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Evaluation of indigenous botanical treatments for enhancing storability of sorghum (*Sorghum bicolor*) against storage pests

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Abstract
Sorghum (*Sorghum bicolor* L. Moench) is an important cereal crop cultivated widely in tropical and semi-arid regions and serves as a major source of food and fodder. However, considerable quantitative and qualitative losses occur during storage due to insect infestation. The present study was conducted to evaluate the effect of different indigenous natural and plant products on the storability of sorghum grains under laboratory conditions. The experiment was conducted in a Completely Randomized Design (CRD) with three replications. Various botanical treatments, including red earth slurry, gingelly oil, Neem leaf paste, chilli powder, and botanical mixtures, were evaluated. Observations were recorded on seed damage, egg number, and adult survival at 20, 40, and 60 days of storage. The results revealed that the treatment consisting of mixing ash, sweet flag powder, sand, neem, nochi, and thulasi leaves (T_{11}) significantly reduced seed damage, oviposition, and adult insect population compared to other treatments and the untreated control. The lowest seed damage (11.66%), the minimum number of eggs laid (99.66), and the lowest adult population were recorded in T_{11} during storage. The findings demonstrate that indigenous plant-based formulations offer a sustainable, eco-friendly, and cost-effective alternative to synthetic pesticides for protecting stored sorghum grains, with strong potential for adoption in smallholder farming systems.

Keywords: Sorghum, Indigenous practices, Botanical insecticides, Storage pests, Seed damage, Grain protection

1. Introduction
Sorghum (*Sorghum bicolor* L. Moench) is an important cereal crop widely cultivated in tropical and subtropical regions of the world. It serves as a staple food for millions of people and also plays a significant role in livestock feeding and industrial uses. Sorghum is particularly important in semi-arid regions because of its ability to withstand drought and adverse climatic conditions (Hossain *et al*., 2022; Mwamahonje *et al*., 2024; Srivastava *et al*., 2025) [5, 13, 23]. In India, sorghum contributes significantly to food security and the livelihood of farmers in dryland agricultural systems (Kanthaswamy *et al*., 2025; Ronanki *et al*., 2022; Sahara *et al*., 2023) [6, 19, 20]. However, a substantial quantity of stored sorghum grains is lost due to insect pests and poor storage conditions. Storage pests such as rice weevil (*Sitophilus oryzae*), lesser grain borer (*Rhyzopertha dominica*), and red flour beetle (*Tribolium castaneum*) are responsible for considerable losses in stored grains (Desta & Yeshitila, 2024; Kłyś *et al*., 2017) [2, 10].

Post-harvest losses of grains in developing countries are estimated to range between 10–30 per cent due to insect infestation and other storage problems (FAO, 2011). Chemical pesticides and fumigants are widely used to control storage pests; however, excessive use of these chemicals has resulted in several problems including pest resistance, environmental pollution and health hazards to humans and animals (Ahmad *et al*., 2024; Kashyap *et al*., 2024; Shekhar *et al*., 2024) [1, 7, 21]. In recent years, there has been increasing interest in eco-friendly pest management strategies using botanical products. Indigenous knowledge systems developed by farmers over generations provide effective and sustainable solutions for grain storage. Traditional storage practices involve the use of plant materials such as neem leaves, sweet flag rhizomes, chilli powder, and wood ash to protect stored grains from insect pests (Ahmad *et al*., 2024; Singh *et al*., 2021) [1, 22]. Botanical products contain biologically active

compounds which exhibit insecticidal, repellent, and antifeedant properties against storage pests (Ngegba *et al*., 2022; Pavela *et al*., 2025a) [14, 15]. Neem-based products contain azadirachtin, which interferes with insect growth and reproduction (Kuhar *et al*., 2022; Mordue, 2004) [11, 12]. Sweet flag (*Acorus calamus*) rhizome powder has also been reported to be effective in controlling rice weevil infestation in stored grains (Khanal *et al*., 2021) [9]. Although several indigenous plant products are traditionally used by farmers for protecting stored grains, scientific evaluation of their effectiveness in sorghum storage is limited. Therefore, the present investigation was undertaken to evaluate the effect of different indigenous natural and plant products on the storability of sorghum grains.

The objective of this study was to evaluate the effectiveness of different indigenous natural and plant products in improving the storability of sorghum grains. The study aimed to assess their influence on seed damage, egg laying, and adult insect population during storage. It also focused on identifying eco-friendly and economical botanical treatments for protecting sorghum grains from storage pests.

Previous studies have mainly focused on chemical methods for controlling storage pests in grains. However, there is limited scientific validation of indigenous natural and plant products used by farmers for sorghum storage. Many traditional practices remain undocumented and under-researched. Therefore, this study attempts to fill the gap by evaluating the effectiveness of indigenous plant-based treatments for safe sorghum grain storage.

2. Materials and Methods

2.1 Experimental Location

The experiment was conducted in the laboratory of the Agricultural Laboratory Complex, School of Agriculture and Animal Sciences, Gandhigram Rural Institute, Tamil Nadu.

2.2 Experimental Design

The experiment was laid out in a Completely Randomized Design (CRD) with three replications.

2.3 Treatments

Table 1: Description of Different Treatments Applied for Storage Protection

Treatment	Description	
T_1	Mixing with red earth slurry	15 g
T_2	Coating with Gingelly oil	15ml
T_3	Coating with Neem Leaf Past	15g
T_4	Putting pods of dried chillies in containers	15g
T_5	T1+T2	
T_6	T1+T3	
T_7	T1+T4	
T_8	T2+T3	
T_9	T2+T4	
T_{10}	T3+T4	
T_{11}	T1+T2+T3+T4	
T_0	Control	

Table.1 presents various treatments (T0–T11) used to evaluate the effectiveness of natural materials in storage protection. Treatment T1 involves mixing with red earth slurry (15 g), while T2 consists of coating with gingelly oil (15 ml). T3 uses neem leaf paste (15 g), and T4 includes placing dried chilli pods (15 g) in storage containers. Combinational treatments (T5–T11) integrate two or more of these materials to assess their synergistic effects in enhancing protection. T0 serves as the control without any treatment. These treatments are designed to study eco-friendly, low-cost methods for protecting stored materials against pests and spoilage.

2.4 Preparation of Botanical Materials

Plant materials were collected, shade-dried and ground into fine powder. The required quantities of each botanical were mixed thoroughly with sorghum grains before storage.

2.5 Storage Procedure

Treated grains were stored in airtight containers under laboratory conditions for six months. Observations were recorded at intervals of 20, 40 and 60 days. The Sorghum variety CSH -14 was used in the study for both years.

2.6 Observations Recorded

The following parameters were recorded:

- Seed damage percentage
- Number of eggs laid
- Number of alive adults

2.7 Statistical Analysis

Data obtained from the experiment were analyzed using Analysis of Variance (ANOVA) and treatment means were compared using appropriate statistical tests.

3. Results and Discussion

3.1 Effect on Seed Damage

The results revealed significant differences among the treatments in reducing seed damage during the storage period. Among the treatments, T_{11} ($T_1 + T_2 + T_3 + T_4$) recorded the lowest seed damage at all observation intervals during both years of study Table. 2. The seed damage recorded in T_{11} was 17.66, 14.33, and 11.66 per cent on the 20th, 40th, and 60th day, respectively, during the first year, whereas in the second year the values were 0.60, 3.00 and 0.00 per cent. Among the individual treatments, T_2 (coating with gingelly oil) showed comparatively better performance in reducing seed damage compared with other treatments. The untreated control (T_0) recorded the highest seed damage throughout the storage period.

The reduction in seed damage may be attributed to the repellent and insecticidal properties of botanical materials and oils, which interfere with feeding and reproduction of storage pests. Similar findings were reported by (Rajesh *et al*., 2022) [18], who observed reduced insect infestation in seeds treated with botanical products.

Table 2: Effect of indigenous natural and plant products on reducing the damage of seeds under storage in sorghum

Treatments/ Year/ Days	I-Year			II- Year		
	20	40	60	20	40	60
T_1	37.33	32.33	28.66	1.00	13.60	6.00
T_2	23.66	22.00	19.33	0.00	2.30	0.00
T_3	42.00	36.66	29.33	4.00	18.00	13.30
T_4	33.00	29.33	25.33	1.00	13.00	13.30
T_5	30.00	29.00	23.33	1.30	4.30	0.00
T_6	30.00	27.33	21.33	1.00	8.60	5.60
T_7	32.66	28.66	23.66	2.30	19.00	5.60
T_8	31.66	27.00	20.66	0.00	2.60	5.60
T_9	25.66	21.33	20.00	0.30	3.00	0.00
T_{10}	29.00	25.00	21.66	5.00	11.00	16.60
T_{11}	17.66	14.33	11.66	0.60	3.00	0.00
T_0	64.66	63.33	50.00	1.00	5.00	21.00
Sed	2.11	4.02	2.20	2.79	5.22	5.22
CD (5%)	4.39	8.35	4.57	5.79	10.84	10.83

3.2 Effect on Number of Eggs Laid

The number of eggs laid by storage pests was significantly influenced by different treatments. Among the treatments, T_{11} (combination of red earth slurry, gingelly oil, neem leaf paste and dried chilli pods) recorded the lowest number of eggs laid during the storage period. The number of eggs laid in T_{11} was 123.33, 109.00 and 99.66 on the 20th, 40th and 60th day respectively during the first year. In the second year, the values were 8.00, 12.30 and 14.60, which were considerably lower than the untreated control Table. 3. Among the individual treatments, T_2 (gingelly oil coating) also showed better effectiveness in reducing egg laying. The untreated control recorded the maximum number of eggs laid during the storage period. The reduction in oviposition might be due to the repellent and antifeedant properties of botanical products, which deter insects from laying eggs on treated grains. Similar results were reported by (Pavela *et al*., 2025b; Rajashekar *et al*., 2025) [16, 17].

Table 3: Effect of indigenous natural and plant products on reducing the number of eggs laid under storage in sorghum

Treatments/ Year/ Days	I-Year			II- Year		
	20	40	60	20	40	60
T_1	445.00	343.66	428.66	15.00	22.00	35.60
T_2	140.00	123.33	113.33	19.00	22.00	34.00
T_3	351.00	333.66	309.66	17.00	16.60	28.30
T_4	242.33	226.66	207.66	12.30	14.60	35.60
T_5	177.33	163.33	145.66	19.30	29.00	33.60
T_6	243.33	220.66	203.33	26.00	29.60	32.30
T_7	346.00	328.33	313.33	19.60	19.00	35.60
T_8	295.66	278.00	221.00	12.30	15.60	34.00
T_9	166.66	143.33	121.33	13.30	16.60	21.30
T_{10}	313.66	297.00	278.66	21.60	24.00	28.30
T_{11}	123.33	109.00	99.66	8.00	12.30	14.60
T_0	579.33	559.00	526.66	25.30	35.60	50.00
Sed	18.02	18.21	17.59	4.23	4.51	5.85
CD (5%)	37.38	37.76	36.48	8.77	9.37	12.14

3.3 Effect on Number of Alive Adults

The number of live adult insects varied significantly among the treatments during the storage period shown in the table. 4. The lowest number of live adults was observed in T_{11}, indicating the effectiveness of the combined treatment in suppressing insect population. In the first year, T_{11} recorded 35.33, 26.66 and 30.66 live adults on the 20th, 40th and 60th day respectively. In the second year, the values were 0.30, 0.00 and 0.00, which were considerably lower than the untreated control.

Among individual treatments, T_2 (gingelly oil coating) also showed significant reduction in adult insect population. The untreated control recorded the highest number of adult insects during the storage period. The reduction in adult population may be attributed to the toxic and repellent effects of botanical treatments on storage pests. These findings are in agreement with the results reported by (Dougoud *et al*., 2019; Kessy *et al*., 2024) [3, 8].

Table 4: Effect of indigenous natural and plant products on reducing the number of alive adults under storage in sorghum

Treatments/ Year/ Days	I-Year			II- Year		
	20	40	60	20	40	60
T_1	136.66	126.00	112.66	3.30	7.00	5.60
T_2	56.00	43.00	34.00	0.00	0.00	0.00
T_3	125.00	112.00	100.66	6.60	8.60	10.00
T_4	115.00	102.00	95.33	9.60	7.30	3.60
T_5	63.66	53.33	49.00	0.00	0.00	0.00
T_6	116.66	106.66	94.66	5.60	5.00	9.00
T_7	123.33	108.66	96.66	9.60	16.00	10.00
T_8	75.66	65.00	56.00	0.00	0.00	0.00
T_9	92.66	81.33	54.33	0.00	0.30	0.00
T_{10}	84.66	73.33	60.00	7.30	12.30	4.00
T_{11}	35.33	26.66	30.66	0.30	0.00	0.00
T_0	163.33	157.00	138.00	15.30	5.30	16.60
Sed	10.25	8.30	12.33	2.59	2.82	4.62
CD (5%)	21.20	17.22	25.58	5.38	5.85	9.60

4. Conclusion

The present study demonstrated that indigenous natural and plant products play an important role in improving the storability of sorghum grains. Among the different treatments, the combined treatment T_{11} (red earth slurry + gingelly oil + neem leaf paste + dried chilli pods) was found to be the most effective in reducing seed damage, egg laying, and adult insect population during the storage period. The results indicate that traditional botanical materials possess repellent and insecticidal properties that help in protecting stored grains. Therefore, the use of such indigenous practices can be promoted as eco-friendly, economical, and sustainable alternatives to chemical pesticides for safe grain storage and reduction of post-harvest losses.

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