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An Overview Of Black Pepper : Cultivation And Challenges

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ABSTRACT

Black pepper, renowned for its strong taste and medicinal properties, is a widely traded spice worldwide. This article provides an overview of black pepper farming, highlighting the challenges it faces and suggesting sustainable solutions. The pungent flavor comes from its main chemical component, piperine, typically present in concentrations below 9%. Over time, the plant trade that historically originated from India has experienced significant growth, with Indonesia, Vietnam, Brazil, India, and Malaysia emerging as major global producers. However, despite the expansion of pepper plantations in Indonesia, there has been a decline in both production value and productivity growth. This can be attributed to factors such as the use of subpar seeds, limited availability of suitable land, pest and disease infestations, less intensive farming methods, farmers' limited knowledge, and pesticide residues from excessive chemical pesticide use. To overcome these challenges, farmers can collaborate through groups, adopt intensive cultivation methods, grow pest and disease-resistant varieties, incorporate refuge plants, employ biopesticides for pest control (particularly for major pests like Lophobaris piperis, Dasynus piperis, Diconocoris hewetti, and Thrips sp.), use chemical pesticides sparingly and responsibly, and ensure effective post-harvest processing.

KEYWORD

pest, Piper nigrum, piperine, production

INFORMATION

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1. INTRODUCTION

Black pepper (Piper nigrum L.) boasts a wide range of benefits. Referred to as the "king of spices", it is widely utilized in culinary applications due to its unique flavor. Additionally, this plant holds significant prominence in traditional medicine, attributed to its diverse pharmacological properties such as antioxidative, antifungal, antimicrobial, antiepileptic, antidiarrheal, and various others (Nahak & Sahu, n.d.; Wulandari, 2021)

The pepper plant is categorized as a climbing and spreading annual plant. It possesses circular roots in the soil that serve as nutrient absorbers, while above-ground roots function as adhesive roots. The plant stem is broad, and it can grow up to a height of 10 meters (Figure 1) (Wulandari, 2021). The leaves possess a glossy appearance with a dark green color on the upper surface and a lighter shade of green on the lower surface. They are shaped like ovals, featuring pointed tips, and have a size ranging from 13 to 25 cm (5 to 10 inches) in length. After three years of planting, a small harvest becomes viable, but it takes approximately 7 to 8 years for the plants to reach their maximum production potential. The plants exhibit their highest productivity between 8 and 20 years of age, and they can continue bearing fruit for as long as 30 years (Nelson & Cannon-Eger, n.d.).

Figure 1. Black pepper cultivation

(source: personal documentation)

It takes around 9 months from the time of flowering for the berries to ripen. The ripening process spans from 2 to 6 months, which varies depending on the climate or latitude. Harvesting of the berries occurs typically every 7 to 14 days within the designated harvest period, although the specific months on the harvesting calendar differ across various regions of the world. Berries are harvested when most of the fruit is red or reddish orange (Nelson & Cannon-Eger, n.d.).

Figure 2. Unripe pepper fruits (a) and pepper fruits that are in the process of ripening fully (b).

(source: personal documentation)

Apart from black pepper and white pepper, there are various derivative products that incorporate pepper. One such product is pepper oil, which is extracted through the vapor or steam distillation process commonly used in the production of fragrances or condiments. Black pepper yields approximately 1-2.4% essential oil. Pepper is also utilized in the making of cookies, crackers, and tea, often combined with tea leaves. Additionally, dried parts of the pepper plant are used in the production of perfumes, while pepper oil/resin is included in candies and sweets. Furthermore, pepper plays a role in sausage preservation (Nelson & Cannon-Eger, n.d.).

2. Chemical Content Of Black Pepper

The chemical content in black pepper includes piperine, saponins, flavonoids, essential oils, chavisin, piperylline, piperoleine, piperanine, dihydrocarveol, karyo fillene oxide, cariptone, tran piocarrol, and pepper oil; where the percentage of chemical content varies, mainly depending on the quality and variety of black pepper (Hammouti et al., 2019; Wulandari, 2021).

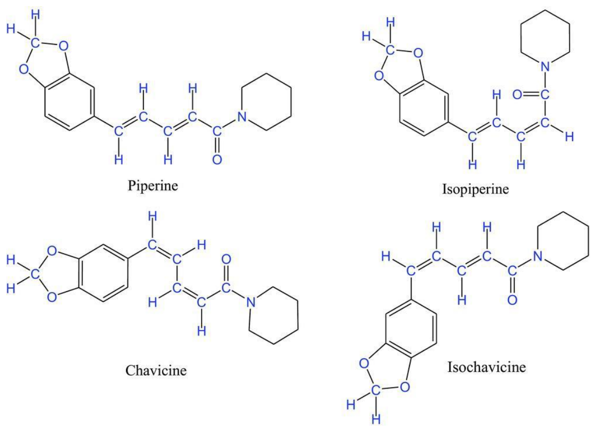

Figure 3. Chemical structure of piperine, chavicine, isochavicine, and isopiperine

(source: (Wulandari, 2021))

This plant contains piperine as its main chemical constituent, where the piperine content typically does not exceed 9% but it brings black pepper specifics pungent taste. Piperine showcases various activities such as central nervous system depression, cytotoxic effects, anti-inflammatory properties, hepatoprotective benefits, and the ability to enhance bioavailability (Hammouti et al., 2019; Nahak & Sahu, n.d.; Stojanović-Radić et al., 2019).

Clinical research has revealed the impressive antioxidant, antitumor, and drug-enhancing properties of piperine, along with its potential as an immunomodulatory agent. It has been found to effectively lower both total plasma cholesterol and low-density lipoprotein (LDL) cholesterol levels. In laboratory studies conducted on various cancer cells, piperine demonstrated selective cytotoxic action against multiple types of cancer, including breast, lung, prostate, cervical, and other cancers. While piperine exhibits numerous benefits based on both in vitro and in vivo data, it should be noted that high doses can have adverse effects on liver function and male fertility. Therefore, it is crucial to determine a safe therapeutic dosage for pure piperine, as it holds significant potential as a treatment option for various human disorders (Stojanović-Radić et al., 2019).

3. Black Pepper Trading And Production

Black Pepper, originally from India, is a plant renowned for its valuable spice. In the past, it held great significance, particularly during the period when salted and preserved meat was a staple in European cuisine. With its aromatic and savory characteristics, pepper enhanced the flavor of food, making it more delightful. Due to its limited availability, pepper commanded a high price, especially during that era. However, the pepper trade witnessed significant growth, particularly in the 17th and 18th centuries (Govindarajan & Stahl, 1977).

Pepper trade then developed rapidly from century to century. Where during the last 10 years Indonesia has become one of the largest pepper producers in the world along with Vietnam, Brazil, India, and Malaysia (Amorita et al., 2021). Vietnam has gained recognition for being the leading producer of black pepper, whereas Indonesia holds the title of the foremost producer of white pepper (Azahari et al., 2021). In Indonesia, pepper plantations are dominated by community plantations (96.26%) where there are six major centers where pepper is produced, which include Bangka Belitung, West Kalimantan, Lampung, South Sulawesi, Southeast Sulawesi, and South Sumatra. Lampung is renowned for its cultivation of black pepper, while Bangka Belitung stands out as a prominent producer of white pepper (Buku Statistik-Perkebunan 2019-2021, n.d.).

4. The Obstacles In Pepper Farming

Despite the expanding area of pepper plantations in Indonesia, there has been a decline in both production value and productivity growth. Consequently, while the export volume of Indonesian pepper is on the rise, its value is decreasing (Azahari et al., 2021). The decrease can be attributed to a variety of factors, such as the utilization of subpar seeds, diminishing land availability for pepper cultivation, pest and disease infestations, the implementation of less intensive cultivation practices, farmers' limited knowledge and understanding, and the presence of pesticide residues resulting from excessive use of chemical pesticides (Evizal & Prasmatiwi, 2021; Karmawati et al., 2020; Prasmatiwi et al., n.d.; Sudarsono et al., n.d.).

Figure 4. Indonesia's Export Volume and Value in 2017-2019

Source: (Buku Statistik-Perkebunan 2019-2021, n.d.)

4.1 Utilization Of Subpar Seeds and Diminishing Land Availability

The majority of farmers opt not to utilize certified seeds and breeders, instead choosing to rely on seeds sourced from their own gardens (Karmawati et al., 2020). Additionally, certain regions are experiencing a decrease in pepper cultivation land due to changes in primary crops, as well as a shift towards more remote areas and neighboring regions (Evizal & Prasmatiwi, 2021). Nevertheless, in spite of the obstacles, numerous pepper farmers opt to sustain their pepper plantations because they believe that cultivating pepper remains a profitable venture. However, there is still a need to minimize the significant disparity between producer price, export price, and the global market price (Purwasih et al., 2020; Zulkarnain & Ranchianowarganegara, 2020). Moreover, the considerable distance of these plantations makes it impractical for farmers to replace their main crops with seasonal alternatives (Prasmatiwi et al., n.d.).

4.2 Pepper Farmers

Pepper farmers certainly have a significant effect on pepper productivity (Naufal et al., 2022). The insufficient knowledge and understanding among farmers can stem from various factors. One contributing factor is the lack of interest among the younger generation in engaging in black pepper farming, resulting in an aging demographic of pepper farmers who may struggle to adopt the latest cultivation techniques (Evizal & Prasmatiwi, 2021). Furthermore, the educational background of pepper farmers tends to be low, which is a common occurrence not only in Indonesia but also in other countries. For instance, research conducted in Sarawak, Malaysia revealed that a majority of pepper farmers had no formal education, and only 35% having completed primary school (Johny et al., 2020).

4.3 Less Intensive Cultivation Practices

Implementing effective practices for pepper cultivation undoubtedly leads to improved productivity of pepper plants (Meliyana et al., n.d.). However, presently there are several primary issues faced in pepper cultivation. These include the prevalence of aging and damaged plants, as well as inadequate land maintenance practices such as fertilization and weeding. Farmers often have limited access to organic fertilizers, which leads to their infrequent usage. This is primarily due to challenges related to the limited supply and impracticality of transportation, particularly considering the considerable distance between the farmers' residences and the pepper plantations (Munif & Sulistiawati, 2014). Additionally, the cultivation of pepper plants in polyculture with other crops like coffee, dogfruit, and bananas in certain pepper-centric regions further detracts from direct focus on pepper plants (Kardinan et al., 2022; Karmawati et al., 2020; Prasmatiwi et al., n.d.; Rosman, 2017).

4.4 Pesticide Residues

An inherent issue in crop cultivation, such as pepper farming, is the excessive dependence on chemical pesticides. It is crucial to prevent or minimize the occurrence of chemical residues in agricultural products resulting from their overuse. Research conducted in Bangka indicates that a majority of farmers, despite utilizing pesticides regularly (95%), lack awareness regarding the potential health risks associated with chemical pesticides and their adverse effects on the environment. Alarmingly, 17% of these farmers have experienced poisoning incidents due to pesticide exposure. Furthermore, nearly half of the farmers tend to apply the same pesticide indiscriminately on all occasions (Wiratno et al., 2007).

Tests on pepper fruit have been carried out several times. For example, examinations on the effects of fipronil at the recommended dosage. When applied correctly, fipronil results in a minimal residue level in pepper fruit. This residue then becomes undetectable after the 9th day of application (Chin Ann & M, 2016). Examinations have been conducted on the presence of residues from various chemical compounds, including deltamethrin and λ-cyhalothrin, in pepper. The samples used for testing were pepper fruits obtained from supermarkets, and the results indicate the absence of residues in these samples (Refindra Fitriadi et al., 2016). Similarly, positive outcomes were observed in pepper samples collected from farmers in Bangka, Kutai, and Lampung. The results indicate that the aflatoxin content in these samples falls within safe consumption limits, as it remains below the thresholds established by authorities such as BPOM and the European Union regulations (Penelitian et al., n.d.).

Tests conducted in Malaysia to detect chlorpyrifos residue on pepper berries revealed that the levels remained low even after 13 days of application, ensuring their safe consumption (Yap & Jarroop, 2018). However, despite being classified as safe, the use of chlorpyrifos still requires careful consideration. Further study has indicated the presence of chlorpyrifos residues in the urine and blood of farmers who handle this pesticide, underscoring the tangible and direct exposures they encounter (Wiratno et al., 2007).

4.5 Diseases

Several diseases pose a significant threat to the production and productivity of pepper plants. These include foot rot caused by Phytophthora capsici, anthracnose caused by Colletotrichum gloeosporioides, basal wilt caused by Sclerotium rolfsii, and yellow disease caused by plant-parasitic nematodes Radopholus similis and Meloidogyne spp. (Hasan et al., 2023; Munif &

Sulistiawati, 2014). In addition to the main diseases above, there are also mild diseases in black pepper plants such as CMV (Cucumber Mosaic Virus) (Samiul Ahsan Talucder et al., 2020). For instance, yellow disease is a prevalent issue faced by farmers in Bangka, with an incidence rate reaching up to 60%. Infected pepper plants typically exhibit symptoms such as swollen roots (indicating nematode attack by Meloidogyne spp.) or rotting roots (indicative of nematode attack by R. similis nematode) (Munif & Sulistiawati, 2014).

Figure 5. Foot Rot Disease

Source: (Hasan et al., 2023)

Figure 6. Anthracnose Disease

Source: (Hasan et al., 2023)

Figure 7. Yellow Disease

Source: (Wiratno et al., 2020)

4.6 Pests

Pepper cultivation is susceptible to various pests, which include the pepper stem borer (Lophobaris piperis), biting black ants (Tetramorium sp.), brown stink bug (Euschistus spp.), pollu beetle (Longitarsus nigripennis), Thrips sp., stink bugs (Pentatomidae), Planococcus minor, scale insects (Lepidosaphes piperis), large pepper berry bug (Dasynus piperis), and pepper lace bug (Diconocoris hewetti) (Laba et al., 2006; Samiul Ahsan Talucder et al., 2020; Teshale et al., 2017; Yani, 2018). In addition, there are several insect pests that, while not considered significant pests, act as vector insects capable of transmitting viral diseases to pepper plants. These include Ferrisia virgata and Planococcus minor (Miftakhurohmah et al., 2022). However, it's important to note that the main pests can vary depending on the country or region. In Ethiopia, for instance, Tetramorium sp., Euschistus spp., and Longitarsus sp. are the primary pests of pepper plants. The biting black ants (Tetramorium sp.) are considered pests in Ethiopia as they nest predominantly between two leaves, causing wounded and deformed symptoms. These ants also indirectly affect agronomic practices, particularly during harvest, by spreading rapidly, biting severely, and injecting formic acid into wounds, leading to irritation (Teshale et al., 2017). In Indonesia, there are several pests that are considered as major pests on pepper, such as L. piperis, Thrips sp., D. piperis, and D. hewetti.

Pepper Stem Borer (Lophobaris piperis)

The larvae of the pepper stem borer penetrate the stems and branches of the pepper plant, resulting in initial symptoms of wilting and yellowing. The affected stems and branches subsequently become dry and fragile, easily breaking apart. Severe infestation by this pest can lead to the death of the plant. The adult form of this insect tends to remain motionless, resembling a lifeless state, and falls down when disturbed. L. piperis is commonly observed during the rainy season, particularly in shaded areas of the plant (Deciyanto 1993, n.d.; Laba et al., 2006).

L. piperis is one of the primary pests, notably in pepper plantations in Lampung. It not only infests fully-grown plants but also affects pepper plants during their early stages in the nursery (Yani, 2018). The incidence of L. piperis infestation in the Tanggamus area, Lampung, has been recorded at an average of 38% (Kardinan et al., 2022). This rate is significantly higher than the previously documented infestation rate of L. piperis, which ranged from 4-7% in the Sambas area, West Kalimantan (Trisawa 1992, n.d.).

Figure 8. Signs of L. piperis infestation (a) and the presence of L. piperis larvae within a pepper branch (b).

(source: personal documentation)

Large Pepper Berry Bug/Fruit Sucker

D. piperis

D. piperis, characterized by its brownish-green body color, has a mouth adapted for piercing and sucking. These pests feed on various parts of the plant, including flowers, young shoots, petioles, and especially fruits. By inserting their stylet into the pepper fruit, they extract the fruit's juices, resulting in empty and damaged fruits with visible puncture marks (often turning black). Additionally, the infestation causes premature fruit drops, leading to clusters of empty fruits (Hama Serangga pada Tanaman Lada di Kabupaten Bangka Selatan et al., 2021; Laba 2004, n.d.; Laba et al., 2006).

D. piperis is a prevalent pest in pepper plantations throughout Indonesia, particularly in the Bangka region (Laba et al., 2006; Prayoga et al., 2020). The highest recorded damage rate caused by this pest was approximately 36% in Bangka back in 2002 (Laba 2004, n.d.). A recent assessment conducted in Lampung during 2021 indicate a relatively lower pest attack rate of 9% (Kardinan et al., 2022).

Figure 9. Signs of D. piperis infestation

(source: Rohimatun & Laba, 2015)

Pepper Lace Bug/ Blossom Sucking Lace Bug

(D. hewetti)

D. hewetti feeds on the liquid of flowers, preventing their development into fruits. As a result, the color of the fruit undergoes a transformation from yellow green to brown or black. This pest can also target young fruits, often leaving behind brown spots and occasionally excreting thick liquid (Laba 2005, n.d.; Soetopo 1988, n.d.; Laba et al., 2006).

The abundance of D. hewetti is influenced by different pepper varieties. For instance, the LDL variety exhibited a higher mean abundance of D. hewetti compared to the Chunuk variety, particularly during the period from November to April (Rauf, 2016). Tests indicate that flower damage caused by D. hewetti ranged from 67% to 87% in greenhouse conditions and 61% to 85% in the field. The percentage of yield loss was recorded between 55% and 83% in greenhouses and 35% to 82% in the field (Laba 2005, n.d.). Within 12 and 24 hours, D. hewetti was responsible for damaging 18.96% and 40.67% of the flower heads, respectively (Soetopo 1988, n.d.).

Figure 10. Signs of D. hewetti attack in flowers

source: (Laba 2005, n.d.)

Thrips sp.

Thrips present a risk to both established and young plants in nurseries (Yani, 2018). These pests inflict damage on plants by piercing the plant tissue and extracting the sap, particularly targeting the leaves. The resulting damage is easily noticeable as the leaf edges tend to thicken, wrinkle, and curl upwards on both sides (Kardinan et al., 2022; Samiul Ahsan Talucder et al., 2020). A study revealed that the Tanggamus area in Lampung experienced a significant Thrips infestation, with an attack rate of 23% (Kardinan et al., 2022). This high level of infestation raises concerns due to the potential direct damage caused by thrips. Moreover, it is crucial to monitor the presence of these pests as they can serve as vectors, transmitting diseases to various crops including soybean and watermelon (Jeger, 2020).

Figure 11. Symptoms of attack on the leaves due to Thrips sp.

Source: personal documentation

5. Proposed Problem-Solving Approach

Pepper farmers have various options available to address the aforementioned challenges directly, such as:

- Increasing the activity of farmer groups. This can enhance the dissemination of information regarding both pepper cultivation and derivative product development (Karmawati et al., 2020).
- Implement more intensive cultivation practices.

  Increasing the frequency of weed removal and fertilization will undoubtedly contribute to the improved well-being of the plants. Initiating the replacement of damaged, aging plants is also essential. Proper disposal and incineration of diseased plants or plant parts can effectively mitigate the transmission of diseases to other healthy plants (Munif & Sulistiawati, 2014; Naufal et al., 2022; Prasmatiwi et al., n.d.).

- Planting plant varieties that are more resistant or more tolerant to pests and diseases (Rauf, 2016).
- Planting refugia plants.

  Refuge plants or cover crops like Arachis pintoi offer a means to enhance the effectiveness of natural enemies by providing them with shelter and a food source (Lestari et al., 2019). The utilization of A. pintoi has been found to effectively reduce the impact of pests such as D. piperis, L. piperis, and Thrips sp. (Apriyadi & Lestari, 2021; Funderburk et al., 1969; Lestari et al., 2019).

  One strategy involves rearing natural enemies such as parasitoids and predators until their population reaches a suitable level. These beneficial organisms can then be released into pepper cultivation areas where refugia plants are already present. For instance, an example of a parasitoid species, Anastatus dasyni, specifically targets D. piperis eggs. To rear these parasitoids, alternative hosts such as eggs of Riptortus linearis and Nezara viridula can be used (Trisawa 2010, n.d.; Trisawa et al., 2007).

- Biopesticide as pest control

  The effectiveness of biopesticides for pest control is generally regarded as quite effective, despite being lower than that of chemical pesticides (Rini Pribadi et al., n.d.). For instance, the utilization of plant-derived pesticides such as neem, citronella, and cloves can decrease the incidence of pest attacks and enhance the production capacity of pepper plants (Kardinan & Maris, 2021; Rini Pribadi et al., n.d.).

  Pests can also be controlled using microbial agents, including viruses, bacteria, fungi, protozoans, and nematodes. Among these, entomopathogenic fungi like Metarhizium anisopliae and Beauveria bassiana are widely utilized, making their commercial products readily available in the market (Devasahayam et al., 2020).

- Chemical pesticides as a final option and in strict compliance with usage guidelines.

  Using chemical pesticide in accordance with its regulations is crucial, as it not only minimizes residue levels on pepper pods, but also to reduce the threat to the health of pepper farmers and reduce pollution to the environment (Wiratno et al., 2007).

- Effective post-harvest processing.

  Proper household techniques like washing and blanching can decrease the pesticide levels in fresh peppers (Shim et al., 2023). Furthermore, it is important to ensure that the application of chemical pesticides is avoided close to the harvest period to minimize residue levels and maintain them below the acceptable threshold (Chin Ann & M, 2016; Yap & Jarroop, 2018).

6. CONCLUSION

From the above review, it appears that black pepper farmers can address these challenges by improving collaboration through farmer groups, implementing intensive cultivation methods, growing plant varieties that are resistant or tolerant to pests and diseases, integrating refugia plants into their fields, utilizing biopesticides for pest control, and resorting to chemical pesticides only as a last resort. It is also important to ensure efficient post-harvest processing. Therefore, additional experiments should be conducted to assess the potential impact of these actions, taken by farmers without government intervention, on enhancing the value of the black pepper commodity.

DAFTAR PUSTAKA

Amorita, C., Daryanto, A., & . S. (2021). Competitiveness Analysis of Indonesian Pepper in International Market. International Journal of Research and Review, 8(5), 38–52. https://doi.org/10.52403/ijrr.20210507

Apriyadi, R., & Lestari, T. (2021). Pengaruh Teknik Pengendalian Gulma dan Frekuensi Aplikasi Insektisida terhadap Kelimpahan Populasi dan Intensitas Serangan Hama Utama pada Tanaman Lada (Piper nigrum L.). Agrosainstek: Jurnal Ilmu Dan Teknologi Pertanian, 5(1), 64–71. https://doi.org/10.33019/agrosainstek.v5i1.241

Azahari, D. H., Purba, H. J., Erwidodo, Darwis, V., Dabukke, F. B. M., Hestina, J., & Yusuf, E. S. (2021). The competitiveness of Indonesia's pepper export and its challenges. IOP Conference Series: Earth and Environmental Science, 892(1). https://doi.org/10.1088/1755-1315/892/1/012074

BUKU STATISTIK-PERKEBUNAN 2019-2021. (n.d.).

Chin Ann, Y., & M, Z. A. (2016). Residue and Dissipation of Fiproniland Its Metabolites in Black Pepper (Piper Nigrum L.). IOSR Journal of Environmental Science, 10(6), 28–37. https://doi.org/10.9790/2402-1006012837

Deciyanto 1993. (n.d.).

Devasahayam, S., Jacob, T. K., Senthil Kumar, C. M., & Balaji Rajkumar, M. (2020). Biorational strategies for the management of insect pests of spice crops. Journal of Spices and Aromatic Crops, 21–37. https://doi.org/10.25081/josac.2020.v29.i1.6330

Evizal, R., & Prasmatiwi, F. E. (2021). Farmers' perception to climate change and adaptation to sustain black pepper production in North Lampung, Indonesia. IOP Conference Series: Earth and Environmental Science, 739(1). https://doi.org/10.1088/1755-1315/739/1/012019

Funderburk, J., Olson, S., Stavisky, J., & Avila, Y. (1969). Managing Thrips and Tomato Spotted Wilt in Pepper. EDIS, 2004(12). https://doi.org/10.32473/edis-in401-2004

Govindarajan, V. S., & Stahl, W. H. (1977). Pepper - Chemistry, technology, and quality evaluation. C R C Critical Reviews in Food Science and Nutrition, 9(2), 115–225. https://doi.org/10.1080/10408397709527233

Hama Serangga pada Tanaman Lada di Kabupaten Bangka Selatan, D., Apriyadi, R., Herry Marta Saputra, dan, Agroteknologi, J., Pertanian, F., dan Biologi, P., Bangka Belitung, U., Terpadu UBB Jalan Raya Balunijuk Kec, K., Bangka, K., & Kepulauan Bangka Belitung, P. (2021). Distribution of Insect Pests on White Pepper Plantation in South Bangka Regency. Jurnal Agrotek Indonesia (6), 1, 28–32.

Hammouti, B., Dahmani, M., Hammouti, B., Dahmani, M., Yahyi, A., Ettouhami, A., Messali, M., Asehraou, A., Bouyanzer, A., Warad, I., & Touzani, R. (2019). Valorization of Crocus sativus L. By-products View project Synthesizing Nanomaterials for Photocatalytic Activities and structural studies of single crystals. View project. Arabian Journal of Chemical and Environmental Research, 06, 12–56. https://www.researchgate.net/publication/343510625

Hasan, W., Verma, B., & Minnatullah, M. (2023). Pests and Disease Management of HORTICULTURAL CROPS-Editors-BIOTECH BOOKS ®. www.biotechbooks.in

Jeger, M. J. (2020). The epidemiology of plant virus disease: Towards a new synthesis. In Plants (Vol. 9, Issue 12, pp. 1–50). MDPI AG. https://doi.org/10.3390/plants9121768

Johny, F., Saupi, N., & Ramaiya, S. D. (2020). Status of pepper farming and flower composition of different pepper varieties in Sarawak. Pertanika Journal of Tropical Agricultural Science, 43(4), 467–476. https://doi.org/10.47836/PJTAS.43.4.04

Kardinan, A., & Maris, P. (2021). Effect of biopesticides against stem borer (Lophobaris piperis) and Thrips sp. on pepper (Piper nigrum). E3S Web of Conferences, 306. https://doi.org/10.1051/e3sconf/202130601022

Kardinan, A., Maris, P., Wahyono, T. E., Tarigan, N., & Perkasa, G. (2022). The intensity of major pests on pepper (Piper nigrum) in Tanggamus Regency - Lampung Province. IOP Conference Series: Earth and Environmental Science, 974(1). https://doi.org/10.1088/1755-1315/974/1/012035

Karmawati, E., Ardana, I. K., Siswanto, & Soetopo, D. (2020). Factors affecting pepper production and quality in several production center. IOP Conference Series: Earth and Environmental Science, 418(1). https://doi.org/10.1088/1755-1315/418/1/012051

Laba 2004. (n.d.).

Laba 2005. (n.d.).

Laba, I. W., Trisawa, D. I. M., Penelitian, B., Obat, T., & Aromatik, D. (2006). Pengelolaan Ekosistem Untuk Pengendalian Hama Lada (Vol. 5).

Lestari, T., Apriyadi, R., & Husein, A. M. (2019). Damage Intensity of Pepper Stem-Borer (Lophobaris piperis) on Different Weed Control in Bangka Belitung Archipelago Province.

Meliyana, R., Abbas Zakaria, W., Nurmayasari Jurusan Agribisnis, I., Pertanian, F., Lampung, U., Soemantri Brodjonegoro No, J., & Lampung, B. (n.d.). Daya Saing Lada Hitam Di Kecamatan Abung Tinggi Kabupaten Lampung Utara (Competitiveness Black Pepper in Abung Tinggi Subdistrict of North Lampung Regency). In JIIA (Vol. 1, Issue 4).

Miftakhurohmah, Hidayat, S. H., Mutaqin, K. H., Soekarno, B. P. W., & Wahyuno, D. (2022). Study on Ferrisia virgata and Planococcus minor as vectors of mottle disease in black pepper. IOP Conference Series: Earth and Environmental Science, 974(1). https://doi.org/10.1088/1755-1315/974/1/012030

Munif, A., & Sulistiawati, I. (2014). Pengelolaan Penyakit Kuning pada Tanaman Lada oleh Petani di Wilayah Bangka. Jurnal Fitopatologi Indonesia, 10(1), 8–16. https://doi.org/10.14692/jfi.10.1.8

Nahak, G., & Sahu, R. K. (n.d.). Phytochemical Evaluation and Antioxidant activity of Piper cubeba and Piper nigrum. Journal of Applied Pharmaceutical Science, 2011(08), 153–157.

Naufal, F. A., Krisnamurthi, B., & Baga, L. M. (2022). Analisis Faktor-Faktor yang Memengaruhi Produksi Lada di Provinsi Lampung. Forum Agribisnis, 12(1), 1–11. https://doi.org/10.29244/fagb.12.1.1-11

Nelson, S. C., & Cannon-Eger, K. T. (n.d.). Farm and Forestry Production and Marketing Profile for Black pepper (Piper nigrum) Specialty Crops for Pacific Island Agroforestry (http://agroforestry.net/scps). http://agroforestry.net/scps

Penelitian, P., Standardisasi, P., & Nasional, B. S. (n.d.). Kandungan Aflatoksin Pada Lada (Piper Nigrum L.) Indonesia Dalam Pengembangan Standar Internasional Codex the Contents of Aflatoxin in Indonesian Pepper to Codex Standard Development Suminto dan Reza Lukiawan.

Prasmatiwi, F. E., Evizal, D. R., Agribisnis, J., Agroteknologi, J., Pertanian, F., & Lampung, U. (n.d.). Keragaan Dan Produktivitas Perkebunan Lada Tumpangsari Kopi di Lampung Utara Performance and Productivity of Black Pepper Plantation Mixed Culture with Coffee in North Lampung. In Oktober (Vol. 19, Issue 2).

Prayoga, G. I., Ropalia, Aini, S. N., Mustikarini, E. D., & Rosalin, Y. (2020). Diversity of black pepper plant (Piper nigrum) in Bangka Island (Indonesia) based on agro-morphological characters. Biodiversitas, 21(2), 652–660. https://doi.org/10.13057/biodiv/d210230

Purwasih, R., Pranoto, Y. S., & Atmaja, E. J. J. (2020). Muntok white pepper price transmission in Bangka belitung island province. In Agraris (Vol. 6, Issue 2, pp. 107–122). Department of Agribusiness, Universitas Muhammadiyah Yogyakarta. https://doi.org/10.18196/agr.6294

Rauf, A. (2016). Fenologi Pembungaan dan Kelimpahan Populasi Kepik Diconocoris hewetti (Dist.) (Hemiptera: Tingidae) pada Pertanaman Lada Geographic distribution of the invasive mealybug Phenacoccus manihoti and its introduced parasitoid Anagyrus lopezi in parts of Indonesia View project. https://www.researchgate.net/publication/304058504

Refindra Fitriadi, B., Ayutia Ciptaningtyas Putri Balai Besar Perbenihan dan Proteksi Tanaman Perkebunan Surabaya Jl Raya Mojoagung No, dan, & Jawa Timur Indonesia, J. (2016). Indonesian Journal of Chemical Science. J. Chem. Sci, 5(2). http://journal.unnes.ac.id/sju/index.php/ijcs

Rini Pribadi, E., Wayan Laba, I., Yolanda, K., Mahrita Willis, dan, Penelitian Tanaman Rempah dan Obat, B., & Pengkajian Teknologi Pertanian Kepulauan Bangka Belitung Jalan Mentok Km, B. (n.d.). Kelayakan Ekonomi Pengendalian Hama Pengisap Buah Lada (Dasynus Piperis China) Dengan Insektisida Nabati Berbahan Aktif Minyak Seraiwangi Dan Cengkeh The economic feasibility on pest control of Dasynus piperis China with botanical pesticide based active compound of lemongrass and clove.

Rohimatun & Laba, I. W. (2015). Pengendalian Terpadu Hama Pengisap Buah Lada Dasynus piperis China. Sirkuler. Balai Penelitian Tanaman Rempah dan Obat. Pusat Penelitian dan Pengembangan Tanaman Perkebunan. Badan Penelitian dan Pengembangan Pertanian. Kementerian Pertanian.

Rosman, R. (2017). Strategi Penelitian Dan Pengembangan Menghadapi Dinamika Perkembangan Lada Dunia / Research and Development Strategy to Face World Dynamics of Development of Pepper. Perspektif, 15(1), 11. https://doi.org/10.21082/psp.v15n1.2016.11-17

Samiul Ahsan Talucder, M., Ullah Khan, A., Ahmed Robi, M., & Panna Ali, M. (2020). Production of tomato in off-season in home garden View project Naturalists View project. www.sciencedirect.com

Shim, J. H., Eun, J. B., Zaky, A. A., Hussein, A. S., Hacimüftüoğlu, A., & Abd El-Aty, A. M. (2023). A Comprehensive Review of Pesticide Residues in Peppers. In Foods (Vol. 12, Issue 5). MDPI. https://doi.org/10.3390/foods12050970

Soetopo 1988. (n.d.).

Stojanović-Radić, Z., Pejčić, M., Dimitrijević, M., Aleksić, A., Anil Kumar, N. V., Salehi, B., Cho, W. C., & Sharifi-Rad, J. (2019). Piperine-A Major Principle of Black Pepper: A review of its bioactivity and *studies. In Applied Sciences (Switzerland) (Vol. 9, Issue 20). MDPI AG. https://doi.org/10.3390/app9204270*

Sudarsono, H., Syarif, A., Yusuf Sulfarano Barusman, M., Purisky Redaputri Irmayani Noer, A., Abbas Zakaria, W., Hasanudin, U., Persada, C., Vivit Nurdin Khairunnisa Berawi, B., Rangga, A., Hikam, S., Evizal, R., Erry Prasmatiwi Henita Astuti, F., Anggraininova Anggraini, N., & Komoditas Warisan, S. (n.d.). Editor: Hamim Sudarsono & Erwanto Lada Lampung. www.aura-publishing.com

Teshale, D., Habetewold, K., Girma, H., & Wakjira, G. (2017). Insect pests infesting black pepper (Piper nigrum L.) in southwestern part of Ethiopia. African Journal of Agricultural Research, 12(21), 1817–1823. https://doi.org/10.5897/ajar2016.11684

Trisawa 1992. (n.d.).

Trisawa 2010. (n.d.).

Trisawa, I. M., Rauf, A., & Kartosuwondo, U. (2007). Biologi Parasitoid Anastatus dasyni Ferr (Hymenoptera: Eupelmidae) pada Telur Dasynus piperis China (Hemiptera: Coreidae) Biology of Anastatus dasyni Ferr (Hymenoptera: Eupelmidae) on Egg of Dasynus piperis China (Hemiptera: Coreidae). HAYATI Journal of Biosciences, 14(3), 81–86.

Wiratno, Maris, P., Wahyuno, T. E., & Djiwanti, S. R. (2020). Control Strategies of Plant Parasitic Nematodes in Black Pepper Plantation. IOP Conference Series: Earth and Environmental Science, 418(1). https://doi.org/10.1088/1755-1315/418/1/012053

Wiratno, Taniwiryono, D., Van Den Brink, P. J., Rietjens, I. M. C. M., & Murk, A. J. (2007). A case study on Bangka Island, Indonesia on the habits and consequences of pesticide use in pepper plantations. Environmental Toxicology, 22(4), 405–414. https://doi.org/10.1002/tox.20277

Wulandari, W. (2021). Review: Black Pepper (Piper Nigrum L.) Botanical Aspects, Chemical Content, Pharmacological Activities. International Journal of Pharmaceutical Sciences and Medicine, 6(1), 83–91. https://doi.org/10.47760/ijpsm.2021.v06i01.007

Yani, R. (2018). Hama Utama Pada Pembibitan Lada Dan Pengendaliannya. https://www.researchgate.net/publication/328233298

Yap, C. A., & Jarroop, Z. (2018). Residue levels and dissipation behaviors of chlorpyrifos in black pepper berries and soil. Food Research, 2(6), 587–593. https://doi.org/10.26656/fr.2017.2(6).127

Zulkarnain, Z.-, & Ranchianowarganegara, M. G. (2020). Analisis Kelayakan Finansial Pada Tanaman Lada di Kabupaten Lampung Timur. Jurnal Penelitian Pertanian Terapan, 20(1), 38. https://doi.org/10.25181/jppt.v20i1.1223