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Management of Rice Weevil, *Sitophilus oryzae* L. (coleopteran; curculinoidae) by Botanicals and inert Dusts in Stored Wheat

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ABSTRACT: Grain storage is important in agriculture for future generations and food security. Insect pests are economically important because they cause major losses and affect the destiny of grains during storage. The expanding demands of the world's growing population can be met by lowering or eradicating insect pest populations while storing food. Traditionally, synthetic pesticides have been used to control various insect pests, which are hazardous to the environment and ecosystem in a variety of ways, including the elimination of natural enemies, insect resistance and resurgence, making soil, water, and air sick, and having residual effects that cause various disorders or diseases in animals and humans. These problems have sparked a world-wide interest in developing a biodegradable, non- residual and easily available techniques such as use of botanicals that may prove better option for control of stored grain pests. In the present study, locally available botanicals and inert dusts viz, *Acorus calamus, vitex negundo, Adhatoda vasica, Calotropis gigentae,* wheat straw, kaolinite clay, and diatomaceous earth were evaluated at different doses, during different storage periods against the major storage pest viz, *Sitophilus oryzae* L. in stored wheat seeds (variety WH-1080) during 2018-2019. The sample of 100g seeds were kept in plastic jars and adults were released at the rate of 20 weevils per jar and the jars were kept in B.O.D. incubator. The observations on number of adult emergence, seed damage, weight loss were recorded after 2, 4, and 6 months of storage. The results revealed that all the treatments were significantly superior as compared to untreated check, however among these treatments the botanical *A. calamus*, @1g, 5g, 10g/100gm seed was most effective in preventing the number of adult emergence (0.11), weight loss (0.001%) and per cent seed damage (0.29) while as among inert dusts kaolinite clay @ 1g, 5g, 10g/100g of seed and diatomaceous earth @ 1g, 5g, 10g/100g of seed were found most effective in preventing adult emergence (0.00), reduced seed damage (0.00), weight loss(0.00) respectively.

Keywords: Botanicals, Inert dusts, *Sitophilus oryzae,* wheat seeds.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the world's second most common grain after rice, and it is thought to have originated in South Western Asia. India is the world's second largest wheat producer, with a total area of 30.72 million hectares and a record wheat production of 98.5 million tons with an average national productivity of 3,172 kg/ha, accounting for about 36% of the country's total food grain production during the 2016-17 crop season (Anonymous, 2017). In Jammu & Kashmir, wheat covers an area of 0.29 million hectare with a production of 0.5485 million ton (Anonymous, 2017). Several biotic and abiotic activities degrade grains in stores/godowns (Singh *et al.,* 1997). Insect-pests are key biotic agents that cause significant losses in food grain quality and quantity. Wheat is attacked in the field and in storage by a range of insect pests, including *Sitophillus oryzae, Rhyzopertha dominica, Trogoderma granarium, Tribolium confusum,* and rats, resulting in quantitative and qualitative losses in post-harvest storage. The rice weevil, *S. oryzae* Linn. (Coleoptera: Curculionidae) is the most frequent insect pest that attacks stored wheat (Linn.) in large or small quantities (Mark *et al*., 2010). Insect pests can cause damage to stored grains and grain products, ranging from 5-10 per cent in temperate zones to 20-30 per cent in tropical zones (Talukder, 2006, Rajendran and Sriranjini 2008). Insect pests can cause loss upto 10 per cent in wheat grain weight while storage (Mohammad,

2000). According to Rajashekar *et al*., (2010), numerous stored grain insect pests in India harm roughly 20-25 per cent of the entire food grain output (250 million tons). It has been estimated that storage pests destroyed over 96 million tons of cereal grains and if this could be saved, it would have been enough for 375 million people for one entire year (Dobrovsky, 1965).

Sitophilus oryzae (L.) (Coleoptera: Curculionidae), is a major and destructive pest of wheat and other crops (Hatami *et al.,* 2011). It causes considerable losses in both quantity and quality of stored food grain all over the world. (Arannilewa *et al.,* 2002). It's a grain-boring insect that feeds on stored grains. Adult weevils dig circular holes in the grain and consume largely the endosperm, reducing carbohydrate content, whilst larvae preferentially feed on the grain germ, consuming a significant quantity of protein and vitamins. To address these issues, a variety of approaches were used, synthetic pesticides and phosphine gas are commonly used nowadays throughout the world to control stored grain insect pests of wheat (Anwar *et al.,* 2003). Several laboratories around the world are conducting research to find environmentally friendly alternatives (Silhacek and Murphy, 2006). In Australia, India, and other nations, phosphine resistance is so high that it causes control failures (Mau *et al*., 2012; Ali *et al*, 2013). Although chemical insecticides are effective, such as use of deltamethrin (Decis 2.5 WP; 40 mg/kg) (Mishra and Panday 2014), malation and fenvelerate (Singh *et al.,* 1998) against rice weevil, also use of aluminum phosphide and other fumigants resulted in issues such as residual toxicity, pollution, and detrimental impacts on food and humans in addition to rising costs (Lu and Wu, 2010). However, chemicals being costly and hazards to the environment, there is a need of alternative control strategies that will be cost effective and safer to environment. One of the eco-friendly and economic approaches, to keep the stored food grains free from insect attack is the use of the plant powders as grain protectants. According to reports from all over the world, when mixed with stored grains, plant leaf, bark, seed powder, or oil extracts inhibit oviposition of stored grain pests, suppress their adult emergence and in turn reducing seed damage (Tripathi *et al*, 2009). Plant products are known to have many advantages, as they are safe to environment and consumer. Inability of the insect pest to develop resistance against them is an added advantage. Moreover, it can be easily produced by the farmers as they are less expensive, safe and amenable to apply. In this context, we conducted the study to know the potency of some locally available botanicals and inert dusts for management of rice weevil.

MATERIALS AND METHODS

Establishment of culture of *S. oryzae.* For stock culture of test insect, Rice weevil, (*S. oryzae* L.) was reared in the laboratory at 28±1°C temperature. The sound and healthy wheat seeds were used as culture material and these seeds were cleaned and sieved to remove the fractions of seed or insects if any**.** Later, the wheat seeds were sun dried and then these seeds were freezed at minus 20°C for 72 hours to make it free from insect infestations. Plastic jar of two liter capacity was selected to maintain the main rice weevil culture so that to carry out further experiments. Adult weevils were collected from Indian Grain Storage Management and Research Institute (IGMRI), Hapur. The jar was first cleaned properly and later filled with healthy wheat seeds. After that 60 pairs of adult weevils were transferred into the plastic jar by using brush and the mouth of the jar was covered with moist muslin cloth and the muslin cloth was tightened with rubber bands to avoid the weevils to come out of the jar. After that the culture was maintained at a temperature of 28±1°C and 70±5 per cent relative humidity in Biological Oxygen Demand (BOD) incubator.

Use of botanicals and inert dusts. The botanicals were collected locally from university campus SKUAST–J chatha, such as *Acorus calamus* rhizomes, fresh leaves of *Vitex negundo*, leaves of *Adhatoda vasica*, and leaves of *Calotropis gigantean*. Later the collected rhizomes of *A. calamus* were cleaned and washed with tap water and made into small bits after that these bits were separated on chart papers for drying under shade. Leaves of *V. negundo* ,leaves of *A. vasica*, and leaves of *C. gigantea* were washed with tap water to remove the dirt, then spread on Chart papers and dried for 10-20 days in a well ventilated area at room temperature and after that powders of these botanicals were prepared by grinding in a mixer cum grinder . The inert dusts *viz*, kaolinite clay and diatomaceous earth were brought from market and wheat straw was collected from the agronomy field and grinded in mixer cum grinder to made powder.

Procedure: To evaluate the efficacy of different grain protectants collected from locally available sources against *S. oryzae* infesting wheat in stored condition, 100 grams of wheat seeds were taken in 250 gm plastic jars and weighed by using weighing balance and then required quantities of *A. calamus*, *V. negundo*, *A. vasica*, *C. gigantean*, Kaolinite clay, Diatomaceous earth and wheat straw were added to the respective jars and mixed thoroughly by shaking the jars. After that 20 freshly emerged weevils from main stock culture were released in the plastic jars and the mouth of jars were covered with muslin cloth and the muslin cloth was tightened with rubber bands to avoid coming out of weevils from the jars and then the treated jars were kept in B.O.D. incubator for 2, 4 and 6 months and the following observations were recorded.

Adult emergence. The emergence of weevils was recorded on the basis of number of live and dead insects of *S. oryzae* in each plastic jar. For this the material from each jar was separated on a white chart and the newly emerged weevils coming out from the material were counted and removed to check further breeding.

The seeds were examined after two, four and six months of storage.

Per cent seed damage and weight loss. The seed damage in each plastic jar was observed as per experimental schedule. The loss in weight was obtained after removing all insect stages and frass. The per cent seed damage and weight loss were calculated by using the formula given by Gwinner *et al*., (1996).

Per cent Weight Loss =

$$\frac{(W\mu \times Nd) - (Wd \times N\mu)}{W\mu \times (Nd + N\mu)} \times 100$$

Whereas,

Wμ = weight of undamaged seeds
Nμ = number of undamaged seeds
Wd = weight of damaged seeds
Nd = number of damaged seeds

RESULT AND DISCUSSION

Effect of botanical powders on adult emergence number, per cent seed damage, per cent weight loss of *Sitophilus oryzae.* The data on adult emergence of *S. oryzae* from the seeds treated with different doses of botanical powders and inert dusts showed significant difference when compared with the untreated check. It is evident from the data that among all the plant products used sweet flag (*Acorus calamus*) powder showed maximum protection than any other botanical powder including untreated check. It was found highly effective against *S. oryza* @1g, 5g, and 10g causing no adult emergence, seed damage and weight loss after two months of storage. But after four and six months of storage in *A. calamus*, there was emergence of adults, seed damage, weight loss when applied at @ 1g/100g of seeds which may be due to decrease in toxic effect with increase in storage period. Finally, with the increase in the doses i.e. *A. calamus* @ 5g/100g of seed and 10g/100g of seed; there was no emergence, seed damage, weight loss that may be due to increase of quantity of active ingredient in the botanical powder (insecticidal materials). These findings are in accordance with Panesu *et al.,* (1983) who reported that the dried and ground rhizome of sweet flag used at 50 g per kg of wheat against *S. oryzae* reduced the damage of stored seeds to 5.4 per cent compared to untreated control. Yevoor, (2003) also reported that sweet flag powder at 1.00 per cent caused cent per cent adult mortality of *S. oryzae* on maize grains at three months after storage. The present findings are also supported by Kumar, (2003) who reported that the sweet flag rhizome powder alone at one per cent afforded maximum protection to the seeds upto 60 DAS.

The mean seed damage at different dose levels and different storage period ranged from 0.00 to 10.6 per cent, while per cent weight loss varied from 0.00 to 2.79 per cent. The most effective treatment for reducing the seed damage and weight loss was *A. calamus* followed by *A.vasica* and *C. gigantea*, whereas least effective treatment was *V. negundo*. These results are in confirmation with Padmasri *et al*., (2017). The storage studies revealed that seeds treated with *A. calamus* rhizome powder @ 10 g kg^{-1} seed had recorded lowest infestation (0.18 %) and weight loss (0.02 %) at the end of nine months of storage.

Effect of inert materials on adult emergence number, per cent seed damage, per cent weight loss. The studies were carried out to evaluate the effect of different inert materials against *S. oryzae* at different doses (i.e. @ 1g, 5g and 10g per 100 g of seed) and at different storage periods (e.g. 2 month, 4 month and 6 month) on the adult emergence, per cent seed damage and per cent weight loss by *S. oryzae*. The data revealed that mean adult emergence, per cent seed damage and per cent weight loss was 8.18, 1.02% and 0.178 % in wheat straw. The wheat straw evaluated in the present study proved less effective against *S. oryzae* but caused prevention to some extent when compared with untreated check as it gains moisture from the seeds thereby inhibiting the attack of insects as the latter cannot pierce the hard seeds. The present findings are in agreement with Gemu *et al.,* (2002) who evaluated wood ash, coffee husk, and saw dust at different proportions against stored pest (*Sitophilus zeamais* and *Sitotroga cerealella*) and found coffee husk and wood ash more effective at higher rates. There was no adult emergence, per cent seed damage and per cent weight loss in case of kaolinite clay and diatomaceous earth. Among the inert dusts kaolinite clay and diatomaceous earth were found effective than other tested materials. Wheat seeds admixtured with 1g, 5g, 10g caused prevented adult emergence, seed damage and weight loss upto six months of storage. The present findings are in agreement with Rahman *et al*., (2003) who reported wood ash was highly effective in prohibiting the adult emergence (F_1) of grain weevil on wheat, with higher inhibition rate and showed a reduction in the seed damage and weight loss (%) over other treatments. Similarly, Inge, (2004) reported that sand is effective against different stored insects when 1 kg of sand is mixed with 10 kg of product and ash is also claimed to protect the stored product when 1 kg of ash is mixed with 40 kg of product. Yevoor, (2003) also have reported that kaolinite 10 per cent caused up to 90 per cent mortality of adult at 28 days after release and also caused minimum grain damage and weight loss up to 90 DAS. This result is in consonance with Lorini and Beckel, (2005) who reported the efficacy of "diatomaceous earth" in controlling stored grain pests of (wheat, barley, maize and beans) treated separately with "diatomaceous earth" (Keep dry and Insect), infested with 20 adults of each species and stored in a room with 25 ± 1 ºC of temperature and 60 ± 5 % of relative humidity. The results showed that both insecticide formulations of "diatomaceous earth", Keep dry and insect were effective to control stored grain pests at different dosages and types of grain. Similarly, Ulrichs and Mewis (2000) tested diatomaceous earth (diatomite) Fossil sheildR and neem product Neem Azal- t/s r as single treatment and in combination for

the control of *Sitophilus oryzae* and *Tribolium castaneum*. DE applied in concentrations of 0.5, 1.0 and 2.0g/kg rice reduced number of surviving beetles significantly. A single treatment with neem product, in concentrations of 0.01, 0.1, 0.2, and 1.0g *Azadirachtin* kg^{-1} rice increased the mortality rate for both species significantly.

Table 1: Effect of botanical powders and inert dusts on seed damage (%).

Storage	2 Months				4 Months				6 Months				Mean (Treatments)
	Dose\100g 0f seeds				Dose\100g of seeds				Dose\100g of seeds				
Dose / Treatment	1 g	5 g	10 g	Mean (S*T)	1 g	5 g	10 g	Mean (S*T)	1 g	5 g	10 g	Mean (S*T)	
A. calamus	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.04	0.13	0.00	0.00	0.04	0.29 [a]
V. negundo	1.90	1.40	0.93	1.41	2.40	1.70	1.36	1.82	3.60	2.00	1.80	2.46	1.90 [e]
A. vasica	0.63	0.10	0.00	0.24	1.10	0.30	0.00	0.46	2.00	0.70	0.40	1.03	0.58 [b]
C. gigantean	1.73	1.03	0.53	1.10	2.56	1.16	1.00	1.57	2.93	1.63	1.13	1.90	1.52 [d]
Kaolinite clay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 [a]
Diatomaceous earth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 [a]
Wheat straw	1.26	0.97	0.26	0.83	1.43	0.56	0.50	0.83	2.33	1.01	0.82	1.39	1.02 [c]
Untreated check	4.43	6.33	7.33	6.03	9.1	9.6	9.86	9.53	14.3	16.4	18.2	16.3	10.6 [f]
Mean(D*S)	0.79	0.50	0.24		1.09	0.53	0.41		1.57	0.76	0.59		
Mean (D)	0.4168 (10 g)				0.5997(5 g)				1.1508(1 g)				
Mean (S)	0.5132				0.6778				0.9763				
F value	F value				P value								
Treatment (T)	264.032				0.000								
Dose (D)	147.252				0.000								
Storage (S)	55.609				0.000								
T*S	7.878				0.000								
D*S	6.777				0.000								
T*D*S	1.191				0.263								

Mean of three replications.
DMRT (P=0.05)
T*S= Treatment*Storage, D*S= Dose*Storage, T*D*S=Ttreatment*Dose*Storage

Table 2: Effect of botanical powders and inert dusts on weight loss (%) by *S. oryzae*.

Storage	2 Months				4 Months				6 Months				Mean (Treatments)
	Dose\100g of seeds				Dose\100g of seeds				Dose\100g of seeds				
Dose/Treatment	1 g	5 g	10 g	Mean (S*T)	1 g	5 g	10 g	Mean (S*T)	1 g	5 g	10 g	Mean (S*T)	
A. calamus	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.001 [a]
V. negundo	0.53	0.45	0.24	0.41	0.73	0.44	0.28	0.48	0.73	0.61	0.46	0.60	0.500 [e]
A. vasica	0.03	0.02	0.00	0.01	0.36	0.00	0.00	0.12	0.59	0.13	0.06	0.26	0.134 [b]
C. gigantean	0.55	0.31	0.03	0.29	0.81	0.41	0.30	0.51	1.04	0.35	0.23	0.53	0.448 [d]
Kaolinite clay	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000 [a]
Diatomaceous earth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000 [a]
Wheat straw	0.31	0.15	0.00	0.15	0.47	0.05	0.07	0.20	0.41	0.12	0.03	0.18	0.178 [c]
Untreated Check	1.03	1.46	1.80	1.43	2.59	2.49	2.53	2.53	3.76	4.74	4.81	4.43	2.79
Mean(D*S)	0.20	0.13	0.04		0.34	0.13	0.09		0.39	0.17	0.10		
Mean (D)	**0.0811(10g)**				**0.1454(5g)**				**0.3151(1g)**				
Mean (S)	**0.1257**				**0.1897**				**.2262**				
Factor	**F value**				**P value**								
Treatment (T)	105.685				.000								
Dose (D)	78.949				.000								
Storage (S)	13.977				.000								
T*S	3.105				.001								
D*S	3.712				.007								
T*D*S	1.295				.181								

Data based on three replications.
Mean of three replications.
DMRT (P=0.05)
T*S= Treatment*Storage, D*S= Dose*Storage, T*D*S=Ttreatment*Dose*Storage

The combination of neem and diatomaceous earth (1.0 g DE with 0.2 or 1.0 g *Azadirachtin*) was more effective than the single treatment in reducing the numbers of beetles. Our results are also in agreement with by Verma *et al*., (1976) who reported cent per cent mortality within 72 hours after treatment. Similarly Studies made by Arthur and Puterka, (2002) reported that this pest is more susceptible to diatomaceous earth treatment exposure compared with other assessed pests and also that the mortality rate depends partially on the grain temperature and/or moisture content.

Table 3: Effect of botanical powders and inert dusts on number of adult emergence.

Storage	2 Months				4 Months				6 Months				Mean (Treatments)
	Dose\100g 0f seeds				Dose\100g of seeds				Dose\100g of seeds				
Dose / Treatment	1 g	5 g	10 g	Mean (S*T)	1 g	5 g	10 g	Mean (S*T)	1 g	5 g	10 g	Mean (S*T)	
A. calamus	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00 (0.71)**	0.33 (0.88)	0.00 (0.71)	0.00 (0.71)	**0.11 (0.76)**	0.66 (1.05)	0.00 (0.71)	0.00 (0.71)	**0.22 (0.82)**	**0.11**[a] (0.76)
V. negundo	3.33 (1.93)	2.66 (1.77)	1.66 (1.46)	**2.55 (1.72)**	5.33 (2.40)	3.66 (2.03)	3.00 (1.85)	**4.00 (2.09)**	7.00 (2.73)	6.66 (2.67)	5.00 (2.32)	**6.22 (2.57)**	**4.25**[d] (2.12)
A. vasica	1.33 (1.34)	0.66 (1.05)	0.00 (0.71)	**0.66 (1.03)**	2.33 (1.67)	2.00 (1.55)	1.00 (1.22)	**1.77 (1.48)**	4.66 (2.25)	3.66 (2.03)	1.33 (1.34)	**3.22 (1.87)**	**1.88**[b] (1.46)
C. gigantean	2.66 (1.73)	1.33 (1.34)	0.66 (1.05)	**1.55 (1.37)**	4.33 (2.16)	3.66 (2.03)	1.66 (1.46)	**3.22 (1.88)**	6.66 (2.64)	5.66 (2.47)	3.66 (2.01)	**5.33 (2.37)**	**3.37**[c] (1.87)
Kaolinite clay	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00 (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00 (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00 (0.71)**	**0.00**[a] (0.71)
Diatomaceous earth	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00 (0.71)**	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	**0.00 (0.71)**	0.00 (0.71	0.00 (0.71)	0.00 (0.71)	**0.00 (0.71)**	**0.00**[a] (0.71)
Wheat straw	4.66 (2.24)	1.33 (1.34)	0.66 (1.05)	**2.22 (1.54)**	9.66 (3.18)	8.00 (2.90)	4.66 (2.24)	**7.44 (2.77)**	20.3 (4.56)	15.6 (4.01)	8.66 (3.02)	**14.8 (3.86)**	**8.18**[e] (2.71)
Untreated check	20.3 (4.56)	27.3 (5.27)	29 (5.42)	**25.5 (5.08)**	34.3 (5.90)	53.3 (7.33)	56.6 (7.56)	**48.0 (6.93)**	78 (8.86)	92.3 (7.56)	95 (9.76)	**88.4 (8.72)**	**53.9**[f] (6.91)
Mean(D*S)	**1.71 (1.33)**	**0.85 (1.04)**	**0.429(0.91)**		**3.14 (1.67)**	**2.47(1.52)**	**1.47 (2.22)**		**5.61 (2.09)**	**4.52 (1.90)**	**2.66 (1.54)**		
Mean (D)	**1.52 (1.42)[a]**				**2.62 (2.16)[b]**				**3.49 (2.29)[c]**				
Mean (S)	**1.0000 (1.61)[a]**				**2.36 (2.17)[b]**				**4.27 (2.71)[c]**				
Factor	**F value**				**P value**								
Treatment (T)	(21447)				0.000								
Dose (D)	(22.5)				0.000								
Storage (S)	(405.5)				0.000								
T*S	(69.2)				0.000								
D*S	(4.04)				0.004								
T*D*S	(4.94)				0.00								

Mean of three replications.
Figures in the paranthesis are squar root transformed values. Mean followed by same letters in column are not significantly different by DMRT (P=0.05).
T*S = Treatment*Storage, D*S= Dose*Storage, T*D*S=Ttreatment*Dose*Storage

Summery and Conclusion: The findings of the present investigation concluded that among all botanicals and inert dusts, *A. calamus*, kaolinite clay and diatomaceous earth were found superior seed protactants, suppressed the adult emergence, reduced the seeds damage and weight loss. Application of botanical powders and inert dusts to stored seeds is an eco-friendly, inexpensive, and effective technique as these substances are locally available, cost effective and their easy adaptability are advantageous leading to acceptance of this promising technology by farmers.

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