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Diversity of Stored Grain Pests in North 24 Parganas & Kolkata Districts, West Bengal, India & Their Management by Organic Pesticides

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ABSTRACT

Stored grains or pantry commodities are ravaged by a number of insect pests to meet their nutritional and shelter needs, resulting in both qualitative and quantitative losses. The favourable climatic conditions in India allow these pests to thrive year-round. These insects not only damage but also contaminate food items with their excrement and unpleasant odours, rendering them unfit for consumption and posing significant health risks. Consequently, post-harvest losses in India account for approximately 10% of total grain and 9.5% of total pulses. From the present study during August 2024 to February 2025, eight (8) insect species belonging to two (2) orders namely Coleoptera (87.5%) and Lepidoptera (12.5%) were recorded on stored grains, the prime groups of insects responsible for the post-harvest loss with order Coleoptera being the most dominant group. Out of eight (8) collected, five (5) insects (63%) were reported to be internal feeders while only 3 insects (37%) were recorded as external feeders. *Sitophilus oryzae* Linnaeus was the predominant stored grain pest noticed to attack most of the grain varieties. This research represents the inaugural documentation of insect pests associated with stored grains in North 24 Parganas and Kolkata districts of West Bengal. Our extensive research emphasizes the use of biopesticides (essential oils) as an alternative to traditional methods for the management of stored grain pests. To enhance effectiveness, we suggest employing solid absorbent granules infused with essential oil, which should be placed in perforated cloth bags placed in containers

located in kitchens, stores, and warehouses. This method is expected to yield improved results within minutes to hours, leading to the elimination of pests.

Keywords: Diversity, Stored grain pest, Internal & External feeders, Post-harvest loss, management, North 24 Parganas, West Bengal, India

1. INTRODUCTION

Insects are the most dominant species on the earth with number of known species exceeding over a million. Currently there are 32 orders of insects out of which only three orders viz., Coleoptera, Lepidoptera and Psocoptera contain species that are major pests on stored products (Rees, 2004; Naveena *et al.*, 2015; Harish *et al.*, 2018; Jamwal & Bhatia, 2020; Ahmad *et al.*, 2021; Mounika, 2022; Barbercheck, 2024; Manasa *et al.*, 2024). Agricultural products were destroyed 10-20% annually during harvest, post-harvest operations, handling and storage in India (Weifen, 2003; Khobde et al., 2011; Nanda et al. 2012). Stored grains are heavily damaged by insect pests both qualitatively and quantitatively. The infestation may happen at the processing warehouse, in transit, at the storage store or even at home (Ogebegbe & Edoreh 2014). The primary reason for the emergence of stored grain pests is the existence of conducive climates that support their growth and survival. Certain pests begin to harm the seeds during the ripening phase and persist in doing so throughout storage. Aging bags, storage facilities, and old containers serve as the principal sources of infestation. The dispersal and distribution of stored grain pests are caused by the movement of grains from one area to another either by a passive or active flight of pests as some adult insects possess strong flight potential. Nearly one thousand species of pests affect stored grains from various products globally.

Approximately 500 insect species are linked to stored grain products. Almost 100 species of these insect pests cause economic losses. In India, more than 200 species of insects are known to infest various pulses. The level of insect infestation is an important quality factor of food grains and represents a serious and continuing problem for the grain and milling industries (Campbell 2008). The primary economic impact of insects infesting grains is not solely the actual material they consume, but also the contamination they cause along with their excreta, rendering food unsuitable for human consumption. Many control methods have been suggested for storage insect pest (Muir *et al.*, 2000; Roesli *et al.*, 2003).

Fumigation is said to be a major function in the control of insect pest stored products such as phosphine and methyl bromide. Carbonyl sulphide, ethane dinitrile and ethyl bromide are also used (Haritos and Dojchinov, and make it harder to control them by chemical approach. (2003). According to Wallbank and Collins (2003), insect pest was resistance to the several insecticides and make it harder to control by chemical approach. Due to the high resistance of insects, insecticides need to be pest specific, unharmed to other organism, biodegradable, and less expensive (Isman 2006; Gupta & Chakraborty, 2024a,b). There is an urgent need for an alternative approach that could effectively scale down the use of chemical insecticides (Wakefield *et al.*, 2013). Additionally, the expense of insecticides frequently imposes a financial burden on the economic conditions of small-scale farmers. In this regard, plant volatile organic compounds have long been advocated as effective alternatives to synthetic chemical insecticides for pest management (Demeter *et al.*, 2021; Singh *et al.*, 2021; Singh *et al.*, 2022; Singh & Gupta, 2024).

On this backdrop this study was conducted to determine the diversity and abundance of the insect's pest in various stored grain collected from kitchen, super markets, grocery shops, ration depots, godowns, warehouses, etc. and selection of appropriate non-conventional insecticides for control of various stored grain pests collected.

2. MATERIALS & METHODS

A) Collection, Preservation, Storage

The insects, along with their immature stages, were collected and sampled from several sources of Kolkata & North 24 Pargana districts of West Bengal using standard entomological procedures during September 2024 to June 2025 (Fig. 1). The data was collected on a monthly basis in order to obtain the seasonal availability of the insects so that the maximum infestation rate by these pests can be deciphered. Research was conducted concerning the distribution, habitat, host, external morphology, biology, seasonal occurrence, and the damage inflicted by the documented insects.



Fig. 1. Collection Site.

A portion of the gathered insects was preserved by mounting them on board in fumigated collection boxes for future morphological analysis and taxonomic classification, while the remainder was utilized for laboratory culturing and the documentation of biological observations following Mandali *et al.* (2019); Patil *et al.* (2019); Bhargava & Kumawat (2019); Jamwal *et al.* (2022).

B) Application of Biopesticides in the Laboratory

Aqueous solutions of the test chemicals (Essential oils : Citronella oil, Neem Oil & Lemon grass oil & Synthetic pesticide : Malathion) of gradually increasing concentration were prepared. Filter papers soaked with particular conc. of test chemical were kept in three (3) petridishes for three (3) replications and a group of 10 individuals (beetles) of test stored grain pest were put in each replication glass petridish (Fig. 2). For lepidopterans, test insects were put in a small glass vial containing sprayed pesticides and mouth of that vial was plugged with muslin cloths tightly fitted with rubber band.

The test insects were exposed for particular time period. During the test, each petridish was covered by another petridish. For each conc., 25 ml of particular dilution of conventional & organic pesticides with distilled water were prepared. The observation towards mortality was recorded after every 24 hrs. upto 72 hrs till 100% mortality. After exposure to the test chemical for specific period of time, the death and alive insects in each of the petridish were counted till cent percent mortality. The percentage mortality was calculated following McGregor *et al.*, 1970. By probit graph paper method LC_{50} value of each test chemicals were measured. There was one control treatment on which only distilled water was applied.



Fig. 2. Experimental Protocol.

3. RESULTS & DISCUSSION

Table 1. Details of Stored grain pests collected.

Name of Pest	Commodities attacked	Identification	Life Cycle	Damage
Rice weevil - <i>Sitophilus oryzae</i> (Linnaeus) (Curculionidae: Coleoptera) 	Wheat, maize, chickpea, barley, cowpea.	Adults 3-4 mm, dark brown to black, elbowed antennae, long snout, elytra each with two dull orange spots, thorax with coarse circular punctures.	Optimum 25 days at 30 °C, 70% RH. Range 15-34 °C maximum population growth rate per month: 25. Eggs- laid singly in operated hole in grain then covered with waxy plug. Larvae- Apodous, immobile, develop concealed within single grain. Adult- On emergence leave ragged hole in grain, long-lived feed, fly.	Both grub and adult insects inflict damage. Grains are hollowed out, and kernels are diminished to mere powder. <i>S. oryzae</i> initiates its assault directly in the field. Adults create circular openings. Dry heating occurs during significant infestations. Grains that float in water frequently suggest larval damage.
Granary/Wheat weevil - <i>Sitophilus granarius</i> (Linnaeus) (Curculionidae: Coleoptera) 	Wheat, paddy, barley, chickpea, oats, maize.	Adult-3-4 mm, dark brown, oval, elbowed antennae, long legs, head with long snout, elytra unmarked, thorax with oval-shaped coarse punctures.	Optimum 25 days at 30 °C, 70% RH range 11-34 °C. Maximum population growth rate per month : 15. Eggs- Laid singly in operated hole in grain then covered with waxy plug. Larvae-Apodous, immobile, develop concealed within single grain. Adults-On emergence leave ragged hole in grain, long lived, feed, cannot fly	Both grub and adult insects inflict damage. Grains are hollowed out, and kernels are diminished to mere powder. Adults create rectangular openings. Heating occurs during significant infestations, referred to as 'dry heating'. This can also lead to substantial damage in hot conditions prior to the decline of populations. The larval stages consume the kernels within the grain, leaving only the hulls behind. Severe infestations can transform stored grain into a collection of hulls and frass.

Lesser grain borer - <i>Rhyzopertha dominica</i> (Fabricius) (Bostrichidae: Coleoptera)  	Oats, wheat, rice maize, chickpea, barley, chilli, coriander, turmeric, beans, mung bean, ginger, ground nut, black gram	Adults- 3 mm, dark reddish-brown, cylindrical, head bent downwards and concealed, tip of abdomen pointed, end of elytra curved gradually.	Optimum- 25 days at 34 °C, 70% RH. Range- 20-38 °C, >30% RH maximum population growth rate per month: 20. Eggs- Laid on commodity or in tunnels bored by adults. Larvae- Scarabaei form, legs fully developed, internal feeders producing lots of flour, immobile when mature. Adults- Long-lived, feed and bore into commodity, can fly.	Grubs and adults cause damage and are voracious feeders. Adults reduce the grain kernels to mere frass. Grubs eat their way into the grain or feed on the grain dust and are capable of attacking grain externally.
Pulse beetle - <i>Callosobruchus chinensis</i> (Linnaeus) (Bruchidae: Coleoptera)  	Pigeonpea, chickpea, soybean, black gram, mung bean, cowpea, rice, pea, wheat, groundnut.	Adults are 2.0-3.5 mm long, antennae pectinate in the male, and serrate in the female, elytra patterned and do not fully cover abdomen, inner ridge of lower side of hind femur with or without spine.	Optimum-21 days at 32 °C, 90% RH. Range – 18-37 °C, 20-90% RH. Maximum population growth rate per month: 50. Eggs- Glued individually to pod or seed. Larvae- Scarabaei form, legs partly developed, on hatching bore directly into seed, develop concealed within seed. Adults- Short lived, do not feed on commodity, can fly.	Grubs eat up the grain kernel and make a cavity. Adults come out making exit hole
Red flour beetle - <i>Tribolium castaneum</i> (Herbst) (Tenebrionidae: Coleoptera)	Wheat, groundnut, oats, barley, walnuts, lentil, rice, beans, pea, almond and rye.	Adults- 3-4.5 mm, flattened, parallel-sided, reddish-brown, antennae filiform, with last	Optimum- 20 days at 35-68 °C, >70% RH. Range- 22-40 °C, RH >1%. Maximum population growth rate per month-	Grubs consume milled products. Flour beetles act as secondary pests for all grains and as primary pests for

 		three segments forming club. Life cycle:	70. Eggs- Laid on commodity. Larvae- Elateri form, mobile external feeder. Adults- Long-lived, feed on commodity, can fly.	flour and other milled items. Within grains, they favour the embryo or germ portion. As they navigate through flour and other granular food items, they create tunnels. Furthermore, they emit gaseous quinines into the environment, which can generate a distinct acidic odour during severe infestations.
Sawtoothed grain beetle - <i>Oryzaephilus surinamensis</i> (Linnaeus) (Silvanidae: Coleoptera)  	Oats, wheat, rice, maize, chickpea, barley, rye, cashew	Adults- 3 mm, dark brown to dark grey, highly flattened, parallel-sided, thorax with three longitudinal ridges. laterally with six tooth – like projections	Optimum, 20 days at 30-33 °C, 70-90% RH. Range- 20-38 °C, RH > 10%. Maximum population growth rate per month = 50. Eggs – Laid amongst commodity. Larvae- Campodeiform, mobile, external feeders. Adults- Long-lived, very active, walk long distances, feed on commodity, can fly.	Adults and grub cause roughening of grain surface and off odour in grain. Grains with higher percentage of broken, dockage and foreign matter sustain heavy infestation, which leads to heating of grain.

Cigarette beetle - <i>Lasioderma serricorne</i> (Fabricius) (Ptinidae: Coleoptera)  	Cinnamon, cumin, tobacco, dried red chilli, groundnut, peppers, rice, wheat and cowpea.	Adults- 3-4 mm, brown, globular, antennae long, segments saw-like, elytra smooth with fine hairs.	Optimum- 26 days at 30 °C, 70% RH, range- 20-38 °C RH> 25%. Maximum population growth rate per month: 20. Eggs- Laid in crevices in commodity. Larvae - Scarabaeiform, legs fully developed, internal feeders, immobile when mature. Adults- Active, short-lived, do not feed on commodity, can fly.	Grub causes the damage which made circular, pinhead sized bore holes on processed tobacco & other commodities
Indian meal moth: <i>Plodia interpunctella</i> (Phycitidae: Lepidoptera)   	Rice, wheat, maize, chickpea, dried stored products, groundnut, bell pepper and red gram.	Adults- labial palps; male – short, hidden by scales; female- curved downwards. Forewing (78-13 mm) grey with no markings. Males much smaller than females. Larvae- 15-20 mm, white, rim of abdominal spiracles evenly thickened on one (rear) side.	Optimum- 27 days at 30 °C, 75% RH. Range- 17-37 °C, RH >20%. Maximum population growth rate per month: 10. Eggs- laid on loose in crevices in commodity. Larvae- external feeders produce lots of silk webbing, irregular holes bitten into attacked material. Adults- short-lived, do not feed on commodity, fly.	Larva is only responsible for damage. It contaminates food grains with frass, moults and dense webbing. In whole grains, kernels are bound into lumps upto 2 kg.

Table 2A. Summary of mortality data presented for the three essential oils tested.

Essential Oil	Stored grain pest	Exposure Time	Conc. of insecticide applied (%)	Average % of Mortality
Citronella oil	<i>Sitophilus oryzae</i>	24 hrs.	0.1	43.34
		48 hrs.	0.2	86.66
		72 hrs	0.3	100
	<i>Callobrochus chinensis</i>	24 hrs.	0.1	36.66
		48 hrs.	0.2	76.66
		72 hrs.	0.3	100
	<i>Oryzaephilus surinamensis</i>	24 hrs.	0.1	41.23
		48 hrs.	0.2	70.11
		72 hrs.	0.3	100
	<i>Rhyzopertha dominica</i>	24 hrs.	0.1	30
		48 hrs.	0.2	76.66
		72 hrs.	0.3	100
	<i>Tribolium castaneum</i>	24 hrs.	0.1	46.66
		48 hrs.	0.2	56.66
		72 hrs.	0.3	100
	<i>Plodia interpunctella</i>	24 hrs.	0.1	0
		48 hrs.	0.2	36.66
		72 hrs.	0.3	100
Neem oil	<i>Sitophilus oryzae</i>	24 hrs.	0.1	40
		48 hrs.	0.2	50
		72 hrs.	0.3	73.33
		96 hrs.	1.0	100
	<i>Callobrochus chinensis</i>	24 hrs.	0.2	0
		48 hrs.	0.3	56.67
		72 hrs.	0.4	100
	<i>Oryzaephilus surinamensis</i>	24 hrs.	0.1	33.33
		48 hrs.	0.2	40
		72 hrs.	0.3	100
	<i>Rhyzopertha dominica</i>	24 hrs.	0.1	40
		48 hrs.	0.2	43.33
		72 hrs	0.3	100
	<i>Tribolium castaneum</i>	24 hrs.	0.1	53.33
		48 hrs.	0.2	76.66
		72 hrs.	0.3	100
	<i>Plodia interpunctella</i>	24 hrs.	0.1	0
		48 hrs.	0.2	30
		72 hrs.	0.3	100

Lemon grass oil	<i>Sitophilus oryzae</i>	24 hrs.	0.1	43.34
		48 hrs.	0.2	73.33
		72 hrs.	0.3	100
	<i>Callobrochus chinensis</i>	24 hrs.	0.1	48.76
		48 hrs.	0.2	70.45
		72 hrs.	0.3	100
	<i>Oryzaephilus surinamensis</i>	24 hrs.	0.1	46.66
		48 hrs.	0.2	76.66
		72 hrs.	0.3	100
	<i>Rhyzopertha dominica</i>	24 hrs.	0.1	40
		48 hrs.	0.2	76.66
		72 hrs.	0.3	100
	<i>Tribolium castaneum</i>	24 hrs.	0.1	43.33
		48 hrs.	0.2	63.33
		72 hrs.	0.3	100
	<i>Plodia interpunctella</i>	24 hrs.	0.1	0
		48 hrs.	0.2	30
		72 hrs.	0.3	100

Table 2B. Summary of mortality data presented for one conventional pesticide tested.

Organophosphate	Stored grain pest	Exposure Time	Conc. of insecticide applied (%)	Average % of Mortality
Malathion	<i>Sitophilus oryzae</i>	24 hrs.	0.1	90.00
		48 hrs.	0.2	100
	<i>Callobrochus chinensis</i>	24 hrs.	0.1	83.33
		48 hrs.	0.2	100
	<i>Oryzaephilus surinamensis</i>	24 hrs.	0.1	83.33
		48 hrs.	0.2	100
	<i>Rhyzopertha dominica</i>	24 hrs.	0.1	83.33
		48 hrs.	0.2	100
	<i>Tribolium castaneum</i>	24 hrs.	0.1	86.66
		48 hrs.	0.2	100
	<i>Plodia interpunctella</i>	24 hrs	0.1	86.66
		48 hrs	0.2	100

Experimental Hours	Summary						ANOVA					Bonferroni Correction [α=0.05-4]	POST-HOC Test		
	Groups	Count	Sum	Average	Variance	Source of Variation	SS	df	MS	F	P-value	F _{crit}	Groups	P-value (T test)	Significance?
24 Hrs	Citronella oil	6	197.89	32.98167	294.5275	Between Groups	12104.71	3	4034.905				Citronella oil vs Neem	0.925423668	No
	Neem oil	6	189.99	31.665	834.3222	Within Groups	7371.177	20					Citronella oil vs Lemon grass	0.700686146	No
	Lemon grass oil	6	222.09	37.015	337.9753								Neem vs Lemon grass oil	0.709917773	No
	Malathion	6	513.31	85.55167	741.0377	Total	19475.89	23	368.5589	10.94779	0.000181	3.098391	Citronella oil vs Malathion	2.2868E-05*	Yes
													Neem oil vs Malathion	0.001059002	Yes
													Lemon grass vs Malathion	7.96012E-05*	Yes
48 Hrs	Citronella oil	6	403.41	67.235	321.9538	Between Groups	8263.675	3	2754.558				Citronella oil vs Neem	0.094396574	No
	Neem oil	6	293.33	48.88833	269.5659	Within Groups	4556.509	20					Citronella oil vs Lemon grass	0.838507165	No
	Lemon grass oil	6	390.43	65.07167	319.7521								Neem vs Lemon grass oil	0.135532122	No
	Malathion	6	600	100	0	Total	12820.18	23	227.8255	12.09065	9.7894E-05	3.098391	Citronella oil vs Malathion	0.001192442	Yes
													Neem oil vs Malathion	1.78765E-05*	Yes
													Lemon grass vs Malathion	0.000740571	Yes

Table 3. ANOVA and F- Value of mortality study in respect of eight stored grain pests treated with mentioned conventional & non-conventional pesticides.

Stored grains/pantry commodities are ravaged by a number of insect pests. From the present study, 8 insect species belonging to 2 orders namely Coleoptera (87.5%) and Lepidoptera (12.5%) were recorded on stored grains (Table 1), the prime groups of insects responsible for the postharvest loss of stored grains with order Coleoptera being the most dominant group. Out of 8 collected, 5 insects (63%) were reported to be internal feeders and only 3 insects (37%) were recorded as external feeders. *Sitophilus oryae* Linnaeus was the predominant stored grain pest. For management of stored grains especially in house commodities, chemical insecticides are used to protect this grain from infestation by stored product insects and mites. A restricted selection of products can be applied, and there are apprehensions regarding the safety, efficacy, and environmental consequences of these traditional pesticides.

Furthermore, the expense associated with insecticides frequently imposes a strain on the financial condition of small-scale farmers. There exists a pressing necessity for an alternative strategy that can significantly reduce the reliance on chemical insecticides. In this context, plant volatile organic compounds have been long promoted as viable substitutes for synthetic chemical insecticides in pest management. Essential oils are utilized globally as non-chemical alternatives to chemical fumigation for the control of various stored grain insect pests. Exceptions are for organic products where use of fumigants is not possible then application of essential oils is the best preferred choice. However, their general commercial use needs to be explored over the world.

The perusal of literature on essential oils indicated that the use of most effective natural products needs to be fully exploited for their potential use in the context of pest management in both household and large scale grain storage. All essential oil used proved insecticidal property exhibiting mortality and are as good as conventional chemical insecticide, Malathion (organophosphate) (Table 2A & B). Percentage mortality increased with the increase of time interval upto 100% in Malathion within 24 hrs and the essential oil treatments reached 100% with higher doses at different higher intervals.

Although Malathion initially seemed to outperform essential oil treatments, over time, the other treatments also demonstrated enhanced mortality rates, and no substantial difference was observed in their average values. No mortality was recorded in control treatment at any of the intervals. The results of the statistical analysis (ANOVA) revealed no significant difference among the treatment as their mean values although at the initial stage had shown significant difference but subsequently became at par. Essential oils vs Malathion correlation value (P-value) significantly high (>0.05) (as per POST-HOC Test) in 24 hrs. & 48 hrs. of observations (Table 3).

4. CONCLUSION

Our comprehensive research focuses on the utilization of biopesticides (Essential oils) instead of conventional one. To increase effectiveness, we recommend using solid absorbent granules infused with essential oil, kept in perforated cloth bag which ought to be positioned in a container/s at kitchens, stores and warehouses. This approach is anticipated to produce better outcomes within minutes/hours, resulting in the eradication of pests. Repeated experiments are necessary for large-scale infested commodities for better solution. However, there is a need to study the toxicity effect of these tested essential oils on the health of consumers.

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