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EFFICACY OF ESSENTIAL OILS FOR THE ECO-FRIENDLY MANAGEMENT OF GROUNDNUT BRUCHID, *Caryedon serratus* (OLIVIER), IN STORED GROUNDNUT

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ABSTRACT

The present laboratory investigation was conducted to evaluate the efficacy of selected essential oils for the eco-friendly management of *C. serratus* in stored groundnut. Peppermint, clove, camphor, citronella, eucalyptus and neem oils were evaluated at 5 ml kg^{-1} of pods and compared with deltamethrin 2.8 EC (0.04 ml kg^{-1}) and an untreated control. Fecundity, adult emergence, pod damage, weight loss and seed germination were recorded immediately after treatment and at 30, 60 and 90 days after treatment (DAT). Peppermint oil completely prevented oviposition and adult emergence at 30 DAT, and maintained very low fecundity (8.33 eggs) and adult emergence (1.33 adults) even at 90 DAT. Peppermint oil also minimized pod damage (4.37%) and weight loss (1.10%) while maintaining 100% seed germination up to 90 DAT. Clove oil was the next most effective treatment, whereas camphor oil was the least effective among the essential oils. Although deltamethrin provided the highest overall protection, peppermint oil proved to be the most promising botanical alternative for the eco-friendly management of *C. serratus* in stored groundnut. The results demonstrate that peppermint essential oil possesses strong insecticidal, oviposition-deterrent and protective properties and can be recommended as an environmentally safe alternative to synthetic insecticides for the protection of stored groundnut.

Keywords **:** *Arachis hypogaea*, *Caryedon serratus*, essential oils, stored groundnut.

Introduction

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop. Among the storage pests, the groundnut bruchid, *Caryedon serratus* (Olivier) (Coleoptera: Chrysomelidae), is one of the most destructive pests causing severe quantitative and qualitative losses during storage (Ranga Rao *et al*., 2010). The pest was first reported in Tamil Nadu and Andhra Pradesh, India, by Fletcher (1914). Female beetles lay eggs on the surface of groundnut pods or kernels and the emerging larvae bore into the kernels, causing concealed infestation and extensive internal damage (Dick, 1987). Unlike most storage pests, *C. serratus* can infest kernels enclosed within intact pods (Devi and Rao, 2005). Under severe infestation, *Caryedon serratus* caused up to 90% damage and 70% weight loss in shelled groundnut, while damage reached up to 80% in unshelled groundnut (Oaya *et al*., 2012). Kernel losses may reach 80.6% under severe infestation (Harish *et al*., 2014), while prolonged storage also promotes fungal growth and reduces seed viability. Management of *C. serratus* mainly depends on synthetic insecticides. Although these chemicals provide effective control, their continuous use has raised concerns regarding insecticide resistance, pesticide residues, environmental pollution and adverse effects on human health. Therefore, the search for safer and eco-friendly alternatives has gained increasing importance. Essential oils derived from aromatic plants have emerged as promising botanical protectants

against stored-product insects due to their insecticidal, fumigant, repellent and oviposition-deterrent properties. They are biodegradable, relatively safe to non-target organisms and leave minimal harmful residues. Among them, peppermint, clove, citronella, eucalyptus, camphor and neem oils have shown varying levels of efficacy against storage pests.

The present investigation was undertaken to evaluate the efficacy of selected essential oils against *C. serratus* in stored groundnut under laboratory conditions. The study assessed their effects on fecundity, adult emergence, pod damage, weight loss and seed germination to identify an effective botanical alternative for the eco-friendly management of groundnut bruchid.

Materials and Methods

The laboratory experiment was conducted during 2025-2026 in the Department of Entomology, BJR Agricultural College, Sircilla, Telangana, India. A mother culture of *Caryedon serratus* was obtained from the Regional Agricultural Research Station (RARS), Palem and subsequently maintained in the laboratory on disinfested K6 groundnut pods. Five essential oils, namely peppermint, clove, camphor, citronella and eucalyptus were evaluated at 5 ml kg^{-1} of groundnut pods. Deltamethrin 2.8 EC at 0.04 ml kg^{-1} served as the chemical check and neem oil 5 ml kg^{-1} of groundnut pods served as botanical check while untreated pods were maintained as the control. Five hundred grams of disinfested groundnut pods were treated with the respective essential oils, dried for one hour under shade and transferred to plastic containers. Five pairs of freshly emerged adults of *C. serratus* were released into each container and the containers were covered with muslin cloth and maintained under laboratory conditions. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Fecundity, adult emergence, pod damage, weight loss and seed germination were recorded at 30, 60 and 90 days after treatment.

Results

Oviposition

Peppermint oil and deltamethrin effectively suppressed oviposition throughout storage. At 30 DAT, both treatments recorded 0.00 eggs, whereas the untreated check recorded 136.67 eggs. At 60 DAT, peppermint oil and deltamethrin recorded 5.33 and 1.67 eggs, respectively, compared with 140.00 eggs in the untreated check. At 90 DAT, peppermint oil recorded 8.33 eggs, while the untreated check recorded 143.33 eggs. The effect of treatments on oviposition is shown in Table. 1 and Fig. 1.

Adult emergence

Peppermint oil and deltamethrin effectively reduced adult emergence. At 30 DAT, both treatments recorded 0.00 adults, whereas the untreated check recorded 111.00 adults. At 60 DAT, peppermint oil and deltamethrin recorded 0.67 and 0.00 adults, respectively, compared with 125.00 adults in the untreated check. At 90 DAT, peppermint oil recorded 1.33 adults, while the untreated check recorded 130.67 adults. The variation in adult emergence among treatments is presented in Table. 2 and Fig. 2.

Pod damage

Pod damage increased with storage period in all treatments. Deltamethrin recorded the lowest pod damage (0.00, 0.00 and 1.91% at 30, 60 and 90 DAT, respectively), followed by peppermint oil (0.00, 1.09 and 4.37%). The untreated check recorded the highest pod damage of 20.22, 55.46 and 66.65%, respectively. The trend is depicted in Table. 3 and Fig. 3.

Weight loss

Weight loss increased with storage duration. Deltamethrin recorded the lowest weight loss (0.00, 0.00 and 0.61%), followed by peppermint oil (0.00, 0.76 and 1.10%) at 30, 60 and 90 DAT, respectively. The untreated check recorded the highest weight loss of 12.34, 17.01 and 19.07%, respectively. The effect of treatments on weight loss is illustrated in Table. 4 and Fig. 4.

Seed germination

Seed germination differed significantly among the treatments. Peppermint oil and deltamethrin maintained 100.00% germination throughout the storage period. Clove oil also maintained 100.00% germination up to 60 DAT and 96.67% at 90 DAT. In contrast, the untreated check recorded the lowest germination of 75.00, 68.33 and 66.67% at 30, 60 and 90 DAT, respectively. The germination pattern under different treatments is presented in Table. 5 and Fig. 5.

Discussion

The present investigation demonstrated that peppermint oil @ 5 ml kg^{-1} pods was the most effective essential oil for the management of *Caryedon serratus* in stored groundnut, as it consistently recorded the lowest oviposition, minimum adult emergence, least pod damage and weight loss, while maintaining maximum seed germination throughout the storage period. Zhao *et al.* (2022) reported that menthol, menthone, neomenthol and iso-menthone are the major constituents of peppermint essential oil and are associated with its biological activities. The marked

reduction in oviposition following peppermint oil treatment indicates its strong oviposition-deterrent activity. Similar observations were reported by Tewari *et al*. (2024), who demonstrated the oviposition-deterrent effect of peppermint oil against *C. serratus*. Volatile plant oils may suppress adult emergence by impairing egg viability. According to Raja and William (2008), these oils block the micropyle of the egg chorion, reducing oxygen availability for embryonic respiration and disrupting normal embryonic, hormonal and biochemical processes, ultimately resulting in reduced egg hatchability. Likewise, Nyamador *et al*. (2010) reported that essential oil vapours effectively suppressed the development of *Callosobruchus maculatus* by acting on both eggs and adults, thereby preventing larval penetration into stored seeds. The lower pod damage recorded in peppermint oil-treated pods may be attributed to effective suppression of adult survival, oviposition and larval development, thereby minimizing feeding during storage (Aswini *et al*. 2024). The lower weight loss observed in peppermint oil-treated pods was mainly due to reduced feeding by larvae as a result of lower infestation levels. Weight loss increased gradually with storage duration because successive generations of *C. serratus* continued to consume the cotyledons, resulting in depletion of stored food reserves. Peppermint oil effectively minimized these losses by suppressing insect population development. Similar findings were reported by Manju *et al*. (2018) and Keerthana *et al*. (2026). The present investigation corroborates the findings of Singh and Mishra (2022), who demonstrated that peppermint oil at 10 ml kg^{-1} effectively controlled *Caryedon serratus*, reducing oviposition and adult emergence, minimizing pod damage and weight loss and preserving seed germination during storage. Maheshala *et al*. (2020) reported that storage treatments involving botanical oils for groundnut bruchid management did not significantly affect seed germination, even after storage, indicating that botanical treatments were safe for seed viability. Reddy *et al*. (2023), found that germination percentage decreased progressively with increasing storage period in all treatments. Sundria *et al*. (2012) reported that prolonged infestation by *Caryedon serratus* resulted in a progressive increase in pod damage and weight loss during storage due to the multiplication of the bruchid population. Consequently, the lower insect infestation and reduced pod damage in the treated pods in the present study likely contributed to the maintenance of higher seed germination throughout the storage period.

Conclusion

Peppermint oil @ 5 ml kg^{-1} was the most effective treatment against *Caryedon serratus* in stored groundnut. It significantly suppressed oviposition and adult emergence, reduced pod damage and weight loss and preserved seed germination during storage. Its performance was comparable to that of deltamethrin 2.8 EC @ 0.04 ml kg^{-1}, suggesting that peppermint oil is a promising eco-friendly alternative for the sustainable management of *C. serratus* in stored groundnut.

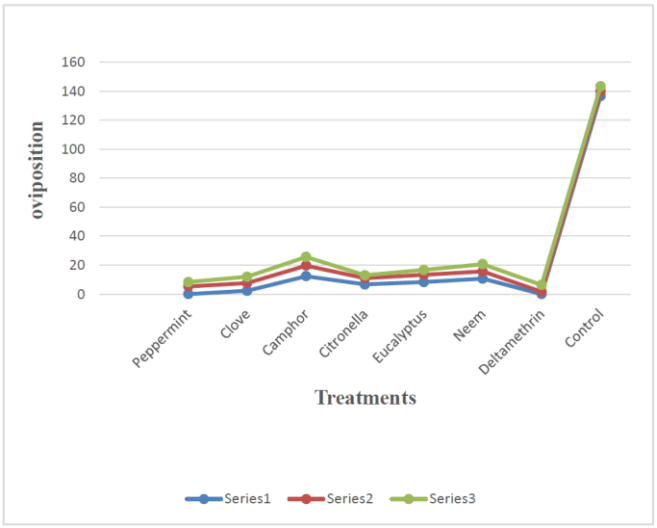

Fig. 1 : Line graph showing oviposition (number of eggs laid) by *Caryedon serratus* at different storage periods following treatment of groundnut pods with essential oils, neem oil and deltamethrin. Each coloured line represents oviposition recorded at 30, 60 and 90 DAT. A: Peppermint oil @ 5 ml kg^{-1} pods; B: Clove oil @ 5 ml kg^{-1} pods; C: Camphor oil @ 5 ml kg^{-1} pods; D: Citronella oil @ 5 ml kg^{-1} pods; E: Eucalyptus oil @ 5 ml kg^{-1} pods; F: Neem oil @ 5 ml kg^{-1} pods (botanical check); G: Deltamethrin 2.8 EC @ 0.04 ml kg^{-1} pods (chemical check); H: Untreated control.

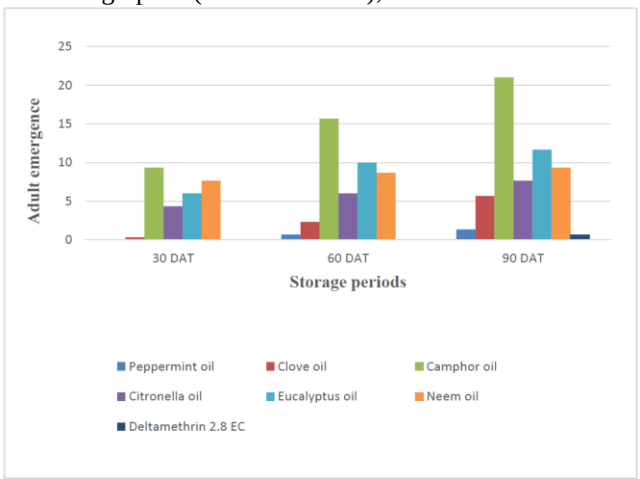

Fig. 2 : Bar graph showing adult emergence of *Caryedon serratus* at different storage periods following treatment of groundnut pods with essential oils, neem oil and deltamethrin.

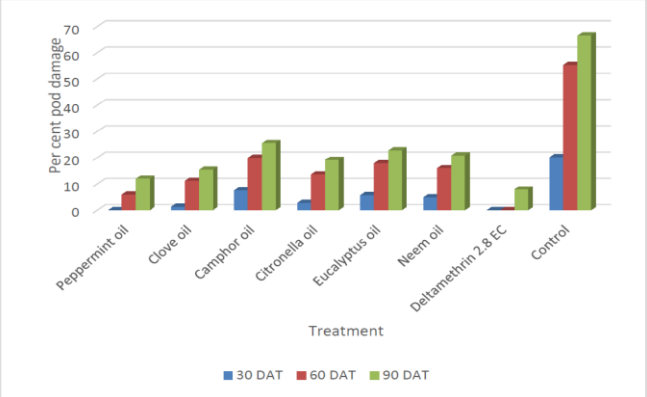

Fig. 3 : Bar graph showing per cent pod damage caused by *Caryedon serratus* at different storage periods following treatment of groundnut pods with essential oils, neem oil and deltamethrin.

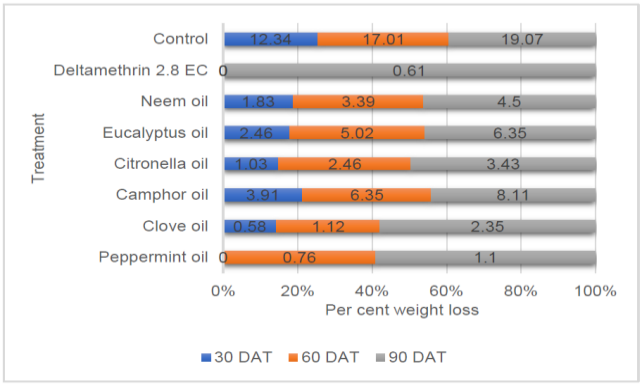

Fig. 4 : Graph showing per cent weight loss of groundnut pods caused by *Caryedon serratus* at different storage periods following treatment with essential oils, neem oil and deltamethrin.

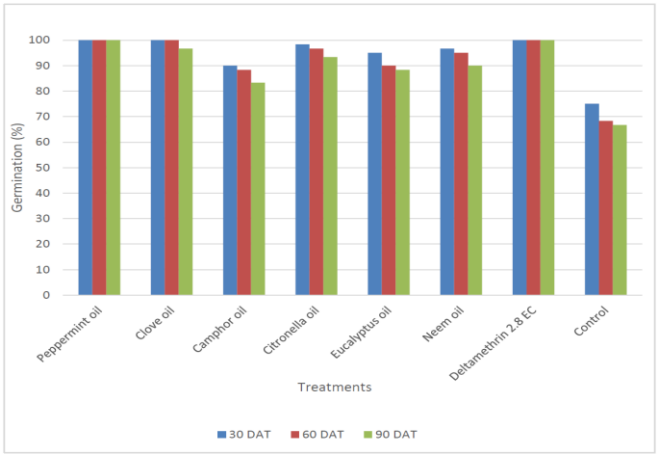

Fig. 5 : Clustered bar graph showing seed germination (%) of groundnut pods at different storage periods following treatment with essential oils, neem oil and deltamethrin

Table 1 : Efficacy of different essential oils on fecundity of *C. serratus* in groundnut under controlled conditions

Treatment	Dosage (ml kg^{-1} of pods)	Fecundity		
		30DAT	60DAT	90DAT
T_1-Peppermint oil	5.0	0.00^{a} (1.00)	5.33^{b} (2.52)	8.33^{b} (3.05)
T_2-Clove oil	5.0	2.33^{b} (1.82)	7.67^{c} (2.94)	12.00^{c} (3.61)
T_3-Camphor oil	5.0	12.33^{f} (3.65)	19.67^{g} (4.55)	25.67^{f} (5.16)
T_4-Citronella oil	5.0	6.67^{c} (2.77)	11.00^{d} (3.46)	13.00^{c} (3.74)
T_5-Eucalyptus oil	5.0	10.67^{e} (3.41)	15.67^{f} (4.08)	20.67^{e} (4.65)
T_6- Neem oil (Standard botanical check)	5.0	8.33^{d} (3.05)	13.33^{e} (3.79)	16.67^{d} (4.20)
T_7- Deltamethrin 2.8EC (Standard chemical check)	0.04	0.00^{a} (1.00)	1.67^{a} (1.63)	6.33^{a} (2.71)
T_8- Control (Untreated pods)	-	136.67^{g} (11.73)	140.00^{h} (11.87)	143.33^{g} (12.01)
C.D.		0.18	0.19	0.17
SE(m)±		0.06	0.06	0.06
C.V.%		2.82	2.49	2.03

DAT-Days after treatment, Figures in parentheses are square root transformed values; Means followed by different letters differ significantly according to
DAT-Days after treatment, Figures in parentheses are square root transformed values; Means followed by different letters differ significantly according to Duncan's Multiple Range Test (DMRT) at $P < 0.05$.

Table 2 : Efficacy of different essential oils on adult emergence of *C. serratus* in groundnut under controlled conditions

Treatment	Dosage (ml kg^{-1} of pods)	Adult emergence		
		30DAT	60DAT	90DAT
T_1-Peppermint oil	5.0	0.00^{a} (1.00)	0.67^{b} (1.28)	1.33^{a} (1.52)
T_2-Clove oil	5.0	0.67^{b} (1.28)	2.33^{c} (1.82)	5.67^{b} (2.58)
T_3-Camphor oil	5.0	9.33^{f} (3.21)	15.67^{g} (4.08)	21.00^{f} (4.69)
T_4-Citronella oil	5.0	4.33^{c} (2.31)	6.00^{d} (2.65)	7.67^{c} (2.94)
T_5-Eucalyptus oil	5.0	7.67^{e} (2.94)	10.00^{f} (3.32)	13.67^{e} (3.83)
T_6- Neem oil (Standard botanical check)	5.0	6.00^{d} (2.65)	8.67^{e} (3.11)	9.33^{d} (3.21)
T_7- Deltamethrin 2.8EC (Standard chemical check)	0.04	0.00^{a} (1.00)	0.00^{a} (1.00)	0.67^{a} (1.28)
T_8- Control (Untreated pods)	-	111.00^{g} (10.58)	125.00^{h} (11.23)	130.67^{g} (11.48)
C.D.		0.19	0.19	0.23
SE(m)±		0.06	0.06	0.08
C.V.%		3.46	3.09	3.35

Table 3 : Effect of different essential oils on per cent pod damage caused by *C. serratus* in groundnut under controlled conditions

Treatment	Dosage (ml kg^{-1} of pods)	Per cent pod damage		
		30DAT	60DAT	90DAT
T_1-Peppermint oil	5.0	0.00^{a} (0.00)	1.09^{a} (5.91)	4.37^{b} (12.06)
T_2-Clove oil	5.0	1.36^{b} (6.61)	3.79^{b} (11.22)	7.05^{c} (15.39)
T_3-Camphor oil	5.0	7.50^{f} (15.90)	11.66^{f} (19.97)	18.61^{g} (25.55)
T_4-Citronella oil	5.0	2.77^{c} (9.55)	5.54^{c} (13.61)	10.80^{d} (19.18)
T_5-Eucalyptus oil	5.0	5.69^{e} (13.80)	9.44^{e} (17.90)	15.00^{f} (22.78)
T_6- Neem oil (Standard botanical check)	5.0	4.88^{d} (12.76)	7.59^{d} (15.99)	12.74^{e} (20.91)
T_7- Deltamethrin 2.8EC (Standard chemical check)	0.04	0.00^{a} (0.00)	0.00^{a} (0.00)	1.91^{a} (7.90)
T_8- Control (Untreated pods)	-	20.22^{g} (26.72)	55.46^{g} (48.13)	66.65^{h} (54.74)
C.D.		0.92	1.26	1.37
SE(m)±		0.30	0.42	0.45
C.V.%		4.93	4.36	3.52

DAT-Days after treatment, Figures in parentheses are arcsine transformed values; Means followed by different letters differ significantly according to Duncan's Multiple Range Test (DMRT) at $P < 0.05$.

Table 4 : Effect of different essential oils on per cent weight loss caused by *C. serratus* in groundnut under controlled conditions

Treatment	Dosage (ml kg^{-1} of pods)	Weight loss%		
		30DAT	60DAT	90DAT
T_1-Peppermint oil	5.0	0.00[a] (0.00)	0.76[b] (5.01)	1.10[b] (6.02)
T_2-Clove oil	5.0	0.58[b] (4.35)	1.12[c] (6.07)	2.35[c] (8.82)
T_3-Camphor oil	5.0	3.91[f] (11.40)	6.35[g] (14.60)	8.11[g] (16.54)
T_4-Citronella oil	5.0	1.03[c] (5.79)	2.46[d] (9.01)	3.43[d] (10.67)
T_5-Eucalyptus oil	5.0	2.46[e] (9.01)	5.02[f] (12.94)	6.35[f] (14.60)
T_6- Neem oil (Standard botanical check)	5.0	1.83[d] (7.77)	3.39[e] (10.59)	4.50[e] (12.24)
T_7- Deltamethrin 2.8EC (Standard chemical check)	0.04	0.00[a] (0.00)	0.00[a] (0.00)	0.61[a] (4.46)
T_8- Control (Untreated pods)	-	0.00[a] (0.00)	17.01[h] (24.36)	19.07[h] (25.89)
C.D.		0.51	0.56	0.44
SE(m)±		0.17	0.18	0.15
C.V.%		3.99	3.08	2.03

DAT-Days after treatment, Figures in parentheses are arcsine transformed values; Means followed by different letters differ significantly according to Duncan's Multiple Range Test (DMRT) at $P < 0.05$.

Table 5 : Effect of different essential oils on germination per centage of groundnut against *C. serratus* under controlled conditions

Treatment	Dosage (ml kg^{-1} of pods)	Germination%		
		30DAT	60DAT	90DAT
T_1-Peppermint oil	5.0	100.00[a] (90.00)	100.00[a] (90.00)	100.00[a] (90.00)
T_2-Clove oil	5.0	100.00[a] (90.00)	100.00[a] (90.00)	96.67[b] (81.39)
T_3-Camphor oil	5.0	90.00[d] (71.57)	88.33[c] (70.12)	83.33[d] (65.95)
T_4-Citronella oil	5.0	98.33[ab] (85.69)	96.67[b] (81.39)	93.33[c] (75.24)
T_5-Eucalyptus oil	5.0	95.00[cd] (77.08)	90.00[c] (71.57)	88.33[cd] (70.12)
T_6- Neem oil (Standard botanical check)	5.0	96.67[bc] (81.39)	95.00[b] (77.08)	90.00[cd] (71.57)
T_7- Deltamethrin 2.8EC (Standard chemical check)	0.04	100.00[a] (90.00)	100.00[a] (90.00)	100.00[a] (90.00)
T_8- Control (Untreated pods)	-	75.00[e] (60.00)	68.33[d] (55.77)	66.67[e] (54.75)
C.D.		6.51	4.98	5.52
SE(m)±		2.15	1.65	1.83
C.V.%		4.62	3.65	4.22

DAT-Days after treatment, Figures in parentheses are square root transformed values; Means followed by different letters differ significantly according to Duncan's Multiple Range Test (DMRT) at $P < 0.05$.

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