International Journal of Agriculture and Plant Science
www.agriculturejournal.in
Online ISSN: 2664-7664, Print ISSN: 2664-7656
Received: 04-01-2024, Accepted: 20-01-2024, Published: 05-02-2024
Volume 6, Issue 1, 2024, Page No. 1-4

Utilize powdered components derived from the *Moringa oleifera* plant as a means to combat the *Callosobruchus maculatus* (Fabricius)

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Abstract
The objective of this study was to investigate the impact of *Moringa oleifera* powders derived from different parts of the plant on *Callosobruchus maculatus* in cowpea seeds under specific environmental conditions. The experiment was conducted at a temperature of 29 ± 2˚C and a relative humidity of 70 ± 5 R.H. To investigate the effects of *Moringa oleifera* plant powders (leaf, stem, root, and flower) on cowpea seeds infested with *Callosobruchus maculatus* adults a study employed a fully randomized design. The results revealed significant variations in the number of eggs laid, hatched eggs, and emerged adults among the different treatments ($P \leq 0.05$). The application of 0.5 g of *Moringa oleifera* flower powder resulted in the lowest average number of eggs (7.30), which differed significantly from the control group that did not use any plant product. Additionally, the control group exhibited the highest number of hatched eggs (44.33), the mean number of hatched eggs displayed a considerable disparty (3.20 and 0.35) observed when the application of leaf and flower powders was done, separately ($P \leq 0.05$). When stem and leaf powders were applied, the total developmental period was significantly reduced to 16.7 days and 18.9 days, respectively, compared to the control group's period of 24.8 days. Within the first 24 hours of insect infestation, the mortality percentages were 88% and 74%. These findings imply that *Moringa oleifera* flower powder has the potential to be used as a bio-insecticide for controlling *Callosobruchus maculatus* in stored cowpea seeds.

Keywords: Moringa plant parts powdered, adults and eggs of *Callosobruchus maculatus*

Introduction

Cowpea is grown in various climates and farming systems in tropical regions. It is commonly cultivated in arid areas alongside sorghum and millet. Cowpea is a yearly herbaceous plant belonging to the sub-tribe Phaseolinae, tribe Phaseoleae, family Papillionaceae, and order Leguminosales. The cowpea grain provides an inexpensive source of protein and complements a diet centered around cereals. In Eastern and Western Africa, the young leaves are consumed after cooking or utilized as a seasoning, while the green or chopped pods are popular in the Far East but not widely used in Africa. The roots are also consumed in Sudan and Ethiopia. Similar to other legume crops, cowpeas are susceptible to insect pests during both growth and storage. Pest problems are especially severe in Africa when compared to other continents. Multiple bruchid species have been identified as cowpea pests. Among these, *Callosobruchus maculatus* is the most significant pest for cowpea storage worldwide. In Nigeria alone, this insect pest causes annual yield losses of approximately $30 million.

Infestation commonly occurs in the field when pods are nearing maturity. The beetles lay their eggs on the pods, but they prefer to enter through pre-existing holes made by other pests and lay their eggs directly on the seed. Once the crop is harvested, the beetles reproduce and cause significant damage to stored cowpeas. In 1964, Howe and Currie conducted a study on the biology of *Callosobruchus maculatus* and discovered that the ideal conditions for egg-laying were a temperature of 35°C and a relative humidity of 70%. Female *C. maculatus* lay an average of 97 eggs, ranging from 71 to 117. The lifespan of adults lasts about 8 to 16 days, with an average of 10 days. During storage, the eggs become attached to the seeds, appearing glossy and oval when fresh, and hatch within 3 to 5 days. The larvae then penetrate the seeds and cause extensive damage by feeding inside them. Each larval stage lasts from 2 to 4 days, followed by a 2-day pre-pupal stage and a 5-day pupal stage. After the pupal stage, adults emerge from an exit hole previously created by the larvae. A study conducted by Owusu-Akyaw in 1987 [34], Sabbour and Abdel-Raheem in 2013 [36], and Magda Sabbour and Mohamed Abdel-Raheem in 2015 [20] and 2020 [4] examined the biology of this pest at IITA. They found that more bruchid eggs were laid on cowpeas intercropped with maize compared to those planted as a monocrop. Furthermore, around 50% of the eggs laid on pods were parasitized by Uscana sp. They also observed differences in pod wall resistance to bruchids and reported that varieties with a strong pod wall suffered the least damage. The damage to cowpea seeds is mainly caused by the larvae feeding inside them. Storing cowpeas on the farm for six months often leads to a weight loss of approximately 30%, with up to 70% of the seeds being infested and unfit for consumption. The genetics of bruchids in cowpeas have been extensively researched by Redden *et al.* in 1983, Adjadi *et al.* in 1985 [9], and Naglaa *et al.* in 2020 [30].

Moringa oleifera, an extraordinary plant belonging to the Moringaceae family, is thought to have originated in the North West region of India Faizi *et al.*, 1999 [16]. It possesses a wide range of potential applications in agriculture and industries Faidi *et al.*, 2001 [15]. The presence of essential vitamins, such as A, B, C, D, and E, as well as minerals like potassium, calcium, iron, selenium, and magnesium, underscores the nutritional and medicinal properties of Moringa. Extensive research has confirmed the safety of consuming Moringa leaves, which have no known harmful side effects or toxins Madukwe *et al*., 2012 [23]. However, concerns have been raised regarding the adverse effects of synthetic chemicals used in pest control Tovignan *et al*., 2001; Mohamed Abdel-Raheem *et al*., 2020 [4] a&b. Consequently, there has been a shift towards non-chemical approaches to safeguard stored produce and the environment, with plant materials being recognized as effective, affordable, and readily available for pest control Onifade and Alabi, 1998 [32]. The efficacy of different plant products in controlling agricultural insect pests has also been highlighted in studies conducted by Akinwumi *et al*. 2007 [10] and Salem *et al*. 2016a [34], 2017 [12], & 2020 [38]. This study aims to investigate the effectiveness of various parts of the Moringa plant (leaves, stem bark, roots, and flowers) in managing *Callosobruchus maculatus* infestation in stored cowpea seeds.

Materials and Methods

The laboratory culture of *Callosobruchus maculatus* was initiated using previously infested cowpea seeds. The culture was maintained in a jar at a controlled temperature of 29 ± 2°C and a relative humidity of 70 ± 5%. The insect culture was managed following the methods outlined by Adenekan and Shosanya in 2006 [6]. The cowpea seeds that were not treated underwent a cleaning and sorting process based on their weight-based sizes. To prevent infestation by insects, these seeds were stored in a refrigerator at a temperature of 10°C until they were required for the experiment. The tested parts of the *Moringa oleifera* plant, including the leaves, stem bark, roots, and flowers, were gathered from well-established plant stands. After being collected separately, these plant parts were air-dried before being pulverized into a powder form. The cowpea seeds that had been stored in the refrigerator were taken out and allowed to acclimate to the environmental conditions of the laboratory for 24 hours before being utilized. Each petri dish was divided into four groups, with 35 grams of seeds placed in each group. The experiment involved using six different treatments, with each treatment repeated four times. The treatments consisted of applying powders derived from various parts of the *M. oleifera* plant, including the leaf, stem, root, and flower, onto cowpea seeds. The application rate for the powders was 0.5 grams per 35 grams of seeds. Three male and three female adult *C. maculatus* insects less than 10 hours old were placed in each Petri dish and kept there for 5 days. The study had a Completely Randomized Design with six treatment groups, including a control group which remained in the laboratory for 7 days before data collection started. The *C. maculatus* insects were given 7 days to lay eggs on the seeds before being taken out of the dishes.

Results and Discussion

Table 1 presents the findings on the effects of *M. oleifera* powders on the hatching, and groth of eggs of *C. maculatus* on cowpea seeds. The results show that the flower powder of the Moringa plant had the fewest eggs laid (7.30), which was significantly different from the control group where the highest number of eggs (49.25) was observed. Additionally, when 0.5 g of Moringa leaf, stem, and root powders were applied, the mean number of eggs laid were 16.21, 15.30, and 13.40, respectively. The application of different *M. oleifera* plant powders also led to varying numbers of dead *C. maculatus*. The control treatment had a significantly different mean number of dead *C. maculatus* compared to the flower and stem powder treatments (4.16 and 2.02, respectively). However, there was nonotable variation in the average quantity of dead *C. maculatus* when leaf and stem powders were applied (2.02). These findings align with previous studies conducted by Adenekan and Sosanya 2006 [6] and Adenekan *et al*. 2013 [8], which illustrated the significant control of *C. maculatus* by the flower powder of *Plumeria rubra* and *M. oleifera* plant during storage.

Table 1: The impact of powdered parts from the Moringa plant on growth and development of *C. maculatus*

***M. oleifera* product**	**Averag No. of eggs laid ± SE**	**Averag No. of eggs hatched ± SE**	**Averag No. of dead *C. maculatus* ± SE**
Leaf	16.21 ± 1.12b	3.20 ± 0.87c	2.02 ± 0.35c
Stem	15.30 ± 1.50b	3.30 ± 1.20c	2.02 ± 0.35c
Root	13.40 ± 2.34b	5.15 ± 1.20b	3.11 ± 1.10b
Flower	7.30 ± 2.70c	0.35 ± 0.11d	4.16 ± 1.40b
Control	49.25 ± 5.25a	44.33 ± 2.21a	1.11 ± 1.20c

n: represents 35 grams of cowpea seed.
r: represents 4 replicates.
rate equals 0.5 grams of powder per 35 grams of cowpea seed.
If example denotes have the same letter, it means that they are not significantly different from each other based on the DMRT 0.05.

Table 2 demonstrates that beetles exposed to *M. oleifera* powders in seeds had varying survival rates until adulthood. The number of adults that emerged differed significantly depending on the type of *M. oleifera* plant powder used. The smallest number of adults, 3.33, was observed when flower powder was applied, and this was significantly different from the control treatment, which had the highest number of adults, 42.35, where no plant powder was used. The total time for development from egg to adult also varied depending on the *M. oleifera* plant part powders used on *C. maculatus*. The shortest average developmental period, 16.7 days, was observed when stem powder of *M. oleifera* was applied, which was significantly different from the longest developmental period of 24.8 days in the control experiment. However, there were no significant differences observed when comparing the developmental periods of 18.9 and 17.6 days for the leaf and flower powders, respectively, to the control. The results regarding the sex ratio (male: female) revealed that the plant powders affected the sex ratio of *C. maculatus*. The ratio of 0:6 strongly suggests that the flower powder influenced the number of males produced compared to the control treatment, which resulted in 28 males and 20 females (7:5). The exact mechanism by which the *M. oleifera* powders impact the sex ratio of *C. maculatus* offspring is not fully understood and may require further scientific investigation.

Table 2: Effects of Moringa plan parts powders on the total developmental period and sex ratio of *C. maculatus*

***M. oleifera* product**	**Average No. of adults emergence ± SE**	**Total developmental period (eggs - adults) (days)**	**Sex ratio (M: F)**
Leaf	3.13 ± 0.31c	18.9 ± 2.99c	9:8
Stem	6.23 ± 1.23c	16.7 ± 2.40c	5:6
Root	4.13 ± 0.14b	20.7 ± 3.33b	9:2
Flower	3.33 ± 0.65b	17.6 ± 1.83c	0:6
Control	42.35 ± 5.40a	24.8 ± 4.54a	7:5

The total weight of cowpea seeds used in the experiment was 35 grams. The experiment was conducted with 4 replicate samples. The rate of powder added to each sample was 0.5 grams per 35 grams of cowpea seed. Samples with the same letter designation in their mean values indicate that they are not significantly different from each other, according to the Duncan's Multiple Range Test at a significance level of 0.05. The mortality rate of *C. maculatus* on cowpea seeds treated with different parts of the Moringa plant was presented in Table 3. The findings indicated that all *C. maculatus* treated with the flower powder had a mortality rate of 100% within 24 hours of being infested by the insects. In comparison, the control group had the lowest mortality rate of 10%, while the powders made from the leaves and stems of *M. oleifera* resulted in insect moralities of 88% and 74% respectively after 24 hours of infestation. These results align with a previous study conducted by Abdullahi *et al*. in 2012 [5], which reported the impact of *Zingiber officinale* and *Allium sativum* on *Dermestid maculatus* larvae reared in Clarias garepinus. Therefore, the findings from this study demonstrate the potential of *M. oleifera* flower powder as a bio-insecticide for controlling *C. maculatus* on cowpea seeds. Farmers are advised to utilize *M. oleifera* flower powder to safeguard cowpea seeds from *C. maculatus* infestations during storage. However, further scientific research is necessary to explore the insecticidal properties of Moringa plant extracts for managing storage insect pests.

Table 3: Percentage of Mortality of *C. maculatus* on cowpea seeds that were subjected to Moringa powder treatment derived from various sections of the plant

***M. oleifera* plant parts**	**% The percentage of death after infestation (hrs.)**				
	6	8	10	12	24
Leaf	23	55	58	85	88
Stem	28	45	67	74	74
Root	11	32	53	76	74
Flower	45	75	82	89	100
Control	0	0	5	8	10

The number of insects that were introduced is 10. The amount of cowpea seed used is 35 grams. The experiment was replicated 4 times. The rate of powder added is 0.5 grams per 35 grams of cowpea seed.

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