasing of disease severity causes a decreasing of yield. R^2 value was 0.4351 (43.51%), indicating that disease severity moderately affects plant yield (Figure 2) and other factors affect more to yield (56.49%) which may include environment stress and damage by insect pests (Bhat *et al.* 2023). High temperature and relative humidity positively correlated to virus symptom expression and disease severity (Ahamedemujtaba *et al.* 2021). Plants having poor nutrition will induce the development of viral disease symptom (Bhat *et al.* 2023).

In perennial and vegetative propagation crops such as black pepper, virus infection occurs for years along with plant growth period, leading to accumulation of virus titers and high disease severity (Van den Bosch *et al.* 2007). In addition, mealybugs feeding activity will have the chance to transmit and inoculate PYMoV. Therefore, virus infection occurres continuously and cause virus titer to increase.

Based on our analysis it is concluded that disease severity has a significant effect on plant yield; while insect abundance has no significant effect. Therefore, planting virus-free cutting plant materials should be recommended as the strategy to control and

Table 2 Multiple linear regression analysis of yield, disease severity, and insect vector abundance

Variable	Regression coefficient	P value	Significance F
Constanta	2.960	-	0.001
Disease severity	-0.475	0.0002	
Planococcus minor	0.006	0.8407	
Ferrisia virgata	-0.113	0.7066	

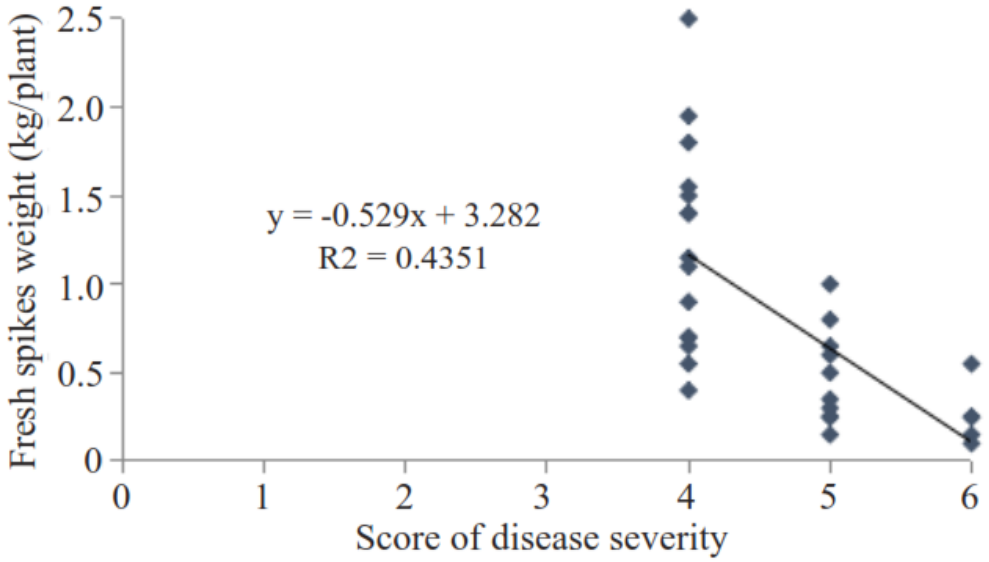

Figure 2 Correlation between severity of mottle disease and black pepper yield.

to prevent the epidemic of mottle disease on black pepper.

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