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Effect of botanical smokes generated using developed indigenous furnace on pulse beetle

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Abstract
Using botanicals in the form of smokes has a great potential, since the research area has not been explored extensively for grain storage pest management. In present study, potential of environmental friendly byproducts in the form of smokes were generated using developed indigenous furnace cum fumigation chamber and were treated against *Callasobruchus chinensis* (L.). The results indicated, the adult mortality of 0.4 to 98.4% observed when smokes of different byproducts were tested. Among the byproducts, the smokes from mustard cake resulted highest mortality (46.2%) and followed by smokes from neem seed cake (37.2%) and karanj seed cake (33.2%). However, the application of phosphine recorded highest mortality 9814%. The longest exposure of smokes at 120 hr found most effective and recorded highest mortality (51.2%), followed by 96hr (40.4%), 72 hr (33.2%), and 48 hr (24.7%). Further, the mortality is linearly correlated with exposure time of smokes. Smokes generated from cake of mustard seeds was found most effective at 120 hr of exposures and recorded (68%) adult mortality. Egg hatchability reduced to 40 to 87% during first four days. However, after five days the smokes not recorded desirable kill. Smokes generated from botanical byproducts can be effectively used as fumigant alternatives for grain storage, with thorough scientific research.

Keywords: Botanicals, smokes, furnace, pulse beetle, fumigation

Introduction

Pulses are the important components of vegetarian diet after cereals. India, in recent years started storing pulses in large-scale; facing major problems from insect pests during storage. Pulse beetles are the major culprits in severe losses caused under storage condition. The pulse beetle, (*Callosobruchus chinensis* (Linn.)) is estimated as one of the most severe stored insect pest lead to quantitative as well as qualitative losses in pulses [1, 2]. It is serious insect pest of stored products in the temperate zones with annual loss of about 0.21 MT of Rs. 315 million [3]. According to estimate, the overall annual contamination caused by stored grain insect pests accounts for 10-40% worldwide each year [4]. It causes weight reduction, decreased germination potential and reduction in the economic value of the seed [5, 6, 7]. Pulse beetle caused damage in the field, after that the develop adults lay their eggs on fresh grains in the storehouse. In the field, the infestation by pulse beetle is about 7.8 to 9.9% and whole grains were damaged when infestation was about 9.9% [8]. Phosphine, is a fumigant in India which is used mainly and it is only available fumigant choice to handle the pests. However, though there are several biological options available in the researched material, but are inadequate in their adequacy at large scale. In addition, resistance to phosphine and its residues in treated grains are matter of concern [9]. The non-chemical methods include: heat disinfections, mechanical cleaning, treatment with toxic gasses, and CO_2 admixture of lime, sand. The most commonly used approach is as phyxination with CO_2. However, the method could not provide effective in checking the development of existing infestation [10]. In recent years the use of CO_2 as an alternative fumigant to phosphine (PH_3) has gained popularity because of unwanted residual effects and development of insect resistance due to application of phosphine as fumigants. However, the initial contribution incurred in obtaining gas cylinders periodically limits the use as a cheaper fumigant. Use of CO_2 proved its effectiveness in managing several stored product pests, causing reduction in metabolism of insects lead to death. However, the sources of CO_2 are not yet standardized for the scientific storage [11].

Using botanicals in the form of smokes has a great potential, since the research area has not been explored extensively for grain storage pest management. The active ingredients present in botanicals were not only extensively used in pest management but also reported with antilisterial, antimicrobial and antioxidant effects [12]. Biomass or byproduct from agro-waste is a major fuel for most of the rural agricultural population in India and 70% of energy consumption is met from biofuel, which include fuel wood, dunk cakes, agricultural residues and charcoal. Burning of the byproduct is associated with a lot of emissions of SO_2, NO_x, organic and elemental carbon and has strong influence on atmosphere if neglected while using properly [13]. Fumigation from burning waste material for storage pest management is time tested technology in rural areas. The biogas, as a fumigant may effectively use at rural farm level and has shown promise in controlling this pest [14]. Fumigation using CO_2 seems best alternative to chemical fumigation. Biogas fumigant was effectively used at farm level and has shown promising insect control. Similarly, plant produced CO_2 can be used as an option. Especially burning of plant material generates CO_2 which proved lethal to insects [11]. With this literature background, recent study was conducted to know the effect of the generated botanical smokes from indigenously developed furnace cum fumigation chamber on pulse beetle.

Materials and Methods

a. Indigenous Furnace cum fumigation chamber: A furnace chamber (Fig. 1) along with fumes collector was designed and fabricated initially. A GI sheet (20 gauge) was molded in to box (L 18"x B 9"). An inverted fume hood was fixed at the top of box to collect the smokes generated from burning cakes. A frying pan was fixed at the bottom of box in a circular form for burning of cakes. The food warmer was used to burn the cakes. KOH (10%) solution was prepared in the glass bottle (1 lit capacity). The bottle had two outlets one for smoke collection and another for smoke exhalation through KOH solution for trapping CO_2 gas from the smokes (act as a CO_2scavenger) so that only smoke without CO_2 can pass through outlet. Further, it was simplified by removing CO_2scavenger and the tube was connected directly to the pearl pet bottle which contains infested grains for testing. This simplified device was used through the experiments.

Fig 1: Indigenous furnace cum fumigation chamber

b. Test insects: The adults of Pulse beetles, *Callosobruchus chinensis* (Linn.) used in this study were originally obtained from infested samples of chickpea grains from Abohar (Punjab). Chickpea grains (var: GNG 663) locally known as Samrat were used for mass culturing. The grains were kept in a deep freezer at 18 °C for 10 days to kill any previous infestation. The moisture of the grains was determined before treatment and it was recorded between 10.9 to 11.1%.

c. Treatment details: Smokes/ fumes from 9 different sources were used as treatments.

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Treatment number	Details
1	Mustard seed cake (MSC)
2	Kinnow peels (KP)
3	Neem seed cake (NSC)
4	Cotton seed cake (CSC)
5	Karanj seed cake (KSC)
6	Wheat straw (WS)
7	Saw dust (SD)
8	Control (Untreated/no smokes)
9	Phosphine (PH_3) @ 6 g/kg

The treatments imposed separately and insects were exposed for 20, 24, 48, 72 and 96 hrs respectively. Two factorial CRD was used for the study in which treatments (smokes) as factor 1 and exposure periods as factor 2.

d. Determination of smoke dosage: Based on the preliminary studies, it was calibrated the time required for purging of smoke to bottles. Approximately 15 minutes for purging and 30 minutes required to fill 200 ml bottle. Based on these results smoke generated from burning byproducts under flameless heating (under controlled air supplement near to pyrolysis about 300°C) was used.

e. effect of smokes on the mortality of *C. chinensis:* Twenty adults of *Callosobruchus chinensis* (0 to 18 hr post emergence from grains) were tested at 24, 48, 72, 96, 120 hr of exposure of smokes from different byproducts separately. Treatments were replicated for five times under factorial CRD. The mortality of adults was observed from one hour after opening lids of bottle.

In second set, chickpea grains with pulse beetles were tested with the smokes as mentioned above. Initially 25 pairs of beetles were inoculated in 2 kg grains. From this, 300 grains with average of 1 egg per grain were exposed to treatments at 1, 3, 5, 7, 9, 11, 13 and 15th day, respectively. Setup was replicated five times. Mortality and adult emergence was recorded as per treatments.

f. Statistical analysis: the laboratory experiment was conducted using factorial CRD, where treatments (smokes) as factor 1 and exposure periods as factor 2. The treatments were replicated five times. Analysis of variance was done using web-agri stat package (wasp), India – a freeware statistical analysis.

Results and Discussion

Smokes generated from different byproducts were tested against *Callasobruchus chinensis* and found mortality in all the cases, varied in per cent mortality. The results obtained during the study are presented below.

Effect of smokes from byproducts alone: Irrespective of exposure times, adult mortality ranged from 0.4 to 98.4%, when smokes of different byproducts were tested. Fig. 2 indicates that the smokes from mustard seed cake resulted highest mortality (46.2%), followed by smokes from neem seed cake (37.2%) and karanj seed cake (33.2%). However, the application of phosphine recorded highest mortality of 98.4% is observed in Table 1. In a similar study, Researchers reported highest mortality (80%) of *C. chinensis* by root smoke treatment of *Peganum harmala* followed by its fruit (58%) after 48 hours of exposure [15]. The highest mortality of *Sitophilus oryzae* after 48 hrs of exposure to *Lantana camara* smoke was observed followed by *Ocimum sanctum* and *Azardirachta indica* [16].

Effect of exposure times: It reveals from figure 3 that the adults were exposed to smokes at different periods *viz.*, 24, 48, 72, 96 and 120 hr for all byproducts, respectively. The mortality of adult was ranged from 20.6 to 51.2%, significantly differed at 0.05. However, longest exposure of smokes at 120 hr found significantly most effective treatment against *C. chinensis* adults and recorded highest adult mortality (51.2%), followed by 96 hr (40.4%), 72 hr (33.2%), and 48 hr (24.7%). There isa report which shows that use of neem smoke twice at monthly interval was found effective in controlling *C. chinensis* in the first integrated pest control strategies [17]. Whereas, the use of biogas has shown effective against *C. chinensis* when exposed for six days [18, 19].

Effect of interactions between exposures and byproducts: Among different smokes, smoke generated from cake of mustard seeds was found most effective at 120 hr of exposures and recorded (68%) adult mortality. It was followed by neem seed cake (59%) and karanj seed cake (57%) smokes. The least mortality (5%) among byproducts was expressed due to smokes from sawdust when exposed at 24 hr. The fumigation with phosphine was resulted in complete mortality after 72 hr of exposure. There were no reports on studies of the efficacy of mustard seed cake smoke against *C. chinensis* for 120 hr exposure. However, the adult mortality can be compared to effectiveness of smokes from neem seed cake from the reports [16, 17].

Effect of smokes on egg and early instar: Table 2 indicates that the mortality affected with exposures of smokes and ranged from 40 to 87% during first four days of egg hatching period. Since newly hatched grub enter the seeds, the smoke was most effective for controlling the newly hatched larvae. However, in later stage i.e., after five days, the smokes did not show desirable kill. It reveals from the studies that egg mortality significantly could be reduced during initial stages of oviposition.

These findings are in accordance with the other reports, which showed that smoke hold fumigant toxicity to various insect pests. Among the potential new fumigants for controlling pests in stored products, CO_2 smoke is a good alternative to methyl bromide and phosphine; the standard fumigants [19]. The use of CO_2 is safe, has no harmful risks and main causes of its toxicity to insects is the catalyst to the opening of spiracles, which leads to water loss and dehydrate [20].

Conclusion

Smoke generated from burnt mustard seed cakes has the potential to protect chickpea grains from *Callasobruchus chinensis* at 120 hr exposure of smokes. It was followed by neem and karanj seed cakes smokes. Further, smokes were effective during initial stages of insect growth (1 to 4 days of egg inoculation). Byproduct smokes can be integrated with reduced dose of phosphine while fumigation, so as to reduce insect resistance and health hazards. In addition, further scientific studies are required to confirm the mode of action and sole management using botanical byproduct smokes on insect complexes infesting in grain storage.

Table 1: Effect of smokes from different botanical byproducts on *Callasobruchus chinensis* (L.)

Treatment number	Smokes	Exposure time (hours)					Mean
		24	48	72	96	120	
1	Mustard cake	27 (31.2)*	33 (34.9)	47 (43.3)	56 (48.4)	68 (55.6)	46.2 (42.7)
2	Kinnow peels	8 (16.2)	11 (19.3)	29 (27.1)	32 (34.4)	48 (43.8)	23.6 (28.2)
3	Neem cake	19 (25.7)	24 (29.3)	38 (37.9)	46 (42.7)	59 (50.2)	37.2 (37.2)
4	Cotton cake	11 (19-3)	18 (24.9)	29 (32.5)	36 (36.8)	51 (45.6)	29.0 (31.8)
5	Karanj cake	15 (22.8)	21 (27.2)	32 (34.4)	42 (40.4)	56(48.4)	33.2 (34.6)
6	Wheat straw	6 (14.1)	9 (17.3)	19 (25.8)	28 (31.9)	40 (39.2)	20 (25.7)
7	Saw dust	5 (12.9)	7 (15.1)	16 (23.5)	24 (29.3)	37 (37.4)	17.8 (23.7)
8	Control	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (5.20	0.4 (1.1)
9	Phosphine (PH_3)	94 (66.6)	98 (84.8)	100 (89.9)	100 (89.9)	100 (89.9)	98.4 (84.3)
	Mean	20.6 (23.2)	24.7 (28-1)	33.2 (34-9)	40.4 (39.3)	51.2 (46.2)	
LSD at 0.05 Smokes: 1.78 LSD at 0.05 Exposures: 1.32 LSD at 0.05 Smokes x Exposure: 3.97 * Figures in parenthes are arc sin transformed values							

Table 2: Cumulative effect of smokes on egg hatching

Tr. No.	Smokes	% hatchability	
		After 1 day	After 3 days
1	Mustard cake	32	13
2	Kinnow peels	53	25
3	Neem cake	38	14
4	Cotton cake	48	21
5	Karanj cake	42	17
6	Wheat straw	57	28
7	Saw dust	60	32
8	Control	100	100
9	Phosphine (PH_3)	2	0

Note: Hatchability was not observed after 3 days (at 5 days' observations)

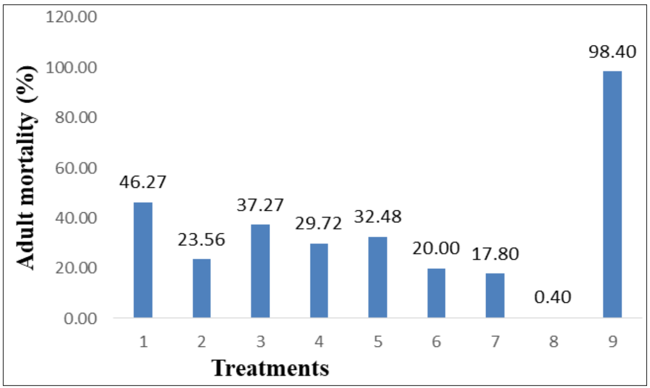

Fig 2: Effect of different byproduct smokes on *C. chinensis*

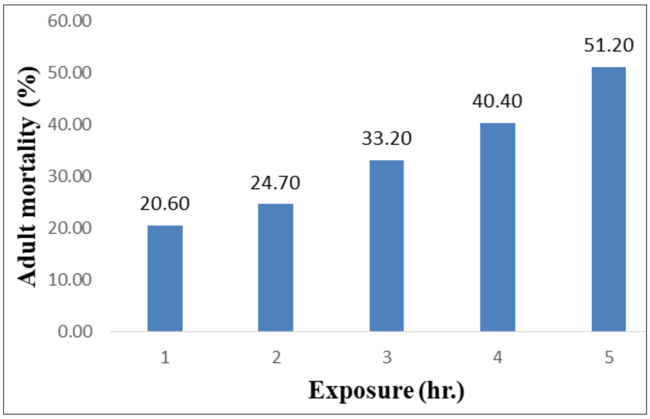

Fig 3: Effect of different exposure times (hr.) on *C. chinensis*

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