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Efficacy of Moringa *oliefera* Lam. leaf and seed powder on postharvest Cowpea Seed bruchid (*C. maculatus* Fab.) during Storage

Liamngee K[1], Fayinminu A. O[1, 2], Agbatar B. L[1, 2], Iornenge B. I[1, 2], San S. J[1, 2], Ibrahim E. M[1, 2]

[1]Department of Biological Sciences, Benue State University, Makurdi, Nigeria
[2]Center for Food Technology and Research, Benue State University, Makurdi, Nigeria

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ABSTRACT

The efficacy of Moringa oliefera Lam. leaf and Seed powder on Cowpea Seed Bruchid (C. maculatus) during Storage was investigated. Two groups of cowpea; one free from weevil infestation and the other consisting of highly infested seeds were obtained from farmers in Makurdi. Moringa oliefera leaf and seed powders were produced by drying the leaves and seeds of the Moringa plant, grinding it with pestle and mortar and sieving to get fine powder; after which three concentrations of 0g, 30g and 45g were prepared for assessment tests. Five pairs each of Callosobruchus maculatus F. consisting of males and females were introduced into plastic containers containing 300g each of wholesome cowpea seeds and left undisturbed for seven days; after which the parent weevils were removed and eggs laid by the parent weevils were allowed to develop. Emerged progenies were introduced into the various treatment levels and left for a period of 28days after which data on quality parameters were taken. The experiment was arranged in 3×2 factorial in a completely randomized design. Days, taken for egg laying by seed bruchid on cowpea was 4days while that for progeny emergence was 23days. Moringa oliefera seed powder produced significantly higher weight, germination and insect mortality (36.65g, 65.75% and 5.22 respectively) compared to Moringa leaf powder (36.28, 65.78% and 4.44). Also significantly higher weight, germination and insect mortality was recorded for cowpea seeds treated with 45g Moringa powder (39.33, 84.67 and 7.83 respectively) compared to 30g (37.92, 61.00 and 4.33 respectively) and 0% (32.16, 43.33 and 2.33 respectively) while higher insect population and grain with holes was recorded for grains treated with 0g of Moringa powder (28.00 and 31.50) compared to 30g (15.67 and 18.50) and 45g (13.50 and 13.33), respectively. Moringa oliefera leaf and seed powder was an effective insecticidal agent against the cowpea weevil Callosobruchus maculatus. They have significant effect on weight maintenance, suppression of weevil population, increasing mortality rate of weevil, prevention of holes in grains and enhancing germination performance which is an indicator of crop viability.

1. Introduction

Cowpea (*Vigna unguiculata* L. Walp) belongs to the family fabaceae (Ibrahim *et al.*, 2017; Organization for Economic Cooperation and Development, 2016). Production of cowpea is both for its grains and vegetables. It is among the recognized African indigenous nutrient-rich foods with the potential to promote food and nutrition security in Sub-Saharan Africa (SSA). The crop is originated from West and Central Africa, from where its cultivation and production spread to Latin America and South East Asia. The 2016 global estimates show that 12.3 million hectares of land are utilized in the production of cowpeas with Western and Eastern Africa leading in terms of production area at 10.5 and 0.9million hectares, respectively (FAOSTAT, 2016).

Cowpea has been exploited for food and feed. They are rich in micronutrients, nutraceuticals, and antioxidants. Some of the antioxidants that have been found in it are alpha tocopherols, flavonoids, lycopene, and anticancer agents (Shetty *et al.*, 2013). Cowpea contains important nutrients that can improve the nutritional status of individuals and households with proper utilization. The rich nutritional property of cowpea makes it ideal for efforts aimed at

*Corresponding Author: Liamngee K
E-mail Address: katorliamgee@yahoo.com
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reducing food and nutrition insecurity (Okonya and Maass, 2014).

Moringa oleifera L., commonly referred to as the "miracle tree" is the most widely cultivated species of the genus *Moringa*, which belongs to the family Moringaceae. It is a fast growing and resistant shrub, native to India but now widely distributed in the tropics and subtropical areas (Gadekar, 2006). In Nigeria, *M. oleifera* is found in all ecological zones where it grows all the year round. The plant is propagated by both seeds and cuttings. The *Moringa* plant grows mainly in semi-arid, tropical, and subtropical areas, and grows best in dry sandy soil. It tolerates poor soils, including coastal areas (Gadekar, 2006).

Today it is widely cultivated in Africa, Central and South America, Sri Lanka, India, Mexico, Malaysia, Indonesia and Philippines. It is considered one of the world's most useful plants, as every part of it is used either for food or other beneficial proposes (Fahey, 2005). Other common names of *Moringa* include: "drumstick" tree, due to the appearance of the long, slender, triangular pods; "horseradish" as a result of the taste of the roots, "benoil tree" from the oil derived from the seeds (Fahey, 2005).

Food security has been greatly threatened by excessive post-harvest losses of grains caused by stored product insect pests, under small holder on farm situations and at a nation level, primarily caused by weevils. This is because of lack of suitable grain storage structures and absence of adequate storage management technologies that force growers to sell their produce immediately after harvest. Consequently, farmers receive low market prices for any surplus grain they may produce. Hence, farmers have not been as such the beneficiaries of this increased production and productivity potential of new varieties of grains.

Breeding for genetic resistance and use of chemicals have been the most effective strategies recommended to control cowpea losses. But, chemicals are often costly for the farmers especially the small scale farmers. The numerous side effects of chemicals such as cancer to humans as well as toxicity resulting from continuous usage are major drawbacks in the use of chemicals. This calls for development of organic crop preservatives as alternatives for synthetic pesticides.

Considering the extent of damage caused by storage pests of cowpea especially *Callosobruchus maculatus*, findings from this study will provide an alternative method for preservation of cowpea against pest damage besides the synthetic preservatives which have been reported to have serious adverse effects on humans and crops on the long run.

This study will provide information to crop scientists and postharvest physiologists on the efficacy of *Moringa oliefera* as a biopesticide and create avenues for exploration of the botanical in control of other crop pests. It will help provide students with well-structured methodology on how to conduct studies relating to biopesticide production and serve as a major footing upon which they could base the scope of their study to other areas not explored by the author.

The study will further provide adequate data for policy makers and government to provide funds for large scale research involving biopesticides. This will help provide employment for the researchers, and provide cheaper means of pest control with mininum side effects for the farmer. The aim of this study is to investigate the efficacy of *Moringa* powders on Cowpea Seed bruchid (*C. maculatus*) during storage.

Materials and methods

Experimental Location

The study was carried out in the Botany Laboratory of Benue State University, Makurdi. Makurdi is located in North central Nigeria along the Benue River, on latitude 07°43'N and Longitude 08°35'E; it is 104m above sea level and lies in the tropical Guinea-Savannah of West Africa where temperature ranges between 21.7°C and a maximum of 29.0° C. The high temperature in Makurdi may be asserted for, by its attitude. It is also an ectone belt that separates the forested South from the true Savannah of North. As such, the vegetation is an assortment of tree and grasses (Nigerian Metrological Association, 2017).

Farm inputs such as fertilizers, improved seed, insecticides and other foreign methods are being increasingly used. However, cost and availability is still a challenge. Important cash crops include soybeans, rice, peanuts, mango varieties and Citrus. Other cash crops include palm oil, melon, African pear, chili pepper and tomatoes. Food crops include Yam, Cassava, Sweet potato, Beans, Maize, Millet, Guinea corn and vegetables (enwikipedia.com, 2019).

Collection and preparation of experimental materials

Source of cowpea seeds

Cowpea seeds were collected from farmers in Makurdi, Benue State. Two groups of cowpea were obtained for this study. The first group, were seeds free from physical manifestation of weevil infestation (no holes in grains, eggs of weevils, or visible signs of weevils) while the last group consisted of highly infested grains with *Callosobruchus maculatus* F. obtained from same location. The infested seeds were stored in plastic containers at room temperature prior to the commencement of laboratory experiment while the un-infested cowpea seeds were sorted and those showing signs of damage in the form of emergent holes, cracks, broken seeds, eggs of weevils and discoloured seeds were discarded. The wholesome seeds were refrigerated at 4-9°C for further studies.

Preparation of *Moringa* leaf and Seed powders

Collection of *Moringa* plant materials were carried out according to the procedure highlighted by Zakki *et al.* (2017). Fresh leaves and seeds of *Moringa oliefera* Lam. were obtained from the campus of the Benue State University Makurdi using a knife to cut leaves and fruits from the tree, the fruits were opened up and the seeds were collected. The plant materials were put in polythene envelopes and taken to the laboratory for further studies. In the laboratory, the leaves and seeds were air-dried for 10days. The dried

leaves and seed were afterwards grounded separately using a pestle and mortar and sieved to get a fine powder. The powders were stored in well covered clean jars and kept in a dust-proof locker.

Preparation of *Moringa* leaf and seed powder concentrations

Concentrations of the *Moringa* leaf and seed powder applied to 300g of Cowpea were calculated using the formula below.

Powder Concentration (g) = $\frac{Percentage\ Level}{100}$ × weight of grains - - - - (i)

Two (2) levels each of 10% and 15% were selected for use in this study, weight of grains was

300g. Therefore,

For 10% level,
Powder Concentration (g) = $\frac{10}{100}$×300 ..... (ii)

: - Powder concentration (g) = 30g of *Moringa* powders leaf and seed respectively
For 15% level,

Powder Concentration $\frac{10}{100}$×300 ..... (iii)

= 45g of *Moringa* powders leaf and seed respectively

Experiment I

Preparation of C. *maculatus* F. under laboratory conditions for assessment tests

(Breeding experiment)

Five pairs each of *Callosobruchus maculatus* Fab. Consisting of males and females were introduced into containers containing 250g each of wholesome white and brown cowpea seeds respectively. The containers which were plastic, transparent and oval shaped with a flat bottom of about 8-10mm diameter was covered with a 10mm mesh sieve to allow free air circulation and also to prevent insects from escaping. This was carried out at room temperature and relative humidity. The setup was left undisturbed for a period of five to seven days after which the parent weevils were removed and eggs laid by the parent weevils were allowed to develop. Progeny of the weevils in the stored cowpea were afterwards harvested by sieving and then left for another 24 hours ready to be used for quality assessment.

Experiment II

Evaluation of the effect of *Moringa* leaf and seed powder on cowpea seed bruchid during storage of cowpea

Wholesome cowpea seeds previously stored in the fridge were removed and sundried to remove moisture and any resident insects. After that, the cowpea seeds (300g) were placed in plastic containers. Afterwards, each treatment level of *Moringa* leaf and seed powder were added respectively to the seeds in containers and mixed effectively to ensure uniform exposure of seeds to *Moringa* powder. Control seeds were left untreated with *Moringa* leaf and seed powder. Thereafter, 5 pairs of one day old adult cowpea bruchids were introduced into each set of treated seeds. Each container was covered with 10 mm-mesh muslin cloth to allow free air circulation and to prevent insect escape. All these were kept at ambient temperature and examined every 7days for 28days.

Experimental Design

Factors involved in the experiment

1. 3 Rates of application of *Moringa* leaf and seed powder (30g, 45g and 0g)
2. 2 plant materials (*Moringa* seed and leaf)

Experimental design is a 2 x 3 factorial in a completely randomized design

Treatment combinations = 6

Replications = 3

Total number of units = 6 x 3 = 18 units/lots

Data were collected at intervals of 7days. These include:

1. Insect population (n)
The total insect population was determined by counting the number of insects in the storage containers.

2. Insect mortality (n)
This was determined by counting the number of insects with no visible characteristic of movement and irritability.

3. Grains with holes (n)
Seeds with holes and cracks were counted after visual inspection.

4. Seed weight (g)
This was obtained by placing 100 seeds of cowpea on a weighing balance and taking the readings thereof.

5. Germination (%)
Fifteen cowpea seeds of each treatment were placed in petri dishes containing absorbent paper with close-fitting to prevent moisture loss. Thereafter, 5mls of water were added at intervals until germination occurred. They were replicated and arranged in a completely randomized design. Seed germination was assessed by counting the seeds with seed leaf and dividing by the total number of seeds in Petri plates expressed as percentage as reported by Liamngee *et al.* (2018).
Thus,

Percentage germination = $\frac{number\ of\ seeds\ germinated}{total\ number\ of\ seeds\ per\ plate}$ **× 100 ....** (iv)

Data Analysis

The data obtained from the study was analyzed using Analysis of Variance (ANOVA) and the Fishers least significant difference was used to separate the means at 5% level of significance.

Results

Preparing *Callosobruchus maculatus* Fab. for assessment

Female cowpea seed bruchids isolated were distinguished from male seed bruchids by having an overall darker appearance in comparison to males which were brown in colour. The females had two characteristic large lateral dark patches midway along the elytra and smaller patches at the anterior and posterior ends while the males were much less distinctively marked. Also, the plate covering the end of the abdomen was larger in females with smaller patches while in the males, the plate was smaller and lacked patches as shown in Plates 1 and 2 respectively. The identification of the insect sexes was confirmed using electronic documentation of the organism including outlines from Orkin insect identification chart.

Plate 1: Male *Callosobruchus maculatus* F.
Plate 2: Female *Callosobruchus maculatus* F.

The seed bruchid eggs became visible on cowpea seeds 3-4days after the adult male and female were introduced into the cowpea seeds as shown in Plate 3. The eggs were small, grey and dome-shaped with flat bases and were cemented to the surface of the seeds. Emerged progenies were visible 23-24 days after eggs were seen (Plate 4).

Plate 3: Eggs of *Callosobruchus maculatus* F. on Cowpea seeds

Time duration from commencement of the breeding experiment to laying of eggs by *Callosobruchus maculatus* was 9 days, duration of time for emergence of progeny was 15 days while active progeny with wings to fly were visible at 19 days after the beginning of the breeding experiment (Figure 1).

Plate 4: Emerged Progeny of *Callosobruchus maculatus* F. from cowpea seeds

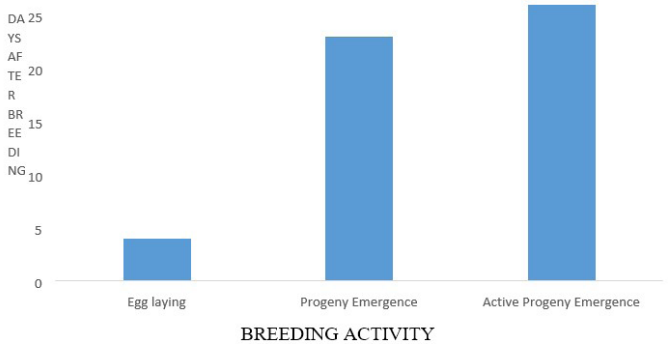

Figure 1: Visible stages in Cowpea Seed Bruchid Breeding

Effect of *Moringa* leaf and seed powder on Weight of Cowpea seeds during Storage

The main and interaction effect of botanical and rate on weight of Cowpea seeds in storage were statistically significant on days 1, 7, 14, 21 and 28 ($P<0.05$) as shown in Tables 1 and 2. Greater weight was recorded for *Moringa* seed powder on days 1, 7, 14, 21 and 28 (42.43, 39.72, 36.61, 33.71 and 30.68g respectively) and this was significantly higher than that of *Moringa* leaf powder (41.89, 38.83, 35.73, 32.53 and 29.67g respectively) ($P<0.05$). Also, greater weights was recorded for seeds treated with 45g of *Moringa* powder on days 1, 7, 14, 21 and 28 (44.60, 42.73, 39.41, 36.63 and 32.68g respectively) and this was significantly higher than 0g (40.77, 36.08, 31.87, 27.92 and 24.08g respectively) and 30g(40.30, 38.38, 37.23, 34.82 and 31.47g respectively). Furthermore, *Moringa* seed powder at a rate of 45g had the most significant effect on weight on days 1, 7, 14, 21 and 28 (44.50, 42.73 40.10, 37.80 and 34.50g) and this was significantly higher than all other treatment combinations considered.

Table 1: Main Effect of Botanical and Rate of *Moringa* on the weight of Cowpea Seeds in Storage

	Weight (g)				
	1	7	14	21	28 (Days)

Continued...

Botanical Leaf	41.89	38.83	35.73	32.53	29.67
Seed	42.43	39.72	36.61	33.71	30.68
LSD(0.05)	**0.67**	**0.70**	**1.02**	**0.97**	**0.98**
Rate 0g	40.77	36.08	31.87	27.92	24.08
30g	40.30	38.38	37.23	34.82	31.47
45g	44.60	42.73	39.41	36.63	32.68
LSD(0.05)	**0.83**	**0.86**	**1.26**	**1.19**	**1.21**

Table 2: Interaction Effect of Botanical and Rates of *Moringa* on Weight of Cowpea seeds in Storage

Botanical	**Rate**	**Weight (g)**				
		1	**7**	**14**	**21**	**28 (Days)**
Leaf	0g	40.77	36.23	32.27	28.33	24.67
	30g	40.30	38.27	36.20	33.80	31.47
	45g	44.60	42.00	38.73	35.47	32.87
Seed	0g	40.90	35.93	31.47	27.50	23.50
	30g	41.90	40.50	38.27	35.83	34.33
	45g	44.50	42.73	40.10	37.80	34.50
LSD(0.05)		**1.17**	**1.22**	**1.78**	**1.68**	**1.71**

Effect of *Moringa* leaf and seed powder on germination of Cowpea seeds in storage

The main and interaction effect of botanical and rate of application of *Moringa* powder on germination percentage of cowpea was significant on days 1, 7, 14, 21 and 28 (P<0.05).

Significantly higher germination were recorded for seeds treated with *Moringa* seed powder (77.78, 68.17, 68.90, 56.70 and 50.0) than the leaf powder (71.11, 65.12, 61.10, 52.20 and 46.70) on days 1, 7, 14, 21 and 28 respectively. Also, significantly higher germination percentages were obtained for seeds treated with 45g *Moringa* seed and leaf powder on day 1, 7, 14, 21 and 28 (95.00, 89.00, 86.70, 76.70 and 70.00 respectively) than with 30g (73.33, 65.20, 61.70, 51.70 and 43.30 respectively) and 0g (55.00, 53.00, 46.70, 35.00 and 26.70 respectively) *Moringa* powder (Table 3).
The interaction effect of botanical and rate of *Moringa* seed and leaf powder on germination was significantly higher for seeds treated with 45g of *Moringa* seed and leaf powders than for interactions at 30g and 0g rate. Seeds with 0g rate of application (control seeds) produced significantly lower germination compared to 30g and 45g respectively on all days of storage (Table 4).

Table 3: Main Effect of Botanical and Rate of *Moringa* on Germination of Cowpea Seeds in Storage

	Germination (%)				
	1	**7**	**14**	**21**	**28 (Days)**
Botanical Leaf	71.11	65.12	61.10	52.20	46.70
Seed	77.78	68.17	68.90	56.70	50.00
LSD(0.05)	4.19	4.35	4.84	5.93	6.41
Rate 0g	55.00	53.00	46.70	35.00	26.70
30g	73.33	65.20	61.70	51.70	43.30
45g	95.00	89.00	86.70	76.70	70.00
LSD(0.05)	**5.13**	**5.15**	**5.93**	**7.26**	**7.84**

Table 4: Interaction Effect of Botanical and Rates of *Moringa* on Germination of Cowpea Seeds in Storage

Botanical	**Rate**	**Germination (%)**				
		1	**7**	**14**	**21**	**28 (Days)**
Leaf	0g	50.00	50.00	43.00	33.30	26.70
	30g	70.00	277.00	53.30	46.70	43.30
	45g	93.33	93.00	86.70	76.70	70.00
Seed	0g	60.00	57.00	50.00	36.70	26.70
	30g	76.67	73.00	70.00	56.70	53.30
	45g	96.67	97.00	86.70	76.70	70.00
LSD(0.05)		**7.26**	**266.4**	**8.39**	**10.27**	**11.09**

Effect of *Moringa* leaf and seed powder on Insect Population of Cowpea Seeds in storage

The main and interaction effect of botanical and rate of application of *Moringa* powder on insect population were not significant on days 1 and 7 (P>0.05) but was significant on days 14, 21 and 28 (P<0.05). Higher insect population was recorded for seeds treated with *Moringa* seed powder (16.56, 27.89 and 42.67) on day 14, 21 and 28 respectively and this was significantly higher than that for *Moringa* leaf powder (14.00, 21.22, 29.67 respectively). Also, a rate of 0g of *Moringa* powder produced higher weevil population on days 14, 21 and 28 (19.83, 38.67 and 61.33 respectively) compared to 30g (14.50, 19.00 and 25.50 respectively) and 45g (11.50, 16.00 and 21.67 respectively) and this was significant (Table 5).

The interaction effect of botanical and rate of *Moringa* powder on insect population showed that *Moringa* seed powder at a rate of 0g resulted in significantly higher insect population (22.00, 44.33 and 73.00) on days 14, 21 and 28 respectively than other treatment combinations with 30g and 45g *Moringa* seed or leaf powder. Also, *Moringa* seed powder at rate of 45g resulted in significantly lower insect population on day 14 (12.33) while *Moringa* leaf powder at rate of 45g resulted in significantly lower insect population on days 21 and 28 (14.00 and 17.67 respectively) (Table 6).

Table 5: Main Effect of Botanical and Rate of *Moringa* on Insect population of Cowpea seeds in Storage

Botanical	**Insect Population (n)**				
	1	**7**	**14**	**21**	**28 (Days)**
Leaf	10.00	10.00	14.00	21.22	29.67
Seed	10.00	10.00	16.56	27.89	42.67
LSD(0.05)	**NS**	**NS**	**1.30**	**1.92**	**3.01**

Continued...

Rate 0g	10.00	10.00	19.83	38.67	61.33
30g	10.00	10.00	14.50	19.00	25.50
45g	10.00	10.00	11.50	16.00	21.67
LSD(0.05)	**NS**	**NS**	**1.59**	**2.35**	**3.69**

Table 6: Interaction Effect of Botanical and Rates of *Moringa* on Insect population of Cowpea Seeds in Storage

Botanical	Rate	Insect Population (n)				
		1	**7**	**14**	**21**	**28 (Days)**
Leaf	0g	10.00	10.00	17.67	33.00	49.67
	30g	10.00	10.00	13.67	16.67	21.67
	45g	10.00	10.00	10.67	14.00	17.67
Seed	0g	10.00	10.00	22.00	44.33	73.00
	30g	10.00	10.00	15.33	21.33	29.33
	45g	10.00	10.00	12.33	18.00	25.67
LSD(0.05)		**NS**	**NS**	**2.59**	**3.32**	**5.22**

Effect of *Moringa* seed and leaf powder on Insect Mortality of Cowpea seeds in storage

The main and interaction effect of botanical and rate of *Moringa* on insect mortality was not significant on day 1 (P>0.05) but was significant on days 7, 14, 21 and 27 (P<0.05). Higher insect mortality was recorded for seeds treated with *Moringa* seed powder (0.22, 2.67, 9.00 and 15.00) than leaf powder (0.33, 2.67, 7.56 and 13.11) on days 7, 14, 21 and 28 days respectively. Also, 45g rate of application of *Moringa* powder resulted in higher insect mortality (0.83, 5.00, 13.50 and 20.00) on days 7, 14, 21 and 28 and this was significantly higher than that of 30g (0.00, 2.17, 7.17 and 12.50 respectively) and 0g (0.00, 0.83, 4.17, 8.67 respectively) (Table 7).

In terms of interaction effect of botanical and rate of application of *Moringa* powder on insect mortality, cowpea seeds treated with 40g *Moringa* seed powder produced significantly higher number of dead insects (0.66, 5.00, 13.36 and 22.00) on days 7, 14, 21 and 28 than any other interactions recorded (Table 8).

Table 7: Main Effect of Botanical and Rate of *Moringa* on Insect Mortality of Cowpea Seeds in Storage

	Insect Mortality (n)				
	1	**7**	**14**	**21**	**28 (Days)**
Botanical Leaf	0.00	0.33	2.67	7.56	13.11
Seed	0.00	0.22	2.67	9.00	15.00
LSD(0.05)	**NS**	**0.24**	**0.64**	**1.30**	**2.37**
Rate 0g	0.00	0.00	0.83	4.17	8.67
30g	0.00	0.00	2.17	7.17	12.50
45g	0.00	0.83	5.00	13.50	20.00
LSD(0.05)	**NS**	**0.29**	**0.784**	**1.59**	**2.90**

Table 8: Interaction Effect of Botanical and Rates of *Moringa* on Insect Mortality of Cowpea seeds in Storage

Botanical	Rate	Insect Mortality (n)				
		1	**7**	**14**	**21**	**28 (Days)**
Leaf	0g	0.00	0.00	0.33	2.33	7.00
	30g	0.00	0.00	2.67	6.67	12.33
	45g	0.00	1.00	5.00	13.67	20.00
Seed	0g	0.00	0.00	1.33	6.00	10.33
	30g	0.00	0.00	1.67	7.67	12.67
	45g	0.00	0.66	5.00	13.36	22.00
LSD(0.05)		**NS**	**0.41**	**1.10**	**2.25**	**1.88**

Effect of *Moringa* leaf and seed powder on Grain with Holes of Cowpea seeds during Storage

The main effect of botanical and rate of *Moringa* powders as well as the interaction effect of botanical and rate of *Moringa* powders on grain with holes was not significant on day 1 (P>0.05) but was significant on days 7, 14, 21 and 28 (P<0.05). Cowpea seeds treated with *Moringa* seed powders produced significantly higher grain with holes (13.11, 21.33, 33.33 and 48.70) on days 7, 14, 21 and 28 respectively than cowpea seeds treated with *Moringa* leaf powder (11.11, 18.78, 28.00 and 39.00 respectively). Also, 0g of *Moringa* leaf and seed powders produced significantly higher number of grain with holes (17.83, 30.00, 45.50 and 67.80) on days 7, 14, 21 and 28 respectively compared to 30g (11.83, 17.67, 26.50 and 36.00 respectively) and 45g (6.67, 12.50, 18.00 and 27.7g) respectively) (Table 9).
In terms of interaction effect, *Moringa* leaf powder at a rate of 0g produced significantly higher number of grain with holes on days 7, 14, 21 and 28 (18.67, 30.67, 48.67 and 74.70 respectively) and this was significantly higher compared to the other interactions with 30g and 45g respectively (Table 10).

Table 9: Main Effect of Botanical and Rate of *Moringa* on Grain with holes of Cowpea Seeds in Storage

	Grain with holes (n)				
	1	**7**	**14**	**21**	**28 (Days)**
Botanical Leaf	0.00	11.11	18.78	28.00	39.00
Seed	0.00	13.11	21.33	33.33	48.70
LSD(0.05)	NS	1.62	1.76	2.52	4.64
Rate 0g	0.00	17.83	30.00	45.50	67.80
30g	0.00	11.83	17.67	26.50	36.00
45g	0.00	6.67	12.50	18.00	27.70
LSD(0.05)	**NS**	**2.01**	**2.15**	**3.09**	**5.69**

Table 10: Interaction Effect of Botanical and Rates of *Moringa* on Grain with holes of Cowpea Seeds in Storage

Botanical	Rate	Grain with Holes (n)				
		1	**7**	**14**	**21**	**28**
Leaf	**0g**	0.00	17.00	29.33	42.33	61.00
	30g	0.00	10.67	16.33	23.67	30.30
	45g	0.00	5.67	10.67	18.00	25.70

Continued...

Seed	**0g**	0.00	18.67	30.67	48.67	74.70
	30g	0.00	13.00	19.00	29.33	41.70
	45g	0.00	7.67	14.33	22.00	29.70
LSD(0.05)		**NS**	**2.84**	**3.05**	**4.37**	**8.04**

Overall Effect of *Moringa* leaf and seed powder on Quality Parameters of Cowpea Seeds in Storage

The overall main and interaction effect of botanical and rate of *Moringa* leaf and seed powders on cowpea seeds in storage is shown in Tables 11 and 12. The main and interaction effect of botanical and rate of *Moringa* leaf and seed powder was significant for weight, germination, insect population, grain with holes and insect mortality. Significantly greater weight, germination and insect mortality was recorded for cowpea seeds treated with *Moringa* seed powder (36.65g, 65.78% and 5.22 respectively) than those treated with *Moringa* leaf powder (36.28, 60.22, and 4.44 respectively). Also, greater weight, germination and insect mortality was recorded for seeds treated with 45g *Moringa* leaf and seed powder (39.33g, 84.67% and 7.83 respectively) and this was significantly higher than 0g *Moringa* leaf and seed powder (32.16, 43.33 and 2.33 respectively) and 30g *Moringa* seed and leaf powder (37.92, 61.00 and 4.33 respectively).

The overall interaction effect of *Moringa* seed and leaf powder on cowpea during storage showed that significantly higher weight, germination and insect mortality was recorded by grains treated with 45g *Moringa* seed powder (39.93, 85.33 and 8.00 respectively) than other treatment interactions. Significantly higher value for insect population and grain with holes was however recorded by cowpea seeds treated with 0g *Moringa* seed (32.00 and 34.33 respectively) and *Moringa* leaf (24.00 and 28.67) powders respectively compared to other treatment combinations.

Table 11: Overall Main Effect of Botanical and Rate of *Moringa* on quality parameters of Cowpea Seeds in Storage

	Quality Parameters				
	Weight (g)	**Germination (%)**	**Insect Population (n)**	**Grains with Holes (n)**	**Insect Mortality**
Botanical					
Leaf	36.28	60.22	16.78	19.00	4.44
Seed	36.65	65.78	21.33	23.22	5.22
LSD(0.05)	1.06	3.62	1.21	1.95	0.80
Rate					
0g	32.16	43.33	28.00	31.50	2.33
30g	37.92	61.00	15.67	18.50	4.33
45g	39.33	84.67	13.50	13.33	7.83
LSD(0.05)	**1.29**	**4.44**	**1.48**	**2.39**	**0.98**

Table 12: Overall Interaction Effect of Botanical and Rates of *Moringa* on quality parameters of Cowpea Seeds in Storage

Botanical	**Rate**	Quality Parameters				
		Weight (g)	**Germination (%)**	**Insect Population (n)**	**Grains with Holes (n)**	**Insect Mortality**
Leaf	0g	32.45	40.67	24.00	28.67	1.33
	30g	37.67	56.00	14.33	16.33	4.33
	45g	38.73	84.00	12.00	12.00	7.67
Seed	0g	31.86	46.00	32.00	34.33	3.33
	30g	38.17	66.00	17.00	20.67	4.33
	45g	39.93	85.33	15.00	14.67	8.00
LSD(0.05)		**1.828**	**6.276**	**2.097**	**3.381**	**1.391**

Discussion

The efficacy of *Moringa oliefera* leaf and seed powder on cowpea seed bruchid (*C. maculatus*) was investigated. The duration from introduction of parent cowpea weevil to visibility of eggs deposited by the weevils was 3-4days. This time is required for successful mating of the adult weevils, laying of eggs and subsequent development of the eggs into larvae whose migration into the seeds determine the adult phase of the seed bruchids. Also, 24-48hours duration is required for development of emerged seed bruchids into adults implying a short time frame for development of emerged seed bruchids into adult weevils (Fox and Reed, 2011). This finding agrees with the report of the Center for Agriculture and Bioscience International (CABI) who reported an-estimated development duration of 24-48hours for emerged seed bruchids into mature adults.

Findings from this study indicated a gradual decrease in weight of cowpea grains from day 1 to 28 with greater weight loss expressed by cowpea seeds without *Moringa* powder treatment (control seeds). The lower weight loss recorded in *Moringa* treated seeds may be due to the reduced infestation of the seeds by cowpea seed bruchids since feeding of the insects on the endosperm of the cowpea seeds results in loss of weight of the seeds in storage. *Moringa* was thus effective in ensuring a deterrent effect on the seed bruchids thereby leading to lowered feeding potentials and weight preservation. This finding is in line with the report of Ojiako (2007) who asserted that botanicals such as *Moringa* have a wide range of biological activities such as repellant ovi-position and feeding deterrence.

Higher weight preservation was observed in seeds treated with *Moringa* seed powder than leaf powder. This implies that the part of *Moringa* plant utilized as crop preservative determines the extent to which preservation will occur. This differential preservative ability of the different plant botanical of *Moringa* observed may be attributed to the quantity of phytochemicals such as phenolics and flavonoids present in each of the botanicals which is a determining factor as to the effect it will have on the cowpea seeds in storage (Ahmed *et al.,* 2020). According to Ahmed *et al.*, (2020), differential amounts of phytochemicals in leaf and seed of crops determines the degree to which they can exhibit their preservative potential. Also, it was revealed that *Moringa* leaf and seed powder levels at 30g and 45g significantly lowered weight preservation than the control. This may be due to the presence of significantly higher amount of biologically active compounds such as tannins and phenolics whose dosage determines the degree to which their effect is felt. This is in agreement with Ojiako (2007) who reported that the efficacy of *M. oliefera* in crop preservation is dose related and the amount of the botanical added determines the extent to which success

will be achieved in maintaining various quality parameters. Also, significantly higher weight preservation observed in cowpea seeds with respect to plant botanical utilized is in agreement with Race *et al.,* (2012) who reported a significantly higher protection of cowpea seeds treated with *Moringa* root powder than leaf powder.

Cowpea seeds treated with *Moringa* seed and leaf powder produced higher germination percentages than those without *Moringa* treatment. This may be due to the fact that *Moringa* powders acts as deterrent to the cowpea seed bruchids and prevents them from entering into the seeds to feed on the germ thereby ensuring their intactness and subsequent increased germination percentage. A reverse effect was felt for seeds without *Moringa* coating since feeding of the seed bruchids on their germ was higher and as such germination percentages greatly affected. *Moringa* addition to cowpea influences formation of radicle and hypocotyl development thereby influencing germination (Phiri and Mbewe, 2010). This, results in greater germination for seeds treated with the *Moringa* than those not treated.
During the study, there was a significantly lowered weevil population for seeds treated with *Moringa* leaf and seed powder than control seeds. The lowered weevil population as a result of treatment with *Moringa* may be attributed to the presence of steroidal glycoside strophantidin which inhibits the membrane protein sodium potassium- ATPase in muscle tissue of seed bruchid and subsequently causes death of weevils. Its presence in *Moringa* therefore possess a suppressing/inhibiting effect to the successful development of weevils to adults hence their lowered population. This is in agreement with Ojiaka (2007) who reported that Strophantidin suppresses the growth of red flour beetle, and tobacco horn worm.

The effect of *Moringa* seed and leaf powder in mortality of the cowpea weevil *Callosobruchus maculatus* was observed in this study. An increased mortality was evident in cowpea seeds treated with *Moringa* powders. The increased mortality might be attributed to the ability of *Moringa* to suppress the weevils' breeding potentials through the presence of Strophantidin which causes a poisonous effect to the weevils rendering them ineffective and killing them at long last. This is in agreement with Ilesanmi and Gungula (2010) who reported an increased morality of weevils with *Moringa oliefera* application. It is also in agreement with Nadia and Huda, (2018) who reported a similar trend in their study on cowpea seeds where a higher mortality rate of weevils was recorded for treated seeds in comparison with untreated seeds. The concentration of *Moringa* applied determines the mortality of weevils in treated seeds than control seeds. This is in agreement with Ojiako (2007) and Ojo *et al.,* (2013) who reported similar trends in their study on Cowpea where increased dosage of *Moringa* leaf resulted in increased insect mortality.

Application of *Moringa* seed and leaf powder proved to be effective in reducing grain holes in cowpea seeds in comparison to control seeds. This finding may be attributed to the effect of *Moringa* in retarding the development of cowpea seed bruchids thereby hampering their migration and feeding behaviours (Ojiaka, 2007). Higher rates of application of 45g *Moringa* powder also resulted in a more pronounced effect than lower rates of 30g and 0g in the aspect of hole in grains prevention. This is similar to the report of Ojo *et al.* (2013) who reported that mortality of cowpea weevils increased with increasing rate/dosage and this in turn leads to reduction in the number of holes in grains.

Conclusion

Moringa oliefera leaf and seed powder was an effective insecticidal agent against the cowpea weevil *Callosobruchus maculatus*. They have significant effect on weight maintenance, suppression of weevil population, increasing mortality rate of weevil, prevention of holes in grains and enhancing germination performance which is an indicator of crop viability.

Different parts of the *Moringa* plant have varying degree of effect on cowpea preservation. The seed powder of *Moringa* plant presented a better preservative ability on cowpea than the leaf powder. Rates of application of 45g of either *Moringa* seed or leaf powder also produces better results than 30g and 0g (no application) or *Moringa* powder. Interaction of *Moringa* seed powder at a rate of 45g was also most effective for utilization by farmers and crop physiologists if best results are to be obtained.

Recommendations

Based on the findings of this study, the following recommendations are made:

Farmers should be enlightened on the need to utilize *Moringa* as a potent alternative in prevention of weevil infestation. This will help them reduce cost and dangers associated with the use of synthetic insecticides.

Farmers should be educated on how to measure rates of plant botanicals. This would help them achieve best results in their storage endeavors. It would also make Nigerian farmers present themselves as scientifically inclined when it comes to international ratings and standards of measurements.

Further studies should be conducted to validate the efficacy of other plant botanicals in ensuring preservation of cowpea which is a major source of protein in Nigeria and the world at large.

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