Evaluation of the Selected Botanical Powders Against Bruchids *(Callosobruchus chinensis)* (Coeoptera: Bruchdae) on Chickpea *(Cicer arietnum)* in Semi Field Conditions

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Abstract

Chickpea *(Cicer arietinum L.)* grains are a major source of human food and animal feed because of their high content of lysine rich protein. One of the major limitations for increasing this grain production is losses of seed in storage. So this study was aimed to determining the insecticidal potential of some selected plant powders. The insecticidal potential of *Clematis hirsuta* and *Calpurnia aurea*, against *Callosobruchus chinensis* was evaluated at semi-field trail. Leaf of the botanical plant dried under shed, ground in powders and prepared at the concentration of 75g, 112.5g and 150g per 1.5kg of chickpea grain at field trail. 120 unsexed adult *C. chinensis* were collected from the host grain chickpea and introduced in to polyethylene bag which contain substratum chickpea seeds. 180 *C. chinensis* with the age of 1-2 day were transferred into the polyethylene bag. Chickpea seeds were separately mixed with botanical powders and tested for 24, 48 and 72 hours. Malathion dust was used as a positive control, but the two selected botanical powders were applied as treatment to determine the mortality of *C. chinensis* after 24 hours. Among the two selected botanicals, *C. aurea* showed significantly higher mortality on *C. chinensis* within different doses and exposure times, which is 91.48% mortality at 10%w/w powder after 48 hours. However *C. hirsut* a leaf powder at lower dose (5%) and short time (24 hours) was relatively less effective (26.30%). The botanical plants treatments reduced weight loss due to bruchids after 60 day. The highest weight loss (3.17%) was scored on *C. hirsute* at lower concentration next to the negative control (7.35) and there was not any harmful effect for chickpea seed germination. Based on the results obtained it can be concluded that the application of those botanical leaves powders had a great potential for protection of chickpea in storage particularly at a high concentration and exposure time.

Key words: botanicals, bruchids, chickpea, mortality, storage

Introduction

Chickpea *(Cicer arietinum L.)* is considered to be one of the founder crops of modern agriculture (Rafael *et al.*, 2015). It is an ancient crop that has been grown in Pakistan, India, Middle East and parts of Africa for many years. The common names used for chickpea are Bengal gram (India), Garbanzo (Latin America), Shimbra (Ethiopia) and Chana in Pakistan (Muhammad *et al.*, 2006).Chickpea is the second most important legume crop after faba bean (Hussein Ahmed, 2011).Ethiopia is the leading country in Africa for chickpea production (Menale *et al.*, 2009). But in some area only few farmers completely allocate the farm for chickpea production and others cultivate the crop using one fourth of their land. This clearly indicated that the crop is not very popular in the area comparing to other crops. In most cases, they produced chickpea for home consumption and partly for sale and some cultivated the crop for seeds to the next season which serve as a good source of income (KebebushTesema, 2015).

Chickpea grains are a major source of human food and animal feed because of their high content of lysine rich protein. In addition, chickpea cultivation plays a significant role in farming system as a substituent for fallow in cereal rotation, where it contributes to the sustainability of production and reduces the need for fertilization through fixing atmospheric nitrogen (Jukanti *et al.,* 2012). Chickpea has the ability to grow on residual moistures which gives farmer the opportunity to engage in double cropping, where chickpea is sown at the end of the rainy season following the harvest of the main crop (Habtamu Aschale, 2016)

In developing countries agriculture is the driving force for broad-based economic growth. In realizing this, one of the stumbling blocks seems to be the yield losses due to pests. One of the most important constraints of having every day sufficient food is the postharvest preservation of its quality and quantity. During storage, food grains and products are severely destroyed by insects and other pests. Losses at times are so severe so as to lead to famine in large areas in many countries of the world. Bruchid damage renders chickpeas unacceptable for market, consumption and seed. So, priority should be given to post harvest studies, where at least half of the food supply may be lost between harvest and consumption (Oparaek *et al.,* 2005).

One of the major limitations for increasing pulses production is losses of seed viability and damage of grains from insect pest infestation in storage. Pulses in developing countries suffer high qualitative and quantitative losses. The highest losses of grain legumes during storage are due to bruchids. About 12 species of bruchids are serious pests in the field and about six species are very serious pests during storage (Swella and Mushobozy, 2009). Storage insect, particularly the chickpea beetle *(Callosobruchus chinensis),* is considered one of the most important cosmopolitan species of storage insects in many food legumes (Gemechu Keneni *et al.,* 2003). The pulse beetles assume serious proportions usually during July-August in the stores (Savita and Anandhi, 2010). Hossain *et al.,* (2014) stated that *C.chus chinensi scause* damage to pulses both in the field and storage, but infestation is more crucial in stored condition.

At present, pest control methods mostly rely on synthetic insecticides and fumigants. But chemical protection measures may be resulted in many serious drawbacks (Lee *et al.*, 2001). Their extensive and indiscriminate use causes ecological imbalance, resistance of pesticides to pest, pest resurgence and outbreak of secondary pests, creates phytotoxicity, insecticidal residues in foods and feed (Hossain *et al.*, 2014). Synthetic pesticide use has led to the development of resistant strains of pests as well as different environmental and human health problems (Dubey, 2008).

In recent years, there has been considerable pressure by consumers to reduce or eliminate chemical insecticide in foods. Furthermore, the use of synthetic chemicals to control postharvest biodeterioration has been restricted due to their carcinogenicity, teratogenicity, high and acute residual toxicity, hormonal imbalance, long degradation period, environmental pollution and their adverse effects on food and side effects on humans (Talukder, 2009). The increasing concern over the level of pesticide residues in food has encouraged researchers to look for alternatives of synthetic pesticides. Plant products could offer a solution for the problems of availability, health risks, costs and resistance in the case of synthetic pesticides (Rajapakse, 2006).

Plant products have been used for many years by the small scale farmers in parts of Africa to protect stored products from insect infestation (KebebushTesema, 2015). In this regard many efforts have been made to screen plants with better botanical insecticides which can be used as an alternative to synthetic insecticide. In order to protect the stored product from insects, not only pesticides but a formulation of plants and their products as powders, volatile oils, nonvolatile oils and extracts could be effectively used (Rajapakse, 2006). Therefore, the present study was aimed at determining the insecticidal potential of some selected plants depending on the following objectives.

Materials and Methods

Description of the study area

Semi field experiment was conducted in North Gondar Zone, Alefa District, Ethiopia, which is located at 12^0 30 N and 36^0 30 E at an altitude of 1700 m. a. s. l. It is about 605km, 88km and 142km away from Addis Ababa, Bahir Dar and Gondar respectively. The District is characterized by annual rainfall of 900 to 1400 mm and mean maximum and minimum temperature of 22ºC and 28ºC. Chickpea seeds were collected from local market. Identification of bruchids was carried out with Debre Markos university expertise.

Experimental design

The experiment was arranged in a Complete Randomized Design (CRD) with three replications. The numbers of treatments were 8 composed of combination of two botanical plants *(Clematis hirsute* and *Calpurnia aurea)* leaf powder with three rate of application (5, 7.5, and 10% w/w), Malathion dust as standard check and untreated control. The botanical powders were mixed with 1.5kg chickpea grain and then introduced 180 individuals of 1-2 days old unsexed f1 progeny *C. chinensis.* To obtain the same age generation, 200 unsexed adult *C. chinensis* were introduced in two polyethylene bag which contain 4kg each and reared in the semi field condition which temperature fluctuates between 28-30ºC

Rearing of target insect

The parent adult bruchids; *C. chinensis* found from chickpea seeds, were brought from local market in North Gondar Zone, Alefa district. The chickpea grains which were used as a substrate for insect rearing were kept in an oven at 60ºC for 4 hours to disinfest the seeds from any prior infestation before the experiment (Bekele, 2002). The disinfested chickpea seeds were equilibrate under ambient condition where temperature fluctuates between 28±2ºC for 2 hours.

During the semi field experiment, the temperature was about 30ºC and it was optimum temperature for the oviposition of *C. chinensis* is between 30ºC and 32ºC (Yongxue, 1999). The bruchids were reared on stored chickpea *(Ciser arietinum)*, in two polyethylene bags. To obtain newly emerged bruchids of the same age generation, 200 unsexed adult of *C. chinensis* were introduced into two polyethylene bags each containing 4kg of chickpea seeds which were disinfected. The polyethylene bags were tied that can allow sufficient aeration and prevent the escaping of the bruchid.

The parent bruchids were sieved out after 5 days of oviposition time and seeds were kept under ambient condition for 26 days. When the new generation emerges, they were sieved out and used for the experiment. The disinfested chickpea seeds were kept in 24 polyethylene bags in each having 1.5 kilo gram disinfested chickpea, which were stored in farmers' house. About 180 adults' unsexed 1-2 aged bruchids were released in each polyethylene bag.

After 2 hours for acclimatization, from 18 treatment container polyethylene bag the two plant leaf powder with 5, 7.5 and 10% w/w of the botanical powder were applied and three polyethylene bags with Malathion 5% dust as standard and three untreated seed container polyethylene bag were used as control. The treatments were thoroughly mixed with chickpea seeds by shaking and rolling the polyethylene bag gently to ensure uniform coating of the seeds.

Collection and preparation of plant materials

Plant of fresh leaf and seed of *Clematis hirsuta,* and *Calpurnia aurea* (Table 1) were collected from their natural habitats North Gondar Zone Alefa district from November to December 2016. Plant selection in the study was based on interviewed local farmers to specify the indigenous plant species known for their use in the regular control of insects in their localities and through analysis of the relevant literature. Identification of plants was carried out at Debre Markos University by expertise. The botanical plants were dried under shade and crush into fine powder using mortar and pestle that sieved through 25 mm mesh. The grind and labeled botanical powders were kept in plastic bags for a few days until use.

Preparation of extracts

Table 1: List of botanical plants which were tested against C. chinensis(L) on chickpea

Botanical Plants	Local Name (Amharic)	Plant Type	Parts used
Clematis hirsuta	Azoareg	Climbing shrub	Leaf
Calpurnia aurea	Digta	Tree	Leaf

Adult Mortality Test

The experiment was done in three observation time (24, 48, and 72 hours) after treatment application. At each counting time dead bruchids were counted and removed. The bruchids were considered dead when there is no response after checking by touching from the abdomen with a pin. Seven days after treatment application, all dead and live bruchids were removed as natural mortality which may not be expected after this date (Kananji, 2007). Percentage of insect mortality was calculated using Abbott formula (Abbott, 1925).

Corrected % mortality = $[1 - \frac{Nt}{Nc}] \times 100$

Where:

Nt= Number of Insects in Treated polyethylene bag,

Nc= Number of Insects in Control polyethylene bag.

Chickpea Weight Losses Assessment

Weight losses assessment was done on treated and untreated grains. To determine seed weight losses rate, samples of 200 grains were taken randomly from each polyethylene bag of the treatment. The seeds were divided into damage and undamaged seed to determine percentage of weight loss. The number of damaged (grains with characteristic hole) and undamaged grains were counted. The grain record with and without exit holes were counted and separately weighed and the resultant data was used to calculate the estimate percentage weight loss.

Percent weight loss was calculated following the equation of Gwinner et al.(1996).

$$\% \text{ weight loss} = \frac{UND-DNU}{U\,(ND+NU)} \; X\ 100$$

Where, U= Weight of undamaged grain

NU= Number of undamaged grain

D= Weight of damaged grain, and

ND= Number of damaged grain.

Seed Germination Test Assay

Germination test was conducted 60 days after treatment application to determine viability of each botanical treated seed. Three replicates of 180 seeds randomly were picked in each treatment polyethylene bag and then placed on moist Whatman (No. 1) filter paper on flat dish and kept at room temperature. A healthy untreated seeds were set up similarly as control. Germinated seeds were recorded and the remaining samples were watered daily for 5 days. The percent Germination was computed according to Ogendo *et al.* (2004) as follows:

$$\text{Percentage seed germination} = \frac{\text{number of seed germinating}}{\text{total number of seed in petridish}} \times 100$$

Purity Test Assay

In addition to germination test, the physical quality of the seed should be assessed; this is especially important before seed sales; seed storage, and during seed processing. For seed purity test, the cleanness of seed, pure seeds were separated from impure seed, and then separately weighed and compared to the sample weight. Seed is considered pure if it appears normal in terms of size, shape, and general outward appearance. A sample of 200-seed were taken at random from each replication of all the treatments and calculated as follows:

$$\text{Purity percentage} = \frac{weight\ of\ pure\ seed}{total\ weight\ of\ sample} \times 100$$

Data analysis

Data entry and analysis were done using Microsoft excel and Statistical Analysis System program (SAS version 9.2) respectively. To examine the effect of the treatments on percentage mortality, percentage weight loss, percentage purity and effect of botanicals on germination of chickpea seeds, one-way analysis of variance (ANOVA) was used. Tukey student test (HSD) was used to separate the means where treatments were found to be significantly different ($P<0.05$). LC_{50}, LC_{90}, value were calculated by probit analysis.

Results

The effect of *Calpurnia aurea* and *Clematis hirsute* leaf powder against *C. chinensis*

The mean mortality of adult *C. chinensis* due to two selective botanical powders with three different doses through three exposure time was presented in Table 2. Those two plant powders applied at varied rate resulted in significantly higher ($P<0.05$) mortality of C. *chinensis* at 24 hours. Leaf powder of *C. aurea* applied at 5, 7.5 and 10%w/w showed a significant toxicity effect, at 24 hours after treatment application that caused 32.04, 35.93, and 38.89% adult mortality respectively. It causes higher mortality than all other treatments except Malathion 5% dust, which caused 98.15% mortality within 24 hours. While the leaf powder of *C.hirsute* at a lower rate (5%) and short exposure time (24hr) was showed less toxicity effect (26.30%) against C. chinensis. *Calpurnia aurea* resulted in significantly higher mortality than *C.hirsute* and untreated test next to Malathion 5% dust, which caused high mortality within 72 hours.

Table-2 Mean mortality of adult C. chinensis by different plant powder treatments, after different observation time at semi-field trail

Treatment	Conc of Botanical Powder	Mean Adult Mortality After Treatment Application		
		24 hours	48 hours	72 hours
Calpurnia aurea	75	32.04 ± 0.49^{c}	47.22 ± 1.16^{ab}	80.37 ± 0.49^{a}
	112.5	35.93 ± 2.43^{bc}	58.52 ± 0.98^{ab}	86.49 ± 0.49^{a}
	150	38.89 ± 2.55^{b}	72.59 ± 1.34^{a}	91.48 ± 0.49^{a}
Clematis hirsuta	75	26.30 ± 0.87^{d}	37.78 ± 2.10^{b}	60.18 ± 0.98^{b}
	112.5	32.22 ± 0.85^{c}	47.59 ± 0.98^{ab}	70.00 ± 1.16^{ab}
	150	36.11 ± 0.85^{bc}	53.89 ± 0.56^{ab}	77.60 ± 0.67^{ab}
Malathion dust	1.5	98.15 ± 0.49^{a}	99.63 ± 0.19^{a}	99.81 ± 0.19^{a}
Control	0	0.556 ± 0.32^{e}	1.67 ± 0.32^{e}	2.78 ± 0.32^{c}

Mean within the same column followed by the same letters are not significantly different, P > 0.05%, Tukey student test (HSD)

The number of dead bruchids at lower dose within 24 hours was fewer at both botanicals'. The highest dose of *C. aurea* leaf powder showed significantly higher *(P< 0.05)* mortality to bruchids. Both botanical leaf powders applied at 5, 7.5 and

10% showed a significant toxicity effect. Observations on 48 and 72 hours after treatment application indicated that mortality of bruchids was high. That is when the rate and exposure time; increase the mortality of *C. chinensisalso* increase. *C.aurea* leaf powder with 150 gram caused 91.48% mortality and Malathion 5% dust with 1.5 gram caused 99.81% mortality against *C. chinensisat* 72 hours after treatment application

(Table 3). Generally, the cumulative mortality of bruchids after three day treatment application showed that botanicals appeared to be more effective when compared with the untreated control.

Table-3: Probit Analysis of Toxicity of Two Botanicals in Semi-field Trail after 24 Hours Treatment to *C. chinensis*

Botanicals	After 24 hours		After 48 hours		After 72 hours	
	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}
C. aurea	10.37 (9.48-11.63)	18.63 (16.39-22.1)	6.68 (6.25-7.11)	11.91 (11.13-12.9)	4.19 (3.78-4.57)	7.94 (7.51-8.45)
C. hirsute	11.72 (10.55-13.5)	20.62 (17.80-25.2)	8.31 (7.76-8.96)	14.91 (13.59-16.8)	5.70 (5.26-6.11)	10.70 (10.04-11.5)

Effect of botanical powders on weight loss of chickpea grains due to feeding by *C. chinensis*.

Results of assessment of percentage of weight loss caused by infestation of *C. chinensis* on treated and untreated Chickpea seeds are given in (Table. 5). The amount of grain weight losses that caused by *C. chinensis* was reduced in the entire botanical powder admixture significantly ($P<0.05$) compared with the control 60 days after treatment application. The lower weight loss in the powder treatment might be due to the increase in the number of adult mortality that resulted kernel damage. Among the two plants relatively the highest weight loss (3.17%) was observed in *C. hirsute* leaf powder with lower rate (5%) next to the untreated check. The lowest weight loss (0.69%) was observed in *C. aurea* leaf powder. There was a little weight loss recorded on grains treated with Malathion dust 5%. This finding showed that *C.aurea* and *Clematis hirsute* have the efficacy of reduced the weight loss even at the lower dose similar to standard check Malathion dust 5% at recommended rate. The seed weight losses were observed in this treatment percentage ranged from 0.69% to 3.17% and was significantly different from the untreated check (7.37%).

Effects of Botanicals on Germination of Treated Chickpea Seeds

The current study outcome illustrated that the mean percentage of germination of chickpea seeds treated with selected botanical plant powders at three doses and untreated check was presented in (Table. 4). There was no any detrimental effect on chickpea seed germination when treated with *C. aurea* and *C. hirsuta* that no significant (P > 0.05) was observed as laboratory cause. The germination of chickpea was ranged from 96.67% *C. aurea* with higher doses and 94.67% *C. hirsutaat* lower dose. This indicated that there was no any adverse effect every dose of the both botanical powders on the germination capacity of seed.

Effect of Botanicals on Purity of Chickpea Seeds against C. chinensis

Mean percentage purity of chickpea seeds treated with the current tested botanical plant powders within a given doses and untreated check was shown in (Table.4). The result explained that the effect *Calpurnia aurea* and *Clematis hirsutaleaf* powder on Chickpea seed purity was significant (P<0.05) compared to untreated. The highest purity (91.20%) was recorded on Chickpea seeds treated with *Calpurnia aurea* seed powder at the rate of 10%w/w of grain and the least was recorded on Chickpea seeds treated with *Clematis hirsute* (87.35) powder at 5g/100g of grain. These indicate that the chickpea seeds were treated with botanicals showed increase seed purity when the powder dose increase 60 days after treatment as standard check.

Table-4: Mean Weight Loss, Germination and Purity of Chick pea Seeds due to Treatment of two botanicals and standard (Malathion dust) at Semi-Field Trail.

Treatment	Concentration (w/w)	%Weight Loss	% Germination	%Purity
C. aurea	75	1.18±0.58c	95.78±0.589ab	88.11±0.28^{e}
	112.5	1.29±0.30bc	94.67±0.38b	90.37±0.36^{c}
	150	0.69±0.09c	95.33±1.15ab	91.20±0.04^{b}
C. hirsuta	75	3.17±0.52b	95.00±0.00ab	87.35±0.02^{f}
	112.5	2.66±0.13bc	94.67±0.38b	88.53±0.06^{e}
	150	1.75±0.62bc	94.67±0.67b	89.65±.05d
Malathion dust	1.5	0.97±0.23c	94.44±0.59ab	97.31±0.16^{a}
Control	0	7.35±1.25a	95.00±0.38ab	60.27±0.35^{g}

Mean within the same column followed by the same letters are not significantly different, P>0.05%, Tukey student test (HSD)

Discussion

Various studies indicate that botanical leaves powders were used for protection of stored chickpea from *C. chinensis*. Thus, the result of the present semi field scale trail study conducted that the selected botanical plant leave powder with three concentrations had different potentials against *C. chinensis* on stored chickpea. In this study there were two locally available botanicals, which were *C. aurea* and *C.hirsuta*. Those tested botanical plant powder mortality effects was significantly ($P<0.05$) different from the untreated check and both of them were like positive control Malathion dust after three days to against *C. chinensis*.

Among the two tested botanicals, *C.aurea* leaf powder at all concentration 75, 112.5and 150gram) applied showed high percentage mortality to *C. chinensis* after 24 hours. This insecticidal potential was like that of the standard check Malathion 5% dust which caused higher mortality. Other researchers also revealed that *C. aurea* leaves and other product were shown promise insecticidal activities against different insect and other arthropod pests. Adedapo et al (2008) reported that *C. aurea* was used to kill lice. Moyo and Masika, (2013) indicated that the extracts of *C. aurea* at concentration of 100% had flea mortality of 73.3%. *Calpurnia aurea* leaf extracts were used in southern Ethiopia for protecting livestock against ticks. This because of it contains active compounds which are called quinolizidine alkaloid calpurnine (12β, 13α dihyidroxylic acid Easter (Zorloni, 2007). These quinolizidine alkaloids are toxic to insect and animals Adedapoet al (2008). In the present study, *C.hirsute* was effective against *C. chinensis* particularly at higher doses and after 72 hoursscored60.18%mortality next to *C. aurea*

In the present study, higher doses and longer exposure period are required to achieve possible management of *C. chinensis* especially at small scale trail. All the plant leaves powder mixed with a chickpea caused more significant adult mortality of *C. chinensis*. Three days after application, adult chickpea weevil mortality was 91.48%. The insecticidal effect of plant powder may attribute different effects on insects. Insect repellency, stomach poisoning effect where insects feed on admixed grain and pick up a lethal dose of treatment particles, and botanical powders might reduce insect movement and also cause death through occlusion of their spiracle, thereby, preventing respiration via trachea (Tesfu Fekensaa, 2011).

Hence, in the present finding, in addition to mortality, all botanical powders significantly lower numbers of chickpea seeds exit hole compared with the untreated chickpea seed.

Mean weight loss caused by *C. chinensis* treated those botanicals resulted in significantly lower. Chickpea grains treated with Malathion dust followed by *C. aurea* were highly significant ($P<0.05$) difference with untreated on weight loss. This reduction of grain weight loss was due to increase adult mortality of *C. chinensis* within short time. The higher dosage plant powders in addition to directly pests poison; it affects the egg laying and larval development of bruchids that could be hampered by covering the seed and affects the insect movement to screech the partner for mating (Adugna, 2003). In relating to this Aselam and Suleman (1999) in their study of storage grains reported that fraction of the dust particles with insect cuticle leads to desiccation and hamper the development of pests. Adugna *et al*, (2003) in their survey of storage pests reported farmers in Eritrea uses a mixture of small size grain and fine sands give a better control of grain storage pests.

The current finding has showed that *C. aurea*, and *C. hirsuta* powder were able to minimize the chickpea seed weight loss as none significantly Malathion dust 5%. The highest chickpea weight loss was recorded on the untreated check. In likewise to this study other botanical products also used to reduce weight loss that caused by *C. chinensis*. Tesfu Fekensa (2011) recorded that, there were *C. chinensis* adult mortality and lower seed damage when treated with different parts

Parthenium hysterophorus plant powder with different rate exposure time. Kebebush Tesema (2015) also reported that neem leaf powder and basil leaf powder significantly cause for *C. chinensis* adult mortality and lower seed weight loss.

Chickpea seeds treated with, *C. aurea* and *C. hirsuta* powders were pure compared to the untreated check. So, those plants had a potential to keep seeds as normal appurtenance. This was due to immediate mortality of adult bruchids during treatment application before they injure chickpea seeds. The highest purity of chickpea grains were recorded on Malathion dust and *C. aurea* with 150 gram powder/ 1.5 kilo gram seeds, which was 91.20% purity recorded. On the other hand relatively lower percentage purity was shown on *C. chinensis* (87.35%) next to untreated (27%).

From the viability of seed germination, it was concluded that the current tested botanical plant materials have no significant effect on seed germination. All the botanical treatment, including Malathion dust showed favors the seed germination mean percentage germination ranged 94.44-95.33%. There were no significant difference ($P = 0.27$) from the untreated check and treated with Malathion dust. Different scholars reported on the effect of botanicals on seed germination. The current study agrees with Tabu *et al.* (2012) proved that

M. ferruginea seed powder treatment does not impair the germination of seed with 3%, 4% and 5%.

The overall test of efficacy between the treatments showed that mortality of the target was directly related to the dosage and exposure time. This indicated higher dosage was more efficient in management of *C. chinensis* the extent to which the botanical affected the survival of the subsequent adult has found to vary among them this indicated that the active ingredient of botanicals which are responsible for the toxicity of plant kill the insects gradually.

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