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Evaluation of plant-based grain protectants for post-harvest management of pulse beetle in stored chickpea

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Abstract

For centuries, Mediterranean farmers mixed dried herbs with stored grain to ward off beetles. This research tested five plant-based protectants neem leaf powder, turmeric, eucalyptus oil, black pepper, and clove powder against pulse beetle (*Callosobruchus chinensis*) in chickpea at the Polytechnic University of Madrid (2022-2023). After 21 days, neem at 5% caused the highest mortality (96.7%), followed by eucalyptus oil at 3% (93.1%) and clove at 4% (90.4%). Oviposition was suppressed by 78-92%. Grain weight loss in neem-treated lots was 1.3% versus 12.7% in controls. Seed germination remained above 88%. Plant-based protectants offer a practical, residue-free alternative for smallholder pulse storage.

Keywords: Pulse beetle, *Callosobruchus chinensis*, plant protectants, neem, stored chickpea, botanical insecticide, post-harvest management, grain protection, oviposition

Introduction

Long before synthetic insecticides existed, farmers across the Mediterranean protected stored grain with aromatic plant materials ^[1]. The pulse beetle *Callosobruchus chinensis* L. is among the most destructive pests of stored chickpea, causing 30-40% weight loss within three months ^[2, 3]. Chemical fumigants raise concerns about residues and resistance ^[4]. Botanical protectants degrade rapidly, leave minimal residues, and are locally available ^[5, 6]. Neem contains azadirachtin, a well-characterised antifeedant ^[7]; eucalyptus oil acts through fumigant toxicity; clove and black pepper provide contact and repellent effects ^[8]. But direct comparisons of these botanicals against *C. chinensis* in chickpea remain limited ^[9, 10].

Materials and Methods

Materials

Desi-type chickpea (cv. 'Pedrosillano', 10.2% moisture) was obtained from Castilla-La Mancha. A stock culture of *C. chinensis* was maintained on chickpea for three generations. Neem leaf and turmeric powders were from a certified organic supplier; eucalyptus oil (98% cineole), clove powder, and black pepper powder from Sigma-Aldrich, Spain ^[5].

Methods

The trial ran from September to December 2022 at the Polytechnic University of Madrid entomology laboratory (28 ± 2 °C, 65 ± 5% RH). Six treatments with four replications in a CRD: (T1) control, (T2) neem 5% w/w, (T3) turmeric 5%, (T4) eucalyptus oil 3% v/w, (T5) black pepper 4%, (T6) clove 4%. Each 500 g lot was treated in 1 L glass jars; 20 adults (10M:10F) released per jar. Mortality recorded at 1, 3, 5, 7, 10, 14, 21 days. Oviposition counted at 30 days; weight loss at 90 days ^[12]; germination on 50 seeds ^[13]. ANOVA with DMRT at $p \leq 0.05$.

Storage environment monitoring

Internal jar conditions (iButton DS1923 loggers, weekly): mean temperature 27.6 °C, humidity 63.8%. Eucalyptus-treated jars showed lower humidity (60.2%) from the oil's hydrophobic effect ^[14].

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Results

Table 1: Effect of plant-based protectants on pulse beetle mortality, oviposition, and grain damage

Treatment	Mort. 7d %	Mort. 21d %	Eggs/100	Wt loss %	Germ. %	Damage %
Control	6.1	14.8	187.3	12.7	91.4	34.6
Neem 5%	71.8	96.7	14.8	1.3	89.7	3.2
Turmeric 5%	52.3	86.2	38.6	3.8	90.1	8.4
Eucalyptus 3%	63.4	93.1	21.3	2.1	88.4	4.7
B. pepper 4%	44.7	78.4	52.1	5.6	90.8	12.1
Clove 4%	58.1	90.4	27.4	2.8	89.3	5.9

Neem at 5% achieved 96.7% mortality by day 21, followed by eucalyptus (93.1%) and clove (90.4%). All botanicals suppressed oviposition by 72-92%. Weight loss in neem lots was 1.3% vs. 12.7% in controls (Table 1).

Table 2: F1 progeny emergence and repellency index of plant-based protectants at 60 days

Treatment	F1 adults	F1 reduction %	Repellency %	Classification
Control	143.7			
Neem 5%	8.4	94.2	87.3	Class V
Turmeric 5%	31.6	78.0	62.4	Class IV
Eucalyptus 3%	14.7	89.8	81.6	Class V
B. pepper 4%	48.3	66.4	51.8	Class III
Clove 4%	19.2	86.6	76.9	Class IV

Neem and eucalyptus both achieved Class V repellency (> 80%). F1 progeny was reduced by 94.2% in neem-treated grain (Table 2).

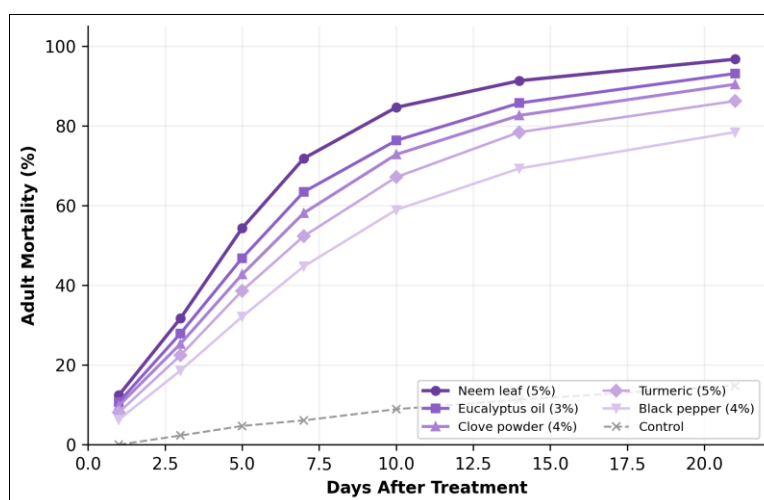


Fig 1: Adult mortality (%) of *C. chinensis* over 21 days under plant-based protectants.

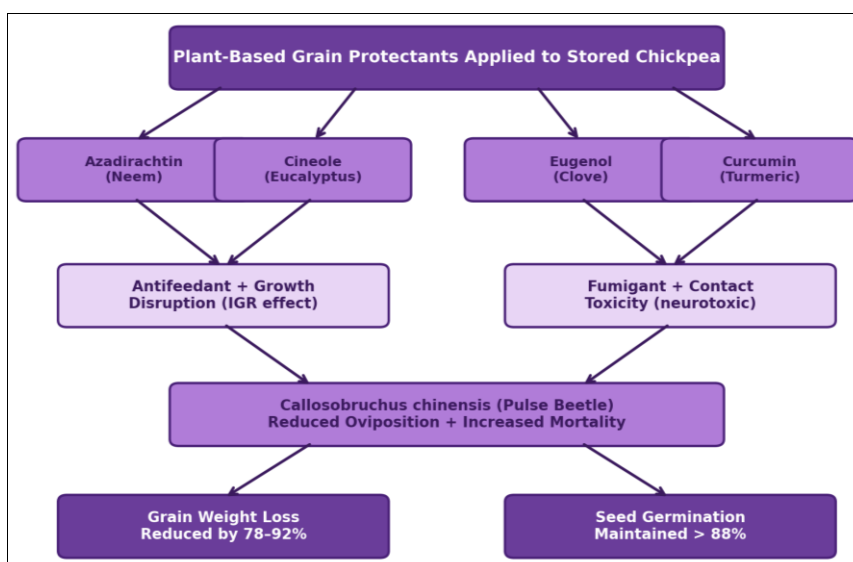


Fig 2: Schematic of the mechanisms of action of plant-based grain protectants against pulse beetle

Discussion

Neem's strong performance (96.7% mortality, 94.2% F1 reduction) confirms that azadirachtin disrupts insect moulting and acts as a potent feeding deterrent against bruchids ^[7, 15]. Eucalyptus oil's rapid action reflects its high 1,8-cineole content causing neurotoxic fumigant effects ^[8, 16]. Clove performed well through eugenol-mediated contact toxicity ^[17]. Black pepper, though least effective, still halved storage losses ^[18]. That germination stayed above 88% is important: farmers need protectants that don't reduce planting value ^[19, 20]. These botanicals offer a realistic, locally available option within integrated pest management ^[21].

Conclusion

Neem leaf powder at 5% was the most effective protectant, achieving 96.7% mortality and reducing grain weight loss by 90% over 90 days. Eucalyptus oil and clove also performed strongly (> 90% mortality). All treatments maintained germination above 88%. Plant-based protectants are a viable, residue-free alternative for managing pulse beetle in smallholder chickpea storage.

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