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 the bruchid beetle 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 spinonsus, Tridax procumbens, Ocimum basilicum, Origanum vulgare, Thymus vulgaris, Senna occidentalis, Syzgium aromaticum, Nigella sativa, Piper nigrum, Zingiber officinale, Coriandrum sativum, Allium sativum, Myristica fragrans and Capsicum annum were used throughout the experiment. The 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 at dose rate of 500 mg/kg botanical powders were applied on to lentil seeds on C. maculatus (F.) were assessed the result reveals that most of the botanical powders tested caused 100% adult mortality and completely inhibited ovipositon, while O. vulgare recorded the least effect 93.3% mortality. The insecticidal activity of these powders showed high potential protection of lentils seeds against C. maculatus infestation and germination percentage ranges between 100-91.6% of the treated seeds after 100 days of storage as compared with untrated control 17.0%. It is concluded that 500 mg/kg dose of botanical powders showed positive effect against C. maculatus mortality, reduced oviposition rate, complete inhibition adult F_1 emergence, seed damage, seed weight loss and increased in germination percentage. It is recommended that the resource poor farmers can use botanical powders in controlling C. maculatus in stored lentils as they may not afford to buy insecticides due to high cost. Furthermore, the use of botanical insecticides to control C. maculatuss is an appropriate strategy to avoid environmental pollution and other hazards, since synthetic insecticides used by farmers and agro-allied industries currently affect the environment.
Key words: *Mortality, Oviposition, Progeny emergence, Callosobruchus maculatus, lentils, 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 are susceptible to attack by stored product insects during storage, especially *Callosobruchus maculatus*. Lentils are 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, supporting heart health, aiding digestion and helping in managing blood sugar and weight. They also contain beneficial phytochemical like polyphenols, which have antioxidant and anti-inflammatory properties contributing to overall health (Akbar *et al*, 2024a, b). *C. maculatus* (Coleoptera: Chrysomelidae) is a multivoltine and one of the most serious insect 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* 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 (Amoura *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, creating undesirable toxic residues in food and potential health hazard for consumers, the environment and high application costs. To solve this problem, many researchers have discovered alternative pest management products derived from plants products, because botanical insecticide offer a sustainable, eco-friendly alternative to conventional synthetic insecticide. Their biodegradable and low residue nature aligns well with the increasing demand for safe, residue free food and environmentally responsible insect pest control strategies (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). Botanical insecticides probably have oviposition deterrent, ovicidal, and lavicidal properties. It is recorded that Botanicals powder had strongest repellent and toxic effects on *C. maculatus* which 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 in the Entomology laboratory of the Department of Agronomy and soil science, Kashim Ibrahim University, Borno state. The experiment was carried out under ambient conditions of temperature 29-35 ^{O}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 (7th January to 4th April, 2025), which lies between latitude 11^{0}50´14´´N and longitude 13^{0} 09´15´´E in the North eastern agro-ecological zone of Nigeria.

Source of Experimental Materials

The lentil seeds were 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 source 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.

Experimental Design and Treatment

The experiment was carried out in Completely Randomized Design (CRD) with twenty (20) treatments replicated three times. All treatments were applied equal quantity of 500mg/g of each botanical powders were thoroughly mixed with one hundred and fifty (150) grams of lentils seeds and shaken for three minutes and then divided into lots of three replicates.

Data Collection

The data were collected on adult mortality, oviposition of rate, adult emergence and grain damage, weight loss and germination percentage. Adult mortality was assessed after 24, 48 and 72 hours after set up of the experiment, after 3 days (72 hours) of exposure adult insects both the live and dead one are sieve out among the 20 unsexed adults initially introduced.

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

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_1 adult emergence.

After 30 days, the F_1 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_1 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):

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

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

$$\text{\% Weight loss} = (Wu \times Nd) - (Wd \times Nu) \times 100 / Wu \times (Nd + Nu) \ldots\ldots\text{iii}$$

Statistical Analysis

Data 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 and Discussion

Twenty (20) botanical plant powder 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 powders. 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	*Vernonia ambigua*	Asteraceae	Leaves
2	Bitter melon	*Momordica charantica*	Cucurbitaceae	Fruits
3	Ashma plant	*Euphorbia hirta*	Euphorbiaceae	Leaves
4	Wild mint	*Mentha arvensis*	Lamiaceae	Leaves
5	Sickle senna	*Cassia tora*	Fabaceae	Seeds
6	Tropical girdlepod	*Mitracarpus spp*	Rubiaceae	Seeds
7	Wood nettle	*Laportea canadensis*	Urticaceae	Leaves
8	Spiny amaranth	*Amaranthus spinonsus*	Amaranthaceae	Leaves
9	Coat buttons	*Tridax procumbens*	Asteraceae	Leaves
10	Basil	*Ocimum basilicum*	Lamiaceae	Leaves
11	Oregano	*Origanum vulgare*	Lamiaceae	Leaves
12	Thyme	*Thymus vulgaris*	Lamiaceae	Leaves
13	Coffe senna	*Senna occidentalis*	Fabaceae	Seeds
14	Clove	*Syzgium aromaticum*	Myrtaceae	Fruit
15	Black cumin	*Nigella sativa*	Ranunculaceae	Seeds
16	Black pepper	*Piper nigrum*	Piperceae	Fruits
17	Ginger	*Zingiber officinale*	Zingiberaceae	Rhizomes
18	Coriander	*Coriandrum sativum*	Apiaceae	Seeds
19	Garlic	*Allium sativum*	Amaryllidaceae	Bulb
20	Nutmeg	*Myristica fragrans*	Myristicaceae	Seeds

Effect of botanical plant powders on mortality of *C. maculatus* exposed to treated lentil seeds

The result of this study shows the effect of twenty (20) botanical plants powders against *C. maculatus*. 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. Data on adult mortality of *C. maculatus* after 24, 48 and 72 hours after treatment (HAT) were recorded and presented in (Table 2). At 72 HAT, complete (100%) adult mortality were recorded on most of the botanical powders tested and the least percent mortality of 93.3% was recorded on *O. vulgare* when compared with untreated control check recorded 2.3% The effectiveness of this botanical powders indicates a possible contact action and toxicity of the active constituents like secondary metabolites such as terpenes, phenolics, nitogen-containing compounds like alkaloid and sulphur containing compounds against the *C. maculatus*. The toxicity and antifeedant effect of alkaloids towards stored products insect pest has been reported and studied by Chaieb (2010), and this insecticidal activities of the tested plants could be due to the presence of these active ingredients which might have interferes with the neuromodulator octopamine leading to the death of insect pests (Kostyukovsky *et al.,* 2002). The mode of action of these complex mixtures present in plants powders, extracts or oils against insect pests of stored produces is through neurotoxic mode of action (Trivedi *et al*., 2018).

The result of this study are in conformity to some degree with the findings of some researchers, 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. Similar results were documented and concluded by Shukula *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*. 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 Shukula *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*. (Table 2).

Table 2: Effect of botanical plant powders on mortality of *C. maculatus* exposed to treated lentil seeds

% SE± Mortality (Hours)			
Plant species	**24 hours**	**48 hours**	**72 hours**
Control	1.3±0.3^{d}	2.0±0.9^{d}	2.3±0.3^{d}
V. ambigua	42.0±3.5^{ab}	69.0±7.0^{bc}	96.0±3.0^{b}
M. charantica	47.3±5.6^{ab}	77.0±2.1^{b}	100.0±0.0^{a}
E. hirta	56.3±5.3^{ab}	90.7±7.9^{ab}	100.0±0.0^{a}
M. arvensis	46.3±4.3^{ab}	73.3±1.4^{bc}	94.3±1.7^{ab}
C. tora	50.3±6.7^{ab}	83.7±4.3^{ab}	100.0±0.0^{a}
M. spp	48.0±4.0^{ab}	80.7±6.4^{ab}	100.0±0.0^{a}
L. canadensis	36.6±2.0^{b}	77.3±1.2^{bc}	98.3±2.3^{ab}
A. spinonsus	49.3±4.4^{ab}	81.3±3.2^{ab}	100.0±0.0^{a}
T. procumbens	53.6±4.9^{ab}	88.3±3.3^{a}	100.0±0.0^{a}
O. basilicum	37.0±3.1^{bc}	83.3±3.4^{bc}	97.0±0.0^{ab}
O. vulgare	33.6±3.8^{c}	76.0±3.0^{c}	93.3±3.7^{bc}
T. vulgaris	50.6±1.2^{ab}	85.7±5.9^{ab}	100.0±0.0^{a}
S. occidentalis	45.0±1.8^{ab}	82.7±4.3^{abc}	95.7±0.3^{b}
S. aromaticum	51.6±6.0^{ab}	89.7±7.1^{abc}	100.0±0.0^{a}
N. sativa	44.6±6.1^{ab}	70.7±3.3^{abc}	98.7±0.3^{ab}
P. nigrum	58.6±2.2^{ab}	92.0±6.4^{a}	100.0±0.0^{a}
Z. officinale	61.3±3.2^{ab}	93.0±8.5^{a}	100.0±0.0^{a}
C. sativum	67.6±2.9^{a}	96.0±7.0^{a}	100.0±0.0^{a}
A. sativum	51.0±3.6^{ab}	87.7±4.5^{ab}	100.0±0.0^{a}
M. fragrans	39.3±3.9^{bc}	78.3±1.4^{bc}	97.6±0.8^{ab}
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 Krammer'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) results were significantly different from each other. The result 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 significant difference on number of eggs laid by *C. maculatus* after 100 days of storage on treated seeds, complete inhibition of eggs laid were recorded on almost all the botanical powder tested and very few number of eggs laid were recorded on *O. vulgare* (21.7±3.8) when compared with highest oviposition rate of 97.0% was recorded on untreated control. However, the ability of some plant powders to reduce or prevent oviposition by female Coleopteran pests and mortality of the developmental stages have been studied by a number of authors and well documented (Adedire *et al*., 2011). The effects of the plant powders on oviposition by *C. maculatus* could be due to metabolic alteration of insects body system (Ileke, 2014). Rathod *et al.* (2019) who found that *A. calamus* at 3g / kg of green gram seeds showed no eggs were laid. Similar trend also observed against F_1 adult progeny emergence was significantly reduced by the concentration of all the tested plant species where very few adult were emerged on all the botanical powder tested as compared with the untreated control with 82.3%. The botanical powders also significantly reduced the production and inhibited F_1 progeny emergence of *C. maculatus* and this could be due to high insect mortality. Also, the few eggs that were laid on lentils seeds exposed to the botanical powders could not develop into adults as the powders must have passed through the chorion of the eggs and thereby disrupt normal developmental stages from eggs to adults (Ileke and Olotuah, 2012). Mahama *et al*. (2018) reported similar result with a significant reduction in the F_1 progeny production of *C. maculatus* on seeds treated with *Eucalyptus camaldulensis* leaf extracts on Bambara groundnut grains. Reduction in the F_1 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). Also on seed damage similar trend were observed *O. vulgare* exhibited the highest percentage of seed damage (1.9±0.1%) but statistically different with untreated control (23.0±5.2%). Kaur *et al.* (2019) who found that *A. calamus* at 1g / 100 g of treated pea seeds no damage was recorded. Furthermore, the result on seed weight loss reveals that no or very few seed weight was recorded in all the treatment *O. vulgare* recorded 1.6±1.8% which was statistically different from untreated (71.7±9.5%). All the powders evaluated for insecticidal properties in this research work significantly reduced seed damage and weight loss caused by *C. maculatus*. The ability of the plant powders to completely prevented seed damage and weight loss could be due to high insect mortality, also due to the fact that the insects could not lay eggs on the treated grains which could have led to larval feeding and consequently prevented seed damage and weight loss as suggested by Alabi and Adewole (2017). 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. Also, 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.

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 ranged from 100.0% to 91.6% while in the untreated control record 17.0% germination (100%) (Table 3).

Table 3: Effect of botanical 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^{a}	82.3±3.3^{a}	23.0±5.2^{a}	71.7±9.5^{a}	17.0±2.9^{e}
V. ambigua	2.0±0.8^{ab}	1.2±0.9^{b}	0.8±0.2^{ab}	0.6±0.6^{b}	98.6±2.0^{ab}
M. charantica	0.0±0.0^{b}	0.0±0.0^{c}	0.0±0.0^{ab}	0.0±0.0^{b}	100.0±0.0^{ab}
E. hirta	0.0±0.0^{bc}	0.0±0.0^{c}	0.0±0.0^{c}	0.0±0.0^{c}	100.0±0.0^{abc}
M. arvensis	1.4±1.5^{b}	1.1±1.0^{b}	0.5±1.5^{ab}	0.3±1.2^{b}	97.7±2.1^{ab}
C. tora	0.0±0.0^{d}	0.0±0.0^{b}	0.0±0.0^{b}	0.0±0.0^{c}	96.3±3.7^{ab}
M. spp	1.9±0.7^{b}	0.3±1.7^{b}	0.7±0.5^{ab}	0.0±0.0^{c}	98.7±1.2^{ab}
L. canadensis	1.8±1.4^{ab}	0.8±0.2^{a}	1.8±0.9^{b}	0.3±0.7^{ab}	96.8±1.2^{ab}
A. spinonsus	1.0±1.5^{bc}	0.9±1.3^{b}	0.0±0.0^{b}	0.0±0.0^{bc}	99.0±3.8^{ab}
T. procumbens	1.3±3.2^{bc}	0.3±1.2^{c}	1.2±0.9^{c}	1.3±0.7^{c}	97.7±4.1^{ab}
O. basilicum	1.7±1.5^{ab}	0.5±0.5^{ab}	1.3±0.0^{ab}	1.0±0.0^{ab}	96.3±1.7^{abc}
O. vulgare	2.7±3.8^{ab}	1.0±0.0^{c}	1.9±0.1^{ab}	1.6±1.8^{ab}	91.6±3.6^{bc}
T. vulgaris	1.3±3.3^{bc}	0.3±2.3^{c}	1.0±0.5^{ab}	0.8±0.2^{c}	94.7±1.3^{abc}
S. occidentalis	1.8±2.1^{ab}	0.9±1.5^{c}	0.0±0.0^{ab}	0.9±0.9^{b}	97.9±2.6^{abc}
S. aromaticum	0.0±0.0^{bc}	0.0±0.0^{c}	0.0±0.0^{ab}	0.0±0.5^{bc}	93.7±0.9^{ab}
N. sativa	1.9±0.3^{b}	0.6±0.8^{c}	1.0±0.0^{ab}	0.3±1.0^{ab}	97.3±6.1^{abc}
P. nigrum	0.0±0.0^{d}	0.0±0.0^{c}	0.3±1.4^{b}	0.0±0.0^{b}	100.0±0.0^{ab}
Z. officinale	0.0±0.0^{d}	0.0±0.0^{c}	0.0±0.0^{c}	0.5±0.3^{c}	100.0±0.0^{a}
C. sativum	0.0±0.0^{d}	0.0±0.0^{c}	0.0±0.0^{c}	0.0±0.0^{bc}	100.0±0.0^{a}
A. sativum	0.0±0.0^{c}	0.0±0.0^{c}	0.0±0.0^{b}	0.0±0.0^{bc}	100.0±0.0^{a}
M. fragrans	2.2±0.8^{b}	1.0±0.0^{c}	0.0±0.0^{ab}	0.0±0.0^{ab}	97.8±0.9^{a}
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 Krammer's HSD Test at 5% level of probability.

Conclusion

Study on the efficacy of botanical powders as insecticidal potentials against *C. maculatus* infesting the stored lentils, the results revealed that the efficacy of the powder caused 100.00 percent mortality after 72 hours of treatments. It caused complete inhibited egg laying and progeny development and also no or less seed damage and weight losses recorded up to 100 days after treatment. It is concluded that 500 mg/kg dose of botanical powders showed positive effect against *C. maculatus* mortality, reduced oviposition rate, complete inhibition adult F_1emergence, seed damage, seed weight loss and increased in germination percentage.

Recommendations

Therefore, the resource poor farmers can use botanical powders in controlling *C. maculatus* in stored lentils as they may not afford to buy insecticides due to high cost. Furthermore, the use of botanical insecticides to control *C. maculatuss* is an appropriate strategy to avoid environmental pollution and other hazards, since synthetic insecticides used by farmers and agro-allied industries currently affect the environment.

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