



**SCREENING OF INSECTICIDAL POTENTIALS OF TWENTY (20) BOTANICAL PLANT POWDERS LOCALLY ACCESSIBLE FOR THE PROTECTION OF STORED LENTIL SEEDS (*LENS CULINARIS*) AGAINST INFESTATION OF *CALLOSOBRUCHUS MACULATUS* IN MAIDUGURI**

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**ABSTRACT**

The insecticidal potential of 20 botanical powders against cowpea weevil (*Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) on stored lentil was evaluated. The powders of *Vernonia ambigua*, *Momordica charantica*, *Euphorbia hirta*, *Mentha arvensis*, *Cassia tora*, *Mitracarpus spp*, *Laportea canadensis*, *Amaranthus spinosus*, *Tridax procumbens*, *Ocimum basilicum*, *Origanum vulgare*, *Thymus vulgaris*, *Senna occidentalis*, *Syzygium aromaticum*, *Nigella sativa*, *Piper nigrum*, *Zingiber officinale*, *Coriandrum sativum*, *Allium sativum*, *Myristica fragrans* and *Capsicum annum* were used throughout the experiment. Data were recorded on adult mortality after 24, 48, 72 hours of exposure and oviposition, progeny emergence, weight loss, damage and germination potentials after 100 days of treatments. The rate of 500 mg/kg botanical powders were applied to lentil seeds infested with *C. maculatus* (F.). The result revealed that, highest number of mortality, oviposition, progeny emergence, weight loss and germination potential were observed with the application of *C. sativum*, *Z. officinale*, *P. nigrum*, *E. hirta*, *T. procumbens*, *S. aromaticum*, *A. sativum*, *T. vulgaris*, *C. tora*, *A. spinosus*, *M. spp*, *M. charantica*, *M. avensis*, *S. occidentalis*, *N. sativa*, *V. ambigua*, *M. fragrans*, *O. basilicum*, *L. canadensis* and *O. vulgare* on lentil seed, while minimum number was recorded under control. The insecticidal activity of these powders was in the order of *C. sativum* > *Z. officinale* > *P. nigrum* > *E. hirta* > *T. procumbens* > *S. aromaticum* > *A. sativum* > *T. vulgaris* > *C. tora* > *A. spinosus* > *M. spp* > *M. charantica* > *M. avensis* > *S. occidentalis* > *N. sativa* > *V. ambigua* > *M. fragrans* > *O. basilicum* > *L. Canadensis* > and *O. vulgare* > showed high potential protection of lentils seeds against *C. maculatus* infestation and germination of the treated seeds after 100 days of storage.

**Keywords:** *Callosobruchus maculatus*, lentils, Seed, Botanical, Powders

**INTRODUCTION**

Due to increase in human population, the demand of food is also increased and it is essential to protect stored grains and legumes from the attack of insect pests (Ahmady *et al.*, 2024). Stored product pests are a great challenge in our economy because they infest, infect and contaminate stored agricultural products and animal feed. Stored products are frequently damaged by insect pests and this may account to 20-30% in the tropics (Sathish, 2020). Lentils is an important legume crop all over the world because it contains a high content of easily digestible protein, iron and folate (Kiran, 2024). It is an important source of vitamins and minerals (Akbar *et al*, 2024a). Lentils is seriously infested by pulse beetles *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) all over the world (Akbar *et al.*, 2024b). *C. maculatus* is one of the most serious pests brought into storage containers with harvested lentils in the field that can cause total loss of the stored crop in a few months (Hajam and Kumar, 2022). *C. maculatus* is a multivoltine insect pests which causes a heavy damages to stored grains and legumes (Santhoshkumar *et al.*, 2024). *C. maculatus* L. attacked lentils are significantly affected not only in terms of quantitative and qualitative, but also these grains lose their germinating capacity completely as well (Jumbo *et al.*, 2018). Reduction of insect damage in stored grains is mainly a serious problem in developing countries of the tropics due to favorable climatic conditions and poor storage structures (Akbar *et al.*, 2024c).

Management of insect pests in many storage systems relies primarily on applying synthetic insecticides (Akbar *et al.*, 2024d). Use of synthetic insecticides is currently the most effective way to



prevent the infestation of stored product pests (Amousa *et al.*, 2021). However, continuous and heavy use of these chemicals has caused adverse effects on non-target organisms, and the development of pesticide resistance in some stored product pests. To solve this problem, many researchers have discovered alternative pest management products derived from plants products (Gitahi *et al.*, 2021). Currently, many farmers in Africa and Asia are using botanicals to protect their legumes from attack by insects, with varying success degrees, due to the type of formulations and the commodities used among others (Manju *et al.*, 2021). Plant products are cheap and are easily accessed by farmers and small-scale industries in the form of crude or partially purified extracts (Mamoon-ur-Rashid *et al.*, 2018). Botanicals powder were recorded as the strongest repellent and had the most toxic effects on *C. maculatus* and significantly reduced the oviposition rate and adult emergence after infestation on seeds (Souto *et al.*, 2021). This study was aimed at screening the insecticidal potential of 20 botanical powders against the bruchid beetle *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) on stored lentil (*Lens culinaris*).

**MATERIALS AND METHODS**

**Experimental Site**

The study was carried out at the Entomology laboratory of the Department of Agronomy and soil science, Kashim Ibrahim University, Borno state, which lies between latitude 11<sup>0</sup>50'14"N and longitude 13<sup>0</sup>09'15"E in the North eastern agro-ecological zone of Nigeria. The experiment was carried out under ambient conditions of temperature 29-35 °C, a relative humidity of 68-80%, and a photoperiod of 12-hour light: 12-hour darkness. The study was carried out for a period of three months (7<sup>th</sup> January to 4<sup>th</sup> April, 2025).

**Sources of Experimental Materials**

The lentil seeds was obtained at seeds bank of Mohamet Lawan College of Agriculture, the seeds are free from insecticide residues, potential insect eggs and larvae, the seeds were handpicked to remove damaged ones and contaminants, the clean seeds were placed in a polyethylene bag tied it firmly with a rubber band and inserted into a transparent airtight plastic bucket before commencement of the experiment.

**Insect Culturing Procedure**

The stock of adult *C. maculatus* was obtained from the Entomology laboratory of Department of Agronomy and Soil science, Kashim Ibrahim University, Maiduguri and were used in raising new progenies of the same cohort. Adult unsexed *C. maculatus* were introduced on 2 kilogram of sterilised untreated lentil seeds, and are placed on plastic bucket and covered with a muslin cloth and held tight with a rubber band to prevent adult weevils from escaping. The culture were left in the laboratory shelf for 10 days, to obtain a steady and sufficient supply of *C. maculatus* of known age for experimental purposes.

**Collection and Preparation of Plant Powders**

The plant powders were sourced out at the university premises and reputable condiment dealer at custom market and then taking to Entomology laboratory; the selected botanical plants were thoroughly cleaned with distilled water to remove all unwanted debris. The washed botanical plants were then left to shade dry at room temperature and grind it into fine powder.

**Identification of adult of *C. maculatus***

The identification and sexing of *C. maculatus* were carried out in the Entomology laboratory, Department of Agronomy and Soil science, Kashim Ibrahim University, Maiduguri.

**Data Collection**

The data were collected on adult mortality, oviposition, adult emergence, grain damage, weight loss and germination percentage. Adult mortality was assessed at 24, 48 and 72 hours after set up of the experiment. After 3 days (72 hours) of exposure, adult *C. maculatus* (both the live and dead ones) were sieved out among the 20 unsexed adults initially introduced.

$$\text{Mortality (\%)} = \frac{\text{Number of dead adults}}{\text{Total number of adults}} \times 100 \dots\dots\dots i$$



Oviposition was assessed by determining the number of seeds with eggs laid on them by *C. maculatus* adult females. The number of seeds with eggs were assessed by randomly selecting 20 seeds and counting the seeds with eggs, with the aid of a hand lens. The seeds were then kept in their respective experimental bottles on the laboratory shelf for F<sub>1</sub> adult emergence.

After 30 days, the F<sub>1</sub> progeny began emerging and newly emerged adults were sieved out and counted every 24 hours, until there was no further emergence.

Damage to the lentil seeds was estimated using the exit holes produced by the newly emerged adults (F<sub>1</sub> progeny), as an indicator of damage. Lentils seeds (20) were randomly selected, and seeds with exit holes were sorted and counted. Percentage seed damage was obtained by adopting the formula used by Kemabonta *et al.* (2010):

$$\text{Damage (\%)} = \frac{\text{Number of grains with exit holes}}{\text{Number of grains sampled}} \times 100 \dots\dots\dots \text{ii}$$

While percentage Seed weight loss was determined using the count and weight method of Gwinner *et al.* (1996) thus:

$$\% \text{ Weight loss} = (W_u \times N_d) - (W_d \times N_u) \times 100 / W_u \times (N_d + N_u) \dots\dots\dots \text{iii}$$

**Statistical Analysis**

Data collected were subjected to analysis of variance (ANOVA) and treatment means were separated using Tukey’s Kramer’s Honestly Test (HSD) at 5% level of probability. The ANOVA was performed with Statistix 9.0 software.

**RESULTS**

**The Botanical Plants Used against *C. maculatus***

The twenty (20) botanical insecticidal plants indicated in Table 1 were collected, were thoroughly washed with distilled water to remove all unwanted debris and shade dried at room temperature for seven days. After about 15 days, completely dried plant products were placed in an electric grinder (Philips HL7756/00 Mixer Grinder, Eindhoven, Netherlands) to ground into a fine powder. The powders were sieved through a 60µm mesh size (60 Mesh Sieve, Pak lab, Karachi, Pakistan), and stored at room temperature in air-tight bottles to preserve the quality before commencement of experiment.

**Table 1: Botanical Plant Species Evaluated against *C. maculatus***

S/No	Wild plants species	Botanical name	Family	Part used
1	Bitter leaf	<i>Vernonia ambigua</i>	Asteraceae	Leaves
2	Bitter melon	<i>Momordica charantica</i>	Cucurbitaceae	Fruits
3	Ashma plant	<i>Euphorbia hirta</i>	Euphorbiaceae	Leaves
4	Wild mint	<i>Mentha arvensis</i>	Lamiaceae	Leaves
5	Sickle senna	<i>Cassia tora</i>	Fabaceae	Seeds
6	Tropical girdlepod	<i>Mitracarpus spp</i>	Rubiaceae	Seeds
7	Wood nettle	<i>Laportea canadensis</i>	Urticaceae	Leaves
8	Spiny amaranth	<i>Amaranthus spinosus</i>	Amaranthaceae	Leaves
9	Coat buttons	<i>Tridax procumbens</i>	Asteraceae	Leaves
10	Basil	<i>Ocimum basilicum</i>	Lamiaceae	Leaves
11	Oregano	<i>Origanum vulgare</i>	Lamiaceae	Leaves
12	Thyme	<i>Thymus vulgaris</i>	Lamiaceae	Leaves
13	Coffe senna	<i>Senna occidentalis</i>	Fabaceae	Seeds
14	Clove	<i>Syzygium aromaticum</i>	Myrtaceae	Fruit
15	Black cumin	<i>Nigella sativa</i>	Ranunculaceae	Seeds
16	Black pepper	<i>Piper nigrum</i>	Piperaceae	Fruits
17	Ginger	<i>Zingiber officinale</i>	Zingiberaceae	Rhizomes
18	Coriander	<i>Coriandrum sativum</i>	Apiaceae	Seeds
19	Garlic	<i>Allium sativum</i>	Amaryllidaceae	Bulb
20	Nutmeg	<i>Myristica fragrans</i>	Myristicaceae	Seeds

**Effect of Plant Powders on Mortality of *C. maculatus* on Lentil Seeds**

The result of effect of twenty (20) botanical plants powders against *C. maculatus*. On stored lentil seed is presented in Table 2. The result clearly indicated that all the treatments revealed a wide variation in mortality compared to untreated control. The botanical powders were tested for their insecticidal action in comparison with untreated control. Among the plant powders tested against *C. maculatus*, the highest level of mortality was recorded on *C. sativum* (67.6±2.9), *Z. officinale* (61.3±3.2), *P. nigrum* (58.6±2.2), *E. hirta*, (56.3±5.3) *T. procumbens* (53.6±4.9), *S. aromaticum* (53.6±4.9), *A. sativum* (51.0±3.6) *T. vulgaris* (50.6±1.2), *C. tora* (50.3±6.7), *A. spinosus* (49.3±4.4), *M. spp* (48.0±4.0), *M. charantica* (47.3±5.6), *M. arvensis* ( 46.3±4.3) *S. occidentalis* (45.0±1.8), *N. sativa* (44.6±6.1), *V. ambigua* (42.0±3.5) *M. fragrans* (39.3±3.9), *O. basilicum* (37.0±3.1), *L. canadensis* (36.6±2.0) and the least mortality of (33.6±3.8) was observed on *O. vulgare* at 500mg/kg recorded after 24 hours of exposure when compared with untreated control with 1.3±0.3. Similar trend of insect mortality were observed after 48 hours of exposure when compared with untreated control (2.0±0.9). At 72 HAT, complete (100%) adult mortality were recorded on *C. sativum*, *Z. officinale*, *P. nigrum*, *E. hirta* while the maximum adult mortality was seen among the different plant powders with almost greater than 90.0%, and the minimum percent mortality of 87.3±2.3, 85.3±3.7% were recorded on *L. canadensis* and *O. vulgare*, respectively when compared with control (2.3±0.3%) at 72 hours after treatment (Table 2).

**Table 2:** Effect of Plant Powders on Mortality of *C. maculatus* on Lentil Seeds

<b>Plant species</b>	<b>24 hours</b>	<b>48 hours</b>	<b>72 hours</b>
Control	1.3±0.3 <sup>d</sup>	2.0±0.9 <sup>d</sup>	2.3±0.3 <sup>d</sup>
<i>V. ambigua</i>	42.0±3.5 <sup>ab</sup>	69.0±7.0 <sup>bc</sup>	92.0±3.0 <sup>b</sup>
<i>M. charantica</i>	47.3±5.6 <sup>ab</sup>	77.0±2.1 <sup>b</sup>	95.0±3.5 <sup>ab</sup>
<i>E. hirta</i>	56.3±5.3 <sup>ab</sup>	90.7±7.9 <sup>ab</sup>	100.0±0.0 <sup>a</sup>
<i>M. arvensis</i>	46.3±4.3 <sup>ab</sup>	73.3±1.4 <sup>bc</sup>	94.3±1.7 <sup>ab</sup>
<i>C. tora</i>	50.3±6.7 <sup>ab</sup>	83.7±4.3 <sup>ab</sup>	97.3±0.8 <sup>a</sup>
<i>M. spp</i>	48.0±4.0 <sup>ab</sup>	80.7±6.4 <sup>ab</sup>	95.3±0.6 <sup>a</sup>
<i>L. canadensis</i>	36.6±2.0 <sup>b</sup>	63.3±1.2 <sup>bc</sup>	87.3±2.3 <sup>ab</sup>
<i>A. spinosus</i>	49.3±4.4 <sup>ab</sup>	81.3±3.2 <sup>ab</sup>	96.3±2.5 <sup>ab</sup>
<i>T. procumbens</i>	53.6±4.9 <sup>ab</sup>	88.3±3.3 <sup>a</sup>	99.0±1.0 <sup>a</sup>
<i>O. basilicum</i>	37.0±3.1 <sup>bc</sup>	65.3±3.4 <sup>bc</sup>	90.0±0.0 <sup>ab</sup>
<i>O. vulgare</i>	33.6±3.8 <sup>c</sup>	59.0±3.0 <sup>c</sup>	85.3±3.7 <sup>bc</sup>
<i>T. vulgaris</i>	50.6±1.2 <sup>ab</sup>	85.7±5.9 <sup>ab</sup>	97.9±3.2 <sup>ab</sup>
<i>S. occidentalis</i>	45.0±1.8 <sup>ab</sup>	71.7±4.3 <sup>abc</sup>	93.7±0.0 <sup>b</sup>
<i>S. aromaticum</i>	51.6±6.0 <sup>ab</sup>	75.7±7.1 <sup>abc</sup>	98.3±3.2 <sup>a</sup>
<i>N. sativa</i>	44.6±6.1 <sup>ab</sup>	70.7±3.3 <sup>abc</sup>	93.0±0.3 <sup>ab</sup>
<i>P. nigrum</i>	58.6±2.2 <sup>ab</sup>	92.0±6.4 <sup>a</sup>	100.0±0.0 <sup>a</sup>
<i>Z. officinale</i>	61.3±3.2 <sup>ab</sup>	93.0±8.5 <sup>a</sup>	100.0±0.0 <sup>a</sup>
<i>C. sativum</i>	67.6±2.9 <sup>a</sup>	96.0±7.0 <sup>a</sup>	100.0±0.0 <sup>a</sup>
<i>A. sativum</i>	51.0±3.6 <sup>ab</sup>	87.7±4.5 <sup>ab</sup>	97.6±2.0 <sup>a</sup>
<i>M. fragrans</i>	39.3±3.9 <sup>bc</sup>	68.3±1.4 <sup>bc</sup>	91.6±0.8 <sup>ab</sup>
F	5.88	13.0	81.0
P	<0.0001	<0.0001	<0.0001

Means followed by same letters within a column are not significantly different from each other according to Tukey Kramer's HSD Test at 5% level of probability.

### **Effect of Plant Powder on Oviposition, Adult Emergence of *Callosobruchus maculatus* and Seed Damage, Weight Losses and Germination**

The number of eggs laid by female, adult progeny emergence of *C. maculatus*, percent seed damage, seed weight loss and potential seed germination of the lentils seeds treated with twenty botanical plant powders was presented in (Table 3). The results revealed a significant difference among

the treatments used. The result further indicated that all the treatments shows a variation in percentage oviposition rate, progeny emergence, seed damage, weight loss and germination when compared to untreated control. The result shows a significant reduction in *C. maculatus* oviposition rates after 100 days of storage of treated seeds. The lowest level of oviposition were recorded on *C. sativum* (3.0±1.0), *Z. officinale* (5.3±2.3), *P. nigrum* (5.7±1.5), *E. hirta*, (6.3±3.6) *T. procumbens* (8.3±3.2), *S. aromaticum* (9.0±0.6), *A. sativum* (12.0±0.7) *T. vulgaris* (14.3±3.3), *C. tora* (14.7±0.3), *A. spinosus* (15.0±1.5), *M. spp* (15.9±0.7), *M. charantica* (16.3±0.6), *M. arvensis* (16.4±1.5) *S. occidentalis* (16.8±2.1), *N. sativa* (16.9±1.7), *V. ambigua* (19.0±3.8) *M. fragrans* (19.7±0.8), *O. basilicum* (20.7±1.5), *L. canadensis* (20.9±1.4), *O. vulgare* (21.7±3.8) and the highest oviposition rate of (97.0±7.5) was observed on untreated control. Similar trend was also observed against F<sub>1</sub> adult progeny emergence which significantly reduced by the concentration of all the tested plant species, where very few adult were emerged on all the botanical powders tested when compared with the untreated control with maximum of (82.3±3.3%). Also, on seed damage, a similar trend were observed where *O. vulgare* exhibited the highest percentage of seed damage (12.9±3.7) but statistically different with untreated control (23.0±5.2). Furthermore, maximum seed weight loss (9.6±1.8%) was observed in seed treated with *O. vulgare* which was statistically different from each botanical treatment followed by <*L. canadensis* (9.3±2.9%) <*O. basilicum* (8.0±2.9%) < *M. fragrans* (7.9±0.3%) and <*V. ambigua* (7.7±0.6%), respectively as compared with control (71.7±9.5%). The results obtained in this study showed that the germination of lentils seeds was influenced differently by botanical plant powders. There is significant difference of germination rate between the control and treated seeds. Germination rate of lentils seeds in treatments ranges from 100.0% to 80.6% while in the untreated control record 17.0% germination, the highest percentage of germination was obtained in lentils seeds treated with *C. sativum* (100%) (Table 3).

**Table 3:** Effect of Plant Powders on Oviposition, Adult Emergence of *Callosobruchus maculatus* and Seed Damage, Weight Losses and Germination

Plant Species	% Oviposition	% Progeny emergence	% Damage	% Weight loss	% Germination
Control	97.0±7.5 <sup>a</sup>	82.3±3.3 <sup>a</sup>	23.0±5.2 <sup>a</sup>	71.7±9.5 <sup>a</sup>	17.0±2.9 <sup>c</sup>
<i>V. ambigua</i>	19.0±3.8 <sup>ab</sup>	10.9±0.9 <sup>b</sup>	11.8±0.9 <sup>ab</sup>	7.7±0.6 <sup>b</sup>	87.6±2.0 <sup>ab</sup>
<i>M. charantica</i>	16.3±0.6 <sup>b</sup>	9.6±0.6 <sup>c</sup>	9.9±1.2 <sup>ab</sup>	6.3±0.7 <sup>b</sup>	88.9±0.9 <sup>ab</sup>
<i>E. hirta</i>	6.3±3.6 <sup>bc</sup>	5.3±0.7 <sup>c</sup>	4.6±0.9 <sup>c</sup>	5.0±0.6 <sup>c</sup>	98.7±5.7 <sup>abc</sup>
<i>M. arvensis</i>	16.4±1.5 <sup>b</sup>	9.8±1.0 <sup>b</sup>	10.5±1.5 <sup>ab</sup>	6.7±1.2 <sup>b</sup>	87.7±2.1 <sup>ab</sup>
<i>C. tora</i>	14.7±0.3 <sup>d</sup>	8.7±1.7 <sup>b</sup>	9.3±0.9 <sup>b</sup>	5.0±1.2 <sup>c</sup>	90.3±3.7 <sup>ab</sup>
<i>M. spp</i>	15.9±0.7 <sup>b</sup>	9.3±1.7 <sup>b</sup>	9.8±1.5 <sup>ab</sup>	5.9±1.9 <sup>c</sup>	88.7±1.2 <sup>ab</sup>
<i>L. canadensis</i>	20.9±1.4 <sup>ab</sup>	11.8±0.6 <sup>a</sup>	12.8±0.9 <sup>b</sup>	9.3±2.9 <sup>ab</sup>	86.8±1.2 <sup>ab</sup>
<i>A. spinosus</i>	15.0±1.5 <sup>bc</sup>	8.9±1.3 <sup>b</sup>	9.7±1.5 <sup>b</sup>	5.7±1.7 <sup>bc</sup>	89.6±3.8 <sup>ab</sup>
<i>T. procumbens</i>	8.3±3.2 <sup>bc</sup>	4.3±1.2 <sup>c</sup>	5.3±0.9 <sup>c</sup>	4.3±1.9 <sup>c</sup>	95.7±4.1 <sup>ab</sup>
<i>O. basilicum</i>	20.7±1.5 <sup>ab</sup>	11.5±0.5 <sup>ab</sup>	12.3±0.0 <sup>ab</sup>	8.0±2.9 <sup>ab</sup>	86.3±1.7 <sup>ab</sup>
<i>O. vulgare</i>	21.7±3.8 <sup>ab</sup>	12.0±0.6 <sup>ab</sup>	12.9±3.7 <sup>ab</sup>	9.6±1.8 <sup>ab</sup>	80.6±3.6 <sup>bc</sup>
<i>T. vulgaris</i>	14.3±3.3 <sup>bc</sup>	8.3±2.3 <sup>ab</sup>	9.0±0.5 <sup>ab</sup>	4.8±0.2 <sup>c</sup>	91.7±1.3 <sup>abc</sup>
<i>S. occidentalis</i>	16.8±2.1 <sup>ab</sup>	9.9±1.5 <sup>ab</sup>	11.0±0.0 <sup>ab</sup>	6.9±0.9 <sup>b</sup>	87.9±2.6 <sup>abc</sup>
<i>S. aromaticum</i>	9.0±0.6 <sup>bc</sup>	5.7±0.9 <sup>c</sup>	8.0±0.5 <sup>ab</sup>	4.0±1.5 <sup>bc</sup>	93.7±0.9 <sup>ab</sup>
<i>N. sativa</i>	16.9±1.7 <sup>b</sup>	10.6±0.8 <sup>b</sup>	11.6±1.5 <sup>ab</sup>	7.3±1.9 <sup>ab</sup>	87.3±6.1 <sup>abc</sup>
<i>P. nigrum</i>	5.7±1.5 <sup>d</sup>	4.7±0.9 <sup>c</sup>	6.3±1.4 <sup>b</sup>	3.8±1.7 <sup>b</sup>	97.0±2.5 <sup>ab</sup>
<i>Z. officinale</i>	5.3±2.3 <sup>d</sup>	4.3±1.5 <sup>c</sup>	5.3±1.2 <sup>c</sup>	3.7±0.9 <sup>c</sup>	99.0±1.0 <sup>a</sup>
<i>C. sativum</i>	3.0±1.0 <sup>d</sup>	1.0±0.0 <sup>c</sup>	3.3±1.8 <sup>c</sup>	2.0±1.5 <sup>bc</sup>	100.0±0.0 <sup>a</sup>
<i>A. sativum</i>	12.0±0.7 <sup>c</sup>	6.7±0.9 <sup>b</sup>	8.7±0.9 <sup>b</sup>	4.3±1.2 <sup>bc</sup>	93.3±0.7 <sup>a</sup>
<i>M. fragrans</i>	19.7±0.8 <sup>b</sup>	11.3±1.5 <sup>b</sup>	12.0±0.0 <sup>ab</sup>	7.9±0.3 <sup>ab</sup>	87.8±0.9 <sup>a</sup>
F	36.3	218	6.60	34.8	35.8
P	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Means followed by same letters within a column are not significantly different from each other according to Tukey Kramer's HSD Test at 5% level of probability.



## DISCUSSION

The present study demonstrated the insecticidal potential of twenty (20) botanical powders in management of *C. maculatus* in stored lentils, based on results showed that botanical powders had caused greater percentage of mortality within 24 hours of exposure and complete mortality after 72 hours of exposure in most of botanical powders used. The effectiveness of this botanical powders indicates a possible contact action and toxicity of the active constituents against the *C. maculatus*. The results of this study are in conformity to some degree with the report of some workers, like Sanon *et al.* (2018), Chichaybelu (2021), who observed that certain botanicals are effectively toxic against storage insect pests including *C. maculatus*. The resultant mortality rates of *C. maculatus* in this investigation could be attributed to the toxic effects of the chemicals in the tested plant powders. The botanical powders also significantly reduced the production and inhibited F<sub>1</sub> progeny emergence of *C. maculatus*. In the current study the tested botanical powders, positively affect all tested parameter (% mortality, % oviposition rate, % progeny emergence, % seed damage, % weight loss and % germination). According to Islam *et al.* (2013), effective control of protectants is attributed to the mortality of adult and/or immature stages, confirmed by lack of progeny generation. Similar results were documented and concluded by Shukla *et al.* (2009) who observed that *Ocimum canum* leaf powder at 5 percent treated green seeds and caused 68.70 percent mortality to *C. maculatus*. Kaur *et al.* (2019) who found that *A. calamus* at 1g / 100 g of treated pea seeds no damage was recorded and also Rathod *et al.* (2019) who found that *A. calamus* at 3g / kg of green gram seeds showed no eggs were laid. Armstrong (2017) also found that the loss of grains weight was lower than that of untreated control. Manju *et al.* (2019) who found that (red pepper-fennel, cumin and garlic) powders had complete protective for cowpea seeds against *C. maculatus* for up to 90 days. This shows that botanical powders are highly effective in controlling *C. maculatus* infestations, which could be due to the presence of some bioactive compounds. Mahama *et al.* (2018) reported similar result with a significant reduction in the F<sub>1</sub> progeny production of *C. maculatus* on seeds treated with *Eucalyptus camaldulensis* leaf extracts on Bambara groundnut grains. Reduction in the F<sub>1</sub> progeny emergence of *C. maculatus* in the Bambara groundnut treated with *Ocimum canum* Sims leaf extract fractions was also obtained by Kosini and Nukenine (2017). This shows that botanical powders probably have oviposition deterrent, ovicidal, and laticidal properties. The highest percentage of inhibition of *C. maculatus* F<sub>1</sub> progeny could be attributed to the highest mortality of the adult *C. maculatus* in the mortality test observed at the last day of exposure. This studies is in agreement with findings of Kaur *et al.*, (2019) stated that no seed damage and weight loss was recorded in pea seeds treated with sweet flag powder at 3g/100g and 5g/100g. In this findings, the powders provide a significant reduction in seed damage and weight loss, and germination activities compared with the untreated seeds.

## CONCLUSION AND RECOMMENDATIONS

The insecticidal potentials of tested botanical powders against *C. maculatus* infesting the stored lentils, revealed that the efficacy of the powders caused 100.00 percent mortality after 14 days of treatments. It caused complete inhibited egg laying and progeny development and also no weight losses recorded up to 60 days after treatment. It is concluded that 500 mg/kg dose of botanical powders are highly effective against *C. maculatus* mortality, suppression of adult emergence, seed damage, seed weight loss and germination percentage. Therefore, the resource poor farmers can use botanical powders in controlling *C. maculatus* in stored lentils in place of using insecticides due to high cost. Furthermore, the use of botanical pesticides to control *C. maculatus* is an appropriate strategy to avoid environmental pollution and other hazards, since the insecticides are used by farmers and in agro industries currently affect the environment.

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