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Biocidal Effect of *Allium sativum* (Garlic) and *Monodora myristica* (African Nutmeg) On *Callosobruchus maculatus* (Bean Weevil)

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ABSTRACT: Pests are estimated to ruin remarkable amount of the world's annual food crop supply before and after harvest, thus necessitating control measures that are proactive, economical, and safe. Consequently, the objective of this paper is to investigate the biocidal effect of *Allium Sativum* (Garlic) and *Monodora Myristica* (African Nutmeg) on *Callosobruchus Maculatus* (Bean Weevil) using appropriate standard techniques. Results obtained show that Pulverised *A. sativum* alone had the highest repellency after 24 hours exposure to *C. maculatus*, while grains treated with one part *A. sativum*, two parts *M. myristica* had the lowest repellency over the same time frame. Similar pattern was observed in mortality trials as *C. maculatus* incurred total mortality with *A. sativum* alone quicker than others. *Allium sativum* without any combinations with *M. myristica* was the most effective for use as a repellent and fumigant. Consequently, its use should be encouraged as a pest deterrent, while further studies should be carried out to ascertain its long term effectiveness as a pest control.

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The United Nations estimates the global population will exceed 10 billion by the year 2100 (Gerland *et al.*, 2014). Currently, the population of Nigeria estimated at 140 million accounts for one-quarter of the population of sub-Sahara Africa or one in every 6 black persons in the world (Elum *et al.*, 2017). However, these statistics are set to soar in the future, resulting in socioeconomic and environmental challenges for future generations (Babanyara *et al.*, 2010). As a result, analysts predict that energy, poverty, and food crises will become recurrent issues in the future (Anger, 2010). In view of the troubling state of things, countries with rising demographics urgently require sustainable strategies to address these issues, particularly the need to meet food requirements of growing demographics (Ruel *et al.*, 2010). Currently, the dilemma facing human civilization is the capacity to enhance sustainable food production and address shortages and wastage (Barrett, 2010). It is estimated that approximately 40% of the yearly crop production is destroyed by pests worldwide prior to harvest (Ivase *et al.*, 2017). Likewise, nearly 20–30% of crops in Nigeria are damaged during post-harvest (Olayemi *et al.*, 2010). Therefore, there is an urgent

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need for advanced food production, pest eradication, and disease management prior to harvest and post-harvest through the adoption of innovative, cost-effective agricultural practices. These efforts will ensure increased crop production and sustainable agriculture (Ivase *et al.,* 2017). Beans (*Vigna unguiculata*) is a food and animal feed crop cultivated in a range of ecologies especially in the savannah region and in the tropics and sub tropics (Wahedi *et al.,* 2014). Beans can also be grown in poor soils with more than 0.2% organic matter and low levels of phosphorus (Singh, 2003). As a grain crop beans is known by different names around the world. In Africa the land of its primary origin, cowpea is known as 'wake' and 'ewa' in much of West Africa and 'kunde' in East Africa (Wahedi *et al.,* 2014). This grain legume is the most economically important African indigenous legume crop (Langyintua *et al.,* 2003). Beans is a major source of dietary protein in tropical and subtropical regions of the world especially where availability and consumption of animal protein is low. It is the most important source of food and fodder in West Africa with 23-25% protein in its grains, and an important source of vitamin B with 62% soluble carbohydrate and small amount of other nutrients (Singh, 2007). Its green peas and dry grains are consumed as food, because of its superior nutritional attributes, adaptability and productivity. Cowpeas are of economic value to humans and livestock but insects such as the bean weevil (*Callosobruchus maculatus*) causes considerable damage to these grains both in the field and storage. Postharvest losses of cowpea due to the bruchid *Callosobruchus maculatus* (F.) constitute a major setback in the storage of this crop (Wahedi *et al.,* 2014). The weevil *Callosobruchus maculatus* (Coleoptera: Chrysomelidae: Bruchinae) is an important pest for stored grains that can cause significant damage to cowpea when left untreated (Gbaye *et al*., 2011). It is the primary storage pest of cowpea, with widespread worldwide occurrence (Ekeh *et al.,* 2013). *C. maculatus* larvae feed on the inside of the grains causing weight losses of up to 80% after six months of storage, where various holes are left by the insects, thereby facilitating the mycotoxin contamination of grain and reducing the commercial value of beans (Kedia *et al*., 2015). The infestations of weevil in cowpea compromise seeds viability, grains physiology, and its nutritional quality, as well as contaminate the product with excrement. Such problems cause qualitative and quantitative losses through, which reduces beans commercial value. Bean weevil causes annual losses between 30 and 50% and sometimes above 90% (Ahmad *et al.,* 2015). The control of this pest in storage systems depends primarily on fumigant insecticides such as deltamethrin, malathion, methyl bromide and phosphine (Manzoomi *et al*., 2010). However, the use of conventional insecticides and fumigant compounds has caused serious side effects such as the selection of specimens resistant to these chemical molecules, toxic waste problems and toxicity for humans and the environment (Mollaei *et al*., 2011). Therefore, there is a need to develop safer alternatives that can reduce the use of conventional insecticides and fumigants for stored products (Jenkins *et al.,* 2003). There are studies in which it was discovered that products derived from plants degrade quickly in the environment and majority are less toxic to mammals, while also being more selective to non-target organisms. There are also reports that state that these products can also delay resistance development of the insect plague (Rahman and Talukder, 2006). Despite global acceptance and utilization, biopesticide penetration remains low, particularly in developing agrarian countries like Nigeria. This is mostly due to widely reported issues such as the high cost, poor efficacy, and inconsistent field performance associated with biopesticide utilization (Glare *et al.,* 2012). In addition, lack of knowledge, cohesive advocacy, and other factors have conspired to limit biopesticide use in Nigeria – and Africa in general. Garlic, *Allium sativum*, is a cosmopolitan plant. It is an herbaceous biennial plant, characterized by its penetrating fragrance. It is a seasoning for soups and sauces and its oil is a flavouring agent. Medically, the bulb is used for reviving convulsive patients, cure for hemorrhoids and diuretic in Nigeria (Ileke and Olotuah, 2012). The pesticidal activities of garlic as a repellent, antifeedant, bactericide, fungicide and nematicide have been reported (Denloye, 2010; Ileke and Olotuah, 2012). African nutmeg, *Monodora myristica*, is a tropical tree of the family Annonaceae. The seed is used as popular spices in West Africa dish. It is also used for medicinal purposes and as well as insect repellent (Obembe and Kayode, 2018). Although various studies have been carried out to assess the insecticidal properties of these plants, the information regarding their use in the control of the bean weevil is near to non- existent hence this study aims to give an insight into this lacking area. Consequently, the objective of this paper is to investigate the biocidal effect of *Allium Sativum* (Garlic) and *Monodora Myristica* (African Nutmeg) on *Callosobruchus Maculatus* (Bean Weevil)

MATERIALS AND METHODS

Study Site: The research was executed at the Animal and Environmental Biology laboratory situated in life sciences at the University of Benin in Benin City. Here, the ambient temperature varies between 32℃ and 65% relative humidity on average. Each setup was executed using a complete randomized design. Repellency tests were investigated using paired-

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choice trial but not for mortality test.

Test Materials (Plants And Insects): Allium sativa and *Monodora myristica* were obtained from the New Benin market in Benin City. *Allium sativa* (Amaryllidaceae) was peeled and sliced into thin layers and air-dried, while the seeds of *M. myristica* (*Annonaceae*) was air-dried and pulverization thereafter. The resultant powders were properly labelled and stored in airtight jars until the bioassay was conducted using wholesome cowpea seeds. Prior to performing the bioassay, they were thoroughly washed in water to remove any foreign substances that might have hampered the performance of the test insects. Before storing them in airtight jars, all seeds were further oven- sterilized at 60 °C for 4 hours to destroy any *C. maculatus* larvae that may have been growing inside the seeds. The cowpea came from Benin City, the test insects were procured locally. *C. maculatus* was raised in plastic jars with lids that were screened with muslin nets for ventilation in a climate-controlled laboratory environment. Prior to the bioassays, the parent beetles were sieved, and the offspring of a specific age in days were employed for the studies in preparation for the various bioassays.

Experimental Structure: The study's experimental jars came in two varieties: (a) one for repellency, and (b) mortality (Figure 1). Type 'a' was created from two PET bottles that were joined together after having the bases of each separated (Figure 1(a1)) and was only utilized for the repellency experiment. After introducing insects through those openings, the bottles' respective lids were placed on each of their ends. The mortality trials employed type "b". The containers were made of cylindrical plastic with a secure lid (Figure 1(b1)).

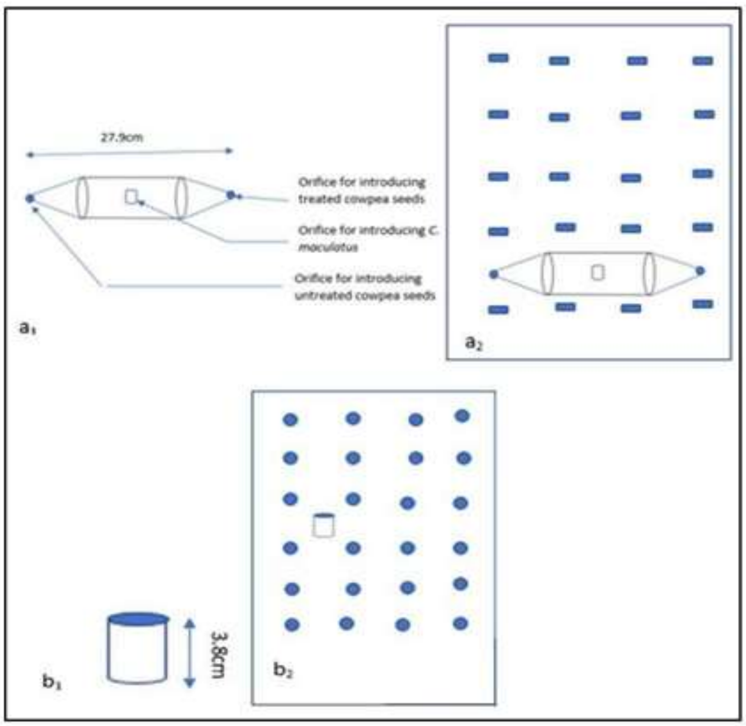

Fig.1: Schematic Representation Of The Experiment (Mgbemere, 2021)

Table 1: Different botanicals used for mixing treatments and their mixing ratios

Treatments	Mixing Ratio	*Monodora myristica*(m)	*Allium sativum*(a)
Monodora myristica	1:0	30	-
Allium sativum	0:1	-	30
Monodora myristica$_1$ + *Allium sativum*$_1$	1:1	15	15
Monodora myristica $_2$ + *Alliumsativum*$_1$	2:1	20	10
Monodora myristica$_1$ + *Allium sativum*$_2$	1:2	10	20

Note: Present in the figure are (a1): the fabricated PET-bottle designed for repellency trials with 3 openings: two at opposite sides for (treated and untreated) grain, and one at the middle for introduction of the test insect, C. maculatus; (a2): the repellency test arena with 20 units of five treatments and four replicates; (b1) represents a typical jar used for mortality trials; (b2) the mortality trials had 24 units

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with six treatments and four replications.

Five pulverized plant materials (botanicals) total, derived from two plants, were employed in the experiment, to ensure a homogenous combination of treatments is obtained, the treatment was weighed using an electronic weighing scale and properly mixed in a jar. The various botanicals utilized for each therapy and their mixing ratios are detailed in Table 1.

Experimental design: Each parameter underwent a different experimental procedure. To increase the accuracy of the results, each experiment had four replications, and the design was entirely random.

Repellency: In the PET-bottle paired-choice arena, sterilized cowpea seeds were introduced from one end of the opening and subsequently given various treatments, while untreated but sterilized cowpea seeds were then inserted from the other end. The apertures were then sealed after the beetles had been injected through the center opening, evenly spaced from the treated and untreated grains (Fig.1ij(a2)). Beetles on either side of the jar were counted and recorded after one hour, two hours, four hours, and 24 hours of the arrangement being watched.

*Mortalit**y:*** Ten cowpea seeds per container were added to the setup after being subjected to five different botanical treatments. The containers also contained 10 untreated cowpea seeds that were labeled "control" and were distributed at the same rate as the treated seeds. After ten 1-day-old, unsexed weevils were put to each container, the time was taken. Every 24 hours, the number of dead weevils was counted.

Data analysis: Statistical analyses were run using Statistical Package for the Social Sciences and R software. The data were assessed for normality and homogeneity of variance using the Shapiro-Wilk's test and Levene's test. Student T-statistic was used to analyze all data that satisfy the assumptions of parametric test at significance level of 5%.

RESULTS AND DISCUSSION

The study evaluated the repellent and biocidal effects of *Allium sativum* and *Monodora myristica* against *Callosobruchus maculatus*. *Allium sativum* demonstrated superior repellency and rapid mortality, achieving 100% mortality in 120 hours. In contrast, *Monodora myristica* alone and in various mixtures with *A. sativum* showed less efficacy, with some mixtures even attracting more beetles rather than repelling them. The combination of one part *M. myristica* and two parts *A. sativum* was effective but less efficient compared to *A. sativum* alone. Overall, *A. sativum* proved to be the most effective for pest management, highlighting the importance of its use in pest control strategies.

Repellency: Cowpea grains treated with *Allium sativum* exhibited the highest repellency among all treatments assessed in this study. This was followed by grains treated with *Monodora myristica*, and then by combinations of *Monodora myristica* and *Allium sativum* in the following order: 1:1, 1:2, and 2:1, respectively. The 2:1 ratio of *Monodora myristica* to *Allium sativum* displayed the least repellency.

Repellency Of Monodora Myristica On Callosobruchus Maculatus: Cowpea grains treated with pulverised seed powder of *Monodora myristica* in a pair choice experiment attracted significantly (Student T-statistic = 3.46; df = 6; p-value = 0.0134) more *Callosobruchus maculatus* with an average of 6.0 ± 0.4 individuals than the untreated grains, which had an average of 4.0 ± 0.4 individuals of *Callosobruchus maculatus* after one hour (Table 2). After four hours, the attraction increased to an average of 6.3 ± 0.5 individuals in treated grains, with this attraction being significant (Student T-statistic = 1.59; p-value = 0.0102). After 24 hours, the attraction in the treated grains was significantly (Student T-statistic = -2.45; p-value = 0.0498) less for *Callosobruchus maculatus* with an average of 4.5 ± 0.3 individuals than the untreated grains, with an average of 5.5 ± 0.3 individuals (Table 2). The results indicate that *Monodora myristica* exhibits weak repellent properties against *Callosobruchus maculatus* in the early hours of exposure. Initially, the pulverized seed powder of *M. myristica* actually attracted more beetles compared to the untreated grains, with significant differences observed within the first hour and continuing for up to four hours. This attraction suggests that *M. myristica* may not be effective as a repellent in the critical initial period, which is essential for preventing pest damage. After 24 hours, the results show a reversal, with fewer beetles being attracted to the treated grains compared to the untreated ones. However, this delayed repellency is inadequate for effective pest management, as the beetles might have already caused damage or laid eggs during the initial hours. The poor repellent performance of *M. myristica* could be attributed to the loss of its aromatic compounds when pulverized, as these compounds are likely responsible for any repellent effects (Edwin and Fidelis, 2019). This aligns with previous observations that *M. myristica*'s efficacy diminishes when its volatile compounds are lost, highlighting its limitations as a standalone repellent.

Repellency Of Allium Sativum On C. Maculatus:

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Cowpea grains significantly repelled *C. maculatus* in treated grains after 1- and 24-hour's exposure in a paired choice trial (Student T-statistic = -3.46 and -7.07; p-value = 0.0134 and 0.0004, respectively) with an average of 4.0 ± 0.4 and 3.8 ± 0.3 individuals in treated grains while untreated grains had 6.0 ± 0.4 and 6.3 ± 0.3 after 1 and 24 hours, respectively. After two hours, cowpea grains repelled more *Callosobruchus maculatus* in treated grains as well but this repellency was not significant (Student T-statistic = -0.56; p-value = 0.5945). Nonetheless, after four hours after commencement, neither attraction nor repellency in treated and untreated cowpea grains was observed as both had an average of 5.0 ± 0.7 individuals in treated and untreated grains (Table 2). The results demonstrate that *Allium sativum* is an effective repellent against *Callosobruchus maculatus* in treated cowpea grains. Significant repellency was observed after both 1 and 24 hours of exposure, with treated grains attracting significantly fewer beetles than untreated grains. This strong repellent effect within the first hour is crucial for preventing immediate pest damage and suggests that *A. sativum* is highly effective in deterring *C. maculatus*. While the repellency was not statistically significant after two hours, and no difference was observed between treated and untreated grains after four hours, the overall pattern still supports *A. sativum*'s effectiveness. The temporary loss of significant repellency might be due to fluctuations in the release or perception of the repellent compounds, but the marked repellency after 24 hours reinforces its potential use in pest management strategies. The superior performance of *A. sativum* aligns with its known repellent properties, likely due to the presence of sulfur compounds that contribute to its strong odor (Edwin and Fidelis, 2019). This study confirms that *A. sativum* can effectively reduce the presence of *C. maculatus* in stored grains, making it a reliable option for protecting cowpea from infestations.

Repellency Of Even Mixture Of Monodora Myristica And Allium Sativum On Callosobruchus Maculatus: Cowpea grains treated with an even mixture of *Monodora myristica* and *Allium sativum* attracted more *Callosobruchus maculatus* after one, two and four hours than in untreated grains with an average of 6.0 ± 0.4, 5.3 ± 0.9 and 5.3 ± 0.6 individuals, respectively, in treated grains and an average of 4.0 ± 0.4, 4.8 ± 0.9 and 4.8 ± 0.6 individuals, respectively, in untreated grains. The repellency after one, two and four hours was significant only after one hour (Student T-test = 3.46, 0.41 and 0.56; p-value = 0.0134, 0.6932 and 0.5945, respectively). After 24 hours, grains treated with an even mixture of *Monodora myristica* and *Allium sativum* attracted less *Callosobruchus maculatus*. This repellency was not significant (Student T-test =-0.82; p-value = 0.4454), with an average of 4.5 ± 0.9 individuals in treated grains and 5.5 ±0.9 individuals in untreated grains (Table 2). The results show that an even mixture of *Monodora myristica* and *Allium sativum* was not particularly effective as a repellent against *Callosobruchus maculatus*. In fact, during the first one to four hours, the treated grains attracted more beetles than the untreated grains, with the repellency being significant only in the first hour. This suggests that the combination may reduce the repellent effectiveness of *A. sativum*, possibly due to an interaction between the compounds in both plants.After 24 hours, the mixture did show some repellent effect, with fewer beetles attracted to the treated grains compared to the untreated grains, but this difference was not statistically significant. This weak repellency indicates that the even mixture does not enhance the repellent properties and may even diminish them, particularly in the critical early hours where immediate pest deterrence is necessary.The results support the conclusion that *Allium sativum* is more effective when used alone rather than in combination with *Monodora myristica*, as the mixture's repellent efficacy was compromised. This could be due to the dilution of *A. sativum*'s active compounds or the interference of *M. myristica*'s less effective repellent components. Thus, for effective pest management, it is advisable to use *A. sativum* alone or in higher concentration rather than in an even mixture with *M. myristica*.

Repellency Of One Part Monodora Myristica And Two Parts Allium Sativum On Callosobruchus Maculatus: Cowpea grains treated with one part *Monodora myristica* and two parts *Allium sativum* repelled more *Callosobruchus maculatus* after one and four hours than untreated grains. The repellency was only significant after four hours (Student T-statistic = -0.74 and -2.45; p-value = 0.4881 and 0.0498, respectively). Grains treated with one part *Monodora myristica* and two parts *Allium sativum* showed neither attraction nor repellency more than untreated grains after 2 and 24 hours. The average individuals in treated grains after 1, 2, 4 and 24 hours were 4.8 ± 0.5, 5.0 ± 0.7, 4.5 ± 0.3 and 5.0 ± 0.7 respectively while untreated grains had an average of 5.3 ± 0.5, 5.0 ± 0.7, 5.5 ± 0.3 and 5.0 ± 0.7 individuals (Table 2). The results reveal that a mixture of one part *Monodora myristica* and two parts *Allium sativum* has some repellent effect against *Callosobruchus maculatus*, particularly noticeable after four hours. The significant repellency after four hours suggests that while the mixture provides some level of pest deterrence, its effectiveness is not immediate. The repellency was not significant after one hour, indicating that the mixture does not offer

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strong initial protection. After two and 24 hours, the treated grains did not show any significant difference in attraction or repellency compared to untreated grains. This suggests that while the mixture may have some repellent properties, they are not as pronounced or consistent as those observed with *A. sativum* alone. The results indicate that the mixture of one part *M. myristica* and two parts *A. sativum* provides a moderate level of repellency but lacks the immediate and strong repellent effect that*A. sativum* alone offers. This supports the notion that *A. sativum* is more effective as a repellent when used alone or in higher proportions relative to *M. myristica*. The mixed formulation may not be as practical for effective pest management compared to using *A. sativum* alone.

Repellency Of One Part Allium Sativum And Two Parts Monodora Myristica On Callosobruchus Maculatus: Cowpea grains treated with one part *Allium sativum* and two parts *Monodora myristica* significantly attracted more *Callosobruchus maculatus* after 1, 2, 4 and 24 hours (Student T-statistic = p-value = 0.0167, 0.0167, 0.0134 and 0.0003, respectively). The average individuals in treated grains were 4.0 ± 0.4, 4.8 ± 0.6, 5.0 ± 0.7 and 3.8 ± 0.3 after 1, 2, 4 and 24 hours, respectively while the average individuals in untreated grains were 3.5 ± 0.7, 3.5 ± 0.7, 4.0 ± 0.4 and 3.5 ± 0.3 after 1, 2, 4 and 24 hours, respectively (Table 1). The results show that a mixture of one part *Allium sativum* and two parts *Monodora myristica* resulted in increased attraction of *Callosobruchus maculatus* across all time intervals (1, 2, 4, and 24 hours). This increased attraction is statistically significant, indicating that this mixture is not effective as a repellent. In fact, the treated grains attracted more beetles than the untreated grains at all observed times. The observed attraction may be due to the dominance of *M. myristica*'s less effective repellent properties, which could outweigh the repellent effects of *A. sativum*. This result is consistent with the notion that *M. myristica* can impair the repellent effectiveness of *A. sativum* when used in higher proportions (Edwin and Fidelis, 2019). The mixture's failure to repel *C. maculatus* suggests that using *M. myristica* in higher amounts, even with *A. sativum*, may not be suitable for effective pest management. In summary, this mixture is not recommended for repelling *C. maculatus*, as it appears to attract the pests rather than deter them. For effective control, *A. sativum* should be used alone or in combinations that favor its higher concentration.

Table 2: Effect of *Allium sativum* and *Monodora myristica* on the repellency of *Callosobruchus maculatus* (Sample size, n = 4; degree of freedom, df = 6)

Treatment Type	Mean ± SE			
	One hour	Two hours	Four hours	24 hours
Monodora myristica Treated	6.0 ± 0.4	6.3 ± 1.1	6.3 ± 0.5	4.5 ± 0.3
Untreated	4.0 ± 0.4	3.8 ± 1.1	3.8 ± 0.5	5.5 ± 0.3
Student T- statistic	3.46	1.59	3.69	-2.45
Probability value	0.0134	0.1619	0.0102	0.0498
CI95%	0.59 - 3.41	-1.33 - 6.34	0.84 - 4.16	-2.00 - -0.00
Allium sativum Treated	4.0 ± 0.4	4.8 ± 0.6	5.0 ± 0.7	3.8 ± 0.3
Untreated	6.0 ± 0.4	5.3 ± 0.6	5.0 ± 0.7	6.3 ± 0.3
Student T- statistic	-3.46	-0.56	0.00	-7.07
Probability value	0.0134	0.5945	1.0000	0.0004
CI95%	-3.41 - -0.59	-2.68 - 1.67	-2.45 - 2.45	-3.37 - -1.63
Monodora myristica 1 Treated	6.0 ± 0.4	5.3 ± 0.9	5.3 ± 0.6	4.5 ± 0.9
*Allium sativum*1 Untreated	4.0 ± 0.4	4.8 ± 0.9	4.8 ± 0.6	5.5 ± 0.9
Student T- statistic	3.46	0.41	0.56	-0.82
Probability value	0.0134	0.6932	0.5945	0.4454
CI95%	0.59 - 3.41	-2.45 - 3.45	-1.68 - 2.68	-4.00 - 2.00
Monodora myristica 1 Treated	4.8 ± 0.5	5.0 ± 0.7	4.5 ± 0.3	5.0 ± 0.7
*Allium sativum*2 Untreated	5.3 ± 0.5	5.0 ± 0.7	5.5 ± 0.3	5.0 ± 0.7
Student T- statistic	-0.74	0.00	-2.45	0.00
Probability value	0.4881	1.0000	0.0498	1.0000
CI95%	-2.15 - 1.16	-2.45 - 2.45	-2.00 - -0.00	-2.45 - 2.45
Monodora myristica 2 Treated	6.5 ± 0.7	6.5 ± 0.7	6.0 ± 0.4	6.5 ± 0.3
*Allium sativum*1Untreated	3.5 ± 0.7	3.5 ± 0.7	4.0 ± 0.4	3.5 ± 0.3
Student T-	3.29	3.29	3.46	7.35
Statistical Probability value	0.0167	0.0167	0.0134	0.0003
CI95%	0.77 - 5.23	0.77 - 5.23	0.59 - 3.41	2.00 - 4.00

Survival Of Callosobruchus Maculatus Exposed To Monodora Myristica And Allium Sativum: Mortality of *Callosobruchus maculatus* exposed to *Monodora myristica* and *Allium sativum* and their different combinations was significantly different from the control after 48, 72, 96, 120, 144, 168 and 192 hours (p-value = 0.0221, 0.0017, 0.0037, 0.0065, 0.0155, 0.0034 and 0.0004, respectively). *Callosobruchus maculatus* exposed to *Allium sativum* alone were the quickest to reach 100% mortality (120 hours). These were followed by *Monodora myristica* alone and one part *Allium sativum* and two parts *Monodora myristica* (*Monodora myristica* 1 *Allium sativum*2) (168 hours). *Callosobruchus maculatus* exposed to an even mixture of *Monodora myristica* and *Allium sativum* as well as one-part *Monodora myristica* and two parts *Allium sativum* took the longest to reach 100% mortality (192 hours) (Table 3). The survival analysis indicates that Allium sativum alone was the most effective in causing rapid mortality of Callosobruchus maculatus, reaching 100% mortality within 120 hours. This aligns with the known biocidal properties of A. sativum, which are likely due to its potent sulfur compounds that cause significant harm to the pests (Edwin and Jacob, 2017).Monodora myristica alone and the mixture of one part A. sativum with two parts M. myristica were also effective but required more time, reaching 100% mortality after 168 hours. This suggests that while M. myristica has some biocidal activity, it is less effective compared to A. sativum. The combination of one part M. myristica with two parts A. sativum might benefit from the presence of A. sativum's potent compounds, although it still does not match the efficacy of A. sativum alone.The even mixture of M. myristica and A. sativum, as well as the mixture of one part M. myristica with two parts A. sativum, took the longest to reach 100% mortality (192 hours). This prolonged time to achieve full mortality may be due to the dilution of A. sativum's potent biocidal effects or the compromised efficacy of M. myristica. Overall, these findings highlight that A. sativum alone is the most effective for rapid and complete pest control, while the mixtures, particularly those involving higher proportions of M. myristica, are less effective and take longer to achieve similar outcomes. For efficient pest management, A. sativum should be considered as a primary treatment.

Table 3: Effect of *Allium sativum* and *Monodora myristica* on the survival of *Callosobruchus maculatus*

Duration (hours)	Treatment (Mean ± SE) Probability						
	Control	*A. sativum*	*M. myristica*	*M. myristica*1 + *A. sativum*1	*M. myristica*1+ *A. sativum*2	*M. myristica*2 + *A. sativum*1	value
24	0.00 ± 0.00^{a}	0.50 ± 0.29^{a}	0.00 ± 0.00^{a}	0.25 ± 0.25^{a}	0.50 ± 0.2^{a}	0.00 ± 0.00^{a}	0.2191
48	0.00 ± 0.00^{b}	2.50 ± 0.65^{a}	1.50 ± 0.29^{a}	1.75 ± 0.48^{a}	2.50 ± 0.65^{a}	1.00 ± 0.41^{ab}	0.0221*
72	0.00 ± 0.00^{b}	6.75 ± 1.18^{a}	2.00 ± 0.41^{bc}	4.00 ± 0.41^{ac}	4.00 ± 0.41^{ac}	3.25 ± 0.49^{bc}	0.0017**
96	0.50 ± 2.87^{b}	9.25 ± 0.48^{a}	4.50 ± 0.29^{bc}	5.00 ± 0.40^{c}	5.50 ± 0.65^{ac}	5.00 ± 0.41^{c}	0.0037**
120	1.00 ± 0.41^{b}	10.00 ± 0.00^{a}	7.00 ± 1.08^{ac}	6.00 ± 0.91^{bc}	7.25 ± 0.85^{ac}	7.25 ± 1.03^{ac}	0.0065**
144	1.50 ± 0.29^{b}	10.00 ± 0.00^{a}	9.00 ± 0.58^{a}	9.25 ± 0.48^{a}	8.75 ± 0.48^{ab}	9.50 ± 0.50^{a}	0.0155*
168	2.00 ± 0.41^{a}	10.00 ± 0.00^{b}	10.00 ± 0.00^{a}	9.75 ± 0.25^{a}	9.75 ± 0.25^{a}	10.00 ± 0.00^{a}	0.0034**
192	2.75 ± 0.48^{a}	10.00 ± 0.00^{b}	10.00 ± 0.00^{a}	10.00 ± 0.00^{a}	10.00 ± 0.00^{a}	10.00 ± 0.00^{a}	0.0004***

Note: Rows followed by similar superscripts are not significantly different ($p < 0.05$)

Conclusion: In conclusion, this study assessed the insecticidal effect of *Allium sativum* and *Monodora myristica* on *Callosobruchus maculatus* and found higher potency of *A. sativum* than *M. myristica*. Given that botanicals are vital products against stored product pests, attempts to combine plant extract should be tested before actual implement to avoid undesirable antagonistic outcomes which defeats the purpose of the management strategies *ab initio.* Here the two plants and their combinations exhibited different degree of repellency and lethality on *C. maculatus*. *Allium sativum* without any combinations with *M. myristica* was the most effective for use as a repellent and fumigant against stored product pests, especially *C. maculatus*. The use of *Allium sativum* should be encouraged among stored product managers as a pest deterrent; however, more studies should be carried out to ascertain its long term effectiveness in pest control.

Declaration of Conflict of Interest: The authors declare no conflict of interest (if none).

Data Availability Statement: Data are available upon request from the first author or corresponding author or any of the other authors

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