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Effectiveness of Bilimbi (*Averrhoa bilimbi*) and Lantana (*Lantana camara*) Leaf Extracts as Botanical Insecticides for Controlling Maize weevil (*Sitophilus zeamais*)

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ABSTRACT

Background: Reduced production due to post-harvest pest attacks is a significant issue. Post-harvest pest control is crucial, and botanical pesticides are currently a primary option for post-harvest pest control. Bilimbi leaves (*Averrhoa bilimbi*) and lantana leaves (*Lantana camara*) contain active ingredients that have the potential to control the maize weevil (*Sitophilus zeamais*).
Aims: This study aimed to determine the effect of bilimbi and lantana leaf extract on the Sitophilus zeamais population and the quality of maize seeds in storage, and to obtain the best concentration of bilimbi and lantana leaf extract in suppressing the *Sitophilus zeamais* population so that it can maintain the quality of maize seeds in storage.
Methods: The experiment was arranged in a Completely Randomized Design (CRD) consisting of 7 treatments and 4 replications: control/no treatment (K), bilimbi leaf extract concentration of 3% (B1), 6% (B2), 9% (B3), and lantana leaf extract concentration of 3% (T1), 6% (T2), and 9% (T3). The variables observed were the *Sitophilus zeamais* population, germination power, and maize seed vigor index.
Results: The results showed that various concentrations of bilimbi and lantana leaf extracts were effective in maintaining maize seed quality, particularly in terms of seed vigor index. The 9% concentration of bilimbi and lantana leaf extracts is best at suppressing *Sitophilus zeamais*.

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1. Introduction

Maize is a commodity with high economic value and development prospects. Maize plays a crucial role as the primary source of carbohydrates and protein after rice and is also the most required for animal

feed in Indonesia (Ilmawan, 2019). Maize is highly suitable as a carbohydrate source because it contains approximately 71-73% of its carbohydrates, primarily starch, with a small amount of sugar and fiber. Starch is found in the endosperm, sugar primarily in the germ, and fiber in the husk (Syukri & Dina, 2022).

Maize production in Indonesia fluctuates and is still insufficient to meet national demand. Maize production in 2018 was 30.1 million tons of dry maize, then decreased to 22.59 million tons in 2019, and then increased to 29.02 million tons in 2020 (BPS Indonesia, 2021). Maize needs for seed are 20 kg/ha, direct consumption is 1.67 kg/cap/year, for local livestock farmers it is 2.92 million tons, and for the feed industry is 8.59 million tons (Ismaryati, 2020). Various efforts to increase maize production continue despite numerous obstacles.

The decline in maize production is partly due to post-harvest pests that attack maize seeds, reducing the quality of the maize crop. Sitophilus zeamais, known as the maize weevil, is a primary pest in storage. This pest is a major pest of post-harvest grain commodities, especially those that are essential food sources for humans, such as rice and maize. Sitophilus zeamais is characterized by an elongated, snout-shaped head and a dark black imago with four yellowish-brown spots on its wings (elytra). This pest attack causes holes in the seeds and their destruction into flour. The seeds and flour are held together by saliva, thus reducing the quality of the seeds (Sartikanti, 2004; Roge *et al.,* 2023). *Sitophilus zeamais* attacks on maize stored for six months cause 85% seed damage and 17% seed weight loss (Arrahman *et al.,* 2022).

Food storage is a crucial aspect that still faces challenges in post-harvest technology. During storage, staple foods such as maize can undergo changes or damage that can reduce quality and quantity (Molenaar, 2020). Control of Sitophilus zeamais, more commonly known as the maize beetle, at the farmer level uses chemical pesticides. Chemical pesticides are derived from synthetic chemical compounds that can damage non-target organism populations, which can then disrupt population stability in nature, increase target insect resistance, and leave residues in the environment (Sinambela, 2024).

In general, Sitophilus zeamais control at the farmer level is still often carried out using synthetic chemical pesticides. The use of these chemicals can have various negative impacts, such as damage to non-target organisms, insect resistance and resurgence, and leave residues that are harmful to plants and the environment. Therefore, the impact of chemical pesticide use needs to be reduced by implementing alternative, safer, and more environmentally friendly control methods (Syah & Purwani, 2016). One environmentally friendly control method currently being widely developed is biological control, for example, through the use of botanical pesticides. Plant parts often used as the base material for botanical pesticides include roots, stems, leaves, and fruit. The effectiveness of these botanical pesticides generally comes from active compounds in the form of secondary metabolites, such as terpenoids, phenolics, and alkaloids (Danong *et al.,* 2020). Tembelek leaves are known to contain alkaloids, flavonoids, saponins, tannins, and counion (Hidayati & Asngad, 2020), while starfruit leaves contain flavonoids, saponins, and tannins (Hasim *et al.,* 2019). These compounds have the potential to be active ingredients in botanical pesticides. Therefore, this study aimed to assess the insecticidal efficacy of starfruit and tembelekan leaf extracts against the development of the post-harvest pest Sitophilus zeamais Motsch.

2. Metode

The research was conducted at the Plant Protection Laboratory, Faculty of Agriculture, UPN Veteran Yogyakarta, from January to July 2021. The materials used in this experiment included Bisma variety maize seeds, 500 grams of *Averrhoa bilimbi* and *Lantana camara* leaves, *Sitophilus zeamais* adults (imago), distilled water, methanol solvent, soil, and sand. The equipment used included plastic containers/jars, measuring glasses, a hand counter, a blender, Erlenmeyer flasks, insect tweezers, an oven, a plastic germination tray, measuring cylinders, and filter paper.

The experiment was arranged in a Completely Randomized Design (CRD) with four replications, consisting of seven treatments: untreated control (K), *Averrhoa bilimbi* leaf extract at concentrations of 3% (B1), 6% (B2), and 9% (B3), and *Lantana camara* leaf extract at concentrations of 3% (T1), 6% (T2), and 9% (T3). Each treatment was replicated four times, resulting in 28 experimental units. Each experimental unit consisted of three sample units, with each sample unit containing 100 grams of maize seeds. The observed parameters included the population number of *Sitophilus zeamais*, maize seed germination rate, and seed vigor index. One sample unit was observed until the first month, while the other two sample units were observed up to two months of storage.

2.1. Preparation Stage

a. Rearing *Sitophilus zeamais* was conducted to obtain the desired number of insects with uniform age. The initial *Sitophilus zeamais* specimens were collected from Beringharjo Market, Yogyakarta. The insects were reared by placing the test insects along with healthy maize kernels as food in a plastic container, which was then covered with a muslin cloth. After five days, the insects were removed from the container, and the maize kernels containing eggs were maintained until the eggs hatched into larvae and further developed into adults. The emerged adults were used as test insects.

Figure 1. *Rearing Sitophilus zeamais*

b. Preparation of maize seeds, obtained from the Agricultural Seed Supervision and Certification Center (BPSBP) in Yogyakarta, Special Region of Yogyakarta. Maize seeds were used without treatment, thus minimizing the influence of other than treatment on the research.

c. Preparation of botanical insecticide extract. *Averrhoa bilimbi* and *Lantana camara* leaves were cleaned from any dirt, then oven-dried for 2 × 24 hours at a temperature of 50ºC. After drying, both materials were ground using a blender to produce fine leaf powder of *Averrhoa bilimbi* and *Lantana camara*.

   The dried leaf powder was then soaked in 70% methanol with a material-to-solvent ratio of 1:3 and left to soak for 48 hours. Afterward, the mixture was filtered using filter paper. The resulting extract was evaporated using a rotary evaporator until a minimal volume was obtained and was assumed to have a concentration of 100%. The extract was then diluted to concentrations of 3%, 6%, and 9% and was ready for application.

Figure 2. *Averrhoa bilimbi* leaf

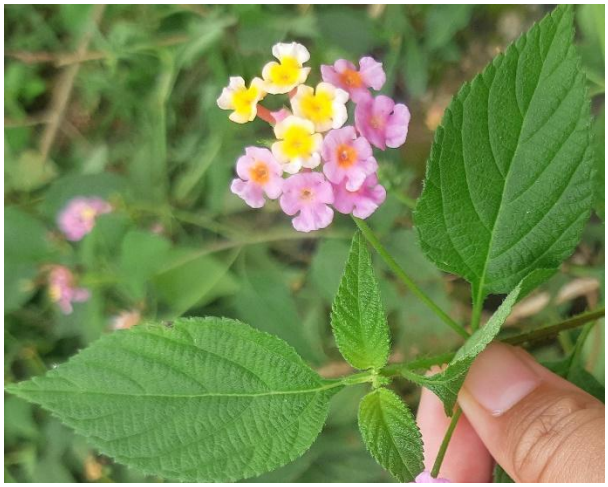

Figure 3. *Lantana camara* leaf

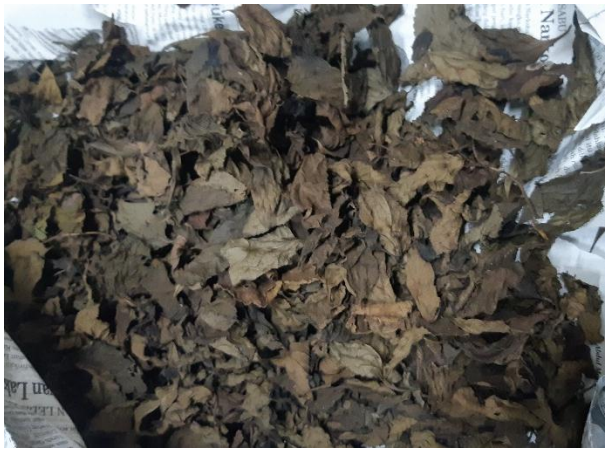

Figure 4. Leaf after oven

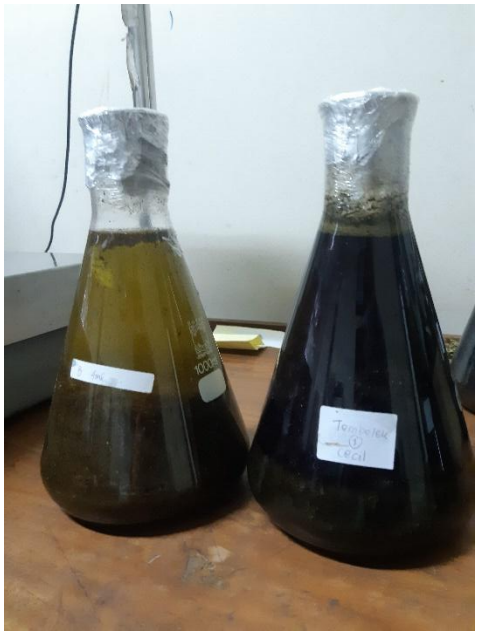

Figure 6. Maceration using methanol

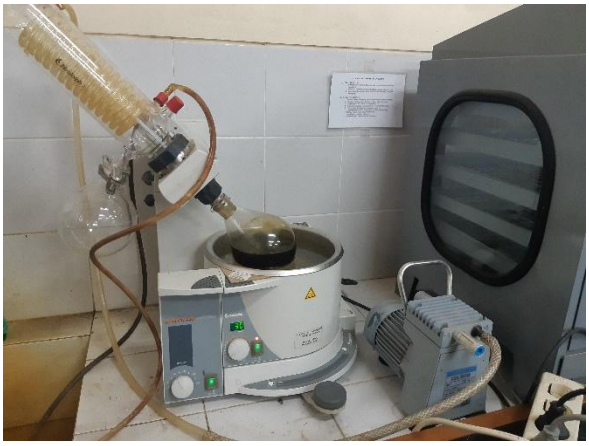

Figure 7. Evaporation Process using rotary evaporator

2.2. Testing Stage

a. Seed Testing: A total of 100 g of maize seeds were soaked in the extract according to the treatment for approximately 2 minutes, then air-dried and placed into plastic cups. Ten test insects were introduced into each plastic cup, which was then covered with muslin cloth. The seeds were infested with 10 *Sitophilus zeamais* adults aged 7–14 days. The insect incubation period was carried out for 60 days.
b. Contact Test: Ten test insects were placed into a dipping mesh and then immersed in the extract according to the treatment. For the control treatment, the insects were dipped in distilled water. The dipping was performed three times, each for 10 seconds. After dipping, the insects were drained on tissue paper and then placed into plastic jars containing 100 grams of maize. The number of dead insects was recorded daily until the seventh day after treatment (Asmaliyah *et al.,* 2010).

a. Parameter Analysis

a. Population Size

The amount of population increase can be calculated using the formula: $KP = \frac{pB}{pA} \times 100\%$

Where:
KP = Population increase
pB = Final population
pA = Initial population

Observations included the number of *Sitophilus zeamais* imago populations at 30 and 60 Days After Application (DAA), seed germination rate, and seed vigor. The research data were analyzed using Analysis of Variance (ANOVA) at a 5% significance level. To determine significant differences between treatments, a post-hoc test was conducted using the Duncan Multiple Range Test (DMRT) at the 5% level.

3. Results and Discussion

3.1 Population Number of *Sitophilus zeamais*

Observations on the adult population of *Sitophilus zeamais* were conducted after treatment to determine the effectiveness of each treatment in suppressing the population. The increase in adult population at 30 DAA showed the lowest results in treatments B3, T2, and T3, although not significantly different from treatments B1 and B2. Meanwhile, at 60 DAA, the adult population in treatments B3 and T3 was significantly lower than the other treatments, but not significantly different from B1, B2, and T2 (Table 1).

Tabel 1. Average percentage increase in Sitophilus zeamais population at 30 DAA and 60 DAA (%)..

Treatment	Population of *Sitophilus zeamais* imago	
	30 DAA	60 DAA
Control	382.50 c	910.00 b
B1 (*Averrhoa bilimbi* 3%)	297.50 abc	707.50 ab
B2 (*Averrhoa bilimbi* 6%)	265.00 ab	700.00 ab
B3 (*Averrhoa bilimbi* 9%)	232.50 a	612.50 a
T1 (*Lantana camara* 3 %)	312.50 bc	910.00 b
T2 (*Lantana camara* 6 %)	242.50 a	645.00 ab
T3 (*Lantana camara* 9 %)	220.00 a	522.50 a

Note: Means followed by the same letter in the same column indicate no significant difference based on the Duncan Multiple Range Test (DMRT) at a significance level of α = 5%.

The population of *Sitophilus zeamais* in treatments B3 and T3 showed lower results compared to the other treatments. This was due to the high mortality rate of *Sitophilus zeamais* in those treatments, resulting in fewer individuals in the subsequent generation. The higher the mortality rate, the more insects die, ultimately leading to a decreased population. Astriadi and Dinarto (2010) stated that the high mortality percentage was caused by the presence of active compounds such as tannins, flavonoids, and saponins found in *Averrhoa bilimbi* and *Lantana camara* leaves.

Additionally, the low population is also associated with the antifeedant properties of the leaf extracts from *Averrhoa bilimbi* and *Lantana camara* against *Sitophilus zeamais*, which can reduce the insects' appetite. Antifeedants work by stimulating specific feeding-deterrent nerves, in the form of chemical receptors (chemoreceptors) located in the insect's mouthparts. These chemoreceptors interact with other chemical receptors, disrupting the perception of feeding stimuli (Szentesi & Bernays, 1984; Mordue (Luntz) *et al.,* 2000).

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3.2. Maize Seed Germination Power

The analysis of variance of the decrease in the germination power of maize seeds showed that the treatment of *Averrhoa bilimbi* and *Lantana camara* leaf extracts at various concentrations showed no significant effect on the average decrease in germination power after application. The decrease in germination power at T2 and T3 significantly differed from the decrease at B1 but was not significantly different from the Control, B2, B3, and T1 treatments (Table 2).

Table 2. Decrease in maize seed germination power (%)

Treatment	Decrease in maize seed germination power
Control	33.51 ab
B1 (*Averrhoa bilimbi* 3%)	37.17 b
B2 (*Averrhoa bilimbi* 6%)	29.84 ab
B3 (*Averrhoa bilimbi* 9%)	20.94 ab
T1 (*Lantana camara* 3 %)	23.04 ab
T2 (*Lantana camara* 6 %)	18.85 a
T3 (*Lantana camara* 9 %)	18.85 a

Note: Means followed by the same letter in the same column indicate no significant difference based on the Duncan Multiple Range Test (DMRT) at a significance level of α = 5%.

Table 2 shows the highest decline in germination power in the Control, B2, B3, and T1 treatments. The high decline in seed germination power was due to high insect populations, seed damage, increased water content during storage, and decreased seed quality due to storing maize seeds at room temperature. Good germination power for almost all seeds is ≥ 80% (Rahayu & Tatiek, 2015). The results of observations of germination parameters in all applications were below 80%, which means that seed germination power is classified as low. *Sitophilus zeamais* activity causes physical damage to sweet maize seeds, interfering with seed activity during germination (Simamora et al., 2018).

3.3. Maize Seed Vigor Index

The results of the variance analysis of the vigor index showed that applying liquid botanical pesticides from blimbi and lantana leaves at various concentrations significantly affected the average vigor index of maize seeds. The lowest significant decrease in vigor index occurred in treatments T3 and B3, although not significantly different from treatment T2 (Table 3).

Table 3. Average maize seed vigor index before and after application liquid botanical pesticides

Treatment	Decreasing vigor index (%)	
Control	53.68	d
B1 (*Averrhoa bilimbi* 3%)	52.11	d
B2 (*Averrhoa bilimbi* 6%)	33.84	b
B3 (*Averrhoa bilimbi* 9%)	17.89	a
T1 (*Lantana camara* 3 %)	32.89	b
T2 (*Lantana camara* 6 %)	22.44	ab
T3 (*Lantana camara* 9 %)	19.37	a

Note: Means followed by the same letter in the same column indicate no significant difference based on the Duncan Multiple Range Test (DMRT) at a significance level of α = 5%. Data is transformed in Arc sin.

Based on Table 3, the average decline in vigor index was significantly the lowest in treatments T3 and B3, although not significantly different from treatment T2. The vigor index reflects the uniformity of seed germination. A decrease in germination ability and vigor is a physiological indication of seed deterioration. A higher seed vigor index indicates faster and more uniform germination.

A high seed vigor index reflects both rapid and uniform germination, making it a reliable indicator of seed quality. This is because the vigor index not only measures the seed's ability to germinate under optimal conditions but also reflects the uniformity and speed of seedling growth under such conditions. According to Ali *et al.* (2003), seed deterioration can occur while seeds are still on the parent plant or during storage, influenced by environmental conditions such as temperature and relative humidity (RH).

4. Conclusion

For the parameter of the average percentage increase in *Sitophilus zeamais* population, the most effective treatments were B3 and T3. Regarding the reduction in maize seed germination rate, the most effective treatments in minimizing the decline were T2 and T3. Treatments B3 and T3 (9% concentration of leaf extract) were significantly the most effective in reducing the decline in maize seed vigor index.

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6. Reference

Ali, M.G., Naylor, R.E.L., & Matthews, S. (2003). Effect of ageing (using controlled deterioration) on the germination at 21 °C as an indicator of physiological quality of seed lots of fourteen Bangladeshi rice (Oryza sativa L.) cultivars. *Pakistan Journal of Biological Sciences.* 6, 910–917

Asmaliyah, S. & Musyafa. (2010). Uji Toksisitas Ekstrak Daun Val. Terhadap Serangga Serangga *Spodoptera litura* Fabricus (Lepidoptera: *Noctuidae*). Palembang. Balai Penelitian Kehutanan Palembang.

Arrahman, A., Mirsam, H., Djaenuddin, N., Suriani, Pakki, S., Saenong, M. S., & Sebayang, A. (2022). An in-depth study on Sitophilus zeamais Motsch (Coleoptera: Curculionidae) pests on maize plants. *IOP Conference Series: Earth and Environmental Science*, *1107*(1). https://doi.org/10.1088/1755-1315/1107/1/012060

Astriani, D & Dinarto, W. (2010). Uji toksisitas beberapa gulma sebagai pestisida nabati serangga bubuk pada penyimpanan benih jagung. Jurnal Agrisains.

BPS Indonesia, S. I. (2021). *Statistik Indonesia 2021*, *1101001*, 790. https://www.bps.go.id/publication/2020/04/29/e9011b3155d45d70823c141f/statistik-indonesia-2020.html

Danong, M. T., Damanik, D. E. R., & Billy, T. D. (2020). Inventarisasi Jenis-Jenis Tanaman Berpotensi Sebagai Pestisida Nabati Yang Digunakan Oleh Masyarakat Desa Sonraen Kecamatan Amarasi Selatan Kabupaten Kupang. *Jurnal Biotropikal Sains*, *17*(2), 62–71.

Hasim, H., Arifin, Y. Y., Andrianto, D., & Faridah, D. N. (2019). Ekstrak Etanol Daun Belimbing Wuluh (Averrhoa bilimbi) sebagai Antioksidan dan Antiinflamasi. *Jurnal Aplikasi Teknologi Pangan*, *8*(3), 86. https://doi.org/10.17728/jatp.4201

Ilmawan, E. (2019). Keragaan Genetik Genotipe Jagung (*Zea mays* L.) Toleran Cekaman Kekeringan. *Agrominansia*, *3*(2), 119–128. https://doi.org/10.34003/271978

Ismaryati, Endang. Ari, Wahyuningsih. Nurtamtomo. (2020). *Panduan Teknis Penyusunan Prognosa Ketersediaan dan Kebutuhan Pangan Strategis.* Kementerian Pertanian: Jakarta.Molenaar Robert. (2020). Panen dan Pascapanen Padi, Jagung, dan Kedelai. *Jurnal Eugenia*, *26*(1), 17–28.

Mordue (Luntz) A. J. & A. J. Nisbet. (2000). Azadirachtin from the Neem Tree Azadirachta indica: its Action Against Insects. An. Soc. Entomol. Brasil 29, 615-632.

Muslikah Nur Hidayati, U., & Asngad, A. (2020). Pemanfaatan Ekstrak Daun Tembelekan Dengan Penambahan Ekstrak Daun Kemangi Sebagai Insektisida Nabati Terhadap Mortalitas Larva Nyamuk Dengan Berbagai Konsentrasi. *Jurnal Pararel* , *3*(2), 425–429.

Rahayu, A. D. & Tatiek K. S. (2015). Pengamatan Uji Daya Berkecambah dan Optimalisasi Substrat Perkecambahan Benih Kecipir [Psophocarpus tetragonolobus L. (DC)]. Bogor. Departemen Agronomi dan Hortikultura, Fakultas Pertanian, Institut Pertanian.

Roge, G. N., Fisseha, F., & Bidira, T. (2023). Management of Maize Weevil (Sitophilus zeamais) Using Hermetic and Non-Hermetic Storage Containers: A Short Communication. *Asian Journal of Biological Sciences*, *16*(4), 550–554. https://doi.org/10.3923/ajbs.2023.550.554

Simamora, R. R., Anne N, M.Kadapi, & Dedi Ruswandi. 2018. Kualitas Benih Jagung Manis Calon Tetua Hibrida Unpad Setelah Empat Bulan Penyimpanan. Bandung. Fakultas Pertanian Universitas Padjajaran.

Sinambela, B. R. (2024). Dampak Penggunaan Pestisida Dalam Kegiatan Pertanian Terhadap Lingkungan Hidup Dan Kesehatan. *AGROTEK: Jurnal Ilmiah Ilmu Pertanian*, *8*(2), 178–187.

Syah, B. W., & Purwani, K. I. (2016). Pengaruh Ekstrak Daun Belimbing Wuluh (*Averrhoa bilimbi)* terhadap Mortalitas dan Perkembangan Larva *Spodoptera litura*. Surabaya. Jurnal Sains dan Seni ITS.

Syukri, D., & Dina, M. (2022). *Kumpulan Informasi Terkait Penelitian Dan Pengembangan Produk Olahan Berbahan Baku Jagung*.

Szentesi A, Bernays EA. (1984). A Study of behavioural habituation to a feeding deterrent in nymph of Schistocerca gregaria. *Physiological Entomology* 9, 329-340. https://doi.org/10.33096/agrotek.v8i2.625