MULTIDISCIPLINE - International Conference 2021
December 18th 2021, Page. 490 - 501
E-ISSN: 2809-6142

The Effectivity of Several Botanical Insecticides to Control Powder Beetle Pests (*Sitophilus zeamais* M.) in Corn Seed

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ABSTRACT
Sitophilus zeamais M. is an important pest of corn in storage which can cause damage of around 30-100%. S. zeamais pest control can be done with the application of botanical insecticides. This study aims to determine the effect of botanical insecticides on pest mortality and their effectiveness in controlling S. zeamaispests. The research method was carried out with a factorial Completely Randomized Design (CRD) consisting of 2 factors with 3 replications. The treatment used botanical insecticides, neem seed powder, soursop seed powder, and lemongrass stalk powder with various concentrations of 4%, 8%, and 10% on 100 g of corn seeds. The variables observed in this study were mortality of S. zeamaisimago, repellency, number of F1 imago, intensity of damage, and germination. The data obtained were analyzed using analysis of variance (ANOVA), if the results were significantly different, then proceed with the DMRT significant difference test with a significance level of 5%. The results showed that the interaction that was effective for mortality was soursop 8% (90%), while for repellency the neem treatment was 8% with a repellency of 93.33%. The interaction of 10% soursop powder was effective in suppressing the number of F1 imago (3.67 insects) and seed damage (3.33%). The lowest seed weight loss was in the treatment of soursop powder (1.56%) and a concentration of 10% (2.89%). Botanical insecticides did not affect the germination of corn seeds.

Keywords: *Corn seed, Sitophiluszeamais, Botanical insecticide*

INTRODUCTION

According to Warisno (1998), corn plants (*Zea mays L.*) belong to a type of grain plant from the Gaminaceae family that has been known since ancient times around the world. Corn is one of the commodities that are widely cultivated by Indonesian farmers. Corn can be used as a consumption material or as an animal feed. In Indonesia, Corn production continues to increase every year. According to the Ministry of Agriculture (2020), Indonesia's corn production in 2020 reached 21.53 million tons. While the demand for corn for food factories amounted to 8.5 million tons and for animal foods the need amounted to 3.48 million tons. According to the Ministry of Agriculture (2020), it is also stated that the target for 2020 was to plant 4.49 million hectares of corn. This causes the demand for corn seeds to be quite high, which is around 40,980 tons. In order to meet these needs, it was necessary to take appropriate post-harvest actions to maintain the quality of the corn that was harvested. Post-harvest activities are activities that include harvesting, drying, shelling, and storing. Harvesting is done when the corn kernels harden and shiny and the husks turn yellow. The harvested corn is then dried to reduce the moisture content of the seeds. The dried corn is then continued to the shelling process as an effort to separate the seeds from the cobs. Corn kernels are stored in a place with good and clean conditions. One of the obstacles in the corn storing process is the attack of the powder beetle (*Sitophilus zeamais M.*). *S. zeamais* not only attacks corn, but can also eat rice/grain, sorghum, and wheat. The attack on corn seeds resulted in a loss of 30-100%, so a control measure was needed (Nonci and Muis, 2015).

According to Wulansari *et al.* (2019), *S. zeamais*control can be done in various ways, one of which is with plant-based pesticides. The purpose of the use of plant-based-based pesticides is to reduce the use of chemicals. Several plants that can be used to control *S. zeamais* are neem, soursop, and lemongrass plants

(Saenong, 2016). These ingredients contain secondary metabolite compounds that can affect the behavior of *S. zeamais*, such as resisting insects, lowering appetite, inhibiting the process of skin turnover, and others.

This research uses the basic ingredients of neem, soursop, and lemongrass plants. Based on the results of previous studies, plant-based insecticides with the basic ingredients of neem, soursop, and lemongrass have been tested using different concentrations and formulations. According to the research results of Nukenine et al. (2011), it is stated that the application of neem powder with a concentration of 40 g/kg can cause a mortality of 96% on an observation for 14 days after application. Application of soursop leaf powder with a concentration of 10 g can cause mortality of 92.5% (Sembiring et al., 2014). In addition, soursop leaf powder with a concentration of 10 g can also provide a fairly high repellency power of 90% (Putri et al., 2018). Based on the results of research by Astriani (2012), the concentrations of lemongrass leaves used were 5%, 10%, and 20% in the form of a solution formulation to observe the mortality of *S. zeamais*. The resulting mortality percentage is a concentration of 5% (18.57%), 10% (24.02%), and a concentration of 20% (34.00%).

Based on these references, researchers want to know the interaction between types of plant-based insecticides with various concentrations. In addition, researchers also want to know the effect of several types of plant-based insecticides on mortality and pest repellency of *S. zeamais*. The ingredients used are neem seeds, soursop seeds, and lemongrass stalks. Powder concentrations to be used are 4%, 8%, and 10% on 100 g of corn seed. It refers to the results of previous studies and then the mean concentration value is taken. It is hoped that by interacting the ingredients with concentrations, the type of interaction that is most effective in controlling *S. zeamais* pests can be obtained. So that later they can provide appropriate recommendations to the community or farmers in controlling *S. zeamais* by using plant-based insecticides. According to a book written by Mulyani (2021), it is explained that neem, soursop, and lemongrass are often used as plant-based pesticides and contain different compounds. This is because the three plants come from different families.

METHOD

This research was carried out in November 2020 - January 2021 at the Plant Pest Science Laboratory, Plant Protection Study Program, Faculty of Agriculture, University of Jember. The tools used in this study were stationery, label paper, plastic jars, plastic, digital scales, tweezers, spoons, scissors, knives, blenders, wooden dishes, basins, sieves, microscopes, plastic boxes, plastic cups, and digital cameras. The materials used were neem seeds, soursop seeds, lemongrass stalks, corn seeds, imago pests of *S. zeamai* and sterile soil for seed germination media. This study used a factorial Completely Randomized Design (CRD) consisting of 2 factors, namely the type of plant-based insecticide (I) and concentration (K). Types of plant-based insecticides consist of neem seed powder (I1), soursop seed powder (I2), and lemongrass stalk powder (I3).). While the concentration factor (K) consists of 4% (K1), 8% (K2), and 10% (K3). The treatment combination was repeated 3 times. In this research design, 2 controls were used as comparison, namely positive control, and negative control. Positive control was a control without treatment, while negative control was a control with *S. zeamais* infestation on corn seeds used. The number of *S. zeamais* used in each treatment was 10 heads/100 gram of corn seed.

- Insect Breeding

S. zeamais pests were obtained from the corn storage area and then bred. Rearing of *S. zeamais* is done which aims to obtain insects with a similar age. The rearing process was carried out by inserting 100 *S. zeamais*adults(1: 1 ratio) in a jar containing 500 gram of corn seeds. The corn is left for 7 days so that the imago of *S. zeamais* can carry out the process of laying eggs. The next step, the imago of *S. zeamais* on the corn, was then removed from the jar. Corn kernels are stored for approximately 35 days until new imago appear with the same age.

- Production of plant-based Insecticide Powder

Neem and lemongrass seeds are taken directly from the land in the area of Sapudi Island, while soursop seeds are obtained from the market by buying the fruit first and then separating the seeds. The three ingredients are air-dried until dry. After the ingredients are dry, then coarsely ground to make it easier when in the blender. The powder from the blender is then sifted to obtain the most refined powder. This powder will later be applied to corn seeds. This plant-based powder is contact toxicity when in direct contact with *S. zeamais*, interferes with the working system of the insect skin and can penetrate the cuticle. plant-based powders from neem seeds, soursop seeds, and lemongrass are also stomach poison

when *S. zeamais* eats corn seeds that have been applied with plant-based powder. plant-based insecticide powder enters the insect's body through the digestive system, after entering the insect's body, the plant-based insecticide compound will begin to react. In addition, this plant-based powder can also dispel and reduce the appetite of *S. zeamais* due to its unpleasant smell and taste.

- Plant Insecticide Power Test

Amount 10 individu of Sithopillus adults was 8-14 days old was infested on 100 g corn seeds in a jar, that was added the plant-based insecticide powder according to the predetermined concentration. Observation was done one week after application (WAA) for 5 times.

Observation Variable

Observational variables used in this study were mortality of *S. zeamais*adults, repellency test, number of F1-derived imago, intensity of damage to maize seeds, weight loss of maize seeds, and germination test of maize seeds.

- Mortality of *S. zeamais*Imago

The mortality of *S. zeamais* imago was observed once every 7 days and carried out for 5 observations (5 MSA). According to Yasi and Lestari (2020), the mortality percentage is calculated using the formula:

$$(P_o) = \frac{a-b}{a} \text{ x } 100\%$$

Information: P_o= Mortality percentage
a = Number of live pests before application
b = Number of live pests after application

- Repellency test

According to Liu *et al*. (2006), the repellency test was carried out using the dual-choice test method. How to do a repellency test using a plastic container filled with two glasses. Each glass is filled with 100 gram of corn seeds. The treatment glass was infested with 10 *S. zeamais* and left for 2 days so that *S. zeamais* could adapt in the test jar. The treatment jars were applied to the types of plant-based insecticides. Observations of the repellency test were carried out every 3 hours for 12 hours after applications (haa).

$$\text{Repellency (\%)} = \frac{\text{Number of insects moving on control}}{\textit{Numberofinsectstest}} x\ 100$$

- Number of F1 derivatives

The first insect pests of *S. zeamais* that appeared were observed in the last week, namely at week 5 and then counted. The insects observed were insects's imago.

- Percentage of Corn Seed Damage

S. zeamais attack can cause weight loss and damage to maize seeds. Percentage of weight loss and seed damage was calculated at the end of the observation, namely at week 5. Calculation of the weight loss of corn seeds using the formula:

$$P = \frac{(weightoftheseedearly-weightfinalseed)}{weightoftheinitialseed} \text{ x } 100\%$$

Based on Hendrival and Mayasari (2017), the intensity of corn seed damage is calculated using the formula:

Intensity of Seed Damage

$$(I) = \frac{a}{b} \text{x } 100\%$$

Information: a = Weight of damaged corn seeds
b = Weight of the initial corn seed entirely

- Percentage of Corn Seed Sprout Power
  Calculation of the power of corn seed sprouts using the formula (Elfiani and Jakoni, 2015):

$$DB = \frac{\sum KN}{\sum Plantedseeds} \times 100\%$$

Information: DB = Power of corn seed sprouts
KN = Normal sprouts

RESULT AND DISCUSSION

Result

The results of diversity analysis showed that the type of material and concentration affected the mortality of *S. zeamais*, the repellency, the number of F1 imago seed damage, and seed weight loss. In mortality and repellency there were significantly different interactions, whereas in the number of F1 imago and seed damage there were very different interactions. In seed weight loss there were interactions that were not significantly different. Analysis of seed germination was not significantly different, meaning that the application of plant-based powder did not affect seed germination. The results of the analysis were significantly different and there were interactions, further tests were carried out using the Duncan Multiple Range Test (DMRT) at a level of 5%.

- Mortality of *S. zeamais*imago

Mortality observations were carried out every week until the 5th week with the aim of knowing the effect of plant-based powder and the increase in the number of dead *S. zeamais* pests. The results of the observation of mortality are as presented in Table 2.

Table 2. Effect of Plant-Based Insecticides On Mortality (%) of *S.zeamais* pests in 5 waa

Treatment	$K_{1(4\%)}$	$K_{2(8\%)}$	$K_{3(10\%)}$
I_1 (Neem)	53.33 b A	60.00 b B	66.67 b B
I_2 (Soursop)	70.00 c A	90.00 c B	93.33 c B
I_3 (Lemongrass)	40.00 a A	43.33 a B	53.33 a B

Information : The numbers followed by different letters are not real according to Duncan's test at the 5% level. Lowercase letters are read in vertical directions (columns) and capital letters are read horizontal directions (rows).

Table 2 shows that the application of neem powder with a concentration of 8% was effective against mortality of *S. zeamais*, namely 60%, and it was not significantly different with a concentration of 10% with a mortality of 66.67%. Soursop seed powder application with a concentration of 8% was effective in killing *S. zeamais* pests up to 90%. While in the application of lemongrass powder, the highest mortality rate was at a concentration of 10%, namely 53.33%. The most effective interaction on mortality of *S. zeamais* pest was soursop powder 8 (90%) and it was not significantly different from the 10% soursop powder treatment (93.33%).

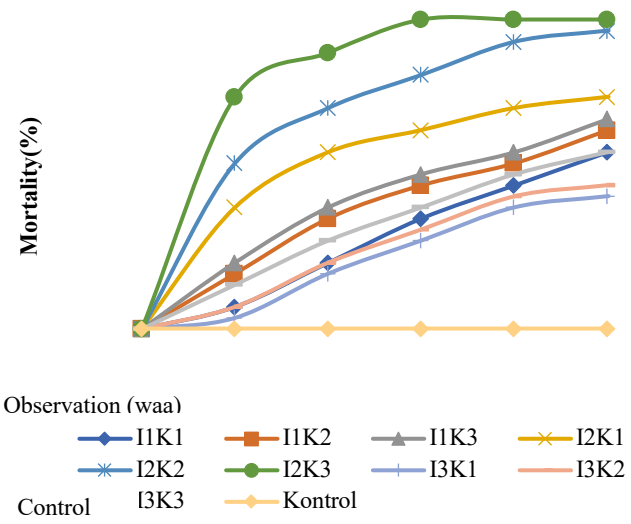

Figure 1. Rate of Mortality of *S. zeamais*Pests

Figure 1 shows that the highest mortality rate in soursop powder occurred in the first week, while entering the 2nd to 5th week the mortality rate slowed down. In the 10% soursop powder treatment, it tends to increase until the 3rd week, then there is no further increase and mortality occurs constantly. The application of 8% neem powder and 10% mortality rate occurred in parallel. In 4% neem treatment, 4% lemongrass powder and 8% the mortality rate was very low since the first week. The 10% lemongrass powder treatment experienced a mortality rate that tends to increase steadily.

- Repelling Powder against *S. zea mays* Pests

Loensive is the repellent power of insect pests against plant-based insecticides. The repelling power is seen from the number of pest insects that move from the container with the application treatment of plant-based powder in the container without treatment or control treatment. Observations of the review conducted for 12 hours gave different results on each treatment. The results of the observation of the repelence power can be seen in Table 3.

Table 3. Effect of Plant-Based Insecticides on S. zeamaisRepelence on 12-Hour Observation (%)

Treatment	K_1 4%	K_2 8%	K_3 10%
I_1 (Neem)	73.33 a A	93.33 c B	96.67 c B
I_2 (Soursop)	70.00 a A	83.33 b B	90.00 b B
I_3 (Lemongrass)	60.00 a A	63.33 a A	66.67 a A

Information : The numbers followed by different letters are not real according to Duncan's test at the 5% level. Lowercase letters are read in vertical directions (columns) and capital letters are read horizontal directions (rows).

Table 3 shows that the application of 8% neem powder is already effective against the repellency power of 93.33%, while at a concentration of 10% the repelling power is higher but different is not real which is 96.67%. Soursop powder treatment is 8% effective against repellency by 83.33%, while at a concentration of 10% the results are differently unreal, which is 90%. Application of lemongrass powder gives the lowest effect when compared to other materials. The application of lemongrass powder is not noticeable at each concentration, for the highest repelence at a concentration of 10% which is 66.67%. The most influential interactions were 8% (93.33%) and were not noticeable with a concentration of 10% (96.67%).

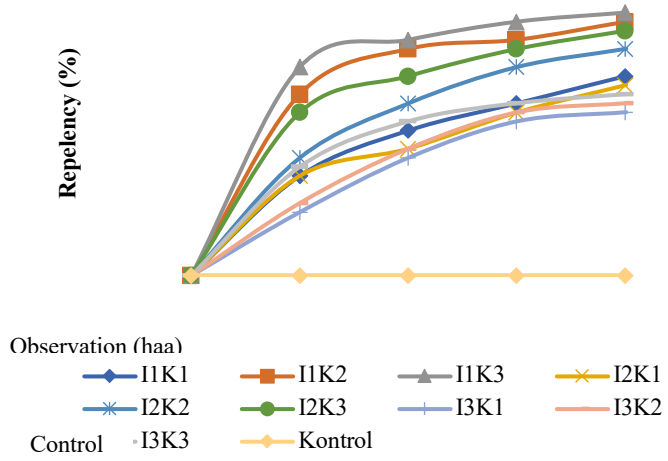

Figure 2. Percentage rate of *S. zeamais* pest repellent

The highest effect of the rate of plant-based powder repellent against *S. zeamais* pests is on the first 3 hours of observation at each treatment, while when entering the observation of the 6th hour the rate of repelence begins to slow down. The most influential treatment of *S. zeamais* repellency is neem seed powder, except for the 4% neem treatment which has a lower effect compared to soursop powder treatment of 8% and soursop treatment 10%. Treatment with application of lemongrass powder has the lowest effect. The rate of repelence between the treatment of 4% lemongrass powder and 8% lemongrass powder tends to increase unidirectionally. The rate of repelence on the control does not change from the beginning of observation, because in this control there is no movement of pests.

- Number of F1 Imago

The appearance of imago F1 is caused by the offspring of *S. zeamais* infested earlier in each treatment. The results of observations of the number of imago F1 are presented in Table 4.

Table 4. Effect of plant-based insecticides on the amount of imago (tail)

Treatment	$K_{1\ 4\%}$	$K_{2\ 8\%}$	$K_{3\ 10\%}$
$I_{1\ (Neem)}$	30.00 b C	23.67 b B	17.00 b A
$I_{2\ (Soursop)}$	7.00 a B	5.00 a B	3.67 a A
$I_{3\ (Lemongrass)}$	42.00 c C	34.33 c B	31.33 c A

Information :The numbers followed by different letters are not real according to Duncan's test at the 5% level. Lowercase letters are read in vertical directions (columns) and capital letters are read horizontal directions (rows).

Based on Table 4 it is seen that all types of materials used can suppress the appearance of F1 imago i.e. at the use of 10% consensual. The number of F1 imago that appears in the treatment of neem as many as 17 tails, soursop powder 3.67 tails, and lemongrass powder treatment 31.33 tails. The best interaction in suppressing the amount of F1 imago is the treatment of soursop powder with a concentration of 10% (3.67 tails), because it causes the appearance of less F1 imago compared to the treatment of soursop powder 8% (5 tails).

- Damage to corn seeds

Damage to seeds is caused due to the feeding activity of larvae that scrape corn kernels, causing corn kernels to be hollow and easily broken. The results of observations of corn seed damage can be seen in Table 5.

Tabel 5. Effect Of plant-based insecticides on the damage of corn seeds (%)

Treatment	$K_{1\ 4\%}$	$K_{2\ 8\%}$	$K_{3\ 10\%}$
$I_{1\ (Neem)}$	16.67 b B	15.33 b B	11.00 b A
$I_{2\ (Soursop)}$	6.67 a C	4.67 a B	3.33 a A
$I_{3\ (Lemongrass)}$	20.33 c B	18.67 c B	17.33 c A

Information : The number followed by the same letter is no different, according to Duncan'stest at the 5% level. Lowercase letters are read in vertical directions (columns) and capital letters are read horizontal directions (rows)

Table 5 shows that the treatment of neem, soursop, and lemongrass powder at all concentrations showed noticeable different results against the rate of damage to corn seeds. All types of materials used exert the most effective influence on concentrations of 10%, where in the application of neem powder causes damage by 11%, soursop powder by 3.33%, and lemongrass powder by 17.33%. The interaction between the type of material and the best concentration is soursop powder 10% with a damage percentage of 3.33%, followed by soursop powder 8% which causes seed damage by 4.67% and soursop powder 4% with damage intensity of 6.67%.

The shrinking weight of the seed is caused by damage to the corn seed. Damaged corn will turn into flour flakes. In addition, the weight of the seed is also caused by the material that is consumed by imago *S. zeamais*, thus reducing the weight of corn seeds. The observations results of the shrink weights of seed can be seen in Table 6 and Table 7.

Table 6. Effect of Plant-Based Insecticide Types on Seed Weight Shrinking (%)

Type (I)	Shrink Weights
$I_{1(neem)}$	3.78 b
$I_{2\ (soursop)}$	1.56 a
$I_{3\ (lemongrass)}$	5.44 c

Information : The numbers followed by the same letter did not differ markedly according to Duncan's test at the level of 5%.

Table 7. Influence of Some Concentrations on Shrinking Corn Seed Weights (%)

Concentration (K)	Srink weight
$K_{1\ 4\%}$	4.33 c
$K_{2\ 8\%}$	3.56 b
$K_{3\ 10\%}$	2.89 a

Information : The numbers followed by the same letter did not differ markedly according to Duncan's test at the level of 5%.

The analysis results showed no real distinct interactions on observations of seed weights, so further tests were conducted independently on each factor. The type of plant-based powder that is most influential both in pressing seed weight shrinking is soursop powder with a weight of 1.56%, followed by neem powder 3.78% and lemongrass powder 5.44%. The most influential concentration in suppressing the weight of corn seeds was a concentration of 10% (2.89%), followed by a concentration of 8% (3.56%) and a concentration of 4% (4.33%).

- Seed Sprout Power

The sprout power test is the last observation of this study that aims to find out the influence of plant-based powders on the power of seed sprouts. Based on the results of variant analysis (ANOVA) showed that the application of plant-based insecticides has no effect on the power of seed sprouts. The results of observations of sprout power can be seen in Table 8.

Table 8. Corn Seed Sprout Power (%)

Treatment	$K_{1\ 4\%}$	$K_{2\ 8\%}$	$K_{3\ 10\%}$
$I_{1\ (Neem)}$	86.67	90.00	88.33
$I_{2\ (Soursop)}$	90.00	88.33	90.00
$I_{3\ (Lemongrass)}$	88.33	88.33	86.67

The results of the variant analysis showed that the seed sprout power test gave different results that were not real, so there was no need for further tests. Based on the results of observations of the sprout power of corn seeds, obtained the results of the germinated power range between 86.67% - 90% in all treatments. It is no different from the control treatment, where the power of corn seed sprouts at the control is 90%.

Discussion

Application of neem powder at a concentration of 8% causes mortality of 60% and differs in unreal with a concentration of 10% with mortality of 63.33%. This is different from the results of research Nukenine et al. (2011), which mentioned that the application of neem seed powder with a concentration of 40 g / kg could cause mortality of 4% in just 1 day. While at the time of observation of the 14th day there was a mortality of 96%. When compared to the results of this study, the mortality rate is higher compared to the results of previous studies. This can be caused by differences in places, so the compounds contained in neem seeds also differ between neem grown abroad and neem grown in Indonesia.

The application of soursop powder at a concentration of 8% causes mortality of 90% and differs in unreal with a concentration of 10% which causes mortality of 93.33%. This is almost the same as the results of the research Sembiring et al. (2014), which states that the application of soursop leaf powder with concentrations of 8% and 10% of the results are not real difference, namely 85% and 92.5%. The addition of 2% soursop powder does not have a noticeable distinct effect on the mortality of the *S. zeamais* pest. The death of imago *S. zeamais* in the application of soursop powder is influenced by the presence of anonain compounds and resins that are stomach toxins and contact toxins. In addition, acetogenin compounds contained in it can give off a distinctive aroma, so it decreases the appetite of *S. zeamais* (Moniharapon et al., 2015).

Application of lemongrass powder is less effective in controlling *S. zeamais* pests, where the percentage of mortality caused is quite low compared to neem powder and soursop powder. Application of lemongrass powder at high concentrations of 10% only causes mortality of 53.33%. A previous study conducted by Astriani (2012), also mentioned that the application of lemongrass flour with a concentration of 10% caused a fairly low mortality rate of 34.98%. If you want to obtain a high mortality rate, then the use of lemongrass powder needs to be used at higher concentrations. According to Astriani (2012), when the concentration increases up to 20% the mortality rate of *S. zeamais* increases to 47.62%.

The most effective interaction was 8% soursop powder which caused mortality of 90% and differed in unreal with 10% soursop powder treatment (93.33%). The results showed that the application of soursop powder exerted the most effective influence compared to powders and lemongrass, both at low concentrations and high concentrations. If all treatment is compared to control, then the results are very different because in the control treatment there is no presence of dead pests. Based on research sembiring et al. (2014), the characteristics of *S. zeamais* who died after being applied plant-based insecticides, namely the body of pests become limp and die, on the limbs bent in and stiff, and on the mouth (muzzle) which is usually straight parallel to the head turns down.

The results of the 5% DMRT test on the review variable (Table 3) showed that in powder 4% (73.33%) the real difference with the concentrations of 8% and 10%, but between concentrations of 8% (93.33%) showed results that were notreallydifferent from concentrations of 10% (96.67%). Soursop powder treatment shows the same thing as in powder treatment. At concentrations 4% (70%) differs markedly by concentrations of 8% and 10%, but between concentrations of 8% (83.33) and 10% (90%)

difference is not real. The repelence values on the treatment of lemongrass powder are not noticeable at each concentration used. The most influential interactions were 8% (93.33%) and were not noticeable with a concentration of 10% (96.67%). When compared to the control the results are very different, because in the control treatment insects do not experience displacement.

The repellency test aims to determine the repulsion of insect pests to plant-based insecticides. The type of material that had the highest to lowest effect on the pest repellency of *S. zeamais* was the application of neem powder, soursop powder, and the lowest was lemongrass powder. The application of neem powder with a concentration of 8% (93.33%) was effective against the repellency of *S. zeamais*, while at a concentration of 10% it caused a repellency rate of up to 96.67%. This is in accordance with the research results of Putri et al. (2018), which stated that the repellency test of neem flour with a concentration of 10% was effective in causing a repulsion percentage of 93.33% at 2 hours of observation after application. The results of the study also explained that neem powder was indeed more effective than soursop powder, where the application of soursop powder at a concentration of 10% caused a repellency rate of 90% after 2 hours of application. The results of this study prove that the plant-based powder used is still effective against repellency up to 12 hours after application.

Application of lemongrass powder was less effective against pest repellency of *S. zeamais* when compared to other materials, both at low and high concentrations. The results showed that the application of lemongrass powder with various concentrations showed results that were not significantly different. At a high concentration of 10% the resulting repellency is 66.67%. This is almost the same as previous research conducted by Astriani (2012), which stated that the application of lemongrass powder with a concentration of 10% was only able to cause a repellency rate of 66.65%.

The results showed that the addition of the concentration of plant-based powder could reduce the number of imago that appeared. The number of F1 imago was obtained by counting the number of imago at the end of the observation minus the number of surviving early pests. The number of F1 imago that appeared was related to the mortality rate of *S. zeamais*. The more pests that die, the fewer F1 imago that appear. The application of neem powder with various concentrations gave significantly different results to the appearance of imago F1. Neem powder with a concentration of 10% caused the appearance of 17 F1 imago at the end of the observation (5th week). In a previous study conducted by Nukenine et al. (2011), stated that the application of neem seed powder with a concentration of 40 g/kg on the 14th day of observation did not find any F1 imago. This difference is due to differences in the time of observation, where in this study the observation time was carried out for a longer period of time. This is in accordance with the life cycle of *S. zeamais* which is about 35 days.

Table 5 shows that the application of soursop powder with a concentration of 4% (7 tails) was not significantly different with a concentration of 8% (5 tails), but both were significantly different with the application of 10% soursop powder (3.67 tails). These results indicate that the application of soursop powder has the best effect in suppressing the emergence of F1 imago. The application of lemongrass powder at each concentration gave a significantly different effect, where for a concentration of 4% (42 tails), 8% concentration (34.33 tails), and 10% concentration (31.33 tails). Application of lemongrass powder with the concentration used is less effective, because the number of imago F1 that appears is quite a lot. When compared with the control, the number of controls F1 imago (56.67 tails) was more than the number of F1 imago produced in each treatment.

S. zeamais attack can cause damage and weight loss on corn seeds. Corn seeds are categorized as damaged if the seeds have holes or cracks. Hollow seeds and whole seeds were separated, then weighed and calculated using a predetermined formula. Based on Table 5, it is known that the addition of plant-based powder concentration gave significantly different results to the level of damage to corn seeds, with the highest effect at a concentration of 10%. The addition of concentration on each ingredient was able to reduce the percentage of damage to corn seeds. The corn seed category is said to be damaged if the corn seed has holes or breaks. In the high damage category, one corn seed can have more than one hoist hole and the corn seed can turn into powder flakes. Several factors affect the feeding activity of *S. zeamais* pests on corn seeds such as food quality, moisture content, humidity, and light intensity (Yasin, 2009). Food quality includes the availability of nutrients in corn seeds needed by *S. zeamais* pests. In addition, *S. zeamais* prefers corn seeds with a less hard texture. This is related to the moisture content of the corn seed. In general, the appropriate moisture content for corn seeds is < 15%, while for special corn seeds the appropriate moisture content is 10-11%. Corn texture with harsh conditions can reduce the eating level of *S. zeamais*, so as to minimize damage to seeds.

The intensity of seed damage is associated with mortality of *S. zeamais*, if mortality is high then the intensity of damage decreases. The results showed that soursop powder had the best effect in suppressing the intensity of seed damage. Soursop powder with a concentration of 10% only causes 3.33% damage. That's in stark contrast to neem powder (11%) and lemongrass powder (17.33%). If all treatment is compared to control, then the results are very different. The percentage of corn seed damage in the control treatment was 36.67%.

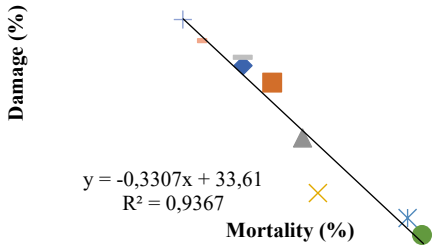

Figure 3. Relationship between Mortality and Seed Damage

Based on Figure 3 it can be known that there is a very strong and significant relationship between mortality and the intensity of damage to corn seeds. Based on the results of linear regression analysis, the relationship between mortality and the intensity of damage to negatif-correlated corn seeds corresponds to the resulting equation i.e. (y = -0.3307x + 33.61). High mortality of *S. zeamais* pests can reduce the percentage of seed damage, so it can also minimize seed decline (Astriani, 2012). At the percentage of mortality, it is known that the treatment of soursop powder causes the highest mortality, so it can reduce the rate of damage and shrink the weight of corn seeds.

How to observe the shrinking weight of corn seeds that corn powder is cleaned first, then corn is weighed and calculated using a predetermined formula. The presence of *S. zeamais* pest infestation can cause weight shrinking in corn, it is because this pest scrapes the inside of the seeds and causes changes to powder or flour. When observed, the flour is found in the affected corn kernels. Larvae can salivate to unite between seeds and flour, so that it can reduce the quality of corn kernels (Surtikanti, 2004). To overcome the shrinking of seed weights in large enough quantities, efforts can be made to control or treat seeds to minimize the attack of *S. zeamais*. Researchers have made one of the efforts to control the *S. zeamais* pest by using plant-based insecticides.

The results of the DMRT 5% test on the seed weight loss variable (Table 7 and Table 8) showed that there were significantly different values for the plant insecticide type factor and also for the concentration factor, but there was no interaction between the two. Based on Table 6 and Table 7, it can be seen that each type of plant-based material has a significantly different effect. The application of neem powder caused a reduction in seed weight of 3.78%. Soursop powder application caused the lowest weight loss at 1.56%. The highest weight loss was in the lemongrass powder treatment of 5.44%. The results showed that the higher the concentration used, the lower the resulting seed weight loss. At a concentration of 4%, the weight loss was 4.33%, the concentration of 8% was 3.56%, and the concentration of 10% was 2.89%. If all these treatments were compared with the control (without the application of plant-based powder), it would give significantly different results. The weight loss of maize seeds in the control reached 7.33%.

The study also looked at the effect of plant-based insecticide applications on the sprout power of corn seeds. The parameters observed in the sprout power test are the number of normal sprouts and abnormal sprouts. Normal sprouts are sprouts that show the potential to grow well and become normal plants. The characteristics of corn seed sprouts are said to be normal when the koleoptil, primary root, seminal root, root hood, and leaves appear (Elfiani and Jakoni, 2015). As for the characteristics of abnormal sprouts, the sprouts look small, the leaves that appear small, and the primary roots are short.

A **B**

Figure 4. Difference between Normal and Abnormal Sprouts.
(A) Normal Sprouts and (B) Abnormal Sprouts

The results of observations showed that the average normal sprout already has 2 numbers of leaves that open. The rooting system looks to grow perfectly with a long size. The results of observations on the sprout power of corn seeds ranged from 86.67% - 90% in all treatments. It is no different from the control treatment, where the power of corn seed sprouts at the control is 90%. The results of the study are in accordance with the standard of testing the power of corn seed sprouts that have been established by the Directorate General of Food Crops (2009), that good corn seeds must have a standard sprouting power of 80%.

Based on variant analysis showed that the type of material used only affects pests but does not affect the sprout power of corn seeds. This is in accordance with the advantages of plant-based insecticides, that the plant-based ingredients used only affect the activity of pests. In a study conducted by Astriani (2012), applying lemongrass powder also proved that the application of lemongrass powder has no effect on the growing power of corn seeds, where the sprouting power of corn seeds is quite high, ranging from 86.67% - 90%. In the test the power of sprouts must also pay attention to other factors, such as environmental factors and the availability of sufficient water. At the time of the study watering was done for 2x a day, namely morning and evening. The experimental unit was placed in a place that was exposed to enough sunlight and not too hot, to help speed up the germination process of corn seeds.

CONCLUSION

- There is an interaction between plant-based insecticide (I) and concentration (K) against mortality, repelence, amount of imago F1, and seed damage, but against seed weight shrinkage there is no interaction.
- Interactions that have an effective effect on mortality are soursop powder concentration of 8% by 90%.
- Interactions that affect effective repellents are powders with a concentration of 8% of 93.33%
- Soursop powder interaction is 10% effective in suppressing the amount of F1 imago (3.67 tails) and the intensity of corn seed damage (3.33%).
- Soursop powder effectively suppresses seed weight shrinking by only 1.56% and 10% concentration causes seed weight shrinking to be only 2.98%.
- Types of plant-based insecticides with various concentrations have no effect on the power of corn seed sprouts, where the power of seed sprouts ranges from 88.33% - 90%.

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