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Effects of Jatropha and Moringa Powders on Khapra Beetle (*Trogoderma granarium* Everts) Infesting Sorghum Grains, Under Laboratory Condition

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Abstract: *Khapra beetle (Trogoderma granarium Everts) of the Dermestidae family is considered as the most destructive stored food pest and its larvae reduce the quality and quantity of stored grains. The objective of the percent was to study the effect of intervention of Jatropha (Jatropha curcas L.) powders at zero time on khapra beetle infesting sorghum (Sorghum bicolor Moench) grains, Gezira State, Sudan. The experiment was carried out under laboratory conditions during the period of September from 2015 to March 2016. The powder of each part of Jatropha plant (seed, leaf and barks) was 6.0 g / kg of sorghum grains (w/w). To each jar of sorghum grains (weight 250 g), except in untreated control. Then five pairs of adult khapra beetles were released in. The variety of sorghum under study was Tabat that was treated with heat at 60°c for 24 hours. The powders and the adults of khapra beetle were placed in the same time (zero time). Gaucho 70 WP (standard) at 3.0 g / kg of sorghum grains (w / w) and control (untreated) were included for comparison. Treatments were arranged in a completely randomized design (CRD) with four replicates on a wooden bench. Larvae, pupae and adults were counted and recorded and then continued monthly for a period of six months. At the seven month from the start of experiment the loss in grains weight was calculated. Data were transformed, when needed, and subjected to statistical analysis of variance (ANOVA). Significant means were separated using Duncan's Multiple Range Test (DMRT) at $P \leq 0.05$. The Jatropha and Moringa powders significantly reduced the number of larvae, pupae, adults and grains weight loss. The seed powders of Jatropha and Moringa were more effective in controlling khapra beetle infestation than the powders of leaves and barks. The leaves powder of Moringa, significantly, increased the number of larvae, pupae and adults as well as the grains weight loss compared to the control (untreated). This study concluded that Jatropha and Moringa powders could be implemented in the integrated management of the Khapra beetle on stored grains of sorghum.*

Keywords: Grains; Jatropha; Khapra; Sorghum; Store;*Trogoderma*

1. INTRODUCTION

Cereals are the main crops grown in Africa and Asia and used for both human nutrition and animal feed. However, the major crops in the above mentioned continents are rice maize and sorghum. Nevertheless, those who depend on sorghum are estimated as more than 300 million people from developing countries [1]. In animal nutrition, grain sorghum is mostly used as an energy source and is a good feedstuff for poultry and ruminants. The stalks remaining after harvest can be grazed as some varieties stay green for a long period of time. Sorghum may also be grown for fodder, for grazing or cut green to make silage and hay [2]. In Sudan sorghum occupies about 40% of the country cropped area mainly in the central rain land belt. However, after harvesting, the grains are stored under various storage practices varying from small to big stores indoor or outdoor, temporary or permanently under individual or community storage structures. The indoor storage is mainly for keeping seeds, whereas the grains for consumption are stored in separate structures that are constructed away from the residential areas [3]. During storage, grains are liable to post-harvest loss by insects, rodents, birds, mites and micro-organisms which cause direct and indirect damage that result into loss of weight and changes in natural components. Post-harvest loss is defined as the degradation in both quantity and quality of a food production, from harvest to consumption. FAO estimated worldwide annual losses in stored products as 10% of all the stored grains. About 13 million tons of grain loss is due to insects in Africa [4]. Proper storage of agricultural products is a very important post-harvest practice. Considerable amounts of grains are spoiled after harvest due to lack of proper and sufficient storage facilities as ideal processing facilities [5]. The losses are generally more common in developing countries [6]. FAO report indicates that at global level, volumes of lost and wasted food in high income regions. The losses are higher in downstream phases of the food chain, but just the opposite in low-income regions where more food is lost and wasted in upstream phases [7].

Khapra beetle *Trogoderma granarium* Everts and other beetles of the Dermestidae family are considered to be the most destructive stored product pests. The pest had been given status as an A2 quarantine organism for European and Mediterranean Plant Protection Organization (EPPO). A2 list of pests recommended for regulation as quarantine [8]. The import restrictions are supported by the facts that feeding by Khapra beetle larvae reduces the quality, grade and weight of grain. The khapra beetle, *T. granarium*, is one of the world's most feared stored-product pests. In fact, it has been described as one of the 100 worst invasive species worldwide [9]. The use of synthetic insecticides for controlling insect pests has

been associated with several problems which became more apparent in recent years [10]. This necessitated the search for eco-friendly alternatives for pest management. Among the proposed alternatives are the uses of biocides specially those of plant origin. However, research on botanical pesticides in Sudan was firstly performed sporadically during the last two decades of the 20th century [11] and [12]. Hence, more research should be encouraged in this aspect.

Objective of the study

This experiment was conducted to assess the effects of leaves, bark and seed powders of Jatropha (*Jatrophacurcas* L.) and Moringa (*Moringa oleifera* L) and on Khapra Beetle (*Trogoderma grnarium* Everts) (Coleoptra: Dermestidae) on Sorghum (*Sorghum bicolor* Moench) grains.

2. MATERIALS AND METHODS

2.1. Experimental site

The experiment was conducted under laboratory condition at Crop Protection Department, Faculty of Agricultural Sciences, University of Gezira, Sudan during the period from September 2015 to March 2016. The laboratory having an average temperature of 26±3° C and relative humidity of 65±5 %.

2.2. Insect culture

From the mixed stages culture of Khapra beetle that collected from different areas in Gezira State, Sudan, the pupae were separated and then adults were allowed on Sorghum, *Tabat* variety. The adults were put on Sorghum grains (250 grams) kept in a glass jar covered with a muslin cloth fixed with the rubber band to allow ventilation and prevent insect from being escaped.

2.3. Preparation of sorghum grains jars and transferring of the khapra beetle

Sorghum variety (*Tabat*), used in this experiment, was bought from local market in Wad Medani city, Sudan, and cleaned to remove the debris and broken grains. Sorghum grain jars and seeds were sterilized in an electric oven running at 60°C for 24 hours to insure that they were free from living insects. The newly emerged adults (0-3days) were collected from the insect culture and transferred to the jars, supplied with the sorghum grains. The jars were covered with muslin and left in the laboratory.

2.4. Natural products

The two products: Jatropha (*J. curcas*) and Moringa (*M. oleifera*), specially the components (leaves, barks and seeds) were ground into powder using kitchen mill (Panasonic, MX.J110P), then sieved and stored in dry place for experimentation.

2.5. Amounts of tested sorghum grains, the natural products and Gaucho (standard)

A series of lots of sorghum grains of 250 grams were weighed for each Jar. A series of lots of powder of each product (leaves, barks and seeds) weighing 6.0 grams were prepared to represent a dose per kilogram of sorghum grains. Gaucho (standard) 3 grams ⁄ kg of sorghum grains (w ⁄ w) were assigned as standard plus a similar weight of sorghum represent untreated control. Each of the above materials was replicated four times, and all treated jars were shaken to ensure effective coating of grains with powders. Every jar supplied with 5 pairs of newly emerged adults of khapra beetle (0- 3 days old) and covered with a muslin cloth, tightened with a rubber band. The labeled jars were arranged in a completely randomized design (CRD) on a wooden bench, under laboratory condition.

2.5. Data collection

Larvae, pupae and adults were monitored and recorded monthly for 6 months after intervention. The grains in each jar were screened using appropriate sieve to separate insect skins, grain dust and excreta. The dead adults were removed and then the grain percentage weight loss was calculated.

2.7. Statistical analysis

The collected data were transformed when needed and then subjected to analysis of variance (ANOVA) at $P \leq 0.05$. Significant means were separated using Duncan's Multiple Range Test (DMRT).

3. RESULTS

Effects of Jatropha (*Jatrophacurcas* L.) and Moringa (*Moringa oleifera* L) powders on the larvae of Khapra Beetle (*Trogoderma granarium* Everts) infesting Sorghum (*Sorghum bicolor*) grains, under laboratory condition were shown in (Table 1, 2, 3 and figure 4 significantly ($P \leq 0.05$). The products affected the number of larvae, pupae and adults of the khapra beetle as well as the weight loss of infested sorghum grains, throughout the period of the study, from September 2015 to March 2016.

3.1. Effects on the larvae

The results showed that the Khapra beetle was failed to increase in number when sorghum treated with Gaucho (Table 1).

Table 1. Effects of Jatropha (*Jatrophacurcas* L.) and Moringa (*Moringa oleifera* L) powders on the larvae of Khapra Beetle (*Trogoderma granarium* Everts) infesting Sorghum (*Sorghum bicolor*) grains, under laboratory condition

Treatments	Number of larvae per jar after consecutive month					
	1	2	3	4	5	6
Jatropha seeds	2.11ab (5.5)	2.59c (7.1)	2.59c (7.1)	2.59c (7.1)	5.04b (31.7)	5.69d (113.7)
Jatropha leaves	4.90a	9.09ab	9.09ab	9.09ab	10.74 a	6.85d

	(29.6)	(84.6)	(84.6)	(84.3)	(119.6)	(168.9)
Jatropha barks	3.98a	8.64ab	8.64ab	8.64ab	10.49a	6.07d
	(19.7)	(75.1)	(75.1)	(75.1)	(123.1)	(130.2)
Moringa seeds	4.97a	8.51ab	8.51ab	8.51ab	11.63a	9.72b
	(27.4)	(84.3)	(84.3)	(84.3)	(136.2)	(351.1)
Moringa leaves	4.93a	12.23ab	12.23ab	12.23ab	13.58a	10.77b
	(32.7)	(151.0)	(151.0)	(151.)	(207.2)	(435.9)
Moringa barks	5.99a	9.66ab	9.66ab	9.66ab	13.63a	12.01a
	(46.3)	(102.2)	(102.2)	(102.2)	(202.1)	(543.4)
Gaucho	0.71b	0.71c	0.71c	0.71c	0.71b	0.71e
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Control	5.95a	7.23b	7.23b	7.23b	13.93a	8.13c
(untreated)	(38.3)	(64.6)	(64.6)	(64.6)	(204.5)	(241.4)
SE±	1.26	1.29	1.29	1.29	1.59	0.52
CV %	60.25	35.38	35.38	35.38	36.10	7.40

* Data were transformed to $\sqrt{x+0.5}$ and the actual data are between parentheses.
** Means in the same column followed by the same letter(s) are not significantly ($P \leq 0.05$) different according to Duncan's Multiple Range Test (DMRT).

However, its increment was greater in the untreated sorghum than in grains treated with Jatropha seeds. Placing the powder of seeds, leaves and barks of Jatropha (*J. curcas* L.) and Moringa (*M. oleifera*) on the adults of khapra beetle, significantly ($P \leq 0.05$) affected the number of larvae of the khapra compared to Gaucho (standard) and control (untreated)(Table 1). Generally, Jatropha (*J. curcas*) seeds powder significantly reduced the number of the Khapra beetle larvae compared to the control (untreated) throughout the period of the study. Moreover, seed powder of Jatropha displayed a comparable number of larvae to that displayed by Gaucho (standard). However, there were no significant differences in the number of the larvae among stored sorghum grains treated with the powder of Jatropha leaves and barks and the control (untreated). There were no significant differences in the number of the larvae among stored sorghum grains treated with the powder of Moringa (*M. olefera*) seeds, leaves, barks and the control (untreated) generally. The seeds powder of Moringa significantly reduced the number of khapra beetle larvae in the month 6. However, the numbers of larvae of the Khapra beetle were significantly increased on sorghum grains treated with Moringa (*M. oleifera*) leaves and barks.

3.2. Effects on the pupae

The trend of low numbers of pupae among sorghum tread with Jatropha seed compared to untreated control were persisting from months 1 to 5 after intervention (Table 2). On the other hand, the numbers of pupae were high among sorghum treated with Moringa leaves compared to control (untreated) during the period under experimentation. Placing the powder of seeds, leaves and barks of Jatropha (*J. curcas* L.) and Moringa (*M. oleifera*) on the adults of khapra beetle on sorghum grains, significantly ($P \leq 0.05$) affected the number of pupae of the khapra compared to Gaucho (standard) and control (untreated). Generally, Jatropha *(J. curcas*) seeds powder reduced the number of the Khapra beetle pupae compared to the control (untreated) throughout the period of the study. Application of Jatropha seed, significantly reduced the number of pupae of the khapra in months 1 and 3 compared to control (untreated). Moreover, the reductions in the number of Khapra beetle pupae were significantly comparable to that of Gaucho (standard) in the month 1 to 5. The powder of Moringa (*M. oleifera*) seeds, leaves and barks had no significant negative effect on the Khapra beetle pupae compared to the control throughout the period of the study. Moreover, there were no significant differences between Gaucho (standard) and control during the month 5.

3.3. Effects on the adults

Placing the powder of seeds, leaves and barks of Jatropha (*J. curcas*) and Moringa (*M. olefera*) and the adults of khapra beetle on sorghum grains, significantly ($P \leq 0.05$) affected the number of adults of the khapra compared to Gaucho (standard) and control (untreated) (Table 3). Generally, Jatropha (*J. curcas*) seed powder reduced the number of the Khapra beetle adult compared to the control (untreated) throughout the period of the study.

Table 2. Effects of Jatropha (*Jatrophacurcas* L.) and Moringa (*Moringa oleifera* L) powders on the pupae of Khapra Beetle (*Trogoderma granarium* Everts) infesting Sorghum (*Sorghum bicolor*) grains, under laboratory condition

Treatments	Number of pupae per jar after consecutive month				
	1	2	3	4	5
Jatropha seeds	1.27c	1.25b	1.73bc	2.10ab	1.24bc
	(1.2)	(1.3)	(2.6)	(4.3)	(2.7)
Jatropha leaves	1.96abc	3.33ab	1.75bc	2.46ab	1.52abc

	(4.0)	(13.5)	(2.8)	(6.8)	(4.9)
Jatropha barks	2.16ab	2.51ab	2.25ab	2.23ab	0.96c
	(4.9)	(8.1)	(4.9)	(5.2)	(1.1)
Moringa seeds	2.42abc	2.63ab	2.63ab	1.76ab	1.95abc
	(5.9)	(7.5)	(6.9)	(2.8)	(10.7)
Moringa leaves	1.64abc	4.59a	3.10ab	3.36a	3.38a
	(2.7)	(28.7)	(9.9)	(10.9)	(40.9)
Moringa barks	2.38ab	3.22ab	2.38ab	2.72a	3.25ab
	(6.2)	(12.2)	(5.9)	(9.6)	(37.3)
Gaucho	0.71c	0.71b	0.71c	0.71b	0.71b
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Control (untreated)	8.3 a	3.25ab	3.36a	3.18a	1.58abc
	(2.9)	(11.2)	(13.2)	(12.1)	(5.9)
SE ±	.40	.86	.45	.57	.80
CV %	41.78	64.70	40.73	49.39	55.21

* Data were transformed to $\sqrt{x+0.5}$ and the actual data are between parentheses.
** Means in the same column followed by the same letter(s) are not significantly ($P \leq 0.05$) different according to Duncan's Multiple Range Test (DMRT).

Table 3. Effects of Jatropha (*Jatrophacurcas* L.) and Moringa (*Moringa oleifera* L) powders on the adults of Khapra Beetle (*Trogoderma granarium* Everts) infesting Sorghum (*Sorghum bicolor*) grains, under laboratory condition

Treatments	Number of adults per jar after consecutive month				
	1	2	3	4	5
Jatropha seeds	4.04d	3.37bc	2.83cd	4.90cd	1.58cd
	(15.9)	(12.4)	(7.6)	(4.3)	(2.7)
Jatropha leaves	7.68bc	7.87ab	6.01ab	8.01ab	3.21bc
	(58.7)	(76.8)	(38.2)	(6.8)	(4.9)
Jatropha barks	7.09c	6.16ab	5.29bc	4.90cd	2.12cd
	(49.9)	(46.5)	(30.4)	(5.2)	(1.1)
Moringa seeds	6.74c	5.41abc	6.77ab	4.06d	2.69bcd
	(46.2)	(32.0)	(45.6)	(2.8)	(10.7)
Moringa leaves	9.35a	9.17a	8.22a	9.19a	5.78a
	(76.9)	(101.2)	(73.1)	(10.9)	(40.9)
Moringa barks	8.75ab	7.80ab	7.14ab	6.44bc	4.21ab
	(76.9)	(70.5)	(55.7)	(9.6)	(37.3)
Gaucho	0.71e	0.71c	0.71d	0.71e	0.71e
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Control (untreated)	7.21c	8.05ab	6.48ab	7.63ab	2.49bcd
	(51.9)	(73.9)	(56)	(12.1)	(5.9)
SE ±	0.35	1.66	0.88	0.64	0.80
CV %	1153	45.81	32.55	22.62	32.50

* Data were transformed to $\sqrt{x+0.5}$ and the actual data are between parentheses.
** Means in the same column followed by the same letter(s) are not significantly ($P \leq 0.05$) different according to Duncan's Multiple Range Test (DMRT).

Placing the powder of Jatropha seeds and the adults of khapra beetleat on stored sorghum grains, significantly reduced the number of adults of the khapra in months 1,3 and 4 compared to control (untreated)(Table 3). Generally, the powder of Moringa (*M. olefera*) seeds, leaves and barks had no significant negative effect on the Khapra beetle adult compared to the control (untreated) throughout the period of the study. Exceptionally, the powder of Moringa seeds in month 4, significantly, reduced the number of Khapra beetle pupae in comparison to control (untreated).

3.4. Effects on the weight loss

Placing the powder of seeds, leaves and barks of Jatropha (*J. curcas*) and Moringa (*M. olefera*) on the adults of khapra beetle on stored sorghum grains, significantly ($P \leq 0.05$) affected the weight loss of infested grain sorghum by khapra beetle compared to Gaucho (standard) and control (untreated). Placing the powder of seeds, leaves and barks of Jatropha reduced the weight loss of infested grain sorghum by khapra beetle compared to control(Table 4). Despite that there were no significant ($P \leq 0.05$) differences in the weight loss of

sorghum grains treated with the powder of seeds, leaves and barks of Jatropha, the lowest weight loss (1.7%) was recorded as Jatropha seed powder was used. On the other hand, the highest weight loss (12.8) was recorded as Moringa leaves powder was used and followed by Meringa barks powder (10.2%).

Table 4. Effects of Jatropha (*Jatrophacurcas* L.) and Moringa (*Moringa oleifera* L) powders on the weight loss of Sorghum (*Sorghum bicolor*) grainsinfested by Khapra Beetle (*Trogoderma granarium* Everts), under laboratory condition

Product	Weight loss %
Jatropha seeds	1.4 cd (1.7)
Jatropha leaves	2.6 ab (7.5)
Jatropha barks	2.4 bc (5.6)
Moringa seeds	2.4 bc (5.7)
Moringa leaves	3.6 a (12.8)
Moringa barks	3.6 a (10.2)
Gaucho	0.7 d (0.0)
Control (untreated)	2.4 bc (5.5)
SE±	0.35
CV%	30.3

* Data were transformed to $\sqrt{x+0.5}$ and the actual data are between two parentheses

** Means followed by the same letter(s) are not significantly ($P \leq 0.05$) different according to Duncan's Multiple Range Test (DMRT).

4. DISCUSSIONS

The results of this study revealed that placing the powders of Jatropha (*J. curcas*) at zero time on the adults of khapra beetle on stored sorghum grains (*Tabat* cultivar), significantly, reduced the number of larvae, pupae and adults as well as the weight loss of infested grain sorghum by khapra beetle compared to the powders of Moringa (*M. olefera*). The seed powder of Jatropha was more effective in controlling khapra beetle infestation than the powders of leaves and barks. The larval stage was more affected by the natural products than the pupal and adult stages. These findings were in line with previous report made by [13] who carried out laboratory studies to determine the effects of extracts of some indigenous plant from Sudan on the larvae of Khapra beetle (*Trogoderma granarium*) in infested stored sorghum grains. He evaluated the lethal, antifeedant and repellency activity of powders and aqueous extracts of eight plants; e.g. Basil (*Ocimum basilicum*), Henna (*Lawsonia inermis*), Senna (*Cassia senna*), Lantana (*Lantana camara*), Datura (*Datura alba*), Usher (*Calotropis procera*), Chili (*Capsicum frutescens*) and Jatropha (*Jatropha curcas*). The results revealed that at all tested plants have played some potential insecticidal effect, but Usher, Jatropha and Datura had the highest lethal and anti-feedant effect on the 3rd larval instar of Khapra beetle. The highest percentages of dead larvae were scored at 30th day in Usher, Jatropha and Datur. Also, the results showed that Datura and Jatropha displayed some potential as anti-feedants to the larvae. On the other side the repellency action of these plants was more effective against the pest. Leaves water extract of Usher showed the lowest repellency percentage, while the higher repellency effects were obvious in Jatropha.The seeds of Jatropha are in general toxic to animal curcin, a toxic protein isolated from the seeds, was found to inhibit protein synthesis in in-vitro studies. The high concentration of phorbol esters present in Jatropha seed has been identified as the main toxic agent responsible for Jatropha toxicity [14] and [15].

The seed powder of Moringa was more effective in controlling khapra beetle infestation than the powders of leaves and barks, and the larval stage was more affected by the natural products than the pupal and adult stages. This findings are in conformity with that report by [16] who conducted a laboratory study at the college of Agricultural studies, Sudan University of Science and Technology Shambat, Khartoum, Sudan, during 2016 to evaluated the insecticidal effects of powders of Moringa (*M. oleifera*) from different plant parts (leaves, flowers, seeds and branches) at three levels of concentrations 1, 2.5, and 5 g/100g grains of test plant powders and the untreated control (0g/100 g grains) against the 3rd instars larvae of khapra beetle (*T. granarium*), were tested in sorghum grains infested with the 3rd instars larvae of khapra beetles. Larvae mortality of khapra beetles were assessed at 1, 3, 7 and 30 days of infestation. The results obtained from study related that all powder from plant parts exhibited that significantly protection of sorghum grains from khapra beetle infestation compared with the control. Larvae mortality accounts increased with increasing amount of Moringa powders and time of exposure. The sorghum grains treated with Moringa seed powder gave the highest range (7.5- 15.0%) larvae mortality at 1 and 3 days, respectively. Also the highest progressive increase in larvae mortality ranging from 37.5 - 42.5% was achieved with in sorghum grains treated with Moringa seed powder, while the lowest increase in larvae mortality ranging from 17.5 – 22.5% in sorghum grains treated with Moringa flower powder was recorded at the highest concentration 5% at 7 and 30 days, respectively.The chemical constituents of the methanolic extract of *M. oleifera* leaves and seeds were investigated using Gas chromatography-mass spectrometry [17]. Several chemical constituents were identified in the leaf and seeds methanolic extract such octadecenoic acid, ascorbic acid, hexadecenal, pentanone, phytol and oleic acid. These relatively diverse chemical constituents may be responsible for the insecticidal properties of Moringa leaves and seeds. Also, it might explain the observation that the leaves powders of Moringa, significantly, increased the number of larvae,

pupae and adults as well as the weight loss of infested grain sorghum by khapra beetle compared to control (untreated).

5. CONCLUTION

The seed powders of Jatropha and Moringa were more effective in controlling the khapra beetle infestation than the powders of leaves and barks. The larval stage was more affected by the natural products than the pupal and adult stages.So that Jatropha and Moringa powders could be implemented in the integrated management of the Khapra beetle on stored grains of sorghum.

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