

Full Length Research Paper

Insecticidal activity of *Jatropha curcas* and *Ocimum canum* powders against *Spermophagus niger*, the major pest of stored roselle (*Hibiscus sabdariffa* L.) seeds in West Africa

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In West Africa, *Spermophagus niger* is recognised as the principal pest of stored roselle (*Hibiscus sabdariffa* L.) seeds and is commonly managed with synthetic insecticides. The use of botanical powders as biopesticides offers a sustainable alternative for managing stored product insect pests. This study aims to evaluate the insecticidal activity of *Jatropha curcas* and *Ocimum canum* powders on larvae 1 growth and on reproductive potential of *S. niger*. The results showed both *J. curcas* kernel and *O. canum* powders significantly reduced the adult lifespan of *S. niger* ($P < 0.05$). The number of offspring was markedly decreased in treatment with *J. curcas* kernel powder, which completely inhibited progeny production at 7.5%. The reproductive inhibition rate also increased with the *J. curcas* kernel. These results demonstrated that *J. curcas* powder effectively protected stored roselle seeds against *S. niger* infestation and could serve as a promising botanical alternative to synthetic insecticides in seed protection programs.

Key words: Biopesticides, *Spermophagus niger*, roselle seeds, pest control, *Ocimum canum*, *Jatropha curcas* kernel.

INTRODUCTION

Roselle, *Hibiscus sabdariffa* L. is a perennial vegetable plant of the Malvaceae family widely valued for its nutritional and economic importance (Morton, 1987). Its seeds are used to produce vegetable oil with properties like those of crude olive oil. The seed has (Atta and Imaizumi, 2002). In some African regions, roselle seeds are consumed post-fermentation locally known as "furundu" in Sudan (Yagoub et al., 2004) or "bicalga" in Burkina Faso (Bengaly et al., 2006). Calyces and leaves are globally used in foods and pharmaceutical industries

(Ifie et al., 2018) due to their richness in minerals, vitamin C, and anthocyanins (Cissé et al., 2009; Da-Costa-Rocha et al., 2014). The calyces, leaves and seeds are traded between various African and European countries constitutes a significant source of livelihood for roselle growers (Egharevba and Law-Ogbomo, 2007; Bakasso, 2010).

However, post-harvest losses are considerable due to *Spermophagus niger* (L.) (Coleoptera: Chrysomelidae), major pest of roselle seeds (Sanon et al., 2017). This

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Table 1. List of the plant species and their parts used as botanical insecticides in various studies against pest.

Plant species	Family	Parts used	Active components	References
<i>O. canum</i>	Lamiaceae	Leaves	Oxygenated monoterpenes, oxygenated sesquiterpenes, 1,8-cineole, cis, transpiperitol and linalool	Kiendrebéogo et al. (2011), Bassolé et al. (2005), and Tchoumboungnan et al. (2006)
<i>J. curcas</i>	Euphorbiaceae	Seeds, kernels, leaves	Phorbol ester, saponins, lectins, curcine, phytates, protease inhibitors, curcalonic acid	Maghuly and Laimer (2013) and Kumar et al. (2014)

seed pest also attacks *Hibiscus cannabinus*, indicating a possible expansion of others hosts (Kabore et al., 2025). It significantly reduces both the quality and quantity of stored roselle seeds withing just after three months (Amadou et al., 2016).

To prevent these losses, farmers commonly rely on synthetic insecticides, such as Chlorpyrifos-methyl (Calthio), Deltaméthrine/pyrimiphos-méthyl (Protect Dp) (Kabore et al., 2024). Although effective (Ogunwolu and Idowu, 1994; Adedire et al., 2011), these chemicals pose risks of pest resistance, user toxicity, and environmental pollution (Ahmad et al., 2024; Oni and Ileke, 2008). Given these drawbacks, safer and more sustainable alternative are urgently needed.

Many studies have shown the insecticidal properties of plant powders from seeds, leaves to control pest insects (Adebowale and Adedire, 2006; Nerio et al., 2010; Ilboudo et al., 2015; Shadia, 2011; Peña-Flores et al., 2025). *Jatropha curcas* and *Ocimum canum* are among the plant species with high insecticidal potential (Ramachandran et al., 2023; Alharbi and Alanazi, 2024). To date, little information is available on the efficacy of *O. canum* and *J. curcas* as biopesticides against *S. niger*. This study aims to evaluate the insecticidal effects of *J. curcas* and *O. canum* extracts for the protection of roselle seeds.

MATERIALS AND METHODS

Experimental conditions

The study was conducted under ambient conditions (25 to 28°C and 65 to 70% relative humidity) at the laboratory of fundamental and applied entomology, in Burkina Faso. The photoperiod during the study period was 12: 12 (L: D).

Mass rearing of *S. niger*

Twenty pairs of *S. niger* were placed in contact with 100 g of healthy seeds in rectangular Plexiglas boxes (length = 17 cm, width = 11 cm, height = 4 cm) using Sanon et al. (2017) method with minor modification. The assay was performed in triplicate. After 24 h, the insects were removed and the infested seeds were kept in ambient conditions (temperature: 25 to 28°C; relative humidity; 65 to 70%; photoperiod: 12:12 h, light: dark) until the emergence of adult insects, which were subsequently used to conduct

experiments.

Obtaining insecticide powders from various plants

In Gogo, a commune located in Zoundweogo province, *O. canum* plants and *J. curcas* seeds (Table 1) were harvested and transported to the laboratory at Joseph KI ZERBO University. There, the plant materials were dried in the shade for one week. After drying, the leaves of *O. canum* and *J. curcas* seeds were cleaned, ground using a mortar, and sieved through a 0.5 mm mesh to obtain a fine powder. *J. curcas* cake was obtained by BELWET society located in Kossodo (N 12°26'13.0", W001°29'5.95") after extraction of *J. curcas* seeds oil, in a mechanical press (model CA59G Komet, Mönchengladbach, Germany).

Assessment of the insecticidal effects of *J. curcas* seed powder and *O. canum* on the reproductive potential of *S. niger*

Powder of *J. curcas* kernel, *J. curcas* kernel cake and *O. canum* were used for the assays. For each botanical powder, four quantities were used: 1, 1.5, 2, and 2.5g. Twenty grams of healthy roselle seeds were placed in 11 jars, which were then covered for 3 min to ensure uniformity of the powder. This procedure allowed the preparation of treatments corresponding to concentrations of 5, 7.5, 10, and 12.5% (powder weight /seed weight). Four pairs of *S. niger* less than 24 h old were introduced into in each glass jar containing either treated or untreated seeds following Kabore et al. (2024b) method with a slight modification. Mortality due to factors other than the botanical powders was corrected using Abbott's formula (Abbott, 1925). Once all insects had died, the eggs laid in each batch were counted under a binocular loupe LEICA EZ4HD and placed under standard rearing conditions. Ten replicates were carried out for each concentration. An absolute control (untreated seeds) was also included with ten replicates. The following parameters were evaluated:

(1) Lifespan of adults (male and female): The duration between the insect's emergence and its death using the following formula:

$$\text{Mean lifespan} = \sum \frac{\text{Date of death} - \text{Date of emergence}}{n}$$

where n=numbers of individuals observed.

(2) Number mean of eggs laid by the female: The total number of eggs laid by a female during her lifetime using the following formula:

$$\text{Mean fecundity} = \sum_{i=1}^n \frac{\text{Total eggs laid by female } i}{n}$$

where n=number of females observed.

(3) The rate of reproductive inhibition (IR %) was calculated using the following formula:

$$\text{Rate of inhibition of reproduction (IR \%): } IR (\%) = \frac{(Cn - Tn)}{Cn} \times 100$$

where Cn = Number of newly emerged adults in the untreated control; Tn = Number of newly emerged adults in the treated grains.

Effect of various oils on the viability of eggs and early larval stages of *S. niger*

The effect of four concentrations (5, 7.5, 10, and 12.5% w/w, powder weight / seed weight) was tested on survival of eggs and early-stage larvae of *S. niger*. Twenty grams of roselle seeds were placed in Petri dishes. Powder of *J. curcas* kernel, *J. curcas* kernel cake and *O. canum* were added to seeds and thoroughly mixed. Ten newly emerged adults were introduced into each Petri dish and maintained under laboratory conditions. After 24 h of exposure, the insects were removed. Sixty seeds, each bearing a single fresh egg for each were selected and transferred to Petri dishes at a rate of 10 seeds per dish, then placed under laboratory rearing conditions following Koussoubé (2018) method with minor modification. The eggs were observed daily under a binocular magnifying glass. Hatched eggs were counted and removed from the dishes until hatching was complete. At the end of the experiment, the following parameters were determined: egg hatching rate determined using the following formula:

$$\text{Eggs hatching rate (\%)} = \frac{\text{Number of eggs hatched}}{\text{Number of eggs laid}} \times 100$$

Larvae penetration rate (%) was determined using the following formula:

$$\frac{\text{Number of larvae that penetrated the seeds}}{\text{Total number of larvae hatched}} \times 100$$

Data analysis

The data obtained were entered and recorded in Excel 2013. Graphs were generated with Graph Pad Prism version 8.4.3. R software version 4.2.2 was used to process the data. The distribution of the data distribution of each measured variable was assessed using the Shapiro - Wilk test. Comparison of the mean adult lifespan, mean number of eggs laid, mean number of emerging insects, reproductive inhibition was performed using a one-way analysis of variance followed by Tukey's post hoc test using "agricolae" package (Mendiburu, 2021). When the assumptions of Analysis of Variance (ANOVA) were not met, the non-parametric Kruskal-Wallis's test was used as an alternative. Statistical significance was considered at the 5% level.

RESULTS

Effect of different plant powders on the longevity of *S. niger* adult

The different plants powder significantly ($P < 0.05$) reduced the adult longevity of *S. niger* (Table 2). *J. curcas* kernel powder caused a significantly greater reduction in the lifespan of *S. niger* adults compared to the other treatments and the untreated control. At a concentration of 12.5%, the recorded mean longevity

values were 2.67 ± 0.244 days for *J. curcas* kernel powder, 3.67 ± 0.25 days for *O. canum*, 4.46 days for *J. curcas* kernel cake, and 9.40 ± 1.5 days for the absolute control.

Effect of different plant powders on the oviposition of *S. niger*

The results of adult *S. niger* oviposition are as shown in Figure 1. All the plants powders tested showed a significant reduction in the oviposition capacity of *S. niger* capacity ($P < 0.05$). A clearly discernible dose-dependent reduction in eggs laying by *S. niger* females was observed across the different powders. At the tested concentration of 12.5%, *J. curcas* kernel powder almost completely inhibited oviposition.

Effect of insecticidal powders on progeny

Table 3 shows the inhibition of progeny production of *S. niger* emerging from seeds treated with *J. curcas* kernel powder, *J. curcas* kernel powder cake and *O. canum* powder applied at different concentrations. All tested powders significantly reduced the emergence of *S. niger*. This reduction in progeny production is dose-dependent, and from a concentration of 10% *J. curcas* kernel powder, progeny emergence was completely inhibited

Effect of plant powders on the reproductive inhibition rate (% IR) in *S. niger*

Figure 2 shows the percentage of reproductive inhibition of *S. niger* emerging from seeds treated with *J. curcas* kernel powder, *J. curcas* kernel powder cake, and *O. canum* at different concentrations. As the concentrations increased, the reproductive inhibition rate also increased. Notably at a concentration of 10%, *J. curcas* kernel powder completely inhibited reproduction.

Effect of plants powders on egg hatching, and larvae 1 penetration rate

Table 4 shows the percentage egg hatching and first instar larval (L1) penetration into the seeds. The different plants powder significantly ($P < 0.05$) reduced both egg hatching and L1 larval penetration. In the untreated seeds, the rate of egg hatching and L1 penetration were approximately 94.00 ± 8.94 and 91.7 ± 0.08 respectively. In contrast, *J. curcas* kernel powder recorded the lowest rate of egg hatching and L1 penetration, starting from concentrations of 10% and 5%, respectively.

DISCUSSION

This study highlights insecticidal effect of extracted

Table 2. Impact of *O. canum* powder, *J. curcas* kernel cake, and *J. curcas* kernel powders on the lifespan of *S. niger* adults.

Treatments	Concentration (%)	Adults lifespan (mean $\pm$ SE)
Protect Dp	-	1.00 $\pm$ 0.00 ^e
Absolute control	0	9.40 $\pm$ 1.5 ^a
<i>Jatropha curcas</i> kernel powder	5	4.10 $\pm$ 0.411 ^{fg}
	7.5	3.63 $\pm$ 0.64 ^{gh}
	10	3.16 $\pm$ 0.35 ^{gh}
	12.5	2.67 $\pm$ 0.244 ^h
<i>Ocimum canum</i>	5	7.13 $\pm$ 0.64 ^b
	7.5	5.68 $\pm$ 0.70 ^d
	10	5.21 $\pm$ 0.46 ^{de}
	12.5	3.67 $\pm$ 0.25 ^{gh}
<i>Jatropha curcas</i> kernel cake	5	6.95 $\pm$ 0.25 ^{bc}
	7.5	5.91 $\pm$ 0.66 ^{cd}
	10	5.5125 $\pm$ 0.8 ^{de}
	12.5	4.4650 $\pm$ 0.89 ^{ef}
Probability	-	$\chi^2 = 128.77$, df = 13, P = 2.2e ⁻¹⁶

Means followed by different lowercase letters in the same column differ significantly according to Fischer's LSD test at the 5% threshold. SE: Standard error.

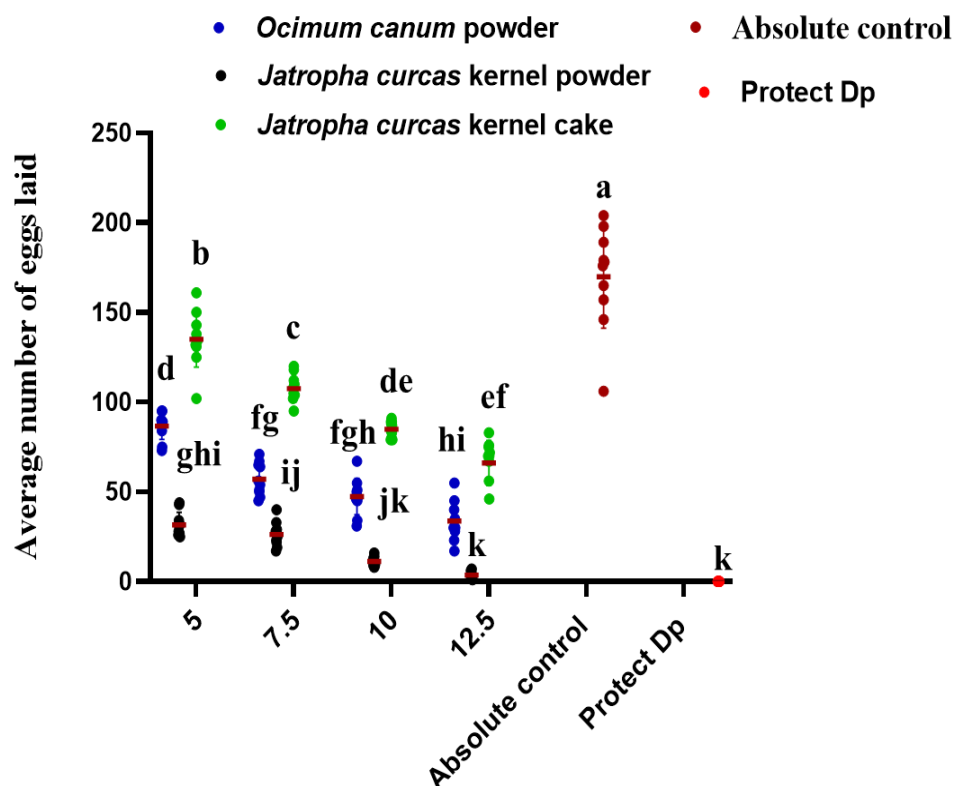
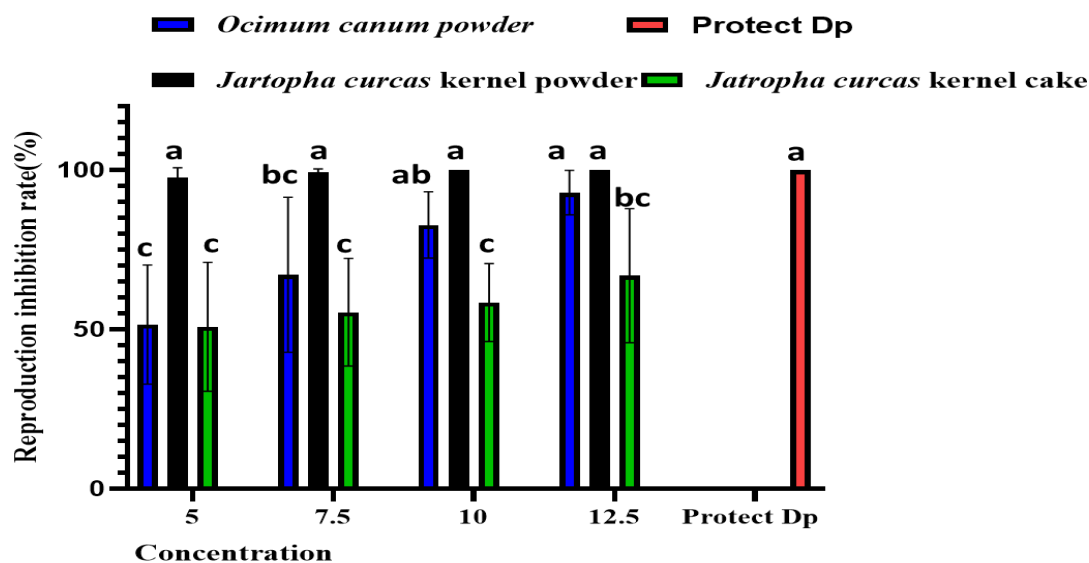
**Figure 1.** Effect of *O. canum* powder, *J. curcas* kernel cake, and *J. curcas* kernel powders on the number of eggs laid.

Table 3. Effect of *O. canum* powder, *J. curcas* kernel cake, and *J. curcas* kernel powder on adult progeny production of *S. niger*.

Treatment	Concentration (%)	Emergence (Mean $\pm$ SE)
Protect Dp	-	0.0 $\pm$ 0.0 ^d
Absolute control	0	87.0 $\pm$ 24.26 ^a
<i>Jatropha curcas</i> kernel powder	5	1.8 $\pm$ 2.44 ^d
	7.5	0.5 $\pm$ 0.84 ^d
	10	0.0 $\pm$ 0.00 ^d
	12.5	0.0 $\pm$ 0.00 ^d
<i>Ocimum canum</i>	5	41.1 $\pm$ 15.37 ^b
	7.5	25.8 $\pm$ 17.54 ^{bc}
	10	14.8 $\pm$ 8.41 ^{cd}
	12.5	6.9 $\pm$ 7.76 ^{cd}
<i>Jatropha curcas</i> kernel cake	5	43.6 $\pm$ 17.58 ^b
	7.5	37.3 $\pm$ 12.52 ^b
	10	34.9 $\pm$ 9.82 ^b
	12.5	26.0 $\pm$ 15.03 ^{bc}
Probability	-	$\chi^2 = 128.77$, df = 13, P = 2.2e ⁻¹⁶

Means followed by different lowercase letters in the same column differ significantly according to Fischer's LSD test at the 5% threshold, SE: standard error.

**Figure 2.** Effect of *O. canum* powder, *J. curcas* kernel cake, and *J. curcas* kernel powder on reproduction inhibition.

powder from aromatic plants of *J. curcas* and *O. canum* on the lifespan, the oviposition, the adult progeny production, and of reproductive inhibition of *S. niger*. Similar results were reported by previous studies,

including those of Alharbi and Alanazi (2024) on *Rhynchophorus ferrugineus*, Kabore et al. (2024a) on *Corcyra cephalonica*, Silva et al. (2012) on *Rhyzopertha dominica* F and *Tribulium costaneum*.

Table 4. Toxicity of *O. canum* powder, *J. curcas* kernel cake, and *J. curcas* kernel powder on egg hatching and first Instar Larval penetration rates.

Treatment	Concentration (%)	Egg hatching rate (%) (mean $\pm$ SE)	Larvae 1 penetration rate (%) (mean $\pm$ SE)
Protect Dp	-	0.00 $\pm$ 0.00 ^g	0.00 $\pm$ 0.00 ^h
Absolute control	0	94.00 $\pm$ 8.94 ^a	91.7 $\pm$ 0.08 ^a
<i>J. curcas</i> kernel powder	5	12.00 $\pm$ 4.47 ^f	0.00 $\pm$ 0.00 ^h
	7.5	4.000 $\pm$ 5.47 ^g	0.00 $\pm$ 0.00 ^h
	10	0.00 $\pm$ 0.00 ^g	0.00 $\pm$ 0.00 ^h
	12.5	0.000 $\pm$ 0.00 ^g	0.00 $\pm$ 0.00 ^h
<i>O. canum</i>	5	70.36 $\pm$ 4.54 ^{bc}	40.56 $\pm$ 4.99 ^{de}
	7.5	64.36 $\pm$ 2.68 ^c	31.36 $\pm$ 1.57 ^f
	10	54.36 $\pm$ 2.68 ^d	25.31 $\pm$ 0.77 ^g
	12.5	38.36 $\pm$ 5.46 ^e	23.76 $\pm$ 1.45 ^g
<i>J. curcas</i> kernel cake	5	78.58 $\pm$ 4.96 ^b	64.36 $\pm$ 2.68 ^b
	7.5	70.35 $\pm$ 3.89 ^{bc}	54.33 $\pm$ 2.58 ^c
	10	69.33 $\pm$ 1.96 ^{bc}	44.36 $\pm$ 2.7 ^d
	12.5	64.36 $\pm$ 2.68 ^c	37.16 $\pm$ 4.13 ^{ef}
Probability	-	$\chi^2 = 331.5$, df = 13, P = 2.2e ⁻¹⁶	$\chi^2 = 628.3$, df = 13, P = 2.2e ⁻¹⁶

Means followed by different lowercase letters in the same column differ significantly according to Fischer's LSD test at the 5% threshold. SE: Standard error.

The results obtained in this work revealed that *J. curcas* and *O. canum* significantly reduced the lifespan of *S. niger* populations. This reduction in longevity may be attributed by the presence of compounds in these plants. According to Wang et al. (2023), *J. curcas* leaves contains phorbol esters, saponins, lignans, biflavonoids, and flavonoids. Bashir and El Shafie (2013) showed that the seed oil from *J. curcas* concentration between 5 and 20% induced significant mortality rate ranging from 22.4 to 59.2%. Similarly, *O. canum* is rich in eugenol, linalool, and 1.8-cineole. These compounds could disrupt the insect nervous system. According to Murugan et al. (2016), *O. canum* powder exhibited insecticidal activity against adult mosquitoes with reported mortality of 93.74 and 79 for *Culex quinquefasciatus*, *Aedes aegypti* and *Anopheles stephensi*, respectively. Moreover, the observed reduction in longevity could be explained by with the inhibition of acetylcholine receptors due to contact toxicity of the powders (Rattan, 2010).

In addition, the results showed that extracted powder *J. curcas* kernel powder and *O. canum* powder significantly reduced the number of eggs laid by *S. niger* females, eggs hatching, and adult progeny production. The most pronounced reduction was obtained with *J. curcas* kernel powder at the 10% concentration. The decrease in oviposition could primarily be attributed to the toxic compounds present in *Jatropha* which reduce female

lifespan.

The toxicity of these compounds adversely affects female longevity, consequently reducing the number of eggs deposited. Adebawale and Adedire (2006), Kshirsagar (2010) similarly reported that *J. curcas* oil effectively reduced oviposition at all tested concentrations. *O. canum* powder also significantly reduced the emergence of *S. niger* to 6.9%, compared with 87% in the untreated control. Bagavan et al. (2009) reported that *O. canum* leaves are rich in flavonoids, saponins, and tannins, and contain considerable amounts of phenolic compounds and alkaloids, which may contribute to its insecticidal activity. According to Ilboudo et al. (2015), *O. canum* affects both egg production and hatchability in *Callosobruchus maculatus*, likely due to its toxic constituents.

These findings also revealed that *J. curcas* kernel powder completely inhibited the offspring production of *S. niger* populations at the 10% concentration. This total suppression of progeny emergence may be attributed to larval mortality resulting from physiological disturbance in the hormonal system, suffocation, antifeedant effect and/or lethal toxicity of chemical compounds present in the powder. Similar findings were reported by Alharbi and Alanazi (2024) on *R. ferrugineus*; Kovendan et al. (2011) on *C. quinquefasciatus*, who highlighted antifeedant and larvicidal properties of *J. curcas* extracts.

Conclusion

J. curcas and *O. canum* exhibit insecticidal properties against *S. niger*. According to the results, both significantly reduced adult lifespan, number of eggs laid by *S. niger* females, emergence. At a concentration of 10%, *O. canum* and *J. curcas* kernel powders inhibited progeny production by 55 and 100%, respectively. In contrast *Jatropha* cake recorded the lowest mortality rate. This botanical powder could serve as a viable alternative to synthetic insecticides for sustainable pest management. The results obtained in this study provide a basis for further investigation into adulticidal and larvicidal efficacy of *J. curcas* and *O. canum*.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interest.

REFERENCES

- Abbott WS (1925). A method of computing the effectiveness of an insecticide. *Journal of Economic Entomology* 18:265-267.
- Adebowale K, Adedire C (2006). Chemical composition and insecticidal properties of the underutilized *Jatropha curcas* seed oil. *African Journal of Biotechnology* 5(10):901-906.
- Adedire CO, Obembe OO, Akinkurolele RO, Oduleye O (2011). Response of *Callosobruchus maculatus* (Coleoptera: Chrysomelidae: Bruchinae) to extracts of cashew kernels. *Journal of Plant Diseases and Protection* 118(2): 75-79.
- Ahmad M, Ahmad F, Alsayegh A, Zeyaulah M, AlShahrani A, Muzammil K, Saati A, Wahab S, Elbendary E, Kambal N (2024). Pesticides impact on human health and the environment with their mechanisms of action and possible countermeasures. *Heliyon* 10(7):E29128.
- Alharbi A, Alanazi A (2024). Studying the effectiveness of *Jatropha curcas* L. Extract as a repellent, antifeedant, and toxic substance against red palm weevil (*Rhynchophorus ferrugineus*) adult insects in Saudi Arabia. *Journal of King Saud University* 36(8):103322.
- Amadou L, Baoua IB, Baributsa D, Williams S B, Murdock L (2016). Triple bag hermetic technology for controlling a bruchid (*Spermophagus* sp.) (Coleoptera, Chrysomelidae) in stored *Hibiscus sabdariffa* grain. *Journal of Stored Products Research* 69:22-25. <https://doi.org/10.1016/j.jspr.2016.05.004>
- Atta MB, Imaizumi K (2002). Some Characteristics of Crude oil extracted from Roselle (*Hibiscus sabdariffa* L.) seeds cultivated in Egypt. *Journal of Oleo Science* 51(7):457- 461.
- Bagavan A, Kamaraj C, Elango G, Zahir AA, Rahuman AA (2009). Adulticidal and larvicidal efficacy of some medicinal plant extracts against tick, fluke and mosquitoes. *Veterinary Parasitology* 166(3-4):286-292.
- Bakasso Y (2010). Ressources génétiques des roselles (*Hibiscus sabdariffa* L.) du Niger: Evaluations agromorphologique et génétique. Université de Niamey, Niger.
- Bashir EM, El Shafie HA (2013). Insecticidal and antifeedant efficacy of *Jatropha* oil extract against the desert locust, *Schistocerca gregaria* (Forsk.) (Orthoptera: Acrididae). *Agriculture and Biology Journal of North America* 4(3):260-267.
- Bassolé IHN, Nébié R, Savadogo A, Ouattara CT, Barra N, Traoré SA (2005). Composition and antimicrobial activities of the leaf and flower essential oils of *Lippia chevalieri* and *Ocimum canum* from Burkina Faso. *African Journal of Biotechnology* 4(10):1156-1160.
- Bengaly M, Béré A, Traoré A (2006). The chemical composition of bikalga, a traditional fermented roselle (*Hibiscus sabdariffa* L.) seeds condiment. Part II: evaluation of mineral, total polyphenols and phytic acid content, predicting the iron bioavailability. *Electronic Journal of Environmental, Agricultural and Food Chemistry* 1(1):7-11.
- Cissé M, Dornier M, Sakho M, Mar Diop C, Reynes M, Sock O (2009). La production de bissap (*Hibiscus sabdariffa* L.) au Sénégal. *Fruits* 64(1):1-14.
- Da-Costa-Rocha I, Bonnlaender B, Sievers H, Pischel I, Heinrich M (2014). *Hibiscus sabdariffa* L-A phytochemical and pharmacological review. *Food Chemistry* 165:424-443. <https://doi.org/10.1016/j.foodchem.2014.05.002>
- Egharevba RKA, Law-Ogbomo KE (2007). Comparative effects of two nitrogen sources on the growth and the yield of Roselle (*Hibiscus sabdariffa*) in rainforest region: a case study of Benin-city, Edo State. *Nigeria. Agronomy Journal* 6(1):142-146.
- Ilboudo Z, Dabiré-Binso CL, Sankara F, Nébié RCH, Sanon A (2015). Optimizing the use of essential oils to protect stored cowpeas from *Callosobruchus maculatus* (Coleoptera: Bruchinae) damage. *African Entomology* 23(1):94-100.
- Ifie I, Ifie BE, Ibitoye DO, Marshall LJ, Williamson G (2018). Seasonal variation in *Hibiscus sabdariffa* (Roselle) calyx Phytochemical profile, soluble solids and α -glucosidase inhibition. *Food Chemistry* 261:164-168.
- Kabore A, Sawadogo RSW, Koussoubé S, Boly A Sanou A, Waongo A, Traore F, Ba MN, Sanon A (2024a). valuation of *Corcyra cephalonica* Stainton (Lepidoptera: Pyralidae) damage and insecticidal efficacy of six plant powders on the three main cereals produced in Burkina Faso. *Journal of Stored Products and Postharvest Research* 15(2):24-30. DOI: 10.5897/JSPPR2024.0344
- Kabore E, Kambou, SF, Kam, KW, Koussoubé J C, KI KFM, Sanon A, Ilboudo Z (2024b). Postharvest management and phytosanitary practices used to preserve sorrel seeds, *Hibiscus sabdariffa* L. in Burkina Faso. *International Journal of Innovation and Applied Studies* 43(3):685-695.
- Kabore E, Koussoubé JC, Sanon A, Ilboudo Z (2025). Morphological identification and assessment of biometric parameters of *Spermophagus niger motschulsky* (Coleoptera: Chrysomelidae), insect pest of kenaf (*Hibiscus cannabinus* L.) seeds during post-harvest storage in Burkina Faso: First report. *Bulletin of Entomological Research* pp. 1-7. <https://doi.org/10.1017/S0007485325100382>
- Kiendrebéogo M, Coulibaly AY, Nebié RCH, Zeba B, Lamien CE, Lamien-Meda A, Nacoulima OG (2011). Antiacetylcholinesterase and antioxidant activity of essential oils of six medicinal plants from Burkina Faso. *Revista Brasileira de Farmacognosia* 21(1):63-69.
- Koussoubé JC (2018). *Spermophagus niger Motschulsky* (Coleoptera : Chrysomelidae : Bruchinae : Amblycerini), ravageur des graines d'oseille (*Hibiscus sabdariffa* L.) en stockage au Burkina Faso: Caractérisation génétique et morphologique, bioécologie et ébauche de lutte. Doctoral dissertation, Thèse Unique de Doctorat, Université JKZ (Burkina Faso), 106p.
- Kovendan K, Murugan K, Vincent S, Kamalakannan S (2011). Larvicidal efficacy of *Jatropha curcas* and bacterial insecticide, *Bacillus thuringiensis*, against lymphatic filarial vector, *Culex quinquefasciatus* Say (Diptera: Culicidae). *Parasitology Research* 109(5):1251-1257.
- Kshirsagar RV (2010). Insecticidal activity of *Jatropha* seed oil against *Callosobruchus maculatus* (Fabricius) infesting *Phaseolus aconitifolius* Jacq. *The Bioscan* 5(3):415-418.
- Kumar V, Singh S, Shukla A, Chaudhary J (2014). Evaluation of subacute toxicity of *Jatropha curcas* seeds and seed oil toxicity in rats. *Indian Journal of Veterinary Pathology* 38(2):88-93.
- Morton JF (1987). *Roselle* (*Hibiscus sabdariffa* L.). In: Dowling CF (ed.), *Fruits of warm climates*. Greensboro, NC: Media Inc., Miami, United States pp. 281-286.
- Maghuly F, Laimer M (2013). *Jatropha curcas*, a biofuel crop: Functional genomics for understanding metabolic pathways and genetic improvement. *Journal of Biotechnology* 8(10):1172-1182. DOI 10.1002/biot.201300231
- Mendiburu F (2021). *agricolae: Statistical Procedure for Agriculture research* (Version 1.3-5) [Rpackage]. <https://CRAN.R-project.org/package=agricolae>.
- Murugan JM, Ramkumar G, Shivakumar MS (2016). Insecticidal potential of *Ocimum canum* plant extracts against *Anopheles stephensi*,

- Aedes aegypti* and *Culex quinquefasciatus* larval and adult mosquitoes (Diptera: Culicidae). *Natural Product Research* 30(10):1193-1196. <https://doi.org/10.1080/14786419.2015.1046069>
- Nerio LS, Olivero-Verbel J, Stashenko E (2010). Repellent activity of essential oils: A review. *Bioresource Technology* 101(1):372-378. doi: 10.1016/j.biortech.2009.07.048
- Ogunwolu EO, Idowu O (1994). Potential of powdered *Zanthoxylum zanthoxyloides* root bark and *Azadirachta indica* seed for the control of the cowpea seed bruchid, *Callosobruchus maculatus* in Nig. *Journal of African zoology* 108:521-528
- Oni MO, Ileke KD (2008). Fumigant toxicity of four botanical plant oils on survival, egg laying and progeny development of the dried yam beetle, *Dinoderus porcellus* (Coleoptera:Bostrichidae) Ibadan. *Jornal of Agricultural Research* 4(2):31-36.
- Peña-Flores C, Zapién-Martínez A, Sánchez-Cruz G, Reyes-Velasco L, Segura-Salvador A, Vargas-Arzola J, Hernández-Osorio LA, Torres-Aguilar H, Bernardino HU (2025). Insecticidal and Repellent Activity of Plant Powders on the Weevil (*Sitophilus zeamais*) in Stored Corn Grains in a Rural Community of Oaxaca, Mexico. *Insects* 16(3):329. <https://doi.org/10.3390/insects16030329>.
- Ramachandran M, Deepika N, Jayakumar M (2023). Toxicity of *Ocimum americanum* L. extracts against *Aedes aegypti* larvae (Diptera Culicidae) and their impact on insecticide resistance. *Archives of Insect Biochemistry and Physiology* 113(1):e21961. <https://doi.org/10.1002/arch.21961>
- Rattan RS (2010). Mechanism of action of insecticidal secondary metabolites of plants origin. *Crop Protection* 29:913-920. <https://doi.org/10.1016/j.cropro.2010.05.008>
- Sanon A, Koussoubé JC, Ba MN, Dabire-Binso LC and Sembène M (2017). Report on *Spermophagus* Niger Motschulsky, 1866 (Coleoptera: Chrysomelidae: Bruchinae: Amblycerini) infesting the seeds of roselle, *Hibiscus sabdariffa* L. (Malvaceae) during post-harvest storage in Burkina Faso. *Journal of Stored Products Research* 72:64-67.
- Shadia EA (2011). Control strategies of stored product pest. *Journal of Entomology* 8:101-122.
- Silva G, Faroni L, Sousa A, Freitas R (2012). Bioactivity of *Jatropha curcas* L. to insect pests of stored products. *Journal of Stored Products Research* 48:111-113. <https://doi.org/10.1016/j.jspr.2011.10.009>
- Tchoumboungang F, Zollo PA, Avlessi F, Alitonou G, Sohounhloue D, Ouamba J, Tsomambet A, Okemy-Andissa N, Dagne E, Agnani H (2006). Variability in the chemical compositions of the essential oils of five *Ocimum* species from tropical African area. *Journal of Essential Oil Research* 18(2):194-199.
- Wang Y, Zhou D, Bai X, Meng Q, Xie H, Wu G, Chen G, Hou Y, Li N (2023). Chemical constituents from leaves of *Jatropha curcas*. *Chinese Herbal Medicines* 15(3):463-469.
- Yagoub AE-GA, Mohamed BE, Ahmed AH, El Tinay AH (2004). Study on Furundu, a traditional Sudanese fermented Roselle (*Hibiscus sabdariffa* L.) seed: Effect on in vitro protein digestibility, chemical composition, and functional properties of the total proteins. *Journal of Agricultural and Food Chemistry* 52(20):6143-6150. <https://doi.org/doi:10.3923/pjn.2008.352.358>