



Efficacy of Food Bait Attractants in Reducing *Sitophilus oryzae* Populations in Stored Paddy

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Abstract: The rice weevil (*Sitophilus oryzae* L.), a major pest of stored grains, relies heavily on olfactory cues for host selection and localization. This study evaluated the behavioral responses and attraction efficiency of *S. oryzae* to various food-based baits under laboratory conditions using olfactometer bioassays, trap-based assessments and bait ratio trials. Bait traps filled with different food attractants wheat flour, sorghum flour, pearl millet flour and combinations thereof were deployed in a simulated storage environment. Observations over 25 days revealed that wheat flour was the most attractive bait, achieving a total attraction rate of 64.70%, followed by sorghum flour (58.71%). Combination bait trials demonstrated that a 2:1:1 ratio (wheat flour: sorghum flour: pearl millet flour) yielded the highest insect recapture (181 out of 700 released), indicating optimal arresting efficacy. Four-arm olfactometer assays further confirmed the strong olfactory-driven orientation of *S. oryzae* towards wheat and sorghum volatiles. Behavioral observations showed a peak in insect settling at 25 minutes after release (MAR) and highest retention on wheat-based substrates. The results suggest that wheat and sorghum flours can serve as highly effective attractants for the monitoring and management of *S. oryzae* in stored grain systems. This study provides a foundation for the development of sustainable, bait-based pest control strategies in post-harvest storage environments.

Keywords: *Sitophilus oryzae*, Wheat flour, Sorghum flour, Pearl millet flour, Paddy storage godown

Rice is a widely consumed cereal grain and it is the staple food for many people in Asian countries (Devi et al., 2017). The impact of insect-related losses in storage significantly affects food availability. Most commonly the insects, mites, birds, rodents, fungi and moisture are the major problems in storage godowns. Adult beetles, especially stored product insects, exhibit a propensity for seeking shelter in the cracks and crevices of warehouses and storage godowns due to their harborage seeking behavior. The rice weevil, *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae), is one of the most widespread and destructive primary pests of stored cereals such as rice, wheat, maize, barley, sorghum, buckwheat, pulses, dried beans, cashew nuts and products derived from them (Nwaubani et al., 2014; Mehta and Kumar 2020). Rice weevils damage rice by boring a hole into a grain or seed to lay their eggs, then sealing the opening. Once the eggs hatch, the larvae feed on the inside of the grain until they mature. The adult weevils then chew their way out, causing considerable loss in both the quantity and quality of the rice (Arafah et al., 2023). Control of this pest is difficult because the immature stages develop inside grain kernels (Mehta et al., 2021). *Sitophilus oryzae* shows host preferences for different stored products in terms of its feeding, development, oviposition and degree of damage (Jalaeian et al., 2021, Mehta and Kumar 2021). Worldwide, chemical control stands out as the most commonly utilized method for managing pests of stored products (Nayak et al., 2020). In addition, the behavior and performance of insects differ depending on the host's physicochemical characteristics, such as the

occurrence of toxins, inhibitors, volatiles, macronutrients and micronutrients, as well as kernel hardness and texture. Infestations of *S. oryzae* have been observed in different types of stored commodities, in terms of both damage and the progeny production capacity (Jalaeian et al., 2021, Mehta and Kumar 2021). However, resistance among several species of stored product insects to conventional pesticides has increased over the last few decades (Isman 2006; Hagstrum and Phillips 2017, Nayak et al., 2020). These challenges and the growing awareness of environmental issues have prompted researchers to explore suitable alternatives to chemical pesticides. One such alternative is the volatiles from different grain commodities because they are environmentally friendly and safe for human health (Phillips and Throne 2010; Pavela and Benelli 2016; Hubert et al., 2018). In this study, the behavioral responses of *S. oryzae* to volatiles from different grain commodities, i.e. Crushed groundnut, wheat flour, cracked corn, sorghum flour, rice flour, pearl millet flour, rice bran, rice bran + rice flour, cracked sorghum and control (without bait) were assessed in storage godown and four arm olfactometer bioassays.

MATERIAL AND METHODS

Bait traps, filled with attractants, are strategically positioned between the stacked bags in the paddy storage godown. Designed with a 4mm entrance, they guide insects into the lower polyethylene receptacle (Fig. 1). Trap catches were recorded at 5, 10, 15, 20 and 25 days after bait

installation (DAI). The number of insects captured in the control (without bait material) was compared with those caught in the various treatment containing bait (Sathiyaseelan et al., 2022). The attraction index was calculated (Smith et al., 1993).

$$\text{Attraction Index} = \frac{T-C}{N}$$

T- Number of insects drawn to the treatment, C- Number of insects drawn to the control

N - Total number of individuals

Rearing of test insects: Adults of the rice weevil, *Sitophilus oryzae*, were reared in plastic jars containing a mixture of wheat flour and whole grains as their diet. Each jar was provisioned with 250 g of grains and 20 to 30 insect pairs, and covered with a piece of kada cloth secured by rubber bands to allow ventilation while preventing escape. The rearing was conducted under controlled environmental conditions, with a 12:12 hour light: dark photoperiod, temperatures maintained between 26–28 °C, and relative humidity levels between 60–65%. All experiments were carried out under these standardized conditions to ensure consistency in culture maintenance.

Trapping efficiency of different food bait mixture: Based on initial bait attractiveness, three promising food bait sources were selected for further evaluation. An experimental setup was designed consisting of four 150 g capacity containers connected to a central 2-litre container using PVC pipes positioned at a 45° angle. The selected bait materials wheat flour, sorghum flour and pearl millet flour were combined in different ratios 1:1:1, 2:1:1, 1:2:1 and 1:1:2 with 20 g of each mixture placed in the respective chambers. A total of 700 *Sitophilus oryzae* adults were released into the central arena, and insect movement towards the bait mixtures was recorded 24 hours after release (HAR) (Fig. 2).

Behavioural / Orientation studies: The test insects, including the rice weevil, *S. oryzae*, underwent a 24h period of starvation in Petri plates prior to initiating the olfactory bioassay. Subsequently, 100 adult insects of mixed sex were introduced into the central chamber of the olfactometer, which featured a 7 mm aperture for movement. To minimize light-induced orientation, the entire setup was covered with cloth. The distribution of *S. oryzae* in response to different bait treatments was recorded at 5, 10, 15, 20 and 25 minutes after release (Vijay et al., 2020). Each treatment, involving wheat flour, sorghum flour and pearl millet flour as attractants, was replicated five times to ensure accuracy and reliability of the results (Fig. 3).

Statistical analysis: The data on attraction index and behavioural response/orientation of *Sitophilus oryzae* were statistically analyzed using a completely randomized design .

The analysis was conducted using IBM SPSS Statistics version 22.0, differences considered statistically significant at $p < 0.05$.

RESULTS AND DISCUSSION

The different attractants revealed significant variation in

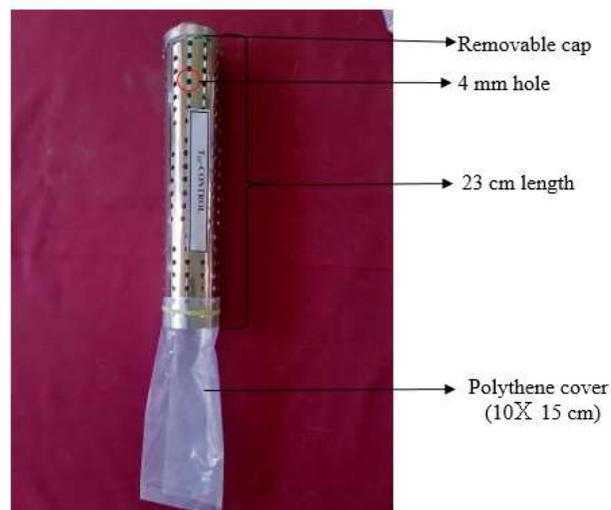


Fig. 1. Structural design of the insect bait trap

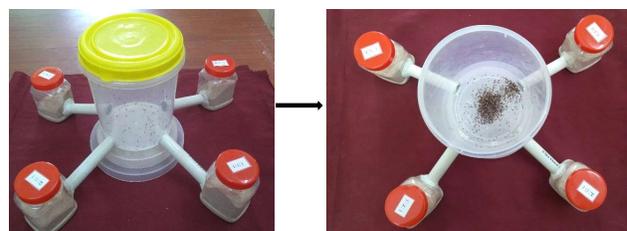


Fig. 2. Test chamber for evaluating insect attraction toward food bait mixtures

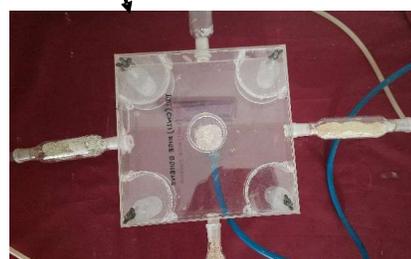


Fig. 3. Four-arm olfactometer arrangement for bioassay

their ability to attract the target species over a 25 days period. The wheat flour was the most attractive substrate, recording the highest total attraction of 64.70%. The weevils showed a consistent preference for wheat flour, with peak attraction observed on the 10th day after placement. Sorghum flour also elicited a strong response, with a total attraction of 58.71%, indicating its effectiveness as an attractant. Cracked sorghum attracted moderate weevil activity, with a total response of 44.90%. Other attractants such as pearl millet flour, rice flour and cracked corn showed intermediate levels of attraction, registering total values of 34.37, 28.46 and 27.60%, respectively. Rice bran and the combination of rice bran with rice flour recorded lower attractiveness, with total responses of 32.25 and 20.41%. Among all the tested substrates, crushed groundnut was the least attractive, with a total attraction of only 19.67%, suggesting limited interest from the weevils. The control treatment, showed no weevil activity throughout the observation period. These findings suggest that wheat flour and sorghum flour are highly attractive to *S. oryzae* and may be effectively utilized in monitoring or management strategies for this pest in stored grain systems (Table 1). Rice is recognized as a preferred host plant for *S. oryzae* (Subedi et al., 2009).

The response of *Sitophilus oryzae* to different bait source ratios composed of wheat flour, sorghum flour and pearl millet flour was assessed to determine the most effective combination for arresting insect movement. The 2:1:1 ratio (wheat flour: sorghum flour: pearl millet flour) recorded the highest recapture, with 181 insects, representing the most effective ratio for insect arrest. This was followed closely by the 1:2:1 ratio, which recorded 179 insects, and the 1:1:1 ratio with 162 insects. The 1:1:2 ratio was the least effective,

with only 137 insects recaptured. Out of the total 94% were recaptured, while 6% insects did not respond to any of the bait treatments, possibly due to mortality or lack of attraction under the test conditions (Table 2).

Orientation of stored product insect in four-way olfactometer: Olfactometer bioassay revealed the significant variations on orientation/behavioural response of *S. oryzae* towards wheat flour, sorghum flour, pearl millet flour and control (without food bait) in a four-arm olfactometer. There was indicated significant variation in the percentage of insects settling on different food sources throughout the study duration, reflecting differences in the relative attractiveness and retention potential of each attractant over time. Wheat flour consistently attracted the highest percentage of settling insects. The settling increased steadily from 21% at 5 MAR to a peak of 38% at 25 MAR, indicating its sustained attractiveness over time. Sorghum flour also demonstrated an initially strong response, attracting 25% at 5 MAR, but the settling percentage declined

Table 2. Effect of bait source ratio on the arrest of insect movement (wheat flour: sorghum flour: pearl millet flour)

Bait ratio	Percent of insect captured	Number of insects recaptured
		<i>S. oryzae</i>
1:1:1	23.14	162
2:1:1	25.85	181
1:2:1	25.57	179
1:1:2	19.57	137
Total		660
Not responded		40

Table 1. Comparative response of *Sitophilus oryzae* to various food attractants

Attractants	**Relative attraction index (%)					Mean attraction	Total attraction (%)
	5 DAP *	10 DAP	15 DAP	20 DAP	25 DAP		
Crushed groundnut	5.23	4.69	3.35	3.77	2.63	3.93	19.67
Wheat flour	7.29	16.89	13.81	13.32	13.39	14.35	64.70
Cracked corn	6.18	5.61	3.97	6.28	5.56	5.52	27.60
Sorghum flour	5.84	13.19	14.40	13.52	11.76	11.74	58.71
Rice flour	5.18	5.67	5.37	5.06	7.18	5.69	28.46
Pearl millet flour	7.68	5.56	3.27	9.69	8.17	6.87	34.37
Rice bran	4.59	5.56	6.84	8.07	7.19	6.45	32.25
Rice bran + Rice flour	6.68	4.63	3.35	2.49	3.26	4.08	20.41
Cracked sorghum	10.90	9.43	8.84	7.56	8.17	8.98	44.90
Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CD Value	0.293	0.243	0.290	0.230	0.180	-	-

*DAP – Days after placement, **Mean of three replications

Table 3. Behavioural/Orientation response of *Sitophilus oryzae* to various food attractants

Food attractants	<i>S. oryzae</i> settled (%)					Mean attraction
	5 MAR*	10 MAR	15 MAR	20 MAR	25 MAR	
Wheat flour	21	26	33	31.33	38	29.87
Sorghum flour	25	20.33	16	24	20	21.07
Pearl millet flour	15	18	19	17	12	16.20
Control (without food)	4.67	4.67	5	5	4	4.67
Unsettled	34.33	31	27	22.67	26	28.20
CD Value	1.864	1.251	1.352	1.105	0.616	-

*MAR- Minutes after release

in the subsequent observations, dropping to 16% at 15 MAR before showing a slight increase by 20 MAR and a decline again at 25 MAR. This trend suggests a reduction in its long-term attractiveness compared to wheat flour. The relatively low and stable response indicates that pearl millet flour is less effective in encouraging insect settlement. The percentage of unsettled insects decreased over time from 34.33% at 5 MAR to 22.67% at 20 MAR, suggesting that more insects were gradually responding to the attractants, particularly wheat flour. However, a slight increase to 26% at 25 MAR indicates some fluctuation in insect behavior, possibly due to environmental or internal factors influencing activity (Table 3).

Responses to plant extracts and pheromones were researched by (Athanasios et al., 2006), the traps with baits like oil and seeds were more attractive than traps without bait to *T. confusum* and *S. oryzae*. Vijay et al. (2020) observed that *Sitophilus oryzae* showed the strongest orientation towards sorghum.

CONCLUSIONS

The study demonstrates that *Sitophilus oryzae* exhibits distinct preferences for specific food-based attractants, with wheat flour emerging as the most attractive and consistently effective substrate across a 25-day period. Sorghum flour also proved to be a strong attractant, particularly in the initial days, while pearl millet flour showed moderate effectiveness. Combination baits, especially the 2:1:1 ratio of wheat flour, sorghum flour and pearl millet flour, resulted in the highest insect recapture rates, indicating their potential in enhancing bait efficacy. The four-way olfactometer assays confirmed that *S. oryzae* and related stored product pests are strongly oriented towards cereal-based volatiles, with minimal response to control setups lacking food cues. Based on these results, it is recommended that wheat flour and sorghum flour, either alone or in optimized ratios, be employed as key components in bait formulations for monitoring and managing *S. oryzae* populations in stored grain environments.

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