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The Efficacy of natural plant extracts in controlling rice weevil (*Sitophilus oryzae*)

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Abstract

Rice weevil (*Sitophilus oryzae*) is one of the significant pests & has caused serious damage in rice storage. The use of synthetic pesticides to control them has had negative effect on environment, animal & human. In order to this issue, natural plant extract based pest control alternative were analysis. This study aimed to evaluate the efficacy of natural plant extract; Neem leaves (*Azadirachta indica*) & Eucalyptus leaves (*Eucalyptus globules*) & mixture of neem leaves powder & eucalyptus oil in tablet form in controlling rice weevil (*Sitophilus oryzae*). The experimental treatment consist of control (T₀) where no plant extract applied, (T₁) Neem leaves, (T₂) Eucalyptus leaves & (T₃) combination of neem leaves powder & eucalyptus oil in tablet form. Each treatment was regulate with 20g dose to 100g of rice, that had 20 weevil added & mortality was assessed after 6,12,18, 24, 30, 36 days. The result showed that (T₃) mixture of neem leaves powder & eucalyptus oil in tablet form was found to more effective overall than the other treatment (86.50%) mortality at 36 days after treatment. When compared to other treatment, followed by (T₁) Neem leaves (78.72%) mortality whereas (T₂) Eucalyptus leaves were found less effective (66.30%) mortality. So natural plants extract treatment (T₃) was found highly effective in controlling rice weevil & reduction in grain damage over than the other treatment. The order of effectiveness of botanicals is ranked as Mixture of neem powder & eucalyptus oil in tablet form>Neem leaves>Eucalyptus leaves respectively. Finally, it was concluded that natural plant extract could be used for protection of stored rice & serve as alternative method to synthetic insecticides in controlling *Sitophilus oryzae* infesting rice.

Keywords: *Sitophilus oryzae*, mortality, rice grain, *Azadirachta indica*, *Eucalyptus globules*

1. Introduction

Rice (*Oryza sativa*) is a universally consumed cereal grain and is the essential food for many people in countries ^[4]. Rice is known as a queen of cereal crops that have a rich nutritional content, which include carbohydrate, protein, fat, minerals profiles & fatty acids. The rice is regarded as one of the important & nutrient - dense essential foods & feeding more than 60% of the world population ^[38]. It is the second most important crop after wheat and continuously infested by numerous pest during the period of storage ^[5]. Infestation can occur at several locations, including processing warehouses, transit, storage & even houses that can lower the quantity & quality of food grain ^[28]. Despite the availability of ultramodern storage facilities farmer in rural India proceeds to use traditional method of storing food grains due to lack of awareness & extension services in hinterland ^[36]. Rice weevil (*Sitophilus oryzae*) is a widely wide spread pest of stored grain that primarily attack on rice & other cereals such as wheat, maize extra & decline the food value ^[27].

Sitophilus oryzae has four pale yellow or reddish dots on the corners of its elytra, which are hard protective forewing & measures between 2-3mm in length. The rice weevils life cycle consist of four phases that can be finished in 28 days; egg, larva, pupa & adult ^[4]. In their life time adults female can deposits up to 400 eggs by boring holes into kernels to release an egg within. After hatching *S. oryzae* larva stay inside the grain to continue feeding until they become adults. A single weevil can eat 10-25 g of grain throughout its 4-5 month life cycle ^[8]. In addition *S. oryzae* at 28°C & 75% relative humidity maximum development takes place with higher growth ^[24]. There have also been reports of 10-20% of the total rice output being lost due to the *S. oryzae*. The kernel is consumed by both larval & adult's stages, which resulting in weight losses ^[13].

For a long time, this pest has been regulated with a variety of synthetic pesticides such as fumigants methyl bromide & phosphine. Similarly, EDCT (ethylene dichloride carbon tetrachloride) & aluminum phosphate are also used, but customers are unaware of chemical residue in cereal grain [29]. Synthetic pesticides use that is careless & unregulated has resulted in a no. of issue including (1) toxic residue on air, water & food (2) pest resistance to pesticides (3) loss of natural enemies (4) disturbance of the ecosystem [9]. These chemical pesticides have detrimental effects on the environment & non-target creature is a globe concern [14].

Consequently, the demand for sustainable, natural plant based products is growing aim to provide a substitute method for protecting stored goods while minimizing environmental & human health risk [35]. Botanicals pesticides are advantageous due to their natural origin, specificity, no adverse effect on insects & minimum residual activity, making them commercially viable green pesticides [37]. Various local product manufactured from the natural plant are reported to be particularly successfully in managing stored grain pest especially on a small scale due to their insecticidal; repellent & anti-feedent qualities [19]. Naturally plants herbs are the substitute sources of pest control because contain a range of bioactive chemicals. One of the potential plant species used for biopesticides is the neem tree (*Azadirachta indica*) [34]. Due to the biological activities of neem tree, including insecticidal, antiviral, antifungal, antifeedent & nematocidal properties, almost every part of tree, but especially its seed, kernels & leaves [3]. Additionally beneficial substance found in bitter neem leaves include quercetin, 6-deacetyl nimbine, nimbine & nimbadiol. These are used to control disease & pest [31]. Essential oils from plant leaves like neem & eucalyptus have been found to be effective against insect pest [21]. Essential oil in warehouses can attract & repel rice weevil, with secondary effects including antifeedent, repellency & oviposition [40]. The volatile ingredient "eucalyptus or 1, 8-cineol is give essential oils from (*Eucalyptus nicholii*, *E. conocarpus*, *E. blakelyi*, *Melaleuca fulgens*) their pesticides qualities [25]. Therefore, this study was initiated to analyze the effectiveness of the natural plant extract such as neem leaves, eucalyptus leaves & combination of neem leaves powder with eucalyptus oil in tablet form in controlling rice weevil. This study is one alternative to help reduce the risk of rice damage, as well as chemical applications in rice storage that can be harmful to environment & human health.

2. Materials and Methods

The experiment was carried out at the laboratory of Abhilashi University, Chailchowk (Mandi) in the month of April -May 2024. Material used and the method employed during the course of investigation for conducting the experiments were presented here;

2.1 Insect rearing

To rear the insects, clean, un-infested rice grain was purchased from the local market [2]. Colonies of rice weevil, *S. oryzae* were collected from naturally infested rice grains from the warehouse and was mass reared in the laboratory maintaining temperature and humidity of 28°C and 73±5% respectively. The rice weevils were put in transparent box of plastic. Moreover the storage box was covered with muslin cloth to allow circulation [12].



Fig 1: Showing the insect rearing

2.2 Preparation of natural plant extract (leaves powder & oil)

The neem and eucalyptus leaves used in experiment collected from the botanical garden. The half kg neem leaves and eucalyptus leaves were dried under shade condition to avoid light induce damage of active compound by Uv-ray [22] and then neem leaves are grinded using a grinding machine. Then neem leaves natural powder obtained. An essential eucalyptus oil was purchased from local market and then mixed the neem leaves powder with oil of eucalyptus in a tablet form. The control treatment was not treated with any natural leaves, powder mixture of oil and neem leaves powder in tablet form.



Fig 2: Neem leaves



Fig 3: Eucalyptus leaves



Fig 4: Neem powder



Fig 5: Mixture of neem powder & eucalyptus oil



Fig 6: Mixture of neem powder & eucalyptus oil in tablet form

2.3 Data collection

In a Petri dish, 100g of rice were treated with several natural plant extract (leaves, powder, oil) with a dosage of 20 g each treatment. Neem leaf (T_1) eucalyptus leaf (T_2) and a

combination of neem leaf powder and eucalyptus oil in a tablet form (T_3) and control (no material treated) (T_0) were all included in the treatments. Each container contained 20 rice weevils, which were observed every week for the course of the 6-weeks storage period. The study parameters encompass the rates of, mortality rate, and grain damage rate. To calculate the mortality rate the no. of dead weevil are counted and, at 6, 12, 18, 24, 30, 36 days treatment. The adult mortality was recorded from each treatment & the data was corrected & converted into percentage from the original data by the Abbotts formula ^[1].

$$\% \text{ of corrected mortality} = \frac{\text{observed mortality} - \text{control mortality}}{100 - \text{control mortality}} \times 100$$

When the storage period came to an end, grain damage was evaluated. Weevil feeding caused the weight of grains with holes to be classified as damaged. The following calculation was used to determine the % of grain weight that had grain damage ^[7]

$$\% \text{ WL} = (IW - FW) \times 100 / IW$$

Where WL; Weight loss index

IW; Initial weight and
FW is the final weight.

2.4 Statistical Analysis

The experiment used one way analysis of variance to collect data which was then analyzed statistically using graph pad in stat software on a microcomputer; F-value & critical difference were obtained using the ANOVA table for analysis of variance.

3. Results

3.1 Effect of natural plants extracts (leaves, powder, and oil) on mortality & survival of *S. oryzae*

The result of the experiment (table 1) showed that most of the treatment revealed significantly ($p < 0.05$) higher mortality at 36 days of exposure when compared to the control. The experimental data showed that there was a significant difference in the rice weevil survival & mortality rate when applied to all treatment. The data on mortality of adult after 6, 12, 18, 24, 30, 36 days of treatment were recorded. Result indicate that all the grain protectants after 6 days of treatments the combination of neem leaf powder & eucalyptus oil in tablet form (T_3) has highest level of protection for the killing 29.60% of the pest. While the eucalyptus leaves (T_2) kill the 12.25% weevil & neem leaf powder (T_1) kill the weevil 20.90% respectively. A similar pattern was seen 14 days post treatment in which (T_1) has 28.34-% mortality, (T_2) has 25.91% mortality & T_3 has 54.40% mortality. Out of all the treatments examined, (T_3) continue to be the most successful at 24 days following treatment with 65.46% mortality & *A. indica* come in second 55.07% & third with 48.91% mortality respectively. If the concentration of treatment were increases, then the mortality rate of rice weevil were also increases.

At 30th & 36th day after testing, however (T_3) treatment was found to more effective overall than the other treatments with an 86.50% mortality rate, followed by (T_1) *A. indica* (Neem) 78.72% & 66.30% in (T_2) *Eucalyptus globulus* treatment.



Fig 7: Controlled Treatment (T₀)



Fig 8: Neem leaves treatment (T₁)



Fig 9: Eucalyptus leaves treatment (T₂)



Fig 10: Mixture of neem powder & eucalyptus oil in tablet form (T₃)



Fig 11: Effect of Natural plants extracts against rice weevil against rice grain

3.2 Effect of the natural plant Extract on Grain damage

Based on this study, among all treatment, combination of neem leaves powder with eucalyptus oil in tablet form (T₃) is the best treatment to control grain damage due to very low rice damage (0.74%) & (T₁) the neem leaves (0.84%) & (T₂) eucalyptus leaves (0.91%) respectively. The weight loss of rice grain as a result of *S. oryzae* infestation ranged from 1.90% in control treatment (T₃) to 0.74%. The treatment with neem leaves (T₁), eucalyptus leaves (T₂) & (T₃) combination of neem leaves powder + eucalyptus oil in tablet form were significantly superior to the untreated control treatment. So this study found that using natural plant extract can prevent *S. oryzae* induced weight loss in rice.



Fig 12: Grain weight loss due to rice weevil

Table 1: Effect of natural plant extract against rice weevil

Treatment (g)	Mean mortality (6-36) days post treatment					
	6	12	18	24	30	36
T ₀ -control treatment	1.33	2.00	2.00	2.15	2.30	2.33
T ₁ -Neem leaves	20.90	28.34	38.11	55.07	70.74	78.72
T ₂ - Eucalyptus leaves	12.25	25.91	37.8	48.91	61.05	66.30
T ₃ -Mixture of neem leaves powder & eucalyptus oil in tablet form	29.60	52.40	58.30	65.46	75.55	86.50
F value	0.002548	0.001016	0.019509	0.008674	0.2264	0.009659
	<i>p</i> <0.05	<i>p</i> <0.05	<i>p</i> <0.05	<i>p</i> <0.05	<i>p</i> <0.05	<i>p</i> <0.05
C.D	4.56	4.60	3.49	3.50	2.80	2.77

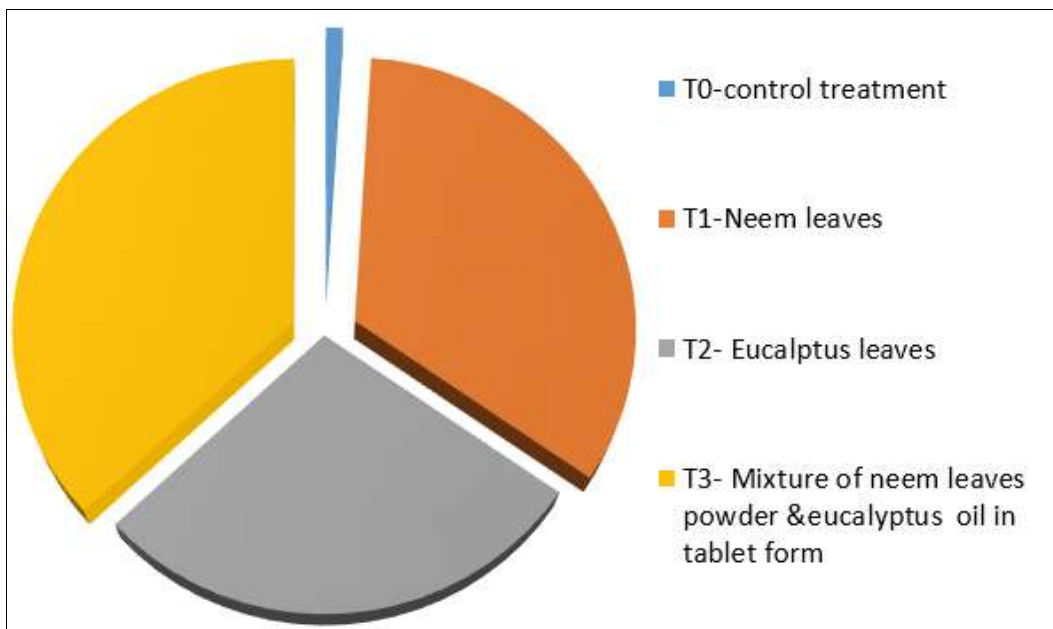
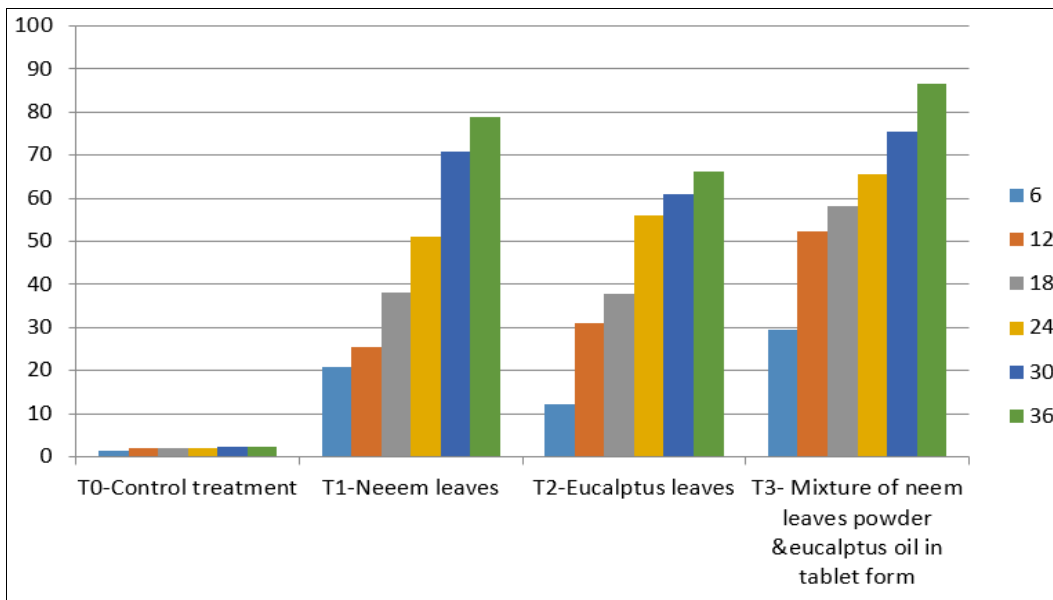


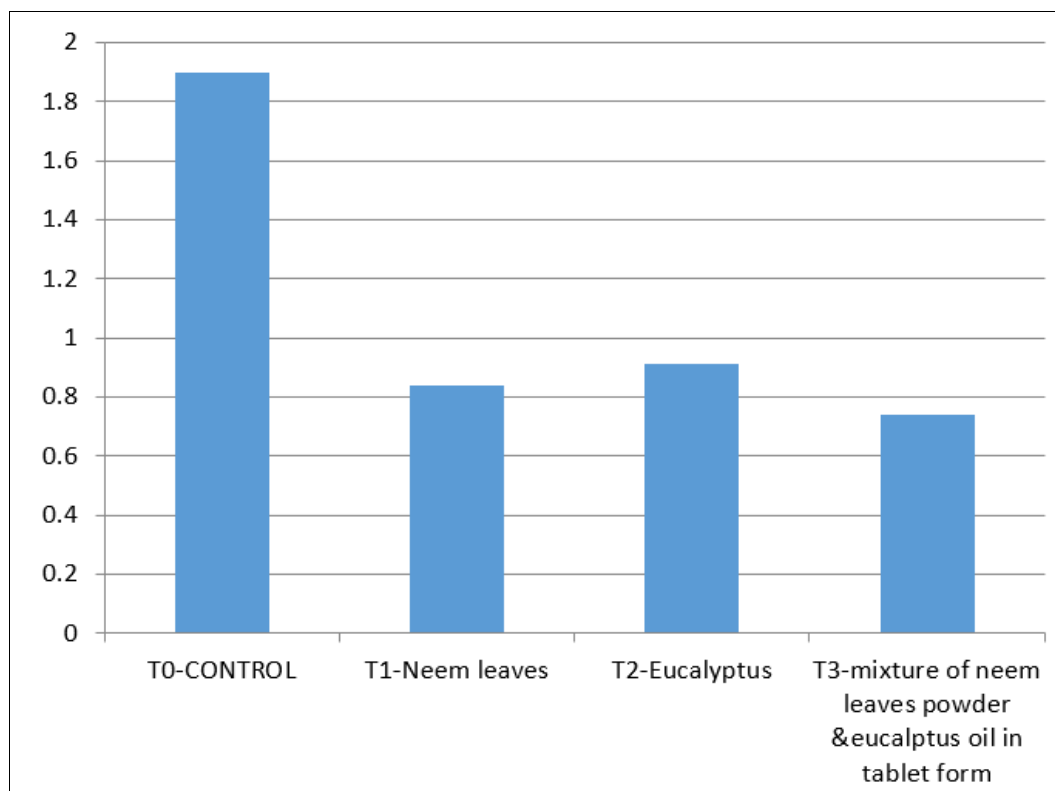
Chart 1: The mortality of rice weevil when treated with natural plants extracts



Graph 1: Percentage of mortality of rice

Table 2: Effect of plants extract on grain weight loss of rice

Treatment	Doses	Grain weight loss%
T ₀ -Control	100g	1.90%
T ₁ -Neem leaves	100g	0.84%
T ₂ -Eucalyptus leaves	100g	0.91%
T ₃ -mixture of neem leaves powder & eucalyptus oil	100g	0.74%



Graph 2: Grain damage after treated rice with natural plant extract

4. Discussion

These results are confirmed by Fauzi & Prastowo in 2021 who reported that neem can kill rice weevil, in line with a prior study [11]. The bitter taste of neem leaves which is due to the presence of active compounds in the neem leaves, especially azadiractin bioactive component that has insect repelling properties & prevent reproduction & have active ingredients that effectively killed the weevil [18] also supported our findings. Azadiractin, present in neem kernels, act as natural anti-feedent, sterilant & insect growth regulator. It reduces insect feeding, mating, moulting & fecundity [20]. Similarly, Bakar *et al.*, 2022 also reported that neem leaves powder was also effective in controlling *Sitophilus oryzae*. In our experimental research treatment (T₁) *A. indica* (Neem) can cause 78.72% mortality of rice weevils which are supported by these researchers. However the essential oils & their components have fumigant & contact toxicities against insects, resulting in secondary effects such as oviposition prevention, repellency & anti-feedent [26, 30]. Past study discovered that the components of Eucalyptus oil have herbicide, acaricide, insecticidal properties [6]. The major component were 1, 8-cineole (43.8%), p-cymene (14.2%) & α -pinene (10%) which has pesticide activity [16]. The dose of lethal (LD₅₀) of 1, 8 -cineole to *S. oryzae* was toxic which are reported by [21]. Elaissi studied the Eucalyptus species & potential use as an alternatives treatment for the natural food preservative [10]. In present research experiment combination of neem & eucalyptus oil in tablet form can cause 86.50% mortality rate that supports the finding of [25] who reported the effectivity of *Eucalyptus grandis* oil against *Sitophilus oryzae*. Therefore, then both of their combinations (neem leaves powder & eucalyptus oil) give the strong, bitter, pungent smell which are very toxic & resulted in high mortality of *S. oryzae*, thereby decreasing their population throughout storage.

Currently, the primary pest management approach for stored

rice grain is chemical, specifically phosphine [17]. In addition to developing insecticidal resistance, the frequent & indiscriminate use of insecticides endangers human health & environment [32]. Beside this use of botanicals pesticides has led to a surge in use of eco-friendly & green alternative [37]. Aromatic plants are highly effective pesticides, with essential oils making up a significant portion of plants extract [2]. Therefore, natural plants extracts are most effective in controlling rice weevil.

The treatment with neem leaves (T₁), eucalyptus leaves (T₂), & (T₃) combination of neem leaves powder + eucalyptus oil in tablet form was significantly superior to the untreated control treatment. So this study found that using natural plant extract can prevent *S. oryzae* induced weight loss in rice. This result is consistent with the studies of [39]. Neem leaves comprise alkaloid compounds, nimbodin, tannins, resins, azadiractin that are suitably used as plant pesticides [15]. Neem carries out the anti-feedent properties that repel rice weevil & reduce rice damage [33]. Some researchers have investigated the effects of essential oils on insects. These oils are a complex blend of volatile components generated by plant secondary metabolism, with a strong fragrance [23]. The present research study mixture of neem leaf powder & eucalyptus oil is best treatment to control grain damage due to very low damage & effective in *S. oryzae* controlling which are supported the finding of [25] effectiveness of *Eucalyptus grandis* oil against *S. oryzae*.

5. Conclusion

This study's objective was to determine how well natural plants extracts suppress rice weevil populations. Out of three botanicals treatments the most effective natural plant extract for managing rice weevil & reduced percentage weight loss on rice grain is (T₃) mixture of eucalyptus oil with neem powder, while the single eucalyptus leaves has least effective in controlling *S. oryzae*. However, neem leaves also have a

considerable effect on controlling rice weevil. If the concentration of natural plants extracts increases then, ultimately the mortality rate of rice weevil also increases. So the order of effectiveness of botanicals are ranked as mixture of eucalyptus oil with neem powder in tablet form >Neem leaves > eucalyptus leaves respectively. Therefore, it can be concluded that this study explore the use of natural bio pesticides as an eco-friendly alternative to chemical insecticides in the rice industry to reduce the risk of rice weevil damage & pest infestation, ultimately aiming to achieve self-sufficiency in rice production.

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