Egyptian Journal of Plant Protection Research Institute

www.ejppri.eg.net

Impacting of some selected plant and cattle dung powders as protectants against *Tribolium castaneum* (Coleoptera: Tenebrionidae) and *Sitophilus oryzae* (Coleoptera Curculionidae) adults

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ARTICLE INFO

Article History
Received: 26 /1/2022
Accepted:30/ 3 /2022

Keywords

Plant oils, plant powders, stored product, toxicity, biology and germination.

Abstract:

Wheat is one of the main crops in Egypt, where the vast majority of the population depends on it for their food. This crop is subjected to sweeping attacks from stored product pests which cause qualitative and quantitative losses. *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) and *Sitophilus oryzae* (L.) (Coleoptera : Curculionidae) are two of the most important insect species which invade the grain crops in store. The aim of this study was to evaluate the efficiency of six plant powders of cotton stem, maize stem, mulberry bough wood, rice haulm, sycamore branch wood, and citrus bough wood, and an animal origin powder, cattle dung against the two mentioned insects, through some of the standard bioassays. The results showed that the two types of powders, either plant or animal achieved moderate toxicity, especially with the highest rates of concentration against the two insects. In addition, they reduced the number of progeny and the weight loss of wheat. The efficiency of all powders fluctuated against the insects and none of them had the first place with the tested parameters. In general, mulberry bough was the one with *S. oryzae* while citrus bough had the same rank against *T. castaneum* based on LC_{50}. Meanwhile, the *S. oryzae* adults were more susceptible than *T. castaneum*. For reduction in progeny and % weight loss, cotton stem powder achieved the lowest effect with *S. oryzae* while rice haulm powder was the premier. On the contrary,rice haulm powder had the fifth position with *T. castaneum* for a reduction in progeny. Maize stem and mulberry bough powder had the third and the fourth order, with both *S. oryzae* and *T. castaneum*, respectively. The effectuation of cattle dung had the same trend as plant powders with the two tested insects, since *T. castaneum* was more tolerant than *S. oryzae* with the all investigated criteria, toxicity, progeny, or weight loss. Findings obtained explained that the rate of 5% of both plant and cattle dung powders had the percent of germination equal to that of control. These current studies suggest introducing these powders as an aspect of an integrated pest management program against stored grain insects especially *S. oryzae* and *T. castaneum* adults.

Introduction

Wheat is one of the main crops in Egypt, where the vast majority of the population depends on it for their food. The volume of Egypt's production of wheat ranges between 8 to 9 million tons annually, while the volume of its consumption reaches 18 million tons per year, the state and the private sector are responsible for filling the gap that ranges between 9-10 million tons by import. The world consumption of wheat in 2020-2021 amounted to 774.3 million tons. This crop is subjected to sweeping attacks from warehouse pests, especially insect pests, which cause a reduction in quality and quantity, as well as the percentage of germination, which costs the state huge burdens.

Most of the postharvest losses can be attributed to storage insect pests (Giga *et al.*, 1991 and Bett and Nguyo, 2007). The rice weevil *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) is a major important pest of stored cereal grain products on the farm or in large commercial elevators in the world. Feeding by *S. oryzae* larvae and adults can reduce grain weight by as much as 56-74% (Koura and El-Halfway, 1972 and Adams, 1976). The adult rice weevil is able to survive up to two years under unfavorable environmental conditions and may transfer to field crops due to its flying capability (Jacobs and Calvin, 2001). The weevils reduce germination resulting in lower prices for seed grain (Kern and Koehler, 1994).

For grain weight losses caused by *Tribolium castaneum* (Herbst) *(* Coleoptera: Tenebrionidae) feeding was highest for wheat followed by rice then maize (Ali *et al.*, 2016). During development, a *T. castaneum* larva consumes a total of 13 mg of wheat flour, and adults during their lifetime consume 315 mg of wheat flour (Hagstrum and Subramanyam, 2000).

T. castaneum also can influence fungal, bacterial and tapeworm problems in grain or animal feeds and at bakeries. Yun *et al.* (2018) found that. *T. castaneum* can spread fungal contamination in stored rice and may consequently increase the mycotoxin problem. There are many ways to combat these pests, the most important of which is the control of chemical pesticides. However, it causes the development of insect resistance and environmental pollution resulting from residues of these pesticides, which has a negative impact on human health. The researchers attention turned to searching for alternative methods that are safe, environmentally friendly, easy to obtain, cheap, highly effective on the pest, relatively quickly to decomposing, and have no harmful residues. Plant materials were the acceptable alternative, as they had previously been used successfully on some pests of stored materials.

In recent years, many workers, have given greater attention to the control of stored grain pests by using some plant products to control postharvest loss caused by some stored product insect pests (Enobakhare and Law-Ogbomo, 2002; Law-Ogbomo and Enobakhare, 2007; Tesema *et al.*, 2015; Ntonifor *et al.*, 2010). Botanical insecticides containing different compounds derived from plants secondary metabolism have been tested in order to control stored grain pests with promising results as an alternative to chemical insecticides (Lale, 2002; Koul *et al.*, 2008 and Isman, 2006). The practice of using botanical insecticides in agriculture dates back at least two millennia in ancient China, Egypt, Greece, and India (Isman and Machial, 2006).

Botanical insecticides act on the physiology and behavior of insects and can be classified as a repellent (Abo-Arab *et al.*, 2014; Elbrense *et al*., 2021;

Guruprasad and Pasha, 2014 and Rahdari and Hamzei, 2017), feeding deterrents antifeedants (Ebadollahi, 2011; Stefanazzi *et al.,* 2011 and Rajkumar *et al.,* 2019), toxicants (Chaubey, 2007 and 2012; Rajkumar *et al.,* 2019; Elbrense *et al.*, 2021), oviposition inhibitors and growth retardation (Akhtar and Isman, 2004; Yusuf *et al.*, 2011) and fumigant (Ajayi *et al.,* 2004). Plant powders were reported by many researchers as insecticidal agents (Ashouri and Shayestch, 2009; Malgorzata and Anna, 2015 and Omran *et al.*, 2020), reducing progeny F_1 (Mahama *et al.*, 2018), reducing the weight loss (Wazid *et al.*, 2020). Many research workers (Gunther *et al.*, 1958; Khare and Agrawal, 1972; Chlranjeevi, 1991 and Sudheer Reddy *et al.,* 1993) investigated some animal origin inert materials as grain protectants, insecticides as well as repellent and desiccation properties with little or no mammalian toxicity.

Therefore, the present study was carried out to evaluate the efficiency of some plant and cattle dung powders against S. *oryzae* and *T. castaneum* adults through some standard experiments, to determine toxicity, population build up, and weight loss of grain as well as their effect on germination under laboratory conditions.

Materials and methods

1. Insects cultures:

The two tested insects were reared and maintained at the laboratory of Stored Product Res. Dept., Plant Protection Research Institute, Sakha Agric Research Station.

1.1. The red flour beetle, *Tribolium castanenum* (Herbst) (Tenebrionidae) (Coleoptera):

Insects were reared on wheat grain mixed with wheat flour. Grain was cleaned and sterilized by heating at 70°C for one hour and put in a glass jar each containing 400g (30% wheat flour) and provided with (100-200) adult insects. Jars were covered and placed under laboratory conditions of 30±2°C and 65±5% RH. The newly emerged adults (1-2 weeks old) were used in the further tests.

1.2. Rice weevil *Sitophilus oryzae* (Curculionidae) (Coleoptera):

The adults of rice weevil, *S. oryzae* were reared on wheat grains under the laboratory conditions of 26±1°C, 65±5% RH. Insects were maintained in small glass jars, each containing 200 gm of wheat grains and 100-200 adult insects. Adults were left for two weeks for egg laying in the jars and were then removed. Two weeks later, insects were collected by sieving the culture using a 10-mesh brass sieve. Insects (1- 2 weeks old) were collected to use in further experiments.

2. Powders

2.1. Plant materials:

Cotton stem, maize stem, mulberry bough wood, rice haulm, sycamore branch wood, and citrus bough wood used as experimental materials were collected from Farm and agricultural land in Kafr El-Sheikh governorate. The collected plant materials were placed in polyethylene bags to prevent the loss of moisture during transportation to the laboratory.

2.2. Procedure of the preparation of the powders:

The experiments mentioned above were washed with distilled water and dried at room temperature to remove residual moisture, then placed in a paper envelope and oven-dried at 55°C for 24 hrs. (Abuye *et al.*, 2003 and Aletor and Adeogun, 1995). The dried stems were ground into powder using a pestle and mortar and sieved through a 300 mesh sieve. The stem powders were used in the next experiments.

2.3. Cattle dung powder:

Cattle dung used as experimental material was collected from Animal Production Farm, Sakha Agriculture Research Station, Kafr El-Sheikh. Cattle dung was freshly taken, then dried in shade with diffuse light, and then, ground into a fine powder using a hand mill (Quern). Cattle dung powder was sieved using a 300 mesh sieve. The sieved powder was used for experiments.

3. Bioassay application method:

The appropriate amount of the plant or cattle dung powder which gives the required concentration was thoroughly mixed with wheat grains (whole or crushed) at four rates (0.5, 1, 2, and 5% w/w). for plant powders and (5, 10, 20, and 25% w/w) for cattle dung powder. 20 adults of *T. castaneum* and *S. oryzae* (1-2 weeks) were introduced to each glass jar (3 x 10 cm) containing 20 gm of treated medium (crushed and whole grain) for the two insects, respectively.

The jars were covered with muslin cloth fixed with the rubber band and kept in the same rearing conditions. Each treatment was conducted in three replicates. In addition, three replicates of untreated grains were used as the control for comparison. The temperature and relative humidity (RH.) conditions of the laboratory were recorded daily until the end of the experiment. The mean daily temperature and R.H. in the laboratory ranged from (20- 35°C) and (66.5-76.5%), respectively.

4. Lethal activity

Mortality was assessed 7 days after treatment application. The number of dead adult insects in each replicate was converted into the proportion of the total number of adult insects introduced and expressed as a percentage. Mortality data were corrected for control mortality using Abbott's correction formula:

$$\%CM = \frac{(\%T - \%C)}{(100 - \%C)} \times 100$$ (Abbott, 1925)

Where:

CM = The corrected mortality

T = The mortality in treated seeds

C = the mortality in untreated seeds

Concentration - mortality response lines were drawn, LC_{50} and slope values were calculated according to the method of Finney (1952).

4.1. F_1 progeny emergence:

At the end of 7 days period, mortality counts of insects were recorded for each treatment, then we removed the dead and lived insects from jars. Jars were covered with muslin kept in position with rubber bands and stored under laboratory conditions to allow insects to complete their life cycle. At the end of the life cycle period, the number of F_1 progeny was recorded.

Adults emerged were counted and the reduction of progeny was calculated as follows:

% Reduction = [(C-T)/C] x 100

Where:

C = No. of adults emerged in control

T = No. of adults emerged in treatment.

4.2. Weight loss:

The contents of each jar were sieved to remove the dust, frass, and any insects present in the grain. The re-weight of the grains was computed as (Harris and Linblad, 1978).

% wt loss = $(W_i - W_f)\ 100/W_i$

Where:

W_i = Initial weight

W_f = Final weight

4.3. Seed germination:

In order to assess the viability of treated seeds after F_1 emergence of *T. castaneum* and *S. oryzae* adults, seed germination was tested using 20 randomly picked seeds from undamaged grains after separation of damaged and undamaged grains in each jar. The seeds were placed on a moistened filter paper in plastic Petri dishes and the number of germinated seeds was recorded after 10 days.

Results and discussion

1. Effect of botanical powders on stored products insects:

In order to reduce the dependence of the farmers on synthetic insecticides for protecting stored food, attempts were made to derive a treatment using a locally available substitute. In the present trials, a variety of botanical powders have been tested on *S. oryzae* and *T. castaneum*. Botanical powders tested were cotton stem, maize stem, mulberry bough wood, rice haulm, sycamore branch wood, and citrus bough.

Table (1) included the results which explain the effectiveness of the tested powders against the two tested insect adults. Based on LC_{50} except for citrus bough powder, *S. oryzae* adults were more susceptible than *T. castaneum*. LC_{50} values ranged from 0.1 – 1.29 and 0.36 – 1.87 w/w for *S. oryzae* and *T. castaneum* 7 days post treatment, respectively. The induction of all powders increased with increasing concentration with the two tested insects. Mortality percent was from 15.60 –100.00 at the all concentrations with the two tested species,

This difference in response may depend on the ability of the tested insect to pick up the tested powder, the surface of the insect exposed to powder, and the abraded wax layer after 7 days of treatment. Moreover, the behavior of movement and habit of nutrition perhaps play a role belonging to the response of tested insects to the tested powders. In addition, the variation of efficacy probably depends on the type of powder (Its persistence and its degradation during the period of the experiment) and the taxonomy position of the tested insect species.

Additionally, the differentiation in toxicity of the used plant powder results from a group of factors such, as the type of tested insect species, the type of plant used, and the ambient conditions. Also, results showed that mulberry had the greatest action against *S. oryzae* while citrus bough had the first order among the powder against *T. castamum*. Maize stem powder had the least effective against both insects. There is no significant difference between rice and sycamore powders against *S. oryzae* or between mulberry and sycamore against *T. castamum*.

2. Effect of plant powders on the biology of tested insects:

The present trials were conducted to evaluate the powders of cotton stem, maize stem, mulberry bough wood, rice haulm sycamore branch wood, and citrus bough as stored product protectants on biology and weight loss besides the germination percentage of seeds exposed to *T. castamum*, and *S. oryzae*. Results in Table (2) comprised the efficacy of plant powders admixed with wheat grains on number of F_1 adult emergence, reduction percent of progeny, and loss weight % of wheat grains. The reduction in F_1 progeny of the two tested insects ranged between 1.49 and 91.79% with all concentrations of all powders. The results showed that *S. oryzae* had a higher response (in F_1 reduction 9.38 – 91.79) compared to *T. castamum* with F_1 reduction (1.49 – 87.38) (Table 2).

The increase in mortality percent and the decrease of progeny compared to control led to the reduction of weight loss percentage in the all tested quantity of powder and the response paralleled with the different levels of powder. Percent loss of weight in grains treated with powder significantly reduced with all levels where the loss percentage ranged between (1.24 – 15.33) for *S. oryzae* and (0.5 – 19.1) with *T. castamum* compared to control which caused % weight loss between 23.40 to 43.22 for

T. castamum and *S. oryzae*, respectively.

Also, there is no significant difference between the highest level (5%) of all powders which achieved the greatest reduction in progeny (F_1). Based on the numbers of progeny and the percent of wheat weight loss may divide the powders into two groups, the first includes the strongest powders, maize, mulberry, rice, and sycamore powders. While the second group comprised that of the least effective, cotton stem and citrus bough powders. For *T. castaneum*, the powders had directions that differ from that of *S. oryzae* except for cotton and rice powders, these achieved the same effect on both *S. oryzae* and *T. castaneum*.

Most may divide the effect of powders on *T. castaneum* adults into 3 categories concerning wheat weight loss since citrus bough was the premier followed by rice, mulberry, sycamore, and maize powders as the second category, then cotton stem powder as the third group which had the least effect. In belonging to the F_1 progeny the cotton stem was the least agent among the tested powders while the other remainder powders present the best compared to the control. In general, the response of the two insects to powders obviously differed, since *S. oryzae* was more susceptible than *T. castaneum*.

These differences between the two insect species may depend on some factors such as morphology (Area of insect surface), physiology, genetics, sensory organs, and eating habits. Results showed that the weight loss often parallels the number of progenies of each insect. One of the abnormal observations is that the many numbers consume less food than the few numbers, and this may be due to the indirect effect of the tested materials on the vital processes inside the insect. F_1 progeny of all treatments decreased compared to control. The corresponding reduction rates in F_1 progeny were from 1.49 – 91.79 with the two tested species. Weight loss percentage was also significantly reduced in treated grains compared to control where % loss was from 0.5 – 19.10 in treated seeds while control was from 23.40-43.22% by the all tested insects.

Stored grains are subjected to attack by a group of insects which might cause serious losses. The use of insecticides on food materials possess many problems. Nowadays, the attention is going to the control of the stored product pests using save alternative agents instead of the traditional toxicants. These alternatives included botanical materials, different inert chemicals, and others (Golob *et al.*, 1982; Ivbijaro, 1984; Su, 1985 and Halawa *et al.*, 1998).

In many areas of the world locally available materials are widely used to protect stored produce against damage by insect infestation (Golob and Webley, 1980). There are various mineral substances, which can be added to stored grains such as fine sand, clay dust, quicklime, and wood ash. The admixture of such mineral materials to the harvest crops causes invisible injury to the protective wax layer of stored product insects, leading to dehydration. The addition of ash to cereal grain legumes is widespread in tile African countries (El-Lakwah *et al*., 1996).

Also, the findings of the current study are in agreement with the results of Golob *et al.* (1982) studied the effectiveness of wood ash, tobacco dust, and sawdust when admixed with maize to protect the grain during storage. They found that all tested ash materials restricted infestation. The effectiveness was directly related to dosage. Also, they found that the protection afforded by wood ash admixed at 30% by weight was of the same order as that provided by admixing pirimiphos-methyl at 8.8 ppm. Don-Pedro (1985) tested the toxicity of powdered sun-dried orange and grapefruit peels to *Callosobruchus maculatus* (Fabricius) (Coleoptera: Chrysomelidae) and *Dermestes maculalus* DeGeer (Coleoptera : Dermestidae) in the laboratory at rates of 4 and 5.62, 14.13 and 14.29%. Orange and grapefruit peels deterred adult test insects produced from admixed cowpea and dried fish chips, respectively.

Orange peel at high dosages was also shown to depress progeny development of *D. maculatus*. Golob and Hanks (1990) reported that paddy husk ash provided good protection against *P. truncatus* and *S. oryzae* when applied to maize grain. El-Lakwah *et al.* (1996) studied the effect of cotton stem ash against *S. oryzae, R. dominica,* and *T. castaneum* in the laboratory. Results revealed that mortalities increased with increasing concentration and exposure period and the mortalities ranged from 60-65%, 35-45% and 33-55% for *S. oryzae*, *R. dominica*, and *T. castaneum*, respectively at rates from (l-4% wt/wt).

El-Kashlan (1999) evaluated the effectiveness of burned rice husks compared to malathion against *S. oryzae* L., *R. dominica* F., and *C. maculatus* (F.). Results indicated that malathion was the most toxic. Burned rice husks showed promising results and could be used as a grain protectant against stored product insects. El-Lakwah *et al.* (2000) investigated the effects of maize husk ash on mortality and reduction in F_1 progeny of *S. oryzae, R. dominica, T. castaneum,* and *C. maculatus*.

Results showed that adult mortalities were concentration and exposure period dependent. Reduction in F_1 progeny was also concentration dependent and reached its maximum at the highest concentration used. Mahdi and Khalaquzzaman (2006) tested the paddy husk ash admixed with cowpea seeds on *C. maculatus*. They found that LD_{50} was 1479.29 and 974.11 ppm after 24 and 48 h, respectively. Golob (1997) stated that dusts such as ash are required in quantities of at least 5% by weight to be effective protectants against storage pests. Smith *et al.* (2006) reported that in the longer term the use of ash may be more effective on *Prostephanus truncates* despite the lower initial rate of morality. It has been suggested that ash can cause mortality by clogging insect spiracles and tracheae (Katanga-Apuuli and Villet, 1996).

Dusts also, cause insect mortality by desiccation because of absorption of cuticular wax (Golob, 1997). Swain and Baral (2005) determined the effect of different ashes (Wood ash, rice straw ash, bamboo ash, and rice husk ash) for controlling rice weevil, *S. oryzae,* and pulse beetle *C. chinensis* in the laboratory in a humidity chamber on wheat and pulse seeds, respectively. The wheat and pulse seeds were thoroughly mixed with ash at 0.5 g/100 g seeds. The results revealed that the different ashes significantly hindered the normal growth of the insect population. Rice husk ash was considered the best in controlling the insects in comparison to other ashes tested.

3. Effect of cattle dung:

Results summarized in Table (3), indicate the percent of mortality increased with increasing concentration with the two tested insects. In addition, *T. castaneum* adults were more tolerant than *S. oryzae* based on the LC_{50}. Results in Table (4), showed that the effect of cattle dung powder on the studied parameters had the same trend as the plant powders for the two insects.

Since the produced F_1 and the weight loss reduced with the increasing of powder rate. Also, the % weight loss was parallel with the insect number, and

S. oryzae adults were more susceptible than *T. castaneum*. All rates of concentration had a significant deterrent effect on the investigated criteria compared to control with the two insects. Except for citrus bough powder which reduced the germination of wheat grain at all concentrations, the highest concentrations of plant powders (2 and 5%) and the lowest concentration (5%) of cattle dung gave a percent of germination equal to that of control.

Overall, the tested materials, plant, and cattle dung powders, the presented results revealed that all plant powders had the greatest deterrent effect in comparison with cattle dung with the two insect species *S. oryzae and T. castaneum* on the all studied standards. Bruce Robin *et al.* (2018) reported that cow dung ash was effective in controlling bean bruchid since there was less bruchid population and damage as compared to control and cow urine seeds. Pradhan (2016) stated that cow dung ash and cow urine are less toxic than commercial insecticides in the market and easy for the local farmers. Ash is reported as an effective measure against bruchid by Chinwada and Giga (1997) and Baier and Webster (1991). According to Sivakumar and Amutha (2012) and Venkatasubramaniam *et al.,* (2017), the major content of cow dung ash composition is silica which has insecticidal properties (EPA, 1991).

4. Effect of tested powders on germination:

A Series of experiments were carried out in the laboratory to estimate % the germination of treated wheat grains exposed to tested insects. Batches of wheat grain were admixed with the tested powders at the required rates of 0.5, 1, 2, and 5% of the treated medium. and exposed to *S. oryzae*, and *T. castaneum* adults. At the end of the experiment, after removing the adults of F_1 progeny, a number of grains were soaked in water and were placed on wet filter paper in a Petri dish, then after 10 days, % germination was estimated and summarized in Table (5).

Despite insect infestation of wheat grains germination percentages were from 87.0-95, with the two types of powders and their rates in comparison with control which reached 96 with *S. oryzae*, and *T. castaneum*. The highest percent germination was found with the higher rates of powder (5%) while the lowest germination was at the least quantity of powder (0.5%). These findings may be due to the decrease of infestation at the highest rates of tested ashes.

Table (1): Comparative toxicity of the tested powders against *Sitophilus oryzae* and *Tribolium castaneum* adults after 7 days post treatment.

Plant powder	Conc.	*Sitophilus oryzae*				*Tribolium castaneum*			
		% M 7 day	LC50	C.L	S.V	% M	LC50	C.L	S.V
Cotton stem	0.5	34.33	1.04	0.82 1.26	1.54	23.40	1.26	1.05-1.50	1.74
	1.0	46.72				42.00			
	2.0	63.40				67.50			
	5.0	87.90				83.43			
Maize stem	0.5	17.20	1.29	1.12-1.47	2.46	15.60	1.87	0.94-2.65	2.23
	1.0	42.40				24.50			
	2.0	59.80				43.70			
	5.0	96.20				89.40			
Mulberry bough	0.5	76.70	0.10	0.09-0.18	0.95	46.60	0.52	0.30-0.71	1.14
	1.0	86.70				66.70			
	2.0	93.30				73.40			
	5.0	100.00				86.60			
Rice haulm	0.5	56.6	0.46	0.32-0.55	2.2	36.70	0.94	0.64-1.16	1.92
	1.0	70.00				46.70			
	2.0	94.70				66.50			
	5.0	100.00				97.00			
Sycamore branch	0.5	53.40	0.49	0.31-0.65	1.39	36.70	0.70	0.52-0.86	1.59
	1.0	64.32				66.70			
	2.0	80.20				76.60			
	5.0	93.35				90.00			
Citrus bough	0.5	45.20	0.80	0.56-1.03	1.24	53.40	0.36	0.14-0.57	0.93
	1.0	48.70				66.70			
	2.0	66.40				80.00			
	5.0	86.70				83.40			
Control	0.00	0.00							

Table (2): Response of *Sitophilus oryzae* and *Tribolium castaneum* adults to wheat grain mixed with the tested powders.

Powder	Conc.	*Sitophilus oryzae*			*Tribolium castaneum*		
		No. of F1 progeny	Reduction in F1	% Loss of wheat grain	No. of F1 progeny	Reduction in F1	% Loss of wheat grain
Cotton stem	0.5	116.00ghi	9.38	15.33g	132.00ij	1.49	18.41ij
	1.0	103.00gh	19.13	13.43.fg	130.00ij	2.98	19.10j
	2.0	99.00g	22.01	9.35ef	113.00i	15.67	12.40h
	5.0	72.00e	43.75	7.74cde	62.00ef	53.73	4.70cde
	Cont.	128.00i	-	43.22h	134.00ij	-	23.40k
Maize stem	0.5	55.00de	57.03	5.40cd	75.00fg	43.88	7.53fg
	1.0	42.00d	66.64	4.37bc	69.00efg	28.29	6.41e
	2.0	30.00bc	75.85	3.99abc	41.cd	69.15	5.37e
	5.0	10.00a	91.79	2.71ab	16.00a	87.38	4.52cd
	Cont.	128.00i	-	43.22h	134.00ij	-	23.40k
Mulberry bough	0.5	38.00cd	69.68	5.52cd	76.00fg	43.28	7.10efg
	1.0	41.00d	97.81	3.14abc	72.00fg	46.26	6.53de
	2.0	38.00cd	70.31	2.21ab	52.00de	60.82	3.47c
	5.0	22.00ab	82.81	1.71a	48.00cde	63.65	1.43ab
	Cont.	128.00i	-	43.22h	134.00ij	-	23.40k
Rice haulm	0.5	43.00d	66.95	5.65cd	102.00h	23.88	7.60gh
	1.0	32.00bcd	74.37	3.93abc	92.00h	31.34	6.70fg
	2.0	25.00ab	80.46	2.13ab	68.00efg	49.25	2.70bc
	5.0	13.00a	89.84	1.24a	38.00bc	71.64	0.50a
	Cont.	128.i	-	43.22h	134.00ij	-	23.40k
Sycamore branch	0.5	41.00d	67.72	6.22cde	62.00ef	53.73	7.23fg
	1.0	35.00cd	72.18	4.11bc	53.00de	60.44	6.67ef
	2.0	29.00bc	77.03	3.19abc	39.00c	70.89	4.35cd
	5.0	22.00ab	82.50	2.65ab	16.00a	87.38	3.99c
	Cont.	128.00i	-	43.22h	134.00ij	-	23.40k
Citrus bough	0.5	92.00fg	28.12	11.04efg	74.00fg	44.77	3.70c
	1.0	87.00ef	32.03	9.82ef	53.00de	60.44	2.10b
	2.0	42.00d	66.48	7.40cde	32.00b	76.11	1.30ab
	5.0	22.00ab	82.10	5.43cd	22.00a	83.05	0.90a
	Cont.	128.00i	-	43.22h	134.00ij	-	23.40k

Means followed by the same letter are not significant at (p=0.05).

Table (3): Toxicity of cattle dung powder on *Sitophilus oryzae* and *Tribolium castaneum* adults after 7 days posttreatment.

Insects	Conc.	% Mortality	LC50	C.L.		Slope value
				Lower	Upper	
Sitophilus oryzae	5 10 20 25	48.33 80.00 86.00 98.00	5.03	2.73	11.79	2.30
Tribolium castaneum	5 10 20 25	37.00 56.70 65.00 75.00	8.57	6.17	10.75	1.32

Table (4): Response of *Sitophilus oryzae* and *Tribolium castaneum* adults to cattle dung powder after 7 days at the indicated concentration.

Insects	Conc.	No. of F1 progeny	Reduction in F1	% Loss weight wheat
Sitophilus oryzae	5	36ef	68.69	5.33c
	10	28cde	75.65	3.22abc
	20	18abc	84.34	2.40ab
	25	9ab	91.47	1.99ab
	control	115i	-	38.33i
Tribolium castaneum	5	65h	57.79	18.43de
	10	42fg	72.70	17.33de
	20	25cd	83.76	9.40cd
	25	20bc	87.01	5.33c
	control	154j	-	29.44f

Table (5): Germination of wheat grain treated with the plant powders and cattle dung after F_1 emergence of *Sitophilus oryzae* and *Tribolium castaneum* adults.

Powder	Conc. % w/w	*Sitophilus oryzae*	*Tribolium castaneum*
Cotton	0.5	91.00 b-f	90.00 a-d
	1.0	91.00 b-f	92.00 b-e
	2.0	92.70 d-h	92.50 b-f
	5.0	93.00 d-h	94.00 ef
Maize	0.5	89.00 abc	89.00 ab
	1.0	90.60 a-d	91.00 ae
	2.0	93.40 e-h	93.00 c-f
	5.0	94.20 fgh	93.40 def
Mulberry	0.5	91.00 b-f	89.00 ab
	1.0	91.50 c-f	91.00 a-e
	2.0	93.00 d-h	93.00 c-f
	5.0	94.20 fgh	94.00 ef
Rice	0.5	90.00 a-d	91.00 a-e
	1.0	90.70 b-e	91.50 a-e
	2.0	92.00 c-g	93.00 c-f
	5.0	95.00 gh	93.90 e-f
Sycamore	0.5	88.00 ab	89.00 ab
	1.0	89.00 abc	89.00 ab
	2.0	91.00 b-f	91.00 a-e
	5.0	93.00 d-h	92.00 b-e
Citrus	0.5	87.00 a	88.00 a
	1.0	89.70 a-d	89.50 abc
	2.0	91.00 b-f	91.00 a-e
	5.0	93.00 d-h	92.00 b-e
Cattle dung	0.5	93.00 d-h	95.00 f
	1.0	92.70 c-g	93.00 cf
	2.0	89.00 a-d	91.00 a-e
	5.0	87.00 a	89.70 abc
Control		96.00 h	96.00 f

References

Abbott, W. W. (1925): A method computing the effectiveness of an insecticide. J. Econ. Entomol., 18: 265-267.

Abo-Arab, R.B.; Awadalla, S.S.; Abd El-Salam, A.H. and El-Maodowy, E.A. (2014): Toxicity and repellent activity of spinosad and orange oil against *Rhizopertha dominica* F. and *Tribolium castaneum* (Herbst). J. Plant Prot. and Path. Mansoura Univ., 5(1): 23-32.

Abuye, C.; Urga, K.; Knapp, H.; Selmar, D.; Omwega, A.; Imungi, J. and Winterhalter, P.A. (2003): Survey of wild, green, leafy vegetables and their potential in combating micronutrient deficiencies in rural populations. East Afr. Med. J., 80: 247-252.

Adams, J.M. (1976): Weight loss caused by development of *S. oryzae*. J. Stored Prod. Res., 12:269-272.

Ajayi, O.E.; Apple, A.G. and Fadamiro, H.Y. (2014): Fumigation toxicity of essential oil monoterpenes to *Callosobruchus maculates* (Coleopetera: Chrysomelidae: Bruchinae). Journal of insects volume, Article ID917212, 7 pages http:/dx.doi.org//10.1155/2014/9/17212.

Akhtar, Y. and Isman, M.B. (2004): Comparative growth inhibitory and antifeedant effects of plant extracts and pure allelochemicals on four phytophagous insect species. J. Apple. Entomol., 128: 32-38.

Aletor, V. and Adeogun, O. (1995): Chemical analysis of the fruit of *Vitex doniana* (Verbenaceae). Food Chem., 53: 375-379.

Ali, Q.M.H.; Hasan, Q.M.; Sagheer, M.; Ranjh, M.H. and Shahbaz, M. (2016): Appraisal of quantitative losses caused by *Trogoderma granarium* (Everts) and *Tribolium castaneum* (Herbst) in different genotypes of wheat, rice and maize during storage. J. Appl. Biol. Sci., 10: 8-14.

Ashouri, S., and Shayesteh, N. (2009): Insecticidal activities of black pepper and red pepper in powder form on adults of *Rhyzopertha dominica* (F.) and *Sitophilus granarius* (L.). Pak. Entomol., 31:2.

Baier, A. H. and Webster, B. D. (1992): Control of *Acanthoscelides obtectus* Say (Coleoptera: Bruchidae) in Phaseolus vulgaris L. seed stored on small farms—I. Evaluation of damage. J. Stored Prod. Res., 28: 289-293.

Bett, C. and Nguyo, R. (2007): Post-harvest storage practices and techniques used by farmers in semiarid Estem and central Kenya. African Crop. Sci. Conf. Pro., 8: 1023-1227.

Bruce Robin, N.; Gorret, K. and Ronald, N. (2018): Evaluating the effectiveness of cow dung ash and cow urine against bean bruchid beetles. https://www.researchgate.net/publication/326655580.

Chaubey, M.K. (2007): Toxicity of essential oils from *Cuminum cyminum* (Umbelliferae), *Piper nigrum* (Piperaceae) and *Foeniculum vulgare* (Umbelliferae) against stored-product beetle *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae). Electr. J. Environ Agric. Food Chem., 6: 1719-1727.

Chaubey, M.K. (2012): Biological effects of essential oils against Rice weevil *Sitophilus oryzae* L. (Coleoptera: Curculionidae). J. Essent. Oil Bear. Plants, 15: 809-815.

Chinwada, P. and Giga, D.P. (1997): Traditional seed protectants for the control of bean bruchid. (www.researchgate.net).

Chlranjeevi, C.M. (1991): Efficacy of some indigenous plant materials and ashes on the damage and viability of greengram seed infested by pulse beetle, *Callosobruchus chinensis* (L.). Bulletin of Grain Technology, 29: 84-88.

Don-Pedro, K.N. (1985): Toxicity of some citrus peels to *Dermestes maculatus* Deg. and *Callosobruchus maculatus* (F). Journal of Stored Products Research, 21(1): 31-34.

Ebadollahi, A. (2011): Antifeedant activity of essential oils from *Eucalyptus globulus Labill* and *Lavandula stoechas* L. on *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae). Bihar., 5(1): 8-10.

Elbrense, H.; El-Hussieny, I.; Abo El Makarem, H.; Abo Arab, R. and Elkholy, S. (2021): Insecticidal, antifeedant and repellent efficacy of certain essential oils against adult rust red flour beetle, *Tribolium castaneum* (Coleoptera: Tenebrionidae). Egypt J. Chem., 65(1): 167-178.

El-Lakwah, F. A., Sanaa M. Mahgoub and Salwa M. Mohamed. (2000): Effect of maize husk ash and mustard seeds powder (Brassica arvesis) as grains protectants on some stored product insects. Annals of Agric. Sci., Moshtohor, 38 (1): 565-571.

El-Lakwah, F. A.; Khaled, O.M. and Halawa, Z. A. (1996): Effect of modified atmosphere of more than 99% nitrogen or enriched with carbon dioxide on mortality of some stored product insects, seed germination, chlorophyll and carotene contents of certain crop seedlings. Annals of Agric. Sci., Moshtohor, 34 (4): 1869-1877.

Enobakhare, D.A. and Law-Ogbomo, K.E. (2002): Reduction of post-harvest loss caused by *Sitophilus zeamais* (Motsch) in three varieties of maize treated with plant products. Postharvest Sci., 1: 1-6.

EPA (1991): Silicon dioxide and silica gel (https://archive.epa.gov/pesticides/reregistration).

Finney, D. J. (1952): Probit analysis: A statistical treatment of the sigmoid response curve (2nd ed.). Cambridge University Press.

Giga, D.P.; Mutemerewa, S.; Moyo, G. and Neeley, D. (1991): Assessment and control of losses caused by insect pests in small farmers' stores in Zimbabwe. Crop Protection, 10 (4): 287-292.

Golob, P. (1997): Current status and future perspectives for inert dusts for control of stored product insects. Journal of Stored Products Research , 3(1): 69-79.

Golob, P. and Hanks, C. (1990): Protection of farm stored maize against infestation by *Prostephanus truncatus* in Tanzania. Journal of Stored Products Research, 26: 187-198.

Golob, P. and Webley, D. J. (1980): The use of plants and minerals as traditional protectants of stored products. G138. Chatham, UK: Natural Resources Institute.

Golob, P.; Mwambula, j.; Mhango, V. and Ngulube, F. (1982): The use of locally available materials as protectants of maize grain against insect infestation during storage in Malawi. journal of Stored Products Research, 18: 67-74.

Gunther, F.A.; Lindgren, D.H. and Blinn, R.C. (1958): Biological effectiveness and persistence of malathion and lindane used for protection of stored wheat. Journal of Economic Entomology, 51: 843- 844.

Guruprasad, B.R. and Pasha, K. (2014): Assessment of repellency and insecticidal activity of *Ajuga parviflora* (Benth) and *Trichilia connaroides* (W&A) leaf extracts against stored product insects. J. Entomol. Zool. Stud., 2(4): 221-226.

Hagstrum, D.W. and Subramanyam, B.H. (2000): Monitoring and decision tools ed. Bh. Subramanyam, D.W. Hagstrum Alternatives to pesticides in stored product IPM. pp 1-28. Kluwer Academic Publishers.

Halawa, Z. A.; Mohamed, R. A. and El-Kashlan, I. H. (1998): Laboratory evaluation of some plants and insecticides against cowpea beetle (*Callosobruchus maculates*, F.) infesting stored products. Egypt. J. Agric. Res., 76 (1): 85-94.

Harris, K.L. and Linblad, C.J. (1978): Post harvest loss assessment methods. A manual of methods for the evaluation of post-harvest losses. American Association of Cereal Chemists, 75-79.

Isman, M.B. (2006): Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annu. Rev. Entomol., 50: 45-66.

Isman, M.B. and Machial, C.M. (2006): Pesticides based on plant essential oils: from traditional practice to commercialization. In M. Rai and M.C. Carpinella (eds.), Naturally Occurring Bioactive Compounds, Elsevier, BV, 29–44.

Ivbijaro, M. F. (1984): Toxic effects of groundnut oil on the rice weevil Sitophilus oryzae. Insect Sci., Appl., 5: 251-252.

Mahdi, S. H. A. and Khalequzzaman, M. (2006): Toxicity Studies of Some Inert Dusts with the Cowpea Beetle, *Callosobruchus maculatus* (Fabricius) (Coleoptera: Bruchidae). Journal of Biological Sciences, 6: 402-407.

Jacobs, S. and Calvin, D. (2001): Weevils on Stored Grain. Penn State College of Agricultural Sciences. Retrieved from the web on October 18th, 2016 from http://ento.psu.edu/extension/factsheets/pdf/weevilsgrain.pdf.

Katanga-Apuuli, J.K. and Villet, M.H. (1996): The use of wood ash for the protection of stored cowpea seed (*Vigna unguiculata* (L.) Walp) against Bruchidae (Coleoptera). African Entomology, 4: 97-99.

Kern, W.H. Jr. and Koehler, P.G. (1994): Rice weevil, *Sitophilus oryzae* (Coleoptera: Curculionidae). Fact sheet ENY-261, A Series of the

Entomology and Nematology Department Florida Cooperative Extension service, Institute of Food and Agricultural Sciences, University of Florida.

Khare, B.P. and Agarwal, R. K. (1972): Effect of nontoxic materials on insect infestation in stored grain. Indian Journal of Entomology, 34:169-172.

Koul, O.; Walia, S. and Dhaliwal, G.S. (2008): Essential oils as green pesticides: potential and constraints. Biopesticides Int., 4(1): 63-84.

Koura, A. and El-Halfawy, M.A. (1972): Weight loss in stored grains caused by insect infestation in Egypt. J. Egypt Entomol. Soc., 56: 413-417.

Lale, N.E.S. (2002): Stored product entomology and acarology in tropical Africa. 204 p. Mole Publications, Maiduguri, Nigeria.

Law-Ogbomo , K. E. and Enobakhare , D.A. (2007): The Use of Leaf Powders of *Ocimum gratissimum* and *Vernonia amygdalina* for the management of *Sitophilus oryzae* (Lin.) in Stored Rice. Journal of Entomology, 4(3):253-257.

Mahama, A.; Saidou, C. ;Tofel, H.K.; Ali, A. ; Adji, M.B. and Nukenine, E.N. (2018): Efficacy of Eucalyptus camaldulensis leaf extracts against the pea beetle *Callosobruchus maculatus* and their impact on biochemical and microbiological properties of the treated bambara groundnut grains. J. Entomol. and Zoology Studies, 6(2): 869–877.

Malgorzata, K. and Anna, P. (2015): The mortality *Oryzaephilus surinamensis* L. (Coleoptera: Silvanidae) induced by powder plants. J. plant protection Research, 55(1): 110-116.

Ntonifor, N.N.; Oben, E.O. and Konie, C.B. (2010): Use of selected plant-derived powders and their combinations to protect stored cowpea grains against damage by Callosobruchus maculatus. ARPN J.Agric. Biol.Sci., 5:13-21.

Omran, I.M.; Hassan, K.S. and Almansour, N. (2020): Effect of some plant powders and insecticides admiral and runner against saw-toothed grain bettle O. Surinamensis L. (Silvanidae: Cleoptera). Plant Archives, 20 (2): 774-778.

Pradhan, B. (2016): Cow urine replaces pesticide in Sikkim farms. https://www.livemint.com/Politics/k8Q1uQ8LvZL5eIQG5OiHcN/Cow.

Rahdari, T. and Hamzei, M. (2017): Repellency effect of essential oils of *Mentha piperita*, *Rosmarinus officialis* and *Coriandrum sativam* on *Tribolium confusum* Duval (Coleoptera: Tenebrionidae). Chem Res. J., 2(2): 107-112.

Rajkumar, V.; Gunasekaran, C.; Christy, I. K.; Dharmaraj, J.; Chinnaraj, P. and Paul, C. A. (2019): Toxicity, antifeedant and biochemical efficacy of *Mentha piperita* L. essential oil and their major constituents against stored grain pest. Pestic. Biochem. Physiol., 156:138–144.

Sivakumar, G. and Amutha, K. (2018): Studies on silica obtained from cow dung ash. Advanced Materials, 584(9): 470-473.

Smith, . M.; Moore, D.; Oduor, G. *et al.* (2006): Effect of wood ash and conidia of *Beauveria bassiana* (Balsamo) Vuillemin on mortality of *Prostephanus truncatus* (Horn). Journal of Stored Products Research, 42(3):357-366.

Stefanazzi, N.; Stadler, T. and Ferrero, A. (2011): Composition and toxic, repellent and feeding deterrent activity of essential oils against the stored-grain pests *Tribolium castaneum* (Coleoptera: Tenebrionidae) and *Sitophilus oryzae* (Coleoptera: Curculionidae). Pest Manag. Sci., 67(6): 639-646.

Su, H. C. F. (1985): Laboratory evaluation of biological activity of *Cinnamomum cassia* to four species of stored product insects. J. Ent. Sci., 20 (2): 247-253.

Sudheer Reddy, V.; Ramesh Babu, T. and Hussaini, S.H. (1993): Effect of inert materials on germination and grain damage by stored grain pets of sorghum. Seed Research, 1: 285- 287.

Venkatasubramanian, C.; Muthu, D.; Aswini, G.; Nandhini, G. and Muhilini, K. (2017): Experimental Studies on Effect of Cow Dung Ash (Pozzolanic Binder) and Coconut Fiber on Strength Properties of Concrete, IOP Conference Series: Earth and Environmental Science. Retrieved from http://iopscience.iop.org/article/10.1088/1755-1315/80/1/012012/pdf.

Wazid, W.S.; Nadagouda, A.; Prabhuraj, R.H.; Shahuntala; N. N.M. and Sharanagouda, H. (2020): The persistence of residual toxicity of zinc, copper and silica green nanoparticles against important storage pests. J. Entomol. Zool. Studies, 8(5): 1207-1211.

Yun, T.S; Park, S.Y.; Yu, J.Y.; Hwang, Y.J. and Hong, K.J. (2018): Isolation and identification of fungal species from the insect pest *Tribolium castaneum* in rice processing complexes in Korea. Plant Path. J., 34: 356-366.

Yusuf, A.U.; Dike, M.C.; Adebitan, S.A. and Ahmed, B. I. (2011): Comparative efficacy of seven plant products on the cowpea burchid, *Callosobruchus maculatus* F. development and damage. J. Biopestici, 4(1): 19-26.