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Evaluation of insecticidal activities of *oroxylum indicum* plant extracts against pulse beetle *callosobruchus chinensis* (Coleoptera: Bruchidae)

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ABSTRACT

Studies on insecticidal properties of Oroxylum indicum (L.) Kurz against Callosobruchus chinensis (L.) were carried out in the Department of Entomology at G.B. Pant University of Agriculture and Technology, Pantnagar, during the rabi season, 2022-23. Under laboratory conditions, different plant extracts of O. indicum leaf, bark, capsule, seed, and neem leaf are phytochemically analysed and tested against C. chinensis in methanol and hexane solvent at different concentrations. In the evaluation of different extracts for contact and fumigant toxicity against C. chinensis, in terms of contact toxicity, the methanol neem leaf extract consistently showed the highest corrected mortality %. At 72 hrs, it achieved a corrected mortality of 85.78 % from 57.82 % after 24 hrs. The methanolic O. indicum seed extract also showed significant corrected mortality %, ranging from 61.24 % to 79.53 % from 24 hrs to 72 hrs, respectively, at a 12 % concentration. Similarly, in fumigation, methanolic neem leaf extract showed the highest mortality of 50 % after 24 hrs and 93.33 % after 72 hrs at 12 % concentration, and among the O. indicum plant extracts, methanol extract of O. indicum seed shows the highest mortality, ranging from 33.33 % to 66.67 % over 72 hrs at 12 % concentration. Different extracts were also evaluated for oviposition deterrence and adult emergence deterrence against C. chinensis; the results revealed that. At a 5 % concentration, the methanol extract of neem leaf showed the highest oviposition deterrence with a value of 84.10 %, while the methanol extract of O. indicum seed showed the second-highest deterrence at 75.47 %. For adult emergence deterrence, the methanol extract of neem leaf showed the highest efficacy with a deterrence of 87.32 % followed by the methanol extract of O. indicum seed with a deterrence of 57.97 %.

Keywords: *Oroxylum indicum, Callosobruchus chinensis, fumigant toxicity, oviposition deterrence, Contact toxicity.*

INTRODUCTION

Chickpea (*Cicer arietinum L.*) is an important and widely cultivated *rabi* pulse crop in India. It is commonly known as 'Bengal gram' or 'Kabuli gram'. It is a rich source of proteins, carbohydrates, minerals, and vitamin C. The tender leaves of the crop could be used for vegetables (Wood and Grusak, 2007). In India, this crop is grown on a 99 Lakh ha area. The nation's highest productivity level was 1086 kg/ha, which resulted in a record-breaking harvest of 107 lakh tonnes in 2021-2022. As usual, Madhya Pradesh supplied a significant 28 per cent of the nation's total cropped area and 34 per cent of its total production, placing it top in both categories (Ministry of Agriculture and Farmers Welfare, 2022). Various biotic and abiotic factors contribute to the decreased productivity of chickpea crops. However, in recent years, the primary constraint affecting chickpea cultivation has been the infestation of insect pests. In India, it is estimated that insect pests cause annual losses of approximately 7-15% in chickpea production, resulting in a monetary loss of 10950 million Indian rupees. In storage conditions, chickpea seeds suffer heavy qualitative and quantitative losses from the attack of pulse beetle, *Callosobruchus chinensis* (L.) (Coleoptera: Chrysomelidae (formerly Bruchidae)) (Demianyk *et al.*, 2007). *Callosobruchus chinensis* is a major economically important pest of all pulses and causes 40-50 per cent losses in pulse storage (Meena *et al.*, 2017). Adults of bruchid do not need food or water and spend most of their lives (1-2 weeks) mating and laying eggs on seeds. The grub only consumes and develops on chickpea seeds. Mature females lay their eggs one at a time, affixing each one to a seed's testa (Varma and Anandhi, 2010). Chickpea seeds lose weight, their value on the market, and their ability to germinate due to pest infestation (Nishad *et al.*, 2017). To manage these pest populations, farmers undergo repeated use of chemicals to reduce these losses and the excessive use of pesticides has not only damaged the environment but has also damaged the health of non-target species, including humans. The harmful effects include the deposition of chemical residues, pest resurgence, secondary pest outbreaks, environmental pollution, and the development of resistance against insecticides. (Dhingra *et al.*, 1988). Additionally, it has been shown that some insects that feed on stored grain have become resistant to methyl bromide and phosphine. So it is vital to look to for alternate pest control strategies to solve these issues. After realising the harmful effects of pesticide usage, farmers are now going for eco-friendly pest management approaches. The public's growing concern over safe food and a healthy environment, along with the failure of chemical pesticides to eliminate the insect, has sparked a search for new, ecologically friendly control ways to deal with these pests.

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Botanical insecticides are plant-derived substances that repel, prevent the growth of, or eliminate pests (Hikal *et al.*, 2017). The importance of botanical pesticides is mainly due to their effectiveness, biodegradability, different modes of action, less toxicity, and availability of source materials (Neeraj *et al.*, 2017). Commonly used botanical pesticides are preferred in organic farming because food grown organically fetches higher prices. Azadirachtin, which is derived from various parts of the neem tree (*Azadirachta indica*) such as the seeds, wood, bark, leaves, and fruits, is widely recognised and extensively utilised. *Oroxylum indicum* (Bignoniaceae), also known as Sonapatha or Shyonaka, is a commonly used herbal medicine in the Ayurvedic system (Joshi *et al.,* 1977). It belongs to the monotypic genus *Oroxylum* and is commonly known as the Indian trumpet tree, Indian trumpet flower, Broken bones, Indian caper, midnight horror, scythe tree, or tree of Damocles (Harminder and Chaudhary, 2011). This plant has the potential to cause mortality at different stages of an insect's life cycle. Therefore, the use of botanicals is one of the main pillars in bio-intensive approaches to pest management.

MATERIAL AND METHOD

Site of experiments

The current research was conducted in the Pulse Entomology Laboratory of the Department of Entomology, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand.

Experimental Details

The experiment included 10 plant extracts (Methanol and Hexane extracts of *O. indicum* leaves, stem bark, fruit pods, seeds, and neem leaves) at 5 different concentrations (100, 125, 250, 500, 1000 ppm) and one control. All the extracts are prepared using a Soxhlet apparatus and concentrated with the help of a rotary evaporator. These were used to assess their fumigant, contact, and oviposition, and adult deterrence under storage conditions against *Callosobruchus chinensis.* Neem leaf treatment is taken as a positive control for comparison.

Fumigant activity

To test the fumigant toxicity, the experiment was carried out as described by Ayvaz *et al*., (2008), Plant extracts were applied 400µl concentration of 5, 8, and 12per cent ppm on a filter paper strip (3×2.5 cm) placed to the lower side of the Petri dish. Five adults were released in the Petri dish separately and the Petri dish was sealed with parafilm. Released insects were kept at 27±1ºC, 70±5 % relative humidity in B.O.D. The released insects were exposed for up to 72 hrs and cumulative mortality was recorded at 24, 48, and 72 hours after exposure.

Under Contact condition

To test the contact toxicity, the experiment was carried out as described by Hossain et al., (2014), fifty grams of undamaged chickpea seeds were placed into a plastic container and plant extracts were applied at 400µl concentrations of 5, 8, and 12per cent in a container. After that, the containers were shaken properly so that the extract would get mixed. Properly with seeds. 10 adults were released in the containers. Released insects were kept at 27±1ºC, 70±5 % relative humidity in B.O.D. The released insects were exposed for up to 72 hrs and cumulative mortality was recorded at 24, 48, and 72 hours after exposure. % corrected mortality was calculated as:

$$\text{Per cent mortality} = \frac{\text{Mortality in treatment(per cent)} - \text{Mortality in control(per cent)}}{100 - \text{Mortality in control(per cent)}} \times 100$$

Effect on the Oviposition and Adult Emergence

Another set of experiments was conducted to study oviposition deterrence. 50 grams of freshly treated grains were taken from each jar and separated into three replications of 50 grams each. In each replication, five pairs of freshly emerged adults were released, and the number of eggs was calculated after seven days from the release of the insects. 5gm seeds were randomly taken, and the number of egged grains was counted. Total adult emerged were also counted after 1 month and % deterrence was calculated.

% deterrence = (control – mean of each treatment/control x 100).

RESULTS AND DISCUSSION

Fumigant mortality

The fumigant mortality effect of all the extracts on the pulse beetle at different DAT is presented in Table 1. All the treatments showed significantly higher mortality compared to control (DMRT, $p \leq 0.05$), and mortality increased with increasing dosages in all the extracts. Methanol extracts generally exhibit higher corrected mortality %ages compared to hexane across all concentrations and days. In the study, among *O. indicum* extracts, chickpea seeds treated with 12% methanol seed extract showed the highest corrected mortality (79.53%) after three days (3 DAT) followed by leaf extract (63.11%). The effectiveness of the seed extract was significantly at par with the corrected mortality caused by methanol neem leaf extract (85.78%) and hexane neem leaf extract (73.90%), suggesting that the methanol seed extract has potential against pulse beetle. These results contradict the study of Danial *et al*. (2015) in which the hexane fraction of the extract was more repellent than methanol and acetone. The hexane fraction also showed superior toxicity, causing 100% mortality of *C. maculatus* at 5 g/kg within 7 days of exposure. Similar to the methanol extracts, hexane extracts of *O. indicum* showed the highest corrected mortality in the seeds extract (56.00%) followed by leaf extract, with hexane also having a comparable mortality rate (55.88%). However, neem leaf extract remained the most effective, causing significantly higher mortality (73.90%) at 12% concentration after 3 days. Chetri et al. (2022) found that the plant extract of *S. robusta* shows 90% repellency, followed by 81.5% with *O. indicum* at 12%.

Contact mortality

The contact mortality effect of all the extracts on the pulse beetle at different DAT is presented in Table 2. All the treatments showed increased mortality with increasing dosages in all the extracts. Methanol extracts generally exhibit better contact toxicity compared to hexane across all concentrations and days. Among *O. indicum* extracts, chickpea seeds treated with 12% methanol seed extract showed the highest corrected mortality (66.67%) after three days (3 DAT), which was significantly at par with leaf extract (63.33%) and hexane neem leaf extract (73.33%). Methanol neem leaf extract with a corrected mortality rate of 93.33% was the most effective. No other treatment came close to achieving such a high mortality rate. Among the hexane extracts, Neem Leaf (positive control) exhibited the highest mortality rate of 73.33%, followed by *O. indicum* Seed (56.67%) and leaf extracts (56.67%). Chetri *et al.* (2022) also found that *O. indicum* extract showed 68.30% mortality at 12% concentration when applied to the dorsal side of the pulse beetle. Zafar *et al.* (2018) investigated the efficacy of six different botanicals (Neem, Bakain, Dharek, Turmeric, Tumha and AK) after an exposure period of 72 hours.

The maximum mortality was recorded in Neem powder treatment at 3% concentration.

Effect on the Oviposition and Adult Emergence

The effect of all the extracts on oviposition deterrence and adult emergence on pulse beetle at 5% concentration is presented in Table 3, Fig.1. Here again, the methanol extract surpassed hexane extract in both oviposition deterrence and adult emergence. Among the *O. Indicum* plant extracts in methanol, the leaf extract showed an egg count of 30.33±2.08 eggs with 75.47% deterrence, followed by the leaf extract of *O. indicum* with 34.67±2.52 eggs and 71.97% deterrence, as compared to the neem leaf extract, which showed the lowest egg count of 19.67±2.53 eggs with significantly higher 84.10% deterrence. Similar to the methanol extracts, In hexane extracts, again the best treatment was neem leaf treatment with the highest deterrence (76.82%) and least egg count (28.67±2.52) followed by *O. indicum* seed extract with 62.53% deterrence and 46.33±1.53. Patel *et al.* (2002) showed that increasing the phenol content of different pulses prolongs the developmental time of the pulse beetle (*C. chinensis*), implying that phenols must have an inhibitory impact on the pulse beetle's developmental process.

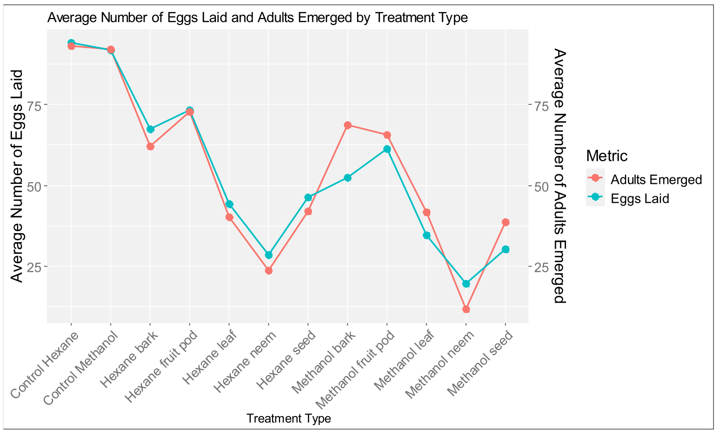

Fig. 1. Average number of Egg laid by female and Adult emerged in chickpea treated with different extracts.

Table 1: Fumigant toxicity of different plant extracts against adult of C. chinensis

S.No.	Treatment		Corrected mortality % at 5 per cent			Corrected mortality % at 8 per cent			Corrected mortality at % 12 per cent		
			1st day	2nd day	3rd day	1st day	2nd day	3rd day	1st day	2nd day	3rd day
1	Methanol	Leaf	33.21^{C}	41.50^{D}	50.98^{C}	51.67^{FG}	56.61^{D}	57.13^{E}	50.79^{FG}	60.24^{D}	63.11^{C}
2		Bark	19.05^{B}	30.17^{C}	34.56^{B}	38.33^{CD}	39.63^{BC}	40.80^{CD}	36.54^{CD}	43.36^{C}	46.94^{B}
3		Fruit pod	19.23^{C}	22.24^{D}	33.68^{B}	33.33^{BC}	37.75^{BC}	38.76^{BC}	33.12^{BC}	41.50^{C}	44.98^{B}
4		Seed	59.48^{E}	64.16^{E}	71.32^{DE}	61.67^{I}	67.93^{E}	75.51^{GF}	61.24^{H}	69.83^{E}	79.53^{DE}
5		Neem leaf	57.82^{E}	69.83^{E}	77.45^{E}	58.33^{HI}	73.59^{E}	79.59^{G}	57.82^{GH}	77.34^{E}	85.78^{E}
6	Hexane	Leaf	33.33^{C}	44.23^{D}	51.96^{C}	43.86^{EF}	50.76^{D}	54.01^{E}	45.61^{EF}	52.85^{D}	55.88^{C}
7		Bark	15.79^{B}	22.98^{B}	30.02^{B}	24.56^{B}	28.83^{B}	32.01^{B}	26.32^{B}	30.72^{B}	41.91^{B}
8		Fruit pod	7.02^{A}	15.36^{A}	13.97^{A}	14.04^{A}	15.37^{A}	18.02^{A}	17.54^{A}	19.06^{A}	30.02^{A}
9		Seed	33.33^{C}	38.45^{D}	45.96^{C}	38.60^{DE}	44.22^{C}	50.01^{DE}	42.11^{DE}	46.19^{C}	56.00^{C}
10		Neem leaf	40.35^{C}	45.97^{D}	63.85^{D}	50.88^{GH}	57.68^{D}	68.01^{F}	40.35^{CDE}	57.73^{D}	73.90^{D}
	SE(m) ±		1.90	1.19	1.25	1.89	1.67	1.55	1.89	1.47	1.39
	C.D. @ 5 per cent		5.60	3.49	3.60	5.55	4.92	4.57	5.45	5.50	4.89

Table 2: Contact toxicity of different plant part extracts of O. indicum against adult of C. chinensis

S.No.	Treatment		Corrected mortality % at 5 per cent			Corrected mortality % at 8 per cent			Corrected mortality at % 12 per cent		
			1st day	2nd day	3rd day	1st day	2nd day	3rd day	1st day	2nd day	3rd day
1		Methanol Leaf	26.67^{CD}	43.47^{CDE}	53.50^{EF}	30.00^{BC}	53.47^{DEF}	56.84^{EF}	36.67^{CD}	56.67^{CD}	63.33^{EF}
2		Methanol Bark	26.67^{CD}	40.10^{CD}	43.43^{CD}	30.00^{BC}	40.10^{BCD}	43.43^{CDE}	26.67^{BC}	43.33^{BC}	46.67^{CD}
3		Methanol Fruit pod	20.00^{CB}	30.10^{C}	33.43^{BC}	26.67^{BC}	30.10^{BC}	33.43^{BCD}	23.33^{B}	33.33^{B}	36.67^{BC}
4		Methanol Seed	33.33^{DE}	53.47^{DEF}	53.54^{EF}	33.33^{BC}	53.47^{DEF}	56.80^{EF}	33.33^{BCD}	56.67^{CD}	66.67^{EF}
5		Methanol Neem leaf	43.33^{E}	63.50^{F}	63.50^{G}	50.00^{D}	63.50^{F}	66.87^{F}	50.00^{E}	66.67^{D}	93.33^{G}
6		Hexane Leaf	26.67^{CD}	43.47^{CDE}	43.60^{DE}	26.67B^{C}	43.47^{CDE}	46.94^{DE}	33.33^{BCD}	46.67^{BC}	56.67^{DE}
7		Hexane Bark	23.33^{CD}	36.39^{C}	30.17^{C}	26.67^{BC}	33.43^{BC}	33.54^{BC}	26.67^{B}	36.67^{B}	43.33^{BCD}
8		Hexane Fruit pod	13.33^{B}	20.13^{B}	16.77^{B}	23.33^{B}	26.73^{B}	30.17^{B}	23.33^{BC}	30.00^{B}	33.33^{B}
9		Hexane Seed	40.00^{E}	43.47^{CDE}	46.97^{EF}	36.67^{BC}	40.13^{BCD}	50.30DF	36.67^{CD}	43.33B^{C}	56.67^{DE}
10		Hexane Neem leaf	43.33^{E}	56.87^{EF}	57.04^{FG}	40.00^{D}	56.84^{EF}	60.37^{EF}	40.00^{DE}	66.67^{D}	73.33^{F}
	SE(m) ±		1.788	2.42	2.42	2.53	2.26	1,97	1.72	3.11	1.86
	C.D. @ 5 per cent		5.22	7.07	7.07 cv	7.399	6.68	5.48	5.03	9.09	5.38

Table 3: Oviposition deterrence and progeny production of adult of C. chinensis on chickpea seeds treated with different leaf extracts

S.No.	Treatment		Dose	Average no of eggs laid by female	Per cent deterrence	Average no of adults emerged	Per cent deterrence
1	Methanol	Leaf	5 per cent	34.67±2.52^{F}	71.97	41.66± 3.05^{C}	54.71
2		Bark	5 per cent	52.33±2.08^{D}	57.68	68.66± 3.51^{AB}	25.36
3		Fruit pod	5 per cent	61.33±2.52^{C}	50.40	65.66±4.04^{AB}	28.62
4		Seed	5 per cent	30.33±2.08^{G}	75.47	38.66±4.51^{C}	57.97
5		Neem	5 per cent	19.67±2.53^{H}	84.10	11.66±3.51^{E}	87.31
6	Hexane	Leaf	5 per cent	44.33±2.08^{E}	64.15	40.33±5.69^{C}	56.63
7		Bark	5 per cent	67.33±2.08^{B}	45.55	62.00±7.00^{B}	33.33
8		Fruit pod	5 per cent	73.33±2.52^{A}	40.70	72.66±4.73^{A}	21.86
9		Seed	5 per cent	46.33±1.53^{E}	62.53	42.00±3.61^{C}	54.83
10		Neem	5 per cent	28.67±2.52^{G}	76.82	23.66±5.51^{D}	74.55
11	Control	Methanol	-	91.67±2.50	-	92.000 ±2.65	-
12	Control	Hexane	-	94.00±3.00	-	93.000 ±7.00	-

CONCLUSION

In conclusion, the study investigated the efficacy of different plant extracts derived from *Oroxylum indicum* against *C. Chinensis.* Methanolic seed extract of *O. indicum* was more effective against *C. chinensis,* closely followed by *O. indicum* leaf extract, although they are not better than neem leaf extract but showed significantly at par results in many parameters. It showed high contact and fumigant toxicities, resulting in the mortality of *C. chinensis*. It also showed good ovipositional deterrence, significantly reducing the number of eggs laid by female insects and the emergence of adults. It can become a good novel option to control the problem of pulse beetle under storage conditions. Further research is focused on identifying and isolating the active compounds responsible for their insecticidal properties and exploring their potential use in pest management strategies.

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Conflict of interest

The authors declare that there is no conflict of interest.

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