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The effect of maize plants as a repellent for *Bemisia tabaci* (Gennadius) on chili plants

Pengaruh tanaman jagung sebagai penolak *Bemisia tabaci* (Gennadius) pada tanaman cabai

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ABSTRACT

Bemisia tabaci (Gennadius) is crital pest of chili plants. Besides using chemical insecticides to control *B. tabaci*, the actions that can be taken for *B. tabaci* management include applying repellent compounds. This research aims to study the potential of various commercial corn varieties in producing repellent compounds for *B. tabaci*. The method used in this research involved testing the response of *B. tabaci* using a Y tube olfactometer and GCMS analysis on varieties P-21, Bisi-18, NK-212, and Pertiwi 3 on a laboratory scale. Volatile compounds were collected from corn plants aged 3–10 weeks after planting (WAP). The results showed that Bisi-18, P-21, NK-212, and Pertiwi 3 maize exhibited repellency against *B. tabaci*. The highest repellency for all corn varieties was observed at 10 WAP. The P-21 variety exhibited 80% repellency, followed by Pertiwi 3 and Bisi-18 with 78% repellency, while NK-212 showed the weakest repellencyat 60%. Results from volatile compounds identification of each maize varieties demonstrated revealed several compounds with repellent properties against *B. tabaci*, including 9-otadecenoic acid (Z)-, 9-octadecenamide, (Z)-, delta-guaiene, alpha-guaiene, beta caryophyllene, and patchouli alcohol. Using maize plants to manage *B. tabaci* has the potential to be an environmentally friendly management technique. Further research is needed on *B. tabaci* management technique to achieve a more effective and efficient combination.

Key word: GCMS, maize, repellence, whiteflies

ABSTRAK

Bemisia tabaci (Gennadius) merupakan hama penting pada tanaman cabai. Selain menggunakan insektisida kimia untuk mengendalikan *B. tabaci*, tindakan yang dapat dilakukan untuk pengendalian *B. tabaci* adalah dengan mengaplikasikan senyawa penolak (*repellent*). Penelitian ini bertujuan untuk mempelajari potensi berbagai varietas jagung komersial dalam menghasilkan senyawa penolak *B. tabaci*. Metode yang digunakan dalam penelitian ini meliputi pengujian respons *B. tabaci* yang diuji dengan menggunakan alat olfaktometer tabung Y dan analisis GCMS pada varietas P-21, Bisi-18, NK-212, dan Pertiwi 3 dalam skala laboratorium. Senyawa volatil dikumpulkan dari tanaman jagung yang berumur 3–10 minggu setelah tanam (MST). Hasil penelitian menunjukkan bahwa jagung varietas Bisi-18, P-21, NK-212, dan Pertiwi 3 memiliki daya tolak terhadap *B. tabaci*. Semua varietas jagung menunjukkan ketahanan tertinggi untuk semua varietas jagung yang diamati pada 10 MST. Varietas P-21 menunjukkan daya tolak sebesar 80%, diikuti oleh Pertiwi 3 dan Bisi-18 dengan daya tolak sebesar 78%, sedangkan NK-212 menunjukkan daya tolak yang paling rendah, yaitu sebesar 60%. Hasil identifikasi senyawa volatil dari setiap varietas jagung yang ditunjukkan menunjukkan beberapa senyawa yang memiliki sifat penolak terhadap *B. tabaci*, seperti *9-otadecenoic acid (Z)-*, *9-octadecenamide*, *(Z)-*, *delta-guaiene*, *alpha-guaiene*, *beta caryophyllene*, dan *patchouli alcohol*.

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Menggunakan tanaman jagung untuk mengelola *B. tabaci* berpotensi menjadi teknik pengelolaan yang ramah lingkungan. Penelitian lebih lanjut mengenai teknik pengendalian *B. tabaci* ini perlu dilakukan untuk mendapatkan kombinasi yang lebih efektif dan efisien.

Kata kunci: GCMS, jagung, kutu kebul, penolak

INTRODUCTION

Bemisia tabaci (Gennadius) is critical pest of chili plants, which are among the most favoured crops by farmers. According to Bahrun & Rohansyah (2020), the average yield produced by farmers in the Village of Pulantan was 241.70 kg per farmer. Host plants of *B. tabaci* belong to various families, including Asteraceae, Malvaceae, Solanaceae, Cruciferaceae, Lamiaceae, Euphorbiaceae, Fabaceae, Begnoniaceae, Lythraceae, and Zygophyllaceae (Oliveira et al. 2001).

Bemisia tabaci damages plants by sucking leaf fluids, which subsequently damages the cell tissues of leaves, causing necrotic lesion and reducing yield. Additionally, *B. tabaci* can transmit *Pepper yellow leaf curl virus* (PYLCV), more commonly known as yellow virus disease in Indonesia. This virus is easily transmitted due to the wide host range of *B. tabaci* (Sulandari et al. 2006).

Yield loss due to *B. tabaci* can reach 80% and even cause crop failure. In addition to the application of insecticides, using repellent compounds can be another effective strategy. Interest in repellent compounds against pest has increased due to more reports of insecticide-resistant pests and community concerns of environmental safety.

Repellent not only focus on scents that cause pest to avoid specific crops, but may also hinder pest's ability to locate hosts (Deletre et al. 2016; Werner & Avery 2019). Extracts of *Andrographis paniculata*, piper betle leaves using n-hexane, and acacia leaves using ethyl acetate have been shown to repel oviposition of *Bactrocera carambolae* Drew & Hancock (Prakoso et al. 2018). Additionally, utilizing garlic extract to repel birds from the Family Lochura has been reported as effective in reducing attacks, from 5–13 to 3–7 attacks during the afternoon, by 6–12 flocks (Hardiansyah et al. 2020).

Mixed cropping with maize is often practiced by farmers to increase incomes, yet the maize's effect in repelling certain pests is often overlooked. Mohamad Roff & Ho (1991) demonstrated that mixed cropping between chili and maize reduced aphid populations. Similarly, Smith & McSorley (2000) showed that mixed cropping between eggplants and maize caused *B. tabaci* to spend more time on maize to locate their main host.

As insecticides lead to resistance in *B. tabaci*, alternaltive methods are needed, such as using volatile compounds from maize to repel *B. tabaci.* Further research is required to explore the potential of this approach and its practical application in pest management. Tyasningsiwi et al. (2019) identified maize volatile compounds as *B. tabaci* repellents, specifically in Bisi-2. However, many maize varieties in Indonesia have been developed to produce different volatile compounds. Hence, this research aims to study the potential of various commercial corn varieties in producing repellent compounds for *B. tabaci*.

MATERIAL AND METHOD

Plants and insects preparation

Four maize varieties, namely P-21, Bisi-18, NK-212, and Pertiwi 3 were utilised in this study. These varieties were planted in polybags measuring 30 cm x 30 cm, with each polybag containing two seeds, resulting in a total of 128 plants. Watering was performed in the morning and afternoon, and fertilizer were applied twice: once when when maize plants were one-week-old and again when they were four-week-old.

Bemisia tabaci specimens were collected from chili or eggplants fields in the Sleman area of Yogyakarta. Mass rearing was conducted in cages covered with gauze, and the *B. tabaci* were fed eggplant plants in the greenhouse of the Faculty of Agriculture, University of Gadjah Mada. The greenhouse maintained a temperature range of 27–30 ^{o}C and relative humidity (RH) of 70%. Plant maintenance measures were implemented to prevent damage from other herbivores.

Maize plants volatile compound collection and GCMS analysis

The collection of compounds was conducted using equipment adapted by Heath & Manukian (1994). The apparatus for collecting volatile compounds from maize plants comproses several components, including a solvent storage measuring tube, a maize plant storage tube, an air pump, and a balloon positioned beneath the plant storage tube. Volatile compounds were gathered from maize plants aged 3–10 weeks after planting. Five maize plants were selected for volatile compound collection using modified equipment, which were set up in the morning and left for one day. Collection tube were filled with 7 ml of n-hexane. Following the collection period, air was forced into the collection tubes to capture volatile compounds, which were then tightly closed, sealed with parafilm and stored in a cooler at 4 ^{o}C. The collected compounds from maize plants were subsequently analyzed using GCMS to determine their identities. This analysis was conducted in the Organic Chemistry Laboratory, Faculty of Natural Science, University of Gadjah Mada.

Y-tube olfactometer test

Adult of *B. tabaci* responses to different volatile sourceswere assessed using Y-tube olfactometer tests. The Y-tube olfactometer consists of a Y-tube (diameter 2 cm; arm length 10 cm), tubes, two glass bottles (diameter 3.5 cm; length 6 cm), filled with activated carbon, an air pump and a flowmeter. Volatile compounds from maize were tested to determine *B. tabaci* response. Five groups of *B. tabaci*, each comprising 10 female individuals, were tested using the olfactometer. Each group were placed in one arm of Y-olfactometer, with each arm equiped wth n-hexane and maize volatile compounds. *Bemisia tabaci* individuals that did not move towards either arm after 5 minutes were noted as non-responsive. Observation were conducted on maize plants aged 3–10 weeks after planting. Repellence was calculated using the formula proposed by Kwon et al. (2010).

$$\text{Repellence} = (p - k)/(p + k) \times 100\%$$

where p: the number of insects that chose the control; and k: represents the number of insects that chose the treatment.

Data analysis

Data from the Y-tube olfactometer test were analyzed using ANOVA and when significant differences occurred, a Tukey HSD post-hoc test was performed (α = 5%). The analysis was conducted using R studio software.

RESULT

GCMS analysis

GCMS analysis showed that 9-octadecenoic acid (Z)- identified in Bisi-18 and NK-212. B-caryophyllen, delta-guaiene, and alpha-guaiene were found in Pertiwi 3, while patchouli alcohol and delta-guaiene were found in P-21 (Table 1). These compounds were identified to have repellent properties against *B. tabaci.*

Y-tube olfatometer test

The results of Y-tube olfactometer test on Bisi-18, NK-212, Pertiwi 3, and P-21 showed that *B. tabaci* exhibited a preference for the control (n-Hexane) over the treatment (maize volatile compounds from each variety), with few individuals choosing either option. *Bemisia tabaci*'s preference between the control and treatments did not show significant differences from week 3–5 after planting, whereas significant differences were observed from weeks 6–10 after-planting. At 10 weeks-after-planting, the number of *B. tabaci* individuals that chose the control reached its highest compared to other observation periods (Figure 1). The highest repellence from all maize

Table 1. Volatile compounds identified by GCMS in different maize varieties were carried out on maize plants aged 3–10 week after planting

Maize variety	Detected repellent compound
Bisi-18	9-Octadecenoic acid (Z)-, 9-Octadecenamide, (Z)-
NK-212	9-Octadecenamide, (Z)-
Pertiwi 3	Delta-Guaiene Beta Caryophyllene Alpha-Guaiene
P-21	Patchouli Alcohol Delta-Guaiene Beta Caryophyllene

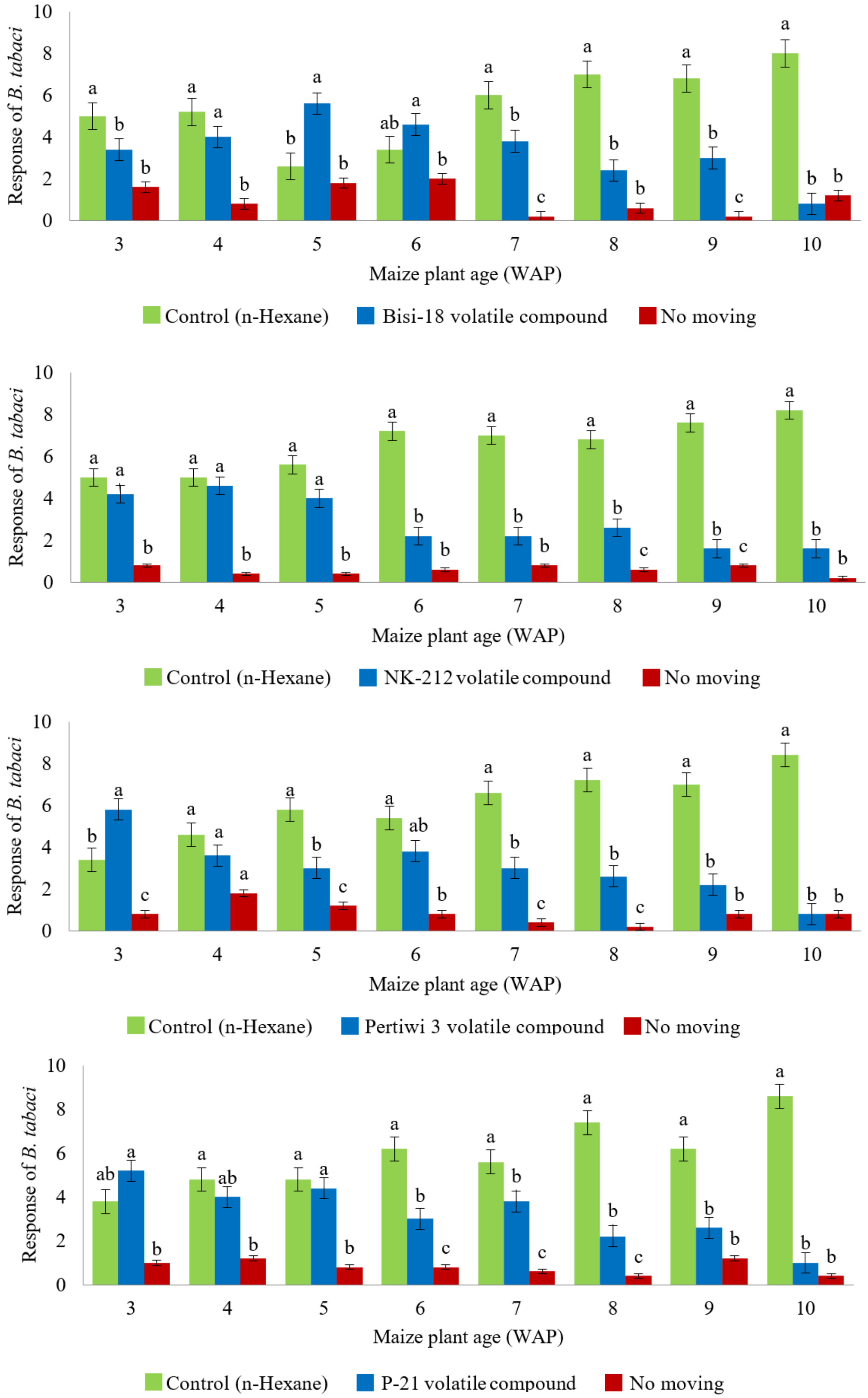

Figure 1. Y-tube olfactometer test results on Bisi-18, NK-212, Pertiwi 3, and P-21. The response is representation of the number of *Bemisia tabaci* in the Y-tube arm according to its movement in the control and treatment arm or no-moving. Numbers followed by the same letters indicate no significant differences.

varieties was observed at 10 weeks-after-planting with P-21 exhibiting 80% repellence, followed by Pertiwi 3 and Bisi-18 with 78% repellence, and NK-212 showing the weakest of 60% (Table 2).

DISCUSSION

The mechanism of disruptions for *B. tabaci* caused by maize may be attributed to two reasons: physical and chemical actions. The physical action is triggered by the height maize plants and the density of their leaves, which complicates *B. tabaci* penetration into the field. The chemical action possibly arises from *B. tabaci* aversion to compounds released by maize, thus avoiding areas containing maize barrier (Friarini at al. 2017). Olfactometer test demonstrated that repellences of all varieties were highest at 10 weeks-after-planting. According to Su et al. (1982) repellences between 60–75% are categorized as fairly strong, while those between 75–95% are categorized as strong. Therefore P-21, Pertiwi 3, and Bisi-18 at 10 weeks-after-planting are categorized as strong repellents, while NK-212 is categorized as fairly strong repellents. During the maize plant ages of 3–6 weeks-after-planting, some varieties showed that *B. tabaci* preferred treatments compared to controls. Bisi-18 at 5 and 6 weeks-after-planting did not exhibit significant differences between the number of *B. tabaci* individuals choosing treatment and control, even though they were numerically different. Similar results were observed for Pertiwi 3 and P-21 varieties at 3 weeks-after-planting. *Bemisia tabaci* behavior of preferring treatments over controls during the early stages of maize growth may be attributed to the low amount of repellent volatile compounds emitted by plants during this period. Plants emit volatile compounds from roots, leaves, fruits, and flowers, which provide defense signal by regulating acquired resistance (SAR) against both biotic and abiotic stressors (Deletre et al. 2016). Plant volatile compounds are synthesized through complex processes and vary over time and across plant organs due to differential gene expression (Picazo-Aragonés et al. 2020).

All of the tested maize varieties showed potential for use as barrier plants that function as repellent against *B. tabaci*. Results from GCMS analysis of each maize variety revealed several compounds with repellent properties against *B. tabaci*, including 9-otadecenoic acid (Z)-, 9-octadecenamide, (Z)-, delta-guaiene, alpha-guaiene, beta caryophyllene, and patchouli alcohol. These findings corroborate results from Tyasningsiwi et al. (2019) which identified citronella, limonene, β-phellandrene, β-caryophyllene, 1.8 cineole, farnesol, caryophyllene, and patchouli alcohol are repellent volatile compounds from maize against *B. tabaci.*

9-octadecenamide, (Z)- is known to possess larvicidal activities and disrupt insect respiration systems. Additionaly, 9-octadecenoic acid (Z)- has been reported to repel female mosquitoes (Kim et al. 2002) and disrupt mosquito larval growth and hinder pupae formation (Ali et al. 2014). B-caryophyllene also exhibits larvicidal properties and inhibits enzyme activity in *Aedes aegypti* (Linnaeus) larvae (Albuquerque et al. 2013). Application of β-caryophyllene in coffee reduces coffee fruit borer infestation by 33–45% compared to the control (Góngora et al. 2020). Patchouli alcohol, delta-guaiene, and alpha-guaiene found in *Pogostemon cablin* have been reported to repel ants (Albuquerque et al. 2013). Additionally, patchouli alcohol has also been reported to repel *Coptotermes formosanus* Shiraki (Zhu et al. 2003).

Table 2. Repellence of different maize varieties against *Bemisia tabaci* at different plant ages by Y-tube olfactometer test

Treatment	Repelency level (%) on maize plant age (WAP)							
	3	4	5	6	7	8	9	10
Bisi-18	25	11	-33	-25	20	56	40	78
NK-212	11	0	20	56	56	40	60	60
Pertiwi 3	-33	11	33	11	40	40	56	78
P-21	-11	11	11	33	20	56	33	80

To protect themselves from herbivory, plants have evolved physical and chemical defences and release a variety of volatile organic compounds (VOCs). By releasing these VOCs, a signalling plant can both reduce herbivory, sometimes by more than 90%, and also warn neighbouring plants about an attack (Skoczek et al. 2017). A range of volatile organic compounds (VOCs) emitted by maize has been found to repel insects. The natural plant activator cis-Jasmone has been found to prime maize for enhanced production of defensive VOCs, including herbivore repellents (Oluwafemi et al. 2013). The emission of VOCs by different African maize varieties when infested by leafhoppers has also been studied, revealing variability in the emitted compounds (Oluwafemi et al. 2011). Additionally, maize has been found to have repellent and toxic effects on *B. tabaci*, further supporting the potential of maize as a natural repellent (El-Ghorab et al. 2007). These studies collectively suggest that maize emits a variety of VOCs that can act as insect repellents. Maize can be utilized as a repellent plant in integrated pest management strategies.

CONCLUSION

Bisi-18, P-21, NK-212, and Pertiwi 3 demonstrated repellence against *B. tabaci*. The highest repellence was observed at 10 week-after-planting maize. P-21 exhibited the strongest repellences, followed by Pertiwi 3, Bisi-18, and NK-212, which had the weakest repellence. Volatile compounds suspected to repel *B. tabaci* included 9-octadecenoic acid (Z)-, 9-octadecenamide, (Z)-, delta-guaiene, alpha-guaiene, beta caryophyllene, and patchouli alcohol. The utilization of maize plants to manage *B. tabaci* has the potential as an environmentally friendly technique. Further studies on this management technique are required to identify more effective and efficient combinations.

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