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Biopesticidal efficacy of tobacco decoction, neem oil emulsion, and betel leaf extract on odoiporus longicollis oliver (Coleoptera: Curculionidae)

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Abstract
The banana pseudostem weevil, also known as *Odoiporus longicollis* Oliver, is a significant pest of banana Plantation in Southeast Asia and is widely distributed in India. Since numerous plants and their extracts have been utilized for crop protection in traditional farming practices, it is generally acknowledged that nature can offer solutions to crop protection problems. This study examines the biopesticidal properties of betel leaf extract, neem oil emulsion, and tobacco decoction on *Odoiporus longicollis*. For this, the life cycle of *O. longicollis* was studied, and biopesticides designed to assess the LC50, repellency, settling reaction, and mortality rate were applied to the adults. The outcomes made it abundantly evident that the neem oil emulsion is an effective biopesticide against *O. longicollis*. Even though betel leaf extract is the least effective of the three biopesticides that were developed, research on it are nevertheless important since they reveal that, at higher concentrations, the extract can still be effective in controlling pests. The previous research on *O. longicollis* is insufficient, especially when it comes to the use of biopesticides. To close information gaps and offer a methodical approach to pest management, the current study set out to determine the concentration of bio-pesticide required to control *Odoiporus longicollis* successfully.

Keywords: *Odoiporus longicollis*, pseudostem weevil, biopesticide, tobacco decoction, neem oil emulsion and betel leaf extract

Introduction
Banana is the most cultivated agricultural food crop in all over the world which is commonly grown in Southeast Asia. India is the largest producer of bananas in the world and 40 million tonnes of fruits are produced in India annually (Padmanaban *et al*., 2009) [15]. As one of the major contributors to economy there are different pest species which is a threat to the banana plantain. The banana plantain is infested by 470 species of insects and mites according to reports. In India banana Corn Weevil, Banana stem weevil, leaf and fruit scarring beetle and leaf eating caterpillars are the major insect pests causing serious damage and yield loss to the Musa cultivation (Alagesan *et al*., 2018) [1]

The banana stem weevil *Odoiporus longicollis* Oliver (Coleoptera: Curculionidae) is a major production constraint in the commercial cultivation of banana. In recent years severe incidents of banana pseudostem weevil attacks have been reported from different parts of India and it is becoming a serious threat in South India particularly in Tamil Nadu and Kerala (Raghunath *et al*., 1992). The female weevil lays eggs inside the air chamber of the outer sheath of the pseudostem through holes made by its rostrum. Emerging grubs make extensive tunnels in the pseudostem for feeding and pupate inside the pseudostem to become adults. The extensive damage caused to the pseudostem makes it hollow and weak and affects the quality of the fruit produced based on the extent of damage. The damages are noticed only when it reaches an advanced stage and grubs are fully grown (Padmanaban *et al*., 2001) [13].

Applications of chemical insecticides are the only management measure but the insect is gaining resistance over it. Bio-pestcides are emerging as promising one now as these are eco-friendly (Bhagawati *et al.*, 2009) [5]. The usage of neem oil (*Azadiracta indica*), crude extract of *Lantana camera* and *Gliricidia sepium* are known to be effective against *Odoiporus longicollis* (Irulandi *et al*., 2009). Insecticidal activity of cassava extract parts such as leaf and tuber rind are effective against *Odoiporus longicollis* (Krishnan *et al.*, 2015) [10].

Though the chemical pesticides are very effective, what concerns over their use is their effect on soil and environment and presence of residue in food products (Pingali, 2012) [16]. India needs to develop its own biocontrol agents (BCA) because it will be cost-effective and also environment-friendly.

Pseudo stem weevil (*Odoiporus longicollis* Oliver) is the major borer pest of all varieties of banana, causing yield loss up to 90%. Tobacco pesticide is one of the common pesticides used against attack of a wide range of pests (Brahmachari, 2004) [4]. A green pesticide industry based on tobacco could provide additional income for farmers and as well as a new ecofriendly pest control agent (McCallan, 1967). India's eco-friendly biopesticides are rapidly growing to reduce all these risks and pollution problems.

The current study is focused on the effect of biopesticides on banana pseudostem weevil. Three commonly used biopesticides are selected for the study to find which is more efficient in pest removal from plantains. The tobacco decoction, neem oil emulsion and betel leaf extract biopesticide were studied for its mortality rate, repellency, toxicity and other factors. This study aims to provide an insight on the importance of bio pesticides and the need to avoid chemical pesticides.

Methodology
Odoiporus longicollis were collected from the banana field near Vellayani Lake, Thiruvananthapuram district, Kerala. The field was thoroughly studied to know the damage

symptoms and the level of damage caused by the pest**.** The symptoms of the pest (*Odoiporus longicollis*) attack were noted wilting of banana plant and blackened mass coming out of the plant (Fig.1 & 2)

Fig 1: Wilting of banana plant

Fig 2: Blackened mass coming out of the plant

Eggs were collected and reared to study the life cycle of *Odoiporus longicollis*. Adult male and female *Odoiporus longicollis* were collected and maintained in the laboratory in perforated plastic containers. Fresh pieces of banana pseudostem were provided as food, and the unfed pseudostem was replaced every three days. The complete life cycle of the insect was studied, and morphometric measurements were taken using a micrometer to understand the developmental stages. Additionally, adult *Odoiporus longicollis* were collected from the field to study the effects of biopesticides at each stage. The stages obtained were preserved in Bouin's fluid for sample fixation.

To make a tobacco decoction to control *Odoiporus longicollis*, 100 g of dried and powdered tobacco leaves were boiled in 1 L of distilled water, left for 24 hours, filtered, mixed with 20 g of non-detergent soap to prepare a 10% w/v stock, and then diluted to different concentrations (1%, 1.5%, 2%, and 2.5% w/v). To prepare a neem oil emulsion for various concentrations (1%, 1.5%, 2%, and 2.5% w/v)., 100 ml of neem oil was mixed with 1 L of warm water and 25 g of non-detergent soap.To prepare a betel leaf extract biopesticide, 100 g of dried and powdered betel leaves were filtered, mixed with 1000 ml of distilled water to create a 10% w/v stock, and then diluted to different concentrations (1%, 1.5%, 2%, and 2.5% w/v).

Observations

The mortality rate of *Odoiporus longicollis* was assessed via a topical application method. Ten adult specimens were divided among four perforated jars labeled with different concentrations (1% w/v, 1.5% w/v, 2% w/v, and 2.5% w/v) and subjected to sprays of the three biopesticides. Their mortality was then monitored at 15, 30, 60, and 90-minute intervals.

Estimation of repellency was conducted by immersing banana pseudostem pieces in biopesticides of different concentrations (1% w/v, 1.5% w/v, 2% w/v, and 2.5% w/v) in a glass container for 24 hours, then transferring them into separate conical flasks where 10 adults of Odoiporus longicollis were released per flask. This process was repeated for three sets of treatments with tobacco decoction, neem oil emulsion, and betel leaf extract biopesticide, while water served as the control. The number of adults moving away from the treated pieces was recorded to calculate the percentage of repellency using the formula C = (B/A) * 100, where A represents the total number of adults released, B is the total number of adults repelled, and C signifies the percentage of repellency.

For the settling response study, a 5 cm diameter Whatmann No.1 filter paper was cut into two parts, with one part serving as the control and the other as the experimental. The experimental part was then impregnated with a specific concentration of a biopesticide, which was allowed to evaporate. Each part was then placed in a separate petri dish, with 10 weevils placed in each dish. After 15 minutes, the number of settled weevils was recorded and used to calculate the Proportion Index with the following formula:

$$\text{API} = \frac{NS-NC}{NS+NC}$$

The LC50 in this context was determined using probit analysis based on insect mortality after 24 hours of exposure to prepared biopesticides (tobacco decoction, neem oil emulsion, and betel leaf extract).

Results

The life cycle of *Odoiporus longicollis* commences with the mating of male and female adults, leading to egg release, with eggs taking 3-5 days to progress to the larval stage. *Odoiporus longicollis* undergoes five larval instars lasting approximately 21-23 days, followed by pupation lasting 14-17 days, after which adults emerge, completing the life span of *O. longicollis* within 44-50 days (Fig.3). The (Table1) displays the morphometric measurements for each stage.

Table 1: Morphometric details of stages in *Odoiporus longicollis* (Mean±SD)

Stages	Measurements (mm)
Egg	3.14±0.36
First instar	3.38±0.44
Second instar	7.23±0.49
Third instar	12.3±1.18
Fourth instar	16.8±2.11
fifth instar	24.3±2.17
Pupa	31.6±2.45
Adult	16.75±2.64


Fig 3.1: Egg

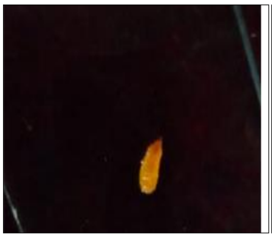
Fig 3.2: I^st^ instar

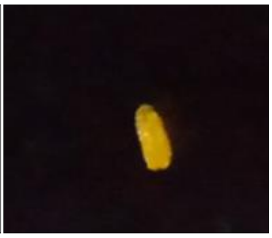
Fig 3.3: II^nd^ instar


Fig 3.4: III^rd^ instar


Fig 3.5: IV^th^ instar


Fig 3.6: V^th^ instar


Fig 3.7: Pupa with cocoon


Fig 3.8: Pupa exposed


Fig 3.9: Adult

Fig 3: Stages in the Life cycle of *Odoiporus longicollis*

Estimation of mortality

The mortality rate test revealed that as both the concentration and exposure duration increase, mortality also rises. Among the three biopesticides, neem oil emulsion demonstrates the highest mortality rate (fig. 2.2) even at lower concentrations compared to the other biopesticides. Adult Odoiporus longicollis exhibit strong survival abilities even in adverse or suffocating conditions. Dead insects were removed at specified intervals. While the mortality rate of tobacco decoction is also satisfactory, it requires a longer time to be effective (fig. 2.1). The betel leaf extract biopesticide shows the lowest mortality rate among the biopesticides tested but can still be used as a preventive measure due to its partial effectiveness against the insect pest.

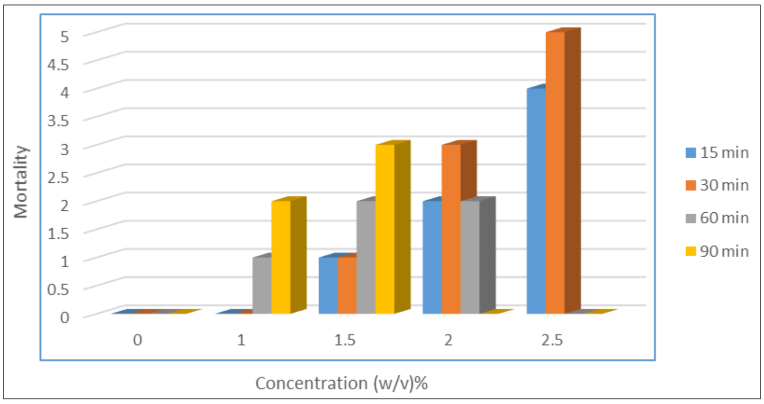

Fig 4: Graph showing the mortality rate of *O. longicollis* in different concentration of tobacco decoction at various time interval

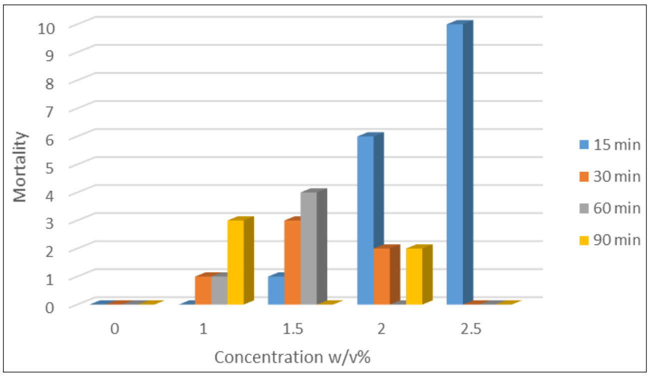

Fig 5: Graph showing the mortality rate of *O. longicollis* in different concentration of Neem oil emulsion at various time interval

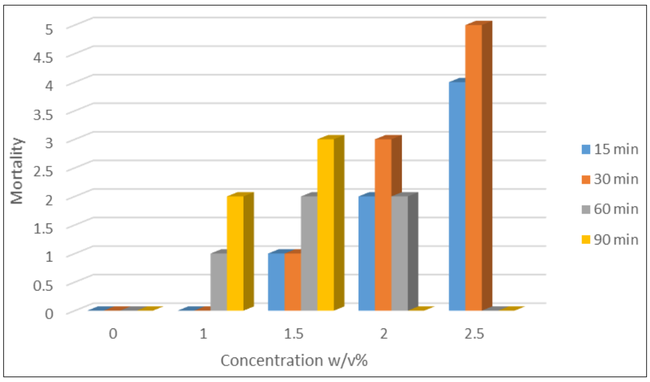

Fig 6: Graph showing the mortality rate of *O. longicollis* in different concentration of Betel leaf extract at various time interval

Estimation of repellency

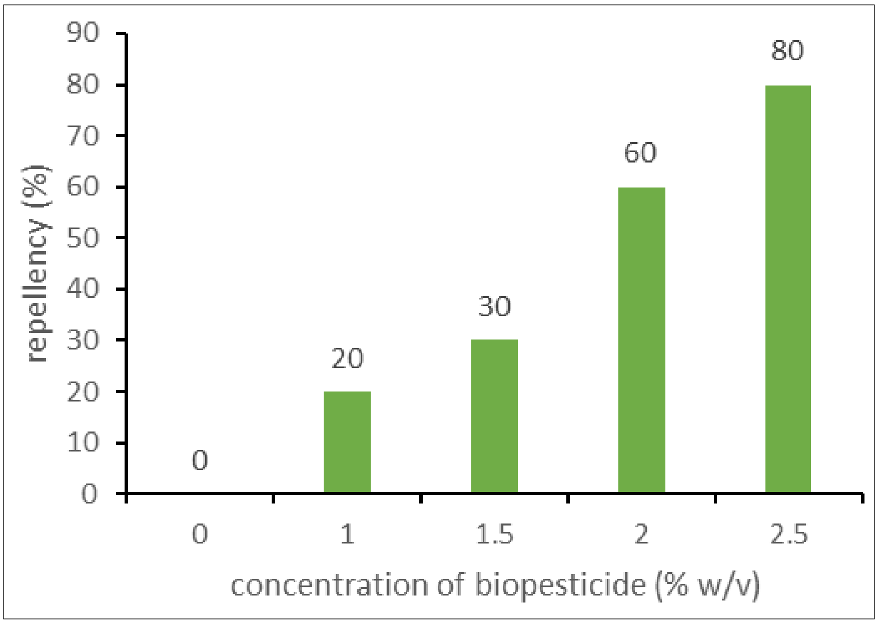

Fig 7: Graph depicting the repellency of *O. longicollis* in tobacco decoction biopesticide.

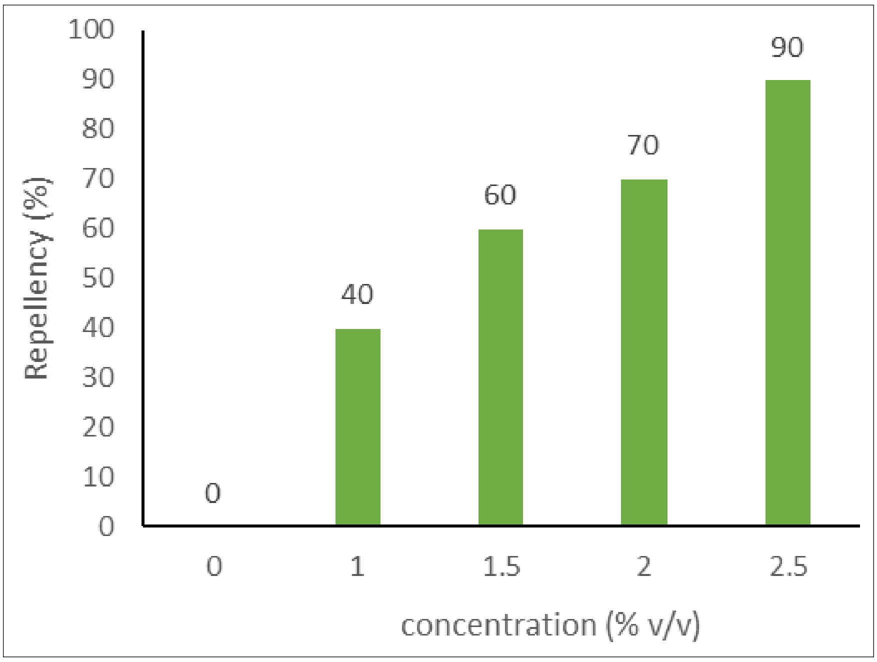

Fig 8: Graph depicting the repellency of *O. longicollis* in neem oil emulsion biopesticide

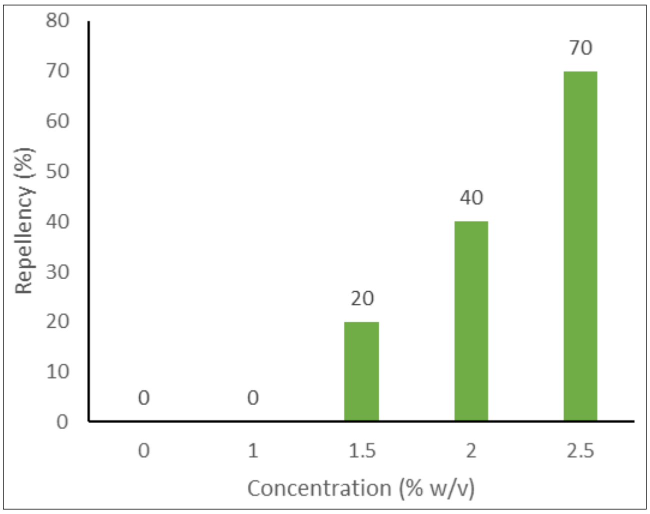

Fig 9: Graph depicting the repellency of *O. longicollis* in betel leaf extract biopesticide

The neem oil biopesticide demonstrates high repellency, while the betel leaf extract biopesticide shows low repellency. Specifically, the neem oil biopesticide achieves 40% repellency at a 1% w/v concentration, whereas the betel leaf extract exhibits no repellency at the same concentration. This indicates that even a small amount of neem oil biopesticide is sufficient to provide a certain degree of repellency (Fig. 3.1, 3.2 and 3.3).

Settling response study

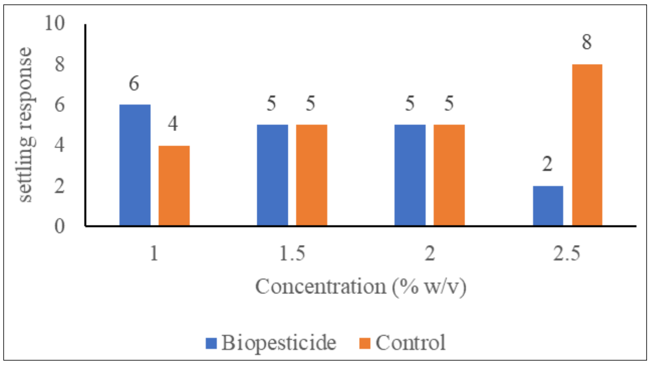

Fig 10: Graph depicting the settling response of *O. longicollis* in tobacco decoction biopesticide.

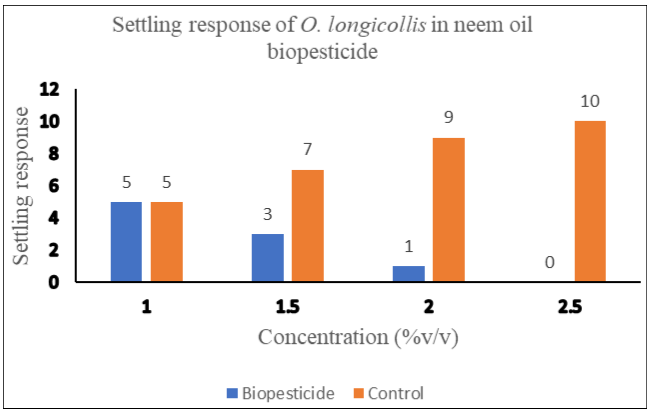

Fig 11: Graph depicting the settling response of *O. longicollis* in neem oil emulsion biopesticide.

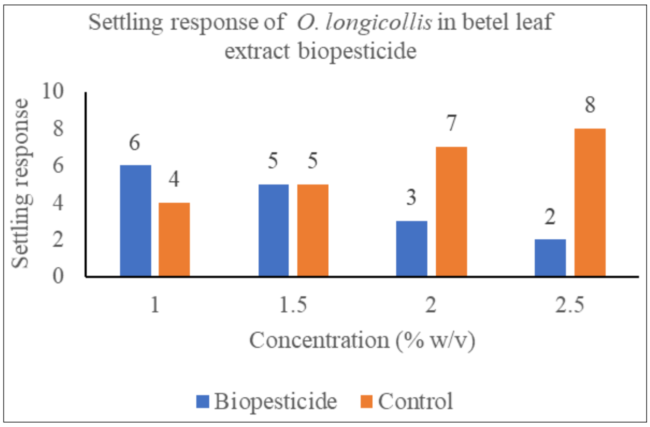

Fig 12: Graph depicting the settling response of *O. longicollis* in betel leaf extract biopesticide.

The high number of adult *Odoiporus longicollis* on the control side in the neem oil biopesticide experiment suggests that the pest cannot tolerate the biopesticide side. The increased presence on the biopesticide side indicates the biopesticide's inefficiency in eliciting an immediate response from the pest. (Fig.4.1, 4.2 and 4.3).

LC50

The LC50 values determined using probit analysis for biopesticides against *Odoiporus longicollis* were 1.954 mg/L for tobacco decoction, 1.440 mg/L for neem oil emulsion, and 2.530 mg/L for Betel leaf extract.

Discussion

Odoiporus longicollis is a pest that only feeds on banana plantains, reducing both their production and growth. It completes its life cycle within the pseudostem and in the decaying tissues of harvested pseudostem. The weevils are nocturnal but can fly during the day if it is cloudy or cooler (Padmanaban *et al*.,2009) [15]. All life stages of the weevil are present throughout the year, and they are strong fliers, so they can move from plant to plant. Adults typically live for one year, and the sex ratio of adults is 1:1.17 (male: female). Sensory structures on the weevil's rostrum allow for sex differentiation. The pre-oviposition period is 15-30 days, and the mean number of eggs laid by a female after mating is nine. Females lay eggs in the leaf sheaths of the pseudostem, and the number of eggs laid decreases as the number of weevils increases, indicating the presence of a spacing pheromone (Azad *et al*., 2019) [3].

Eggs of a particular species are usually a cream color and shaped like a cylinder, with rounded edges. They measure 3.14 mm in length and 1.1 mm in diameter on average. The larvae hatch from the eggs after an incubation period of three to eight days. When they emerge, the larvae are whitish-yellow and have no legs (Padmanaban *et al*., 2003) [14]. They tunnel through the tissue of the succulent sheath and may even reach the true stem if they hatch at the advanced pre-flowering stage of the plant. If this happens, the flower bud and the peduncle inside the pseudostem will be eaten and destroyed, leading to the flower bud not emerging and decaying inside the pseudostem (Padmanaban *et al*., 2001) [13]. The larvae of this species progress through five stages before reaching the pre-pupal stage, and when kept in laboratory conditions, the entire life cycle from egg to adult takes 44 days (Samuel *et al*., 2021) [2].

From the above study it is clear that among the three biopesticides namely Tobacco decoction biopesticide, Neem oil biopesticide and Betel leaf extract biopesticide, the Neem oil biopesticide was more effective against the pest. Previous studies also suggested that plant extracts like neem, castor oil have insecticidal activity (Subramannian *et al*., 2020) [20]. For those who are unable to use chemical insecticides, biopesticides are a better and safer option (Krishnan *et al*., 2015) [10]. The insecticidal activity of neem oil is due to the presence of azadirachtin, a complex tetranortriterpenoid derived from the mevalonic acid pathway in the neem tree (Hansen *et al.*, 1993). The toxicity of azadirachtin varies among insect orders and is influenced by the different penetration rates and activities of detoxifying enzymes (Mani *et al*., 2022) [12].

In previous studies (Sahyaraj *et al*., 2010) also neem oil reported to be effective to significantly reduce the infestation by *C. sordius.* It may be linked in a way that neem oil mostaemulsion can be applied to kill a wide variety of pests. The olfactory responses of the banana stem weevil, *Odoiporus longicollis* toward pseudostem and its crude extract were investigated by Sahayaraj and Kombiah (2009) [17]. Results indicated that seven days old decayed pseudostem had the most attractant activity in comparison to the other categories. A study was conducted to evaluate the effects of biopesticides and Insecticides on pseudostem weevil *Odoiporus longicollis* in red banana by Irulandi *et al*., (2012) [7]. It was determined that monocrotophos was the most effective treatment, followed by a dose of azadirachtin. Each of these treatments were found to improve the fruit yield and provide a better cost-benefit ratio. Das and Bhattacharya (2019) investigated the handling of banana pseudostem weevil and concluded that swabbing *Beauveria bassiana* on the pseudostem was the most successful treatment in reducing the weevil population and increasing plant growth factors and yield.

Conclusion

In recent years, the agricultural industry has benefited from increased pesticide use, but concerns over the environmental and health impacts have spurred research into natural biopesticides. This project focused on evaluating the effectiveness of biopesticides like tobacco decoction, neem oil, and betel leaf extract against the banana pest *O. longicollis*. Detailed tests revealed that neem oil was the most effective, while betel leaf extract showed potential for improved efficacy with higher concentrations. The study underscores the importance of biopesticides in sustainable farming and highlights their potential to reduce chemical waste and environmental impact.

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