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Eco-friendly management of rice weevil (*Sitophilus oryzae* L.) on stored wheat (*Triticum astivum*)" at Prayagraj (U.P)

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Abstract
The laboratory experiments were conducted to study the efficacy of some indigenous plant products such as sweet flag rhizome powder @ 5%, tobacco leaves powder @ 1%, clove powder @ 2%, ginger rhizome powder @ 2%, ajwain seed powder @ 2%, neem leaves powder @ 5%, turmeric rhizome powder @5% against rice weevil, *Sitophilus oryzae* (L.) on stored wheat by undertaking various parameters *viz.*, percent adult mortality, percent seed damage and percent weight loss after three months of storage. The research was carried out at Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, U.P. in department of Entomology 2022-2023. This experiment was conducted under Complete Randomized block Design (CRD). After 90 days of storage for observation. among different plant products evaluated for their efficacy against rice weevil, *Sitophilus oryzae* for stored wheat grains, sweet flag rhizome powder was found significantly superior in reducing 100 percent adult mortality, no seed damage and no seed weight loss was found significantly superior followed by tobacco leaves powder, clove powder, neem leaves powder and ajwain seed powder. Whereas, the minimum efficacy was recorded in ginger rhizome powder and turmeric rhizome powder. The present study clearly revealed that these naturally occurring indigenous plant products could be used to manage the storage insect pests in wheat.

Keywords: Rice weevil, host preference, mortality, seed damage, weight loss, wheat

Introduction
Wheat, (*Triticum aestivum* L.) belongs to family gramineae is the main cereal crop in world and ranks 2nd in total production as a cereal crop. India is the 2nd largest producer of wheat in world with a production level of 95.91 million tones (FAO, 2014). Wheat is one of the most important food grain crop which is cultivated annually in an area of 220 million hectares across the world and provides 21 per cent of the food calories and 20 per cent of the protein for more than 4.5 billion people in 94 countries. The target of wheat production in India is projected around 140 million tons by 2050 considering its growing demand for consumption and trade (Anonymous, 2015) [1]. This is a big challenge keeping in view the present production of 98.61 million tons in an area of 29.72 million hectares under cultivation with a productivity of 33.18 q/ha (Anonymous, 2018) [1].

Rice weevil has got economic importance. It is the most destructive insect pest originated from India and now it has a cosmopolitan. Rice weevil mainly attacks whole grains such as wheat, corn, barley and rice and have been found actively breeding in such grains. Its host range now extended to split legumes (Deepthi and Manjunatha, 2016) [5].

Rice weevil remains active throughout the year, however serious damage is caused from July to November. The important factor is moisture for its development. Under the favourable condition, it can multiply in a large number and the respiration hot spots are developed in grains. In case of heavy infestation there is the mass of broken grains. Sometimes black fungus also develops (Ghosh and Durbey, 2003) [6].

For the control of stored grain insect-pests, synthetic insecticides are used in several countries, however, their indiscriminate use has resulted into many serious problems including resistance of pest species and toxic residues in food grains used for human consumption (Koul *et al.*, 2008) [8]. Methyl bromide and aluminium phosphide, the two most commonly used synthetic fumigants for stored grain protection are being phased out due to ozone layer depletion and control failures (Kedia *et al.*, 2014). Due to long use of phosphine, some insects have gained resistance to chemical fumigation in some countries (Credland *et. al.*, 2002) [4].

Due to all these concerns and also, keeping in view the growing demand for organically produced food, it is essential to find suitable alternatives to the use of chemical pesticides.

Materials and Methods

Studies on the "Eco-Friendly Management of Rice Weevil (*Sitophilus Oryzae* L.) on stored wheat (*Triticum astivum*)" were conducted at Entomology Department SHUATS, Prayagraj, to evaluate the different plant-based products against Rice weevil *Sitophilus oryzae* (L.) in wheat.

Rearing of test insect *S. orzyae*

The cultures of *S. oryzae* were obtained from the local stores of Prayagraj. Plastic containers of 1.5 kg capacity were used for insect rearing. About 500 gm of grains were kept in each container and about 600 adults of insects were released separately. They were allowed to lay eggs for 3 to 5 days and removed after 7 days, when the egg laying was over. These containers were kept at room temperature for the adult emergence of *S. oryzae.* To initiate the culture, healthy seeds of wheat were kept in to 32 × 22.5 cm size cylindrical jar and 10 pairs of adult weevils were isolated and released into jar. The mouth of the container was covered with a muslin cloth secured firmly by rubber band. Fresh seeds were provided periodically for the development of weevils. After few days the new adult weevils emergence, the weevils were introduced into healthy wheat seeds kept in series of cylindrical jars for building up a homogenous population. Density of population per jar was standardized to prevent overcrowding of weevils which was reported to give rise to less reproductive active forms (Sano, 1967). Such conditioning was necessary to prevent short term changes in insect behaviour or biology associated with changes in host grain (Dobie, 1974). These studies were conducted at 30 ^{0}C temperature and 80 per cent relative humidity in laboratory.

Mixing of grain protectants

Ten glass jars of one kg capacity were taken and each filled with 100g of wheat and treated with the above plant products. The treated seed material was stored in the glass jars covered with muslin cloth and fastened with a rubber band. Untreated seed served as control. 100 g wheat were taken into different jars to replicate the treatments for three times. Ten pairs of freshly emerged adults were released in each replication. Adult mortality was noted for 3, 7, 10 and 14 days after treatments and percent weight loss and seed damage was noted at 30, 60 and 90 days after release.

Observations to Be Recorded

Efficacy of treatments based on Mortality

Wheat seeds were weighed and kept in a medium sized (250 g capacity) plastic container at the rate of 100 g each. Respective dosage of powder of each treatment was added to the respective containers and mixed thoroughly by shaking the containers. Twenty (10 pairs) newly emerged adults of rice weevil from the pure culture were released in each of the container containing treated seeds and allowed to feed and oviposit. As per the treatments, plant products which showed promising results were recorded at 3, 7, 10 and 14 days respectively. The purpose of the experiment was to find any change in their effectiveness against the weevil due to storage conditions. Data were recorded on adult mortality of insect released by using sieve (mesh size 10) to separate the weevils. After taking counts on dead insects, the live ones were transferred to the irrespective containers and is calculated by using formula:

$$\text{Percent mortality} = \frac{\text{Number of dead insects}}{\text{Number of insects released}} \times 100$$

Efficacy based on weight loss

The observations will be recorded on % weight loss of treated rice grains. The weight loss caused by one generation of *S. oryzae* will be compared with weight loss obtained in untreated (control) and is be recorded for 30, 60 and 90 days after treatment application and is calculated by using the formula:

$$\text{Percent weight loss} = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100$$

Efficacy based on seed damage

The number of seeds infested by *S. oryzae* counted and per cent infestation was worked out on the basis of seeds with characteristic holes made by weevils. The seed infestation was recorded for 30, 60 and 90 days after treatment application and is calculated by following formula:

$$\text{Percent seed damage} = \frac{\text{Number of damaged seeds}}{\text{Number of seeds taken}} \times 100$$

Statistical Analysis

The data averaged into respective parameter requisite will be subjected to suitable transformation. After analysis, data will be accommodated in the table as per the needs of objectives for interpretation of results. The standard procedures in agriculture statistics given by Gomez and Gomez (1976) were consulted throughout. The interpretation of data will be done by using the critical difference value calculated at 0.05 probability level.

Results and Discussion

Percent adult mortality

Among all botanicals evaluated for efficacy over 14 days of storage, the significantly best treatments was sweet flag rhizome powder @ 5%, retained its residual toxicity and caused significantly maximum adult mortality (100.00%). While, *S. oryzae* were less susceptible to turmeric rhizome powder @ 5% (9.99%). However, the effectiveness of the various botanicals in descending order was sweet flag rhizome rhizome powder @ 5%, (100) > tobacco leaves powder @ 1% (83.33%) > clove powder @ 2%, (58.33%) > neem leaf powder 5% (48.16%) > ajwain seed powder 2% (41.66%) > ginger rhizome powder 2% (29.99%) > turmeric rhizome powder @5 % (9.99 %) > untreated check (0.83%).

Table 1: Mortality of rice weevil as influenced by different botanicals in wheat.

Tr. No.	Treatments	Dosage per 100g of seeds	Percent Mortality				
			3DAT	7DAT	10DAT	14DAT	Mean
T_1	Sweet flag rhizome powder	5%	100	100	100	100	100
T_2	Tobacco leaves powder	1%	80.00	83.33	83.33	86.66	83.33
T_3	Clove powder	2%	53.33	56.66	60.00	63.33	58.33
T_4	Ginger rhizome powder	2%	26.66	30.00	30.00	33.33	29.99
T_5	Ajwain seed powder	2%	36.66	40.00	43.33	46.66	41.66
T_6	Neem leaves powder	5%	43.33	46.00	50.00	53.33	48.16
T_7	Turmeric rhizome powder	5%	6.66	10.00	10.00	13.33	9.99
T_0	Untreated control		0	0	0	3.33	0.83
S.E. (m) ±			1.924	2.041	1.924	1.80	1.06
C.D.			9.994	10.6	9.994	9.348	4.656
C.V.			13.323	13.361	12.262	10.801	6.854

Percent seed damage

Sweet flag rhizome powder @ 5% protected seeds from *S. oryzae* with 100 per cent protection followed by tobacco leaves powder @ 1% (2.44%) showing best results. The seed damage was 5.21, 7.66, 9.44 and 11.44 per cent in order of their efficacy with clove powder @2 %, neem leaf powder @ 5%, ajwain seed powder 2@% and ginger rhizome powder @2%, respectively. While maximum damage was noticed in untreated check (28.77%) followed by turmeric rhizome powder @ 5% (14.96%).

Table 2: Seed damage by rice weevil as influenced by different botanicals in wheat.

Sl. No.	Treatments	Dosage per 100g	Percent Seed damage			
			30DAS	60DAS	90DAS	MEAN
T_1	Sweet flag rhizome powder	5%	0	0	0	0
T_2	Tobacco leaves powder	1%	0.66	2	4.66	2.44
T_3	Clove powder	2%	1.33	4.66	9.66	5.21
T_4	Ginger rhizome powder	2%	2.00	10.66	21.66	11.44
T_5	Ajwain seed powder	2%	3.33	8.33	16.66	9.44
T_6	Neem leaves powder	5%	2.66	7.00	13.33	7.66
T_7	Turmeric rhizome powder	5%	5.33	12.56	27.00	14.96
T_0	Untreated control		15	29.33	42	28.77
S.E.(m) ±			0.15	0.22	0.32	2.62
C.D.			0.79	1.17	1.69	13.64
C.V.			12.03	7.25	5.8	78.891

Per cent weight loss

The botanicals in reducing the weight loss caused by *S. oryzae* in descending order of their efficacy was sweet flag rhizome powder @ 5% (0.00%) >, tobacco leaves powder @ 1% (2.42%) > clove powder @ 2% (7.35%) > neem leaf powder @ 5% (9.23%) > ajwain seed powder @ 2% (11.59%) > ginger rhizome powder @ 5% (14.32%) > turmeric rhizome powder @ 5% (16.36%) > untreated check (27.08%).

Table 3: Loss in weight due to rice weevil as influenced by different botanicals in wheat

Sl. No.	Treatments	Dosage per 100g	Percent weight loss			
			30DAS	60DAS	90DAS	Mean
T_1	Sweet flag Rhizome Powder	5%	0	0	0	0
T_2	Tobacco Leaves Powder	1%	0.5	2.1	4.68	2.42
T_3	Clove Powder	2%	1.53	8.1	12.43	7.35
T_4	Ginger Rhizome Powder	2%	8.03	15.66	19.27	14.32
T_5	Ajwain Seed Powder	2%	2.51	13.88	18.4	11.59
T_6	Neem Leaves Powder	5%	1.96	10.6	15.15	9.23
T_7	Turmeric Rhizome Powder	5%	10.43	16.95	21.72	16.36
T_0	Untreated Control		17.46	27.61	36.19	27.08
S.E.			0.14	0.14	0.25	2.03
C.D.			0.74	0.77	1.33	10.59
C.V.			8.07	3.78	4.83	55.37

Based on percent mortality

Among all botanicals evaluated for efficacy over 14 days of storage, the significantly best treatments was sweet flag rhizome powder, retained its residual toxicity and caused significantly maximum adult mortality. While, *S. oryzae* were less susceptible to turmeric rhizome powder. However, the effectiveness of the various botanicals in descending order was sweet flag rhizome rhizome powder followed by tobacco leaves powder, clove powder, neem leaf powder, ajwain seed powder, ginger rhizome powder and turmeric rhizome powder.

All the treatments were found to be significantly superior to control in enhancing adult mortality of test insect (*Sitophilus oryzae*) in treated wheat. From results of adult mortality in wheat the maximum adult mortality was recorded in sweet flag rhizome powder @ 5% results are similar to Bhargude *et*

al. (2021) [2]. Among all the treatments tobacco leaves powder @ 1% mortality after 14 days of treatment, clove powder @ 2% was found to be the next. The results of tobacco leaves powder @ 1% were supported by Khanal *et al.* (2021) [7] and clove powder @ 2% were supported by Khanal *et al.* (2021) [7]. The next best treatments were neem leaf powder @ 5% were supported by Singh *et al.* (2017) [11] followed by ajwain seed powder @ 2% as supported by Yadav and Tiwari (2017) [12] followed by ginger rhizome powder @ 2% were supported by Chude *et al.* (2020) [15]. Turmeric rhizome powder @ 5% showed least effect when compared with all other treatments.

Based on percent seed damage

Above study concludes that the seed treated with sweet flag rhizome powder was noticed least infestation of the pests after 90 days storage. The next significantly best treatment tobacco leaves powder followed by clove powder, neem leaf powder and ajwain seed powder. Whereas, the minimum seed damage (%) was recorded in ginger rhizome powder and turmeric rhizome powder were also found to be effective in reducing the seed damage caused by the *S. oryzae*.

All the treatments were found to be significantly superior to control in enhancing percent seed damage of test insect (*Sitophilus oryzae*) in treated wheat. From results of adult mortality in wheat the minimum percent seed damage was recorded in sweet flag rhizome powder @ 5% results are similar to Bhargude *et al.* (2021) [2]. Among all the treatments tobacco leaves powder @ 1% percent seed damage after 90 days of treatment, clove powder @ 2% was found to be the next. The results of tobacco leaves powder @ 1% and clove powder @ 2% were supported by Khanal *et al.* (2021) [7]. The next best treatments were neem leaf powder @ 5% were supported by Singh *et al.* (2017) [11] followed by ajwain seed powder @ 2% as supported by Yadav and Tiwari (2017) [12] followed by ginger rhizome powder @ 2% were supported by Chude *et al.* (2020) [15]. Turmeric rhizome powder @ 5% showed least effect when compared with all other treatments.

Based on percent weight loss

The botanicals like sweet flag rhizome powder noticed no insect damage and weight loss followed by tobacco leaves powder. The treatments *viz.*, clove powder, neem leaf powder, ajwain seed powder, ginger rhizome powder, turmeric rhizome powder observed minimize the weight loss percentage after 90 days of storage.

All the treatments were found to be significantly superior to control in enhancing percent weight loss of test insect (*Sitophilus oryzae*) in treated wheat. From results of percent weight loss in wheat the minimum percent weight loss was recorded in sweet flag rhizome powder @ 5% results are similar to Bhargude *et al.* (2021) [2]. Among all the treatments tobacco leaves powder @ 1% percent weight loss after 90 days of treatment, clove powder @ 2% was found to be the next. The results of tobacco leaves powder @ 1% and clove powder @ 2% were supported by Khanal *et al.* (2021)[7]. The next best treatments were neem leaf powder @ 5% were supported by Singh *et al.* (2017) [11] followed by ajwain seed powder @ 2% as supported by Yadav and Tiwari (2017) [12] followed by ginger rhizome powder @ 2% were supported by Chude *et al.* (2020) [15]. Turmeric rhizome powder @ 5% showed least effect when compared with all other treatments.

Conclusion

On the basis of lab experiment, it can be concluded that, sweat flag rhizome powder as it shows toxicity and antifeedant activity towards rice weevil, tobacco leaves powder as it is the results revealed that the chloroform and acetonic extracts of tobacco leaves exhibited more pronounced activity and Nicotine kills the insects rapidly within short time period and clove powder shows mechanisms of killing insects through the bioactive compounds of clove where weevils become paralyzed, twitched, and died treated wheat grains were found effective against major insect pest of stored wheat as being cost effective, eco-friendly and easy to adopt by small-scale farmers which also can be used as an alternative to synthetic insecticides under storage conditions for shorter duration. Since the findings are based on the laboratory experiment done for one time it may be repeated for further confirmation and recommendation.

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