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The Efficacy of Banana *Musa acuminata L.* Water Enhanced with Calcium Carbonate and Sodium Chloride as Insect Repellant

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ABSTRACT

Farmers are challenged by the fact that insects are part of the ecological environment. The presence of insects comes across farm production which purposively affects income. At present, most farmers attest that repellants are unavoidable in the current farming condition. Anchored on the foregoing standpoint, this research aimed to determine the efficacy of banana water enhanced with calcium carbonate and salt as insect repellant. Specifically, it intended to use salt and calcium carbonate as enhancer of effective banana water insect repellant, quantitatively measure the amount of each component to make an effective insect repellant, and test the efficacy of insect repellant. Banana water was obtained from mature fruit harvested banana and acidified for five days. Banana water, calcium carbonate, and salt were combined at different quantities and prepared four different samples. Sample five was pure banana water and used as the control. One-way repeated measure analysis of variance was used to evaluate the efficacy of each repellant. The dependent variable was rank-transformed ratio of the number of insects repelled vs. the total number of insects in the test. One test was performed for the insects in the port and a second for those in the holding chamber. The test was repeated using the different samples. Dunnett's multiple comparison procedure was used with the untreated zero control sample as the control. Result showed that the efficacy of banana water as insect repellant depends of the quantities of banana water, calcium carbonate, and salt. Sample three was the most effective insect repellant among the four samples measured with absolute difference of 6.25 higher than the computed critical value of 5.47. It was recommended in this research to test the effectivity of the insect repellant to different insects and address other farming interventions.

Keywords: *Bio-minerals, pentatomids, intrusion, repellant*

INTRODUCTION

Today's farming is observed to be vulnerable with the attack of phytophagous insects. Local community vegetable farmers sometimes experience low harvest of some vegetables like talong (eggplant), pechay (snow cabbage), and ampalaya (bitter melon) due to insect bites especially during the early stage of fruiting. Farmers also attest that it is almost unavoidable to apply insecticides to protect the plant from insect's intervention. Research findings shows that inorganic pesticide causes environmental degradation and health hazard (Mueller, 2016). At present, farmers are encouraged to use organic pesticide to address the problem they encounter with insect bites on vegetables. Some organic pesticides are made from plants. Most plants contain chemicals that prevent attack of insects. These chemicals fall into several categories, including repellants, feeding deterrents, toxins, and growth regulators (Johnson et.al., 2015).

These can be grouped into five major chemical categories: (1) nitrogen compounds (primarily alkaloids), (2) terpenoids, (3) phenolics, (4) proteinase inhibitors, and (5) growth regulators. According to Gerzhenson (2012), although the primary functions of these compounds is defense against phytophagous insects which feeds on green plants, many are also effective against mosquitoes and other biting Diptera, especially those volatile components released as a consequence of herbivory.

The effectivity of organic insecticide can be measured in terms of alkaloid content of some plant leaves. This is the reason why it is a good option to use plant extract in making organic insecticide that is less harmful to the environment. Banana water has been found to contain inulin, a fructan-type polysaccharide, consists of (2→1) linked β-D-fructosyl residues (*n* = 2–60), usually with an (1↔2) α-D-glucose end group. Inulin and its hydrolyzed form oligofructose (*n* = 2–10) have diverse applications. Food industry widely used inulin to modify texture, replace fat or as low-calorie sweetener. There are several applications in other fields like pharmacy (Kazama et.al., 2020). According to Pascual (2010) banana water is also rich in chemical alkaloid which lead towards the potential of using this organic substance in making an effective and non-hazardous insecticide. Preventive use of inorganic chemicals in farming also address climate change (Martius, 2022).

Tannins of green banana ranges from 122.4 mg to 241.4 mg. Condensed tannins were found to contain in the cell walls, which are a suitable source of natural antioxidant that is biologically accessible in the stomach (Perry, 2017). Plant react to herbivory through a different mechanism such as morphological, biochemical and molecular to fight the effect of herbivore attack. (PSB, 2012). The defense weapons of plants on herbivore are the anti-nutritional factors such as tannin. Tannin's beneficial effect depends on their concentration. High levels of tannin cause negative effects lessen nutrient utilization and animal productivity, and death in certain animals (Ware, 2017). Tannins are water-soluble plant polyphenols that precipitate proteins. Anti-irritant, anti-secretolytic, anti-phologistic, anti-microbal, and anti-parasitic are the various physiological effect of tannins. High tannin concentrations resulted in lessen animal performances and health disorders as in monogastriers (Wochenschr, 2006).

Calcium carbonate ($CaCO_3$) is one of the most abundant bio-minerals and it has attracted considerable attention as smart low price material in many research and development fields. The properties and applications of $CaCO_3$ depend on its morphology, particles size, crystal phase and growth. Calcium carbonate has been widely investigated for different research and industrial aims. Calcium carbonate has no toxicity and its use was exploited for many applications in cosmetics, medicine and agro-food industry (Boyjoo, 2014). Calcium carbonate has been found effective ingredient in making organic pesticides. Usually, plant pathogens and pests are controlled by massive pesticide applications, 90 % of which are dispersed into the environment during application and following leaching phenomena. These critical issues have great negative impact on environmental and economic sustainability of the food chain production. Furthermore, the intense use of pesticides is known to cause pathogen resistance phenomena (Fay & Xianming, 2012). In this context, sustainable management of crops is essential and the use of calcium carbonate as a component of insecticide may represent valuable solutions to enhance plants growth and improve resistance and control ensuring low environmental impact. Nano-materials found in calcium carbonate provide many benefits such as improvement of efficacy due to higher surface area, higher bio-availability, lower toxicity and in situ gradual calcium release. The large surface/volume ratio and pesticides. Different nano-carriers have proved to be suitable for slow release of agrochemicals ensuring protection from chemical and biological degradation. Metal-based materials such as metal nano-oxides or nanocomposites are among the most investigated antimicrobial products. Another type of nanomaterials with a strong antibacterial activity are nano-TiO_2, alumina particles and Cu compounds, which are exploited as antibacterial and antifungal substances for crop disease control (Khan, 2015). However, the application of metal-based phyto-drugs turned out to produce damages under some conditions and toxic on the plants and environment. Some studies shown damages to plants cells following metal nanoparticles uptake, such as Zn, Ag and Cu NPs (Wang, 2016).

Salt solutions have traditionally been used against ants and caterpillars (Baker and Grant, 2020). In addition, sodium chloride is a common inert ingredient in many insecticide formulations, where it shows synergistic effects, increases buffering and solubility, and acts as a diluent. Ivan Corso (2017) in the study “Sodium Chloride: An Insecticide Enhancer for Controlling Pentatomids on Soybeans” concluded that sodium chloride is an efficient insecticide enhancer for controlling pentatomids on soybeans, leading to the reduction of monocrotophos and metamidophos, a broad spectrum used to control the pests in cotton, insecticides that do not have good activity allows the transport of higher concentrations of active substance to the target reducing the amount of pesticide required for pest control. Different nanostructured materials, nanoparticles, nano-clays and nano-emulsions, are used in agro-food industry. Smart delivery systems are exploited for the controlled release of fertilizers, fungicides, insecticides, herbicides,

against stink bugs are not enhanced by NaCl addition, and stink bugs are not attracted to soybeans where an insecticide plus sodium chloride is applied. Pentatomids are insects belonging to hemipteran generally called shield bugs (Floros et. al., 2018)

For farmers and gardeners, pesticides are important part of the growing process and help protect and maintain crops throughout farming and planting. The key difference between organic pesticides versus traditional chemical pesticides is that organic pesticides use chemicals that occur naturally instead of ones that are synthetically man-made. People who garden organically start from the soil-up, focusing first on growing healthy plants by improving the soil with organic material such as homemade insecticide.

This research generally aimed to determine the efficacy of banana water enhanced with calcium carbonate and salt as insect repellant. Specifically, it intends to, a. conduct different trials and test the repelling action of the insect repellant from banana water enhanced with calcium carbonate and salt, b. determine the significance of insect repellant using the calculated Dunnett’s critical value. Research also showed that there is no study yet conducted on the efficacy of banana water enhanced with calcium carbonate and salt as insect repellant.

The following hypotheses were tested and also served as guide in the attainment of the research objectives.

Ho_1 Sample 1 is effective than sample 2, sample 3, and sample 4.
Ho_2 Sample2 is effective than sample 1, sample 3, and sample 4.
Ho_3 Sample 3 is effective than sample 1, sample 2, and sample 4.
Ho_4 Sample 4 is effective than sample1, sample 2, and sample 3.

METHODOLOGY

Collection of Banana Water

Matured and fruit harvested banana *Musa acuminata* x balbisiana (saba) was cut six inches from the surface of the soil. Three inches' concave was drawn from the top of cut banana to serve as a catch basin of the upwelling banana water. Cellophane was used to cover the basin and left for three days to optimize the amount of water. The collected banana water was kept in a sealed container and cured for five days to enhance the level of acidity. In the study of Dineros (2015), curing of banana water in a sealed container for at least three days improved its acid level. The pH level increased from 6.5 to 4.7 after five days of storing in a sealed container. This was determined using a pH meter. This acidity is ideally important in preventing excessive formation of coagulants in a solution with other carbonates such calcium carbonate which was used as enhancer in this insecticide. After five days, banana water was filtered using a clean cloth to remove impurities.

Formulation of Different Samples.

Filtered banana water was mixed with calcium carbonate ($CaCO_3$), and sodium chloride (NaCl) at different quantities. Banana water was measured in milliliter unit while calcium carbonate and salt were measured in gram unit. Salt was mixed first in banana water and stirred thoroughly. Calcium carbonate was later added to the mixture and stirred until totally dissolved. The mixture was kept in a sealed container at room temperature. Four samples with different quantities were prepared for the test/trial.

Table 1
Sample Formulation

Sample	Banana Water (mL)	Calcium Carbonate $CaCO_3$ (g)	Salt NaCl (g)
1	300	50	20
2	300	100	30
3	300	150	40
4	300	200	50
5*	300	0	0

* *control sample*

Table 1 shows that sample 1 is a combination of 300 mL banana water, 50 grams' calcium carbonate, and 20 grams of salt with 3.25 average number of repelled insects. Sample 2 is a combination of 300 mL of banana water, 100 g of calcium carbonate, 30 grams of salt 2.25 average number of repelled insects. Sample 3 is a mixture of 300 mL banana water, 150 grams' calcium carbonate, 40 grams of salt with 6.25 average number of repelled insects. Sample 4 is a mixture of 300 mL banana water, 200 grams of calcium carbonate, and 50 grams of salt with 2.50 average number of repelled insects. Sample 5 is the control sample made of banana water only. The

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control sample was used to calculate the absolute difference and determine the significance of other samples.

Efficacy Test

Four different trials for each sample were conducted to observe the efficacy of the insect repellant. Seven beetle insects were placed in the port. Upon spraying with the sample, some insects flew out of the port to the chamber without turning back which signaled the completion of the repelling action. Number of repelled insects were counted and recorded under each trial.

Statistical Treatment

One-way repeated measure analysis of variance was used to evaluate the efficacy of each repellent. The dependent variable was rank-transformed ratio of the number of insects repelled vs. the total number of insects in the test. One test was performed for the insects in the port and a second for those in the holding chamber. The test was repeated using the different samples. Dunnett's multiple comparison procedure was used, with the untreated zero control sample as the control.

Dunnett's Critical value: $t_d\sqrt{MS_w/n}$

where:

t_d Value found in Dunnett's Table for a given alpha level, number of groups, and group sample sizes.
MS_w Mean Squares of the "Within Group" in the ANOVA output table
n Size of the group samples

RESULTS and DISCUSSIONS

Objective 1. On different trials and repelling action of insect repellant.

Table 2
Trials, and Number of Repelled Insects

Sample	Number of Insects in the Chamber	Number of Repelled Insects			
		T_1	T_2	T_3	T_4
1	7	4	5	2	3
2	7	3	1	2	3
3	7	6	7	6	6
4	7	2	2	3	3
5*	7	0	0	0	0

Table 2 shows the different trials and number of repelled insects using each sample. Seven insects were used in each chamber for the test. Using sample 1, 4 insects were repelled in trial 1, 5 insects were repelled in trial 2, 2 insects were repelled in trial 3, and 3 insects were repelled in trial 4. Using sample 2, 3 insects were repelled in trial 1, 1 insect was repelled in trial 2, 2 insects were repelled in trial 3, and 3 insects were repelled in trial 4. Using sample 3, 6 insects were repelled in trial 1, 7 insects were repelled in trial 2, and six insects were repelled in trial 3 and trial 4. Control sample 5 has zero repelled insects being the control with banana water only without the calcium carbonate and salt. The repelling actions of different samples were based from the amount of calcium carbonate and salt added to banana water. As shown in the table, sample 3 exhibits the ideal concentration of insect repellant which repelled the greater average number of beetle insect as compared to the other samples.

Objective 2. On the determination of the significance of insect repellant using the calculated Dunnett's critical value

Table 3
Mean Square of the Samples

Sample	Average Number of Repelled Insects	Mean Square
1	3.50	3.52
2	2.25	4.15
3	6.25	13.11
4	2.5	3.78
5*	0	0
Average	3.63	6.14

Table 3 shows the mean square of the samples calculated from the average number of repelled insects in each sample and the average number of repelled insects of all the samples including the control. Sample 1 has an average number of repelled insects of 3.50 and a mean square of 3.52. Sample 2 has an average number of repelled insects of 2.25 and a mean square of 4.15. Sample 3 has an average number of repelled insects of 6.25 and a mean square of 13.11, while sample 4 has an average number of repelled insects of 2.5 and a mean square of 3.78. The average number of repelled insects of all samples was 3.63 that was used to calculate the mean square of each sample while the average mean square was 6.14 used to determine the Dunnett's critical value. The control has zero mean square since it has zero number of repelled insects.

Table 4
Dunnett's Critical Value

α	Size of Sample n	Total Number of Samples	Dunnett's Table Equivalent	Calculated Dunnett's Critical Value
0.05	7	5	3.12	5.47

As gleaned in table 4, using the cronbach's alpha of 0.05 at sample size of 7 and total number of sample of 5 with the Dunnett's table equivalence of 3.12, the computed critical value was 5.47. This critical value was used to determine the significance of the sample.

Table 5
Absolute Difference Between the Study and Control Sample

Sample	|Study Sample –Control Sample|	Absolute Difference	Significance
1	3.50-0	3.50	Not Significant

2	2.25-0	2.25	Not Significant
3	6.25-0	6.25	Significant
4	2.5--0	2.50	Not significant

Table 5 shows that using the study sample and the control sample, the absolute difference was computed. The absolute difference of sample 1 is 3.50, sample 2 is 2.25, sample 3 is 6.25, while sample 4 is 2.50. It shows that the absolute difference of sample 3 of 6.25 exceeds the computed critical value of 5.47. Thus, sample 3 was the significant sample which indicated the most effective insect repellant among others. The absolute difference was used to determine the significance of the sample in accordance with Dunnett's critical value.

Conclusion

Based from the result, banana water can be used as effective repellant. The addition of specific amount of calcium carbonate and salt increased the effectivity of banana water insect repellant. Effective repellant from banana water, calcium carbonate, and salt depends on the quantities of the components. Sample 3 which was a combination of 300 mL banana water, 150 grams' calcium carbonate, and 40 grams of salt was found to be the most effective among the samples. The effectivity was measured based from the average number of repelled insects and computed absolute difference of the study and control sample of 6.25 higher than the calculated Dunnett's critical value of 5.47. Hypotheses 1,2, and 4 were rejected while hypothesis 3 was accepted based from the calculated absolute difference and Dunnett's critical value.

This research is significant in addressing the problem on numerous effects of intrusion of undesirable insects. Farmers will have the alternative ways in handling insect intervention which is one of the causes of low farm harvest. This insect repellant is non-toxic for humans and safe for the environment since it is made from organic materials such as banana water. A clean and safe environment will prevent unwanted insects to spread. This study will also help individuals in finding an alternative organic insecticide without compromising human health.

Recommendation

Future researchers may continue to study about the use of *Musa acuminate L.* water as an alternative insect repellant. Its effectivity to different types of insects will be one of the interesting researches to be done in the future which will address farming intervention. It is also recommended to study the safety of the insect repellant and its application on the produce such as fruits and vegetables.

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