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Invitro Evaluation of Some Plant Extract Against Pulse Beetle, *Callosobruchus chinensis* on Stored Chickpea

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ABSTRACT

Chickpea is a significant cash crop for West Shoa farmers as it does for farmers in Ethiopia. Its production has been declining due to biotic and abiotic factors. One of the most important causes of grain loss in stored chickpea is the damage caused by Pulse beetle, Callosobruchus chinensis (L.). This study was conducted with the objective to evaluate the efficacy of available botanical extract at different rates against Callosobruchus chinensis, under laboratory conditions. The experiment was laid out in a Completely Randomized Design with three replications. The results revealed that there was an increasing trend in parent adult mortality over time, i.e., the highest C. Chinensis parent mortality of 100% were recorded from Guizotia abyssinica oil, Ricinus communis oil, Citrus lemon oil, and Azadiracta indica seed extract at the rates of 100mg, 75mg, and 50mg/kg of Chickpea on the fifth day after exposure to treatments. Phytolaca dodecandra seed, and Eucalyptus globules leaves caused 66.67%, 70.0%, and 71.11% mortality after fifth day exposure at the rates of 50mg, 75mg, and 100mg, respectively. The lower mortality of 58.89% and 51.11% were recorded from 'Datura stramonium leaves and Schinus molle at a maximum rate on the 5th day of treatment exposure, respectively. It is concluded that the Guizotia abyssinica oil, Ricinus communis seed, and Citrus lemon oil were found to be the most potent bio-insecticides against C. chinensis. Therefore, these three botanicals are recommended as a safe alternative for the control of C. chinensis in stored chickpea.

Keywords: *Botanicals, Callosobruchus chinensis, Stored chickpea, Mortality, Weight loss*

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INTRODUCTION

Fabaceae is a family of annual legume crops that includes the chickpea (Cicer arietinum L.) (Mounika *et al*., 2021). Both in terms of its proportion of the overall area planted to pulses and its function in direct human consumption, it is one of Ethiopia's most important annual crops. In comparison to other crops, the cultivation of chickpeas requires fewer external inputs and requires less labor. Ethiopia is the seventh-largest producer of chickpeas worldwide, accounting for almost 46% of output on the African continent between 1994 and 2006 (Tessema *et al*., 2015). Two varieties of chickpeas are widely cultivated across the world: the Kabuli, which has a light yellow coating and big seeds, and the Desi, which has smaller seeds and beige testa (Khalil *et al*., 2007; Kinfe *et al*., 2015). Only lately have Ethiopian farmers been exposed to new kabuli kinds. In the nation, the Desi variety dominates (more than 80%) in terms of both consumption and area coverage (Kinfe *et al*., 2015).

In the field, pod borer is the most severe, whereas bruises harm storage (Gahukar & Reddy, 2018). According to estimates, insect pest infestations in sub-Saharan Africa cause between 25 and 40 percent of grain crops to be lost in shops each year (Kimatu *et al*., 2012; Ahmad *et al*., 2015). Stored product pests are more significant than field pests because bruchids in stores generate irreversible storage losses (Hajam & Kumar, 2022). On chickpea seeds, C. chinensis eggs are deposited, and the larvae burrow into the seeds to finish developing inside the grain. In order to reduce this issue, farmers are using traditional chemical pesticides, which have been shown to be successful. Nevertheless, the usage of chemical pesticides is not only beyond the farmers' financial means but also carries significant health risks, residues, pollution, and contamination threats (Boudh & Singh, 2018).

The pulse beetle, also called the adzuki beetle (Callosobruchus chinensis), is one of the insect pests that poses the greatest risk to grain that has been stored (Tessema *et al*., 2015). Because these circumstances encourage the growth of this insect, they harm grains that are kept at 30°C and 70% relative humidity (Srivastava & Subramanian, 2016). Chickpeas suffer significant qualitative and quantitative losses as a result of pulse beetle infestation. Banik (2024) found 32-64% infection of Callosobruchus species in leguminous seeds and 3% in oilseeds. This insect was reported to harm 50-60% of grains in stored state after 6 months of conventional storage (Caswell, 1973; Srivastava & Subramanian, 2016). According to Keneni and Ahmed (2016), insect pest infestations in sub-Saharan Africa cause between 25 and 40 percent of grain crops to be wasted in shops each year. In order to assess the effectiveness of several botanical extracts and their rates against C. chinensis on chickpea, the study was conducted.

MATERIALS AND METHODS

Description of the study area

The research was conducted at the Ambo Agricultural Research Center in the Oromia Regional State's West Shewa Zone. At a height of 2225 meters above sea level, the Ambo Agricultural Research Center is situated 115 kilometers west of Addis Ababa. It's situated at latitude 08°57'N and longitude 37°52'E. With typical monthly minimum and maximum temperatures of around 10.30°C and 26.40°C and 1036 mm of rainfall, respectively, the region has a warm, humid environment (Başar *et al*., 2022; Do *et al*., 2022; Kariri *et al*., 2022). Vertisol is the type of soil used in the experiment.

Chickpea grain used for the experiment

Clean and well-sifted chickpea grain of the variety "Kabuli," which was acquired from the Ambo Agricultural Research Center, was used in all studies. It was grown on their farm and frozen at -6°C to kill any living insects. After that, it was sufficiently dried in the open sun without any prior pesticide treatment. Nearly only bigger grains were utilized in the investigation, and the grains were graded by hand. By hand, dirt and broken chickpeas were removed from the grains.

Collection and preparation of plant materials

The materials indicated in **Figure 1**, eight (8) locally available plants including Oil of *Guizotia abyssinica* (Nuog) and Oil of *Citrus lemon* (Lemon) were bought from Ambo local market. And leaves of *Schinus molle* (pepper tree), *Phytolaca dodecandra* (Endod), leaveas of *Eucalyptus globules* (Eucalyptus), oil of *Ricinus communis* (castor) and Leaves of *Datura stramonium* (Datura) were collected from compound of Ambo Agricultural research center and Ambo University, respectively. And also seed of *Azadiracta indica* (neem) was collected from Melkasa Agricultural Research center. These plant materials were air dried in the shade, crushed individually into a fine powder with a mortar and pestle, then sieved to produce homogeneous fine dust particles. Each plant material was stored in a plastic bag in a cool location until treatment was applied (Ekpo *et al*., 2023; Kwatra *et al*., 2024). Each pair of seeds was put in a test tube (14.7x2.4 cm) and treated with the plant extracts at varied doses (50mg, 75mg, and 100mg/kg).

Figure 1. Drying different botanicals under shade

Mass rearing and maintenance of c. chinensis

The mass culture of C. chinensis was carried out on 250 g of sterilized (hot air oven at 80°C for 2 hours) and disinfected (formalin 1%) chickpea seeds (variety: Kabuli) in a glass jar, as seen in **Figure 2**. In order to achieve a pure culture of the target species, individuals of C. chinensis from the infected stock were taken and released in a glass jar with 250 gm of grains in a male-to-female (1:1) ratio. There was a muslin towel over the container's mouth. Five days later, all of the adults were taken out, and the humidity and temperature needed to produce egg-laying seeds were maintained. For experimental purposes, the recently emerging grownups were employed. Fresh cultures were routinely cultivated on fresh chickpea seeds to promote culture growth and prevent fungal infections. For culture maintenance, the rearing jars were maintained in an incubator between 27 and 30°C and 70 and 75% relative humidity.

Figure 2. Mass Rearing and Maintenance of *C. chinensisat* under laboratory conditions

Treatments application and infestation

Three concentration ratios of 50 mg/kg, 75 mg/kg, and 100 mg/kg powder of treatments are included in each jar together with 250 grams of chickpea grains. The containers holding the disinfested grains were shaken and rolled to apply the treatments and mix them evenly. The untreated control was also utilized for comparison, and the standard check was an insecticide, primiphos methyl (Actellic 2%) dust, applied at a dosage of 0.25 mg/kg of seed. 30 recently emerged adult Callosobruchus chinensis (1:1) were then added to each container. Three replications of eight (8) treatments were used in the trials, which were set up using a completely randomized design (CRD).

Data collection

By selecting 50 seeds from each jar, the number of eggs laid on the chickpea seeds 1, 3, and 5 days after treatment application was noted, along with the number of parent adult C. Chinensis deaths that were tallied and eliminated. Since natural mortality is anticipated to occur after the fifth day following insect introduction, all Bruchids, both dead and living, were taken out of the jars and preserved in the same conditions for the emergence of the F1 offspring.

Emergence, mortality and eggs was laid by progeny adults

Beginning 22 days following treatment, the appearance of the progenies was examined once a week. The number of adults who emerged from each therapy was tallied and documented. At weekly intervals, the number of dead and alive adult offspring was noted. Data was collected on fifty (50) seeds from each treatment that had holes, eggs, and healthy grains during the course of three months of storage (Elshorbagy *et al*., 2022;

Verevkina *et al*., 2024). The information gathered was utilized to assess each botanical's effectiveness against C. chinensis.

Percentage protection

Each treatment's protective effectiveness was determined using the methodology below (Caswell, 1973).

$$\text{Protection (\%)} = \frac{(\text{Total f1 progeny in untreated check} - \text{Total f1 progeny in treated})}{(\text{Total f1 progeny in untreated check})} \times 100 \quad (1)$$

Grain weight loss

On the ninetieth day of treatment, 100 grains were selected at random from each treatment and divided into intact seeds and damaged grains with exit holes. In order to determine the % weight loss, grains with and without exit holes were counted and weighed independently. Using the counted and weighted approach, the percentage of weight reduction was calculated.

$$\text{Percent weight loss (\%)} = \frac{(W\mu \times Nd) - (Wd \times N\mu)}{(W\mu \times (N\mu + Nd))} \times 100 \quad (2)$$

Where:
Wμ = weight of undamaged grains
Nμ = number of undamaged grains
Wd = weight of damaged grains
Nd = number of damaged grains

Effect of botanicals on seeds germination

Three months into the experiment, the treated seedlings' germination was evaluated. A random selection of fifty (50) seeds was taken from each jar and put in petri dishes on damp filter paper. To eradicate fungal infection, seeds from each treatment were individually treated with 10% sodium hypochlorite (Chlorox) for one minute (İlhan *et al*., 2022; Yoong *et al*., 2022). To prevent external damage to the chickpea grains, the seeds were then washed with potable water to remove the chlorox. A completely randomized design (CRD) including eight treatments and three replications was used for the experiment. The seeds that germinated were noted 7 days after incubating. The percentages of germinated seeds were calculated accordingly.

Statistical analysis

Once the data had been appropriately transformed to normalize variance, analysis of variance was conducted (Wang *et al*., 2012). The rule of transformation was used to choose appropriate transformation systems based on the kind of data record from various treatments. The proportion of parent mortality was therefore calculated using an arcsine transformation. When capturing data on eggs deposited by parent adults, the square root transformation was utilized. Bruchids, grains containing an egg or eggs, holes per 50 grains, germination, and weight loss %. The SAS software was used for all statistical operations. Using Tukey's studentized range test (HSD), mean separation was performed. The tables' means are all back-transformed data.

RESULTS AND DISCUSSION

Percent mortality of C. chinensis aftertreatment exposures of five days

Result presented in **(Table 1)** revealed that a significantly (P ≤ 0.05)differences among the treatments. The maximum mortality of *C. chinensis (L.)* was observed in *Ricinus communis, Guizotia abyssinica* and *Citrus lemon* at all rates (100%) followed by *Azadiracta indica* and *Phytolaca Dodecandra* at the rates of 75gm and 100gm/kg of powder (83.35, 83.35; 78.89,82.22%). The minimum mortality recorded by *Schinus molle followed* by *Datura stramonium* and *Eucalyptus globules* Significantly minimum mortality of *Callosobruchus chinensis (L*) was recorded in untreated control which was (3.33%). Significantly minimum per cent mortality was recorded in untreated control (12.22%). The results showed from first day observation to fifth day observation after treatment exposure the percent mortalities were increased indicted in **(Table 1)**.

Table 1. Percent Mortality of *C. chinensis* after Exposure of Treatments.

Treatments	Rate	Percent mortality (%)		
		1st day	3rd days	5th days
Schinus molle	50	17.78(24.95) ±0.42f	26.67(31.1) ±0.51oj	43.33(41.16) ±0.65h
	75	20.00l (26.57±0.45f	25.56(30.36) ±0.50j	48.89(44.36) ±0.69g
	100	25.56(30.37) ±0.51ef	31.11(33.9) ±0.55i	51.11(45.63) ±0.71g
Datura stramonium	50	24.44(29.63) ±0.49ef	31.11(33.9) ±0.55i	50.00(45.0) ±0.7g
	75	25.56(30.37) ±0.51ef	40.00(39.2) ±0.63h	55.56(48.2) ±0.74f
	100	32.22(34.58) ±0.57e	47.78(43.7) ±0.69g	58.89(49.9) ±0.76f
Eucalyptus globules	50	28.89(32.51) ±0.54e	45.56 (42.45) ±0.67g	66.67(55.34) ±82e
	75	32.22(34.58) ±o.57e	52.22(46.27) ±0.72f	70.00(56.78) ±0.83d

	100	33.33(35.26) ±0.58e	57.78(49) ±0.76e	71.11(57.48) ±0.84d
Phytolaca dodecandra	50	44.44(41.81) ±0.67d	62.22(52) ±0.78d	75.56(60.3) ±0.86c
	75	36.67(37.27) ±0.61d	70.00(56.78) ±0.83c	78.89(62.64) ±0.88c
	100	40.00(39.23) ±0.63d	78.89(62.64) ±0.88a	82.22(65.0) ±0.9b
Citrus lemon	50	54.44(47.55) ±0.74c	67.78(55.41) ±0.82c	100.00(90.0) ±1.11a
	75	52.22(46.27) ±0.72c	68.89(56.1) ±0.83c	100.00(90.0) ±1.11a
	100	51.11(45.64) ±0.71c	71.11(57.48) ±0.84bc	100.00(90.0) ±1.11a
Azadiracta indica	50	58.89(50.12) ±0.77b	56.67(48.83) ±075jk	77.78(61.87) ±0.88c
	75	58.89(50.15) ±0.77b	66.67(55.34) ±0.82c	83.33(65.9) ±0.91b
	100	60.00(50.77) ±0.77b	70.00(56.78) ±0.83bc	83.33(65.9) ±0.91b
Ricinus communis	50	53.33(46.91) ±0.73c	72.22(58.2) ±084bc	100.00(90) ±1.00a
	75	57.78(49.48) ±0.76b	74.44(59.63) ±0.86ab	100.00(90) ±1.11a
	100	61.11(51.42) ±0.78b	76.67(61.11) ±0.87a	100.00(90) ±1.11a
Guizotia abyssinica	50	61.11(51.42) ±0.72b	74.44(59.63) ±0.86ab	100.00(90) ±1.11a
	75	61.41(51.48) ±0.78b	75.56(60.37) ±0.86b	100.00(90) ±1.11a
	100	63.33(52.71±0.8b	78.89(62.64) ±0.88a	100.00(90) ±1.11a
Chemical	50	70.00(56.76) ±84a	81.11(64.23) ±0.9a	100.00(90) ±1.11a
Untreated	50	3.33(10.51) ±0.18g	8.89(17.34) ±0.29k	12.22(20.46) ±0.34i
Mean		43.37603	58.16256	77.26513
CV		9.125412	4.678631	2.970875
LSD		6.485262	4.458489	3.760913

Note: Means with the same letter(s) in the same columns are not significantly different for each other.
All treatment effects were significant at P<0.05 (LSD).
Data in the parenthesis represent transformed value

Number of eggs laid per 50 seeds

The findings demonstrated that, in comparison to the 98% eggs on the untreated check, C. chinensis deposited noticeably fewer eggs on seeds treated with Actellic 2% dust and Guizotia abyssinica oil (100 ml) one day following treatment application. These seeds had 2% eggs and 3.33% eggs per 50 seeds, respectively. The results indicated that all the treatments were significantly different from the untreated check one day after treatment application. Eggs counted three days after treatment indicated that *Guizotia abyssinica* of oil and Actellic 2% dust with 3.67% and 2.33% eggs, respectively. In contrast, the other treatments demonstrated efficacy against C. chinensis, which differed markedly from the untreated check. All botanicals were substantially different from the untreated control, according to eggs produced by C. chinensis five days after treatment application. Additionally, as demonstrated by **Table 2**, all treatments were noticeably better than the untreated check following treatment application.

Table 2. Mean percent eggs laid per 50 Seed by parent adults on different dat\es after of exposure of treatment

Treatments	Rate	Percent Eggs laid per 50 Seed (%)		
		1st	3rd	5th
Schinu smolle	50	68.67(55.9) ±0.8b	68.67(55.90) ±0.8b	69.02(56.16) +0.83c
	75	55.67(48.2) ±0.74c	57.33(49.05) ±0.75c	57.07(49) ±0.75d
	100	47.33(44.04) ±0.69d	47.33(44.04) ±0.68d	47.33(44.04 ±0.68e
Datura stramonium	50	37.33(37.0) ±0.61e	38.08(38.04) ±0.61e	38.11(38) ±0.61f
	75	35(36.6) ±0.59f	33.67(35.4) ±0.58e	33.33(35.26) ±0.57g
	100	31.67(34.2) ±0.56g	31(33.8) ±0.55e	31(33.8) ±0.55g
Eucalyptus globules	50	29(32.6) ±0.53h	24.33(29.55) ±0.49ef	41.05(39.8) ±0.64f
	75	23(28.7) ±0.47i	23.33(28.8) ±0.48ef	41.07(39.81) ±0.64f
	100	23.33(28.8) ±0.48i	22.33(28.2) ±049fg	22.33(28.2) ±0.47h
Phytolaca	50	21.67(27.7) ±0.46ij	18.08(25) ±0.42g	22(27.97) ±046h

dodecandra	75	20.33(26.8) ±0.45^{jk}	40.67(39.60 ±0.63^{d}	21(27.27) ±0.45^{h}
	100	19.33(26.1) ±0.43^{k}	19.33(26.0) ±0.43^{g}	19.67(26.32) ±0.44^{h}
Citrus lemon	50	16(23.6) ±0.4^{l}	16.33(23.83) ±04^{g}	16.02(23.5) ±0.4^{hi}
	75	16.67(24.0) ±0.42^{l}	14.67(22.5) ±0.38^{g}	85.67(67.0) ±0.92^{b}
	100	12(20) ±0.34^{n}	11.33(19.60) ±0.33^{h}	12.17(20.0) ±0.34^{i}
Azadiracta indica	50	19(25.8) ±0.43^{k}	19.33(26.0) ±0.43^{g}	52.09(46.14) ±0.34^{e}
	75	18.33(25.3) ±0.42^{k}	17.67(24.85) ±0.42^{g}	39.67(39.0) ±0.61^{f}
	100	17(24.3) ±0.41^{km}	15.13(22.7) ±0.38^{g}	17.33(24.0) ±0.41^{h}
Ricinus communis	50	8.5(16.9) ±0.29^{o}	9.17(17.45) ±0.3^{gh}	8.03(16.4) ±0.28^{i}
	75	8.16(16.6) ±0.28^{o}	7.33(15.7) ±0.27^{h}	8.07(16.42) ±0.28^{i}
	100	4.33(12.0) ±0.2^{p}	5.37(12.9) ±0.22^{h}	5.33(13.34) ±0.23^{i}
Guizotia abyssinica	50	7(15.3) ±0.26^{o}	8.25(16.4) ±0.28^{h}	8.05(16.0) ±0.28^{i}
	75	5.33(13.34) ±0.23^{p}	6.33(14.57) ±0.25^{h}	6.07(14.1) ±.24^{i}
	100	3.33(10.5) ±0.18^{q}	3.67(11.0) ±0.19^{hi}	3.67(11.0) ±0.2^{ij}
Actelic 5%	50	2.13(8.13) ±0.14^{q}	2.33(8.7) ±0.15^{i}	2.67(8.12) ±0.17^{ij}
Untreated	50	91.67(73.2) ±0.95^{a}	93.67(75.4) ±0.96^{a}	98(81.9) ±0.9^{a}
CV (%)		4.53	27.26	10.34
LSD at 0.05		1.84	7.28	5.46

Note: Means with the same letter(s) in the same columns are not significantly different for each other.
All treatment effects were significant at P<0.05 (LSD).
Data in the parenthesis represent transformed value

Percent mortality of eggs laid by Parent C. chinensis

One day following the administration of the therapy, 100 mg of Ricinus communis seed and 100 ml of Guizotia abyssinica oil resulted in 95.6% and 96.4% egg mortality, respectively. Apart from Actellic 2% dust, which caused 97.9% mortality, Guizotia abyssinica oil produced a much greater mortality rate than all other treatments. It was discovered that the untreated check and all other remaining treatments differed substantially. Three days after the application of the therapy, observations showed that Guizotia abyssinica oil treatments caused 98.1% of the egg mortality and Actellic 2% dust treatments caused 98.33%, while 75 ml of Guizotia abyssinica oil caused 96.87% of the C. chinensis mortality. And also, all remains botanical treatments showed significantly better than the untreated check, which was (8.33%). After five days of treatment, the maximum mortality rate recorded insimilar way in *Guizotia abyssinica* oil at the rate of (100ml/kg) and *Ricinus communis* seed at the rate of 100mg/kg was 96.5% and 95.30%, respectively. The remains treatments were effective as compared with untreated check as showed in **(Table 3)**.

Table 3. Mean percent mortality of parent eggs at different dates after exposure of treatments

Treatments	**Rate**	**Percent Mortality of eggs (%)**		
		1st	3rd	5th
Schinus molle	50	31.3(34) ±0.55^{j}	28.05(31.9) ±0.52^{j}	31.14(33.6) +0.55^{h}
	75	44.3(41.7) ±0.66^{i}	42.67(40.7) ± 0.65^{i}	43.05(41.02) +0.65^{g}
	100	51.67(45.95) ±0.71^{h}	53.02(46.8) ±0.72^{h}	53.12(46.71) +0.72^{f}
Datura stramonium	50	61.6(51.95) ±0.78^{g}	62.22(52.07) ±0.78^{g}	62.12(51.9) +0.78^{e}
	75	64.8(53.6) ±0.8^{g}	66.17(54.43) ±0.8^{f}	66.11(54.33) +0.81^{d}
	100	68.1(55.6) ±0.83^{f}	68.78(56.03) ±0.82^{f}	69.11(56.27) +0.83^{d}
Eucalyptus globules	50	70.7(57.22) ±0.84^{f}	72.01(58) ±0.84^{e}	72.68(58.02) +0.84^{d}
	75	76.7(61.13) ±0.87^{e}	77.08(61.4) ±0.87^{d}	77.5(61.05) +0.87^{c}
	100	77.3(61.51) ±0.8^{e}	78.16(62.13) ±0.88^{d}	78.11(62.08) +0.88^{c}
Phytolaca dodecandra	50	78.3(62.23) ±0.88^{e}	78.67(62.5) ±0.88^{cd}	78.11(62.08) +0.88^{c}
	75	79.5(63) ±0.89^{d}	79.67(63) ±0.89^{cd}	79.03(62.7) +0.89^{c}
	100	80.5(63.8) ±0.89^{d}	81.03(64) ±0.9^{cd}	80.14(63.43) +0.89^{c}

Citrus lemon	50	83.8(66.26) ±0.91[c]	83.57(66) ±0.93[c]	84.07(66.02) +0.9bc
	75	85.2(67.3) ±0.92[c]	85.27(67.4) ±0.92[c]	86.02(68.05) +0.9[bc]
	100	88.11(69.7) ±0.93[c]	88.48(70) ±0.94[bc]	88.02(69.7) +0.93[b]
Azadiracta indica	50	80.8(64) ±0.89[d]	80.52(63) ±0.89[cd]	81.05(64.03) +0.9[c]
	75	81.5(64.52) ±0.9[d]	82.05(64.9) ±0.90[cd]	81.05(64.03) +0.9c
	100	83(65.6) ±0.91[cd]	84.83(67) ±0.92g[c]	83.01(65.6) +0.9[c]
Ricinus communis	50	91.2(72.36) ±0.95[b]	91.67(73) ±0.95[b]	92.12(73.5) +0.95[ab]
	75	91.8(73.3) ±0.95[b]	92.93(74.6) ±0.96[ab]	92.12(73.57) +0.95[ab]
	100	95.6(77.8) ±0.97[a]	95.42(77.6) ±0.97[a]	95.02(77.01) +0.97[a]
Guizoti aabyssinica	50	92.6(74) ±0.96[b]	92.67(74) ±0.96[ab]	92.03(73.6) +0.95[ab]
	75	94.2(76) ±0.97[a]	96.87(79.8) ±0.98[a]	94.11(74.07) +0.96[a]
	100	96.4(79) ±0.98[a]	98.1(82.1) ±0.99[a]	96.08(78.46) +0.97[a]
Actelic 5%	0.25	97.9(81.7±0.89[a]	98.33(82.6) ±0.99[a]	98.01(81.87) +0.98[a]
Untreated		2.03(8.2) ±0.14[k]	8.33(16.78) ±0.3[k]	12.06(20.3) +0.34[i]
Mean		74.97	75.39	75.7
CV		1.29	1.21	1.42
LSD		4.59	3.75	4.76

Note: Means with the same letter(s) in the same columns are not significantly different for each other.
All treatment effects were significant at P<0.05 (LSD).
Data in the parenthesis represent transformed value

Effect of botanicals on grain damage

In comparison to the untreated check, there were substantially fewer damaged grains in all treated grains. On Actellic 2% dust, Guizotia abyssinica oil, Ricinus communis oil, Citrus lemon oil, Azadirata indica seed, Phytolaca dodecandra seed, Eucalyptus globules leaves, Datura stramonium leaves, and Schinus molle leaves treated grains, considerably fewer eggs were oviposited than on any other treatment. As seen in **Figure 3**, the quantity of eggs in each treatment was quantitatively less than that of the untreated check. Ricinus communis at 100 ml treated grains, Guizotia abyssinica oil at 100 ml, and Actellic 2% dust had the fewest exit pores. There was a strong positive link between the number of exit holes and the quantity of eggs counted. Grain assessment of 50 randomly chosen seeds per replication after three months, as shown in **Figure 1**, showed that seeds treated with Actellic 2% dust, Ricinus communis oil at a rate of 100 ml, Guizotia abyssinica oil at rates of 75 ml and 50 ml, Ricinus communis oil at rates of 75 ml and 50 ml, and Citrus lemon oil at a rate of 100 ml had produced fewer grains with exit holes. And also, the other remains treatments like all rates of seed of *Azadiractaindica,* seed of *Phytolaca dodecandra*, leaves of *Eucalyptus globules*, leaves of *Datura stramonium* and leaves of *Schninus molle* were significantly different from the untreated check. The result revealed that the maximum number of normal seeds was recorded from Actellic 2% dust,*Guizotia abyssinica* oil at the rates of 100ml and 75ml, and *Ricinus communis* oil at the rate of 100ml which showed 48%, 47%, 46%, and 45.33%, respectively **(Figure 3)**.

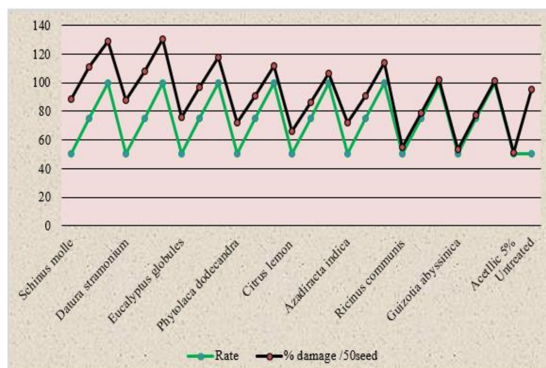

Figure 3. Mean percent damaged seeds within three months after treatment exposure

Developmental period of C. chinensis progeny

According to **Table 4**, the developmental time of C. chinensis ranged from 23.00 days for untreated grains to 35.00 days for grains treated with Guizotia abyssinica. The developmental time of C. chinensis is impacted by all botanicals at all rates in comparison to the untreated check. The developing time was significantly prolonged from 6 to 14 days with Actellic 2% dust and all other treatments.

Infestation level

In comparison to the untreated control, all tested treatments were statistically better and produced a low infestation level against C. chinensis. The percentage of infection level in Cicer arientinum L grains treated with botanicals varied from 16.97% (Pepper tree seed) to 97.9% (Actellic 2% dust). The maximum infestation level was recorded in *Schinus molle* at the rate of

50mg/kg, while the minumum infestation level was recorded in Actellic 2% dust (97.9%), followed by *Guizotia abyssinica* and *Ricinus communis* at all rates **(Table 4)**.

Percent seed germination

After ninety days of the experiment, the germination of Cicer arietinum L. seedlings treated with botanicals was evaluated. In comparison to the untreated control (39%), all of the botanically treated seeds exhibited noticeably greater germination rates, ranging from 67% to 98%. *Guizotia abyssinica* oil and Actellic 2% dust treated *Cicer arientinum L*grains gave 97.67% and 98% germination, followed by *Ricinus communis* at the rate of 100ml which was (95.33%).

Table 4. Mean weight loss, protection, Germination, developmental period, andprogeny Emerged within three months

Treatments	Rate	Developmental period in days	No. of Progeny Emerged per 50 seeds	Infestation reduction (%)	Weight loss (%)	Germination (%)
Schinus molle	50	24.33def	203.67b	16.97r	43.17b	76.00jkl
	75	24.33def	186.00c	24.17q	40.7c	73.33kl
	100	25.00de	173.33d	29.20p	38.00d	74.33ijkl
Datura stramonium	50	24.00def	190.00c	22.53q	38.17d	67.00l
	75	25.00de	175.00d	28.57p	33.33e	78.67hijkl
	100	25.33de	165.00e	32.63o	27.17g	81.33hij
Eucalyptus globules	50	23.67fg	156.67f	36.10n	28.33f	75.33kl
	75	24.00def	148.00g	39.63m	26.00h	81.00hijk
	100	24.3def	142.00h	42.10lm	23.83i	81.67hij
Phytolaca dodecandra	50	24.67def	138.00hi	43.70kl	22.00j	82.33hijkl
	75	24.33def	134.00ij	45.30jk	20.50k	84.00ghi
	100	32.67bc	131.00jk	46.70j	20.27kl	84.00ghi
Citrus lemon	50	29.33c	29.00n	88.13g	11.00o	85.67efg
	75	30.00c	25.00no	89.77fg	8.67p	87.00ef
	100	31.00bc	22.67op	90.73ef	8.50p	88.00de
Azadiracta indica	50	25.33de	128.00kl	47.73ij	19.13l	85.00fgh
	75	26.67de	124.00lm	49.43hi	17.53m	85.67efg
	100	28.33cd	120.00m	51.07h	15.00n	87.00ef
Ricinus communis	50	34.00a	18.00pq	92.63de	7.70pq	88.00de
	75	35.00a	15.33qr	93.73cd	7.00qr	89.50cd
	100	35.00a	15.00qr	93.87cd	6.27r	95.33bc
Guizotia abyssinica	50	32.33b	12.00rs	95.10bcd	4.00s	89.67cd
	75	33.33b	10.00rst	95.90abc	3.60s	95.33bc
	100	35.00a	8.00st	96.73ab	3.00st	97.67ab
Acetllic 5%	50	34.67a	5.00t	97.90a	1.97t	98.00a
Untreated	50	23.00fg	245.33a	0.00s	68.83a	39.00m
Mean		28.26	104.61	57.32	20.90	35.39
CV		3.25	3.32	2.69	3.39	4.64
LSD		1.51	5.69	2.52	1.16	2.69

Note: Means with the same letter(s) in the same columns are not significantly different for each other.
All treatment effects were significant at $P<0.05$ (LSD).

Percent weight Losses

The percentage of weight loss was recorded in **Table 4** at three months. Notably, Guizotia abyssinica at all rates (100 ml, 75 ml, and 50 ml) was found to be very effective in minimizing the percentage of weight loss, i.e., 3%, 3.6%, and 4.0 percent of chickpea seeds. Ricinus communis at all rates (100 ml, 75 ml, and 50 ml) produced results of 6.2%, 7%, and 7.7%, and citrus lemon at rates of 100 ml, 75 ml, and 50 ml demonstrated 8.5%, 8.67%, and 11% of grain weight loss. The untreated control showed the highest percentage of seed weight reduction, whereas the remaining botanicals, including Phytolaca dodecandra, Eucalyptus globules, Datura stramonium, and

Azadiracta indica, remained superior to the untreated control (Elshorbagy *et al*., 2022; Verevkina *et al*., 2024).

Guizotia abyssinica reported the lowest quantity of C. chinensis, but other botanical remnants were more effective than the untreated control. The outcome was also consistent with the findings of (Banik, 2024), who found that Guizotia abyssinica effectively reduced the percentage of pulse beetle killing in chickpea seeds. Eknath (2022) conducted a similar study and found that Guizotia abyssinica oil was significantly more effective than other botanicals.

At the first, third, and fifth days following treatment exposure, the results showed that Guizotia abyssinica, Ricinus communis seed, and citrus lemon were more successful than the others; still, all treatments outperformed the untreated control. The current result is consistent with the findings of other researchers who have documented the efficacy of vegetable oils that result in significant mortality rates among bruchids. According to earlier research, applying vegetable oils to seeds helps stop insects from attacking grains that have been kept (Upadhyay & Ahmad, 2011). Vegetable oils are penetrated the egg of Bruchids, decrease oviposition and increase adult mortality (Singh *et al*., 2012). At different concentrations, *Guizotia abyssinica* oil gave comparable results in reducing longevity of *C. maculates* (Alemayehu & Getu, 2015).

The minimum egg laid was found in *Guizotia abyssinica* oil (100ml, 75ml and 50ml) treatment, followed by *Ricinus communis* seed (100mg, 75mg and 50mg) and *Citrus lemon* oil (100ml, 75ml and 50ml). Similarly by Mahmoud *et al*. (2020) also observed *Ricinus communis* seed effective to reduce fecundity of *C. chinensis* (Thakur *et al*., 2023).

Percent of adult emergence of chickpea bruchid within three months after treatments exposure at all rates *Guizotia abyssinica* was highly effective to minimized adult emergence followed by *Ricinus communis* seed and *Citrus lomen*. Similarly, observation carried out by Shaheen *et al*. (2016) and Alemayehu and Getu (2015) found *Guizotia abyssinica* oil effective to minimized emergence of *C. chinensis*.

The results therefore showed a substantial difference in the percentage of germination between chickpea seedlings treated with botanicals after three months. Plant extracts provided protection against insect pests of stored chickpeas and preserved the capacity of seeds to germinate, according to a paper by Hossain *et al*. (2014). Additionally, Singh *et al*. (2012) found that coating grains with oil had no effect on Cicer arietinum (L) germination or water absorption.

Guizotia abyssinica at all rates (100ml, 75ml and 50ml) was found highly effective to minimized percent of weight loss. Similarly, an investigation supported by Tabu *et al*. (2012) showed minimum weight loss percent of seed by *Guizotia abyssinica* oil.

CONCLUSION

The results showed that the majority of the botanical plant powders tested against C. chinensis have insecticidal qualities that may be used to prevent the disease in chickpea grain that has been stored. The most promising cytotoxic activity against C. chinensis in stored chickpea grain was demonstrated by Guizotia abyssinica, Ricinus communis, and Citrus lemon out of all the botanicals examined. *Azadiracta indica* seed, *Phytolacca dodecandra* seed, *Eucalyptus globules* leaves, *Datura stramonium* leaves, and *Schninus molle* which were found effective in controlling their damage on stored chickpea seed. All rates(100ml, 75ml and 50ml) of *Guizotia abyssinica*, *Ricinus communis* and *Citrus lemon* were highly effective which resulted in high adult mortality, while reducing fecundity, grain damage, weight loss, and minimizing progeny emergence. In place of synthetic pesticides, these botanicals can be used as a safe alternative approach, either alone or in integrated pest management (IPM), to control C. chainensis since they are environmentally benign and do not pose any risks to humans or the environment.

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