BIOCIDAL EFFECT OF SOME QUINOA EXTRACTS AGAINST COTTON LEAFWORM INSECT

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Field trials were conducted to evaluate the biological activity of quinoa extracts using different parts and solvents against the cotton leafworm *Spodoptera littoralis* under laboratory conditions. The results concluded that saponin extract, water and acetone extracts of quinoa grains, followed by water, acetone and ethanol extracts of quinoa leaves and roots were very active against cotton leafworm especially after four days of exposure periods with 100% corrected mortalities percentage. Ethanol extract of quinoa grains and hexane extract of quinoa leaves as well as roots showed 90% corrected mortalities against cotton leafworm after four days of exposure periods. However, all stem extracts and leaf extracts using hexane and petroleum ether showed the least toxicity against the cotton leafworm with corrected mortalities between 54.0 to 20.0%. While ether extract of quinoa roots and grains showed 80.0 and 75.0% corrected mortalities, respectively after four days of treatment and calculated lethal concentration (LC_{50}) values were in opposite relationship with the time post-treatment for all the tested treatments, after 1, 2, 3 and 4 days of treatment. The results of concentrations using efficiency (CUE) showed that the highest efficiency rate was recorded when using saponin, grains, leaves and roots extracted from quinoa plants at a concentration of 20, 40%. The results suggest that all extractions are associated with the death of cotton leafworms and have potential insecticidal activity. Further investigations may be needed to

develop formulation from quinoa extracts to include in *Spodoptera littoralis* integrated management programs.

Keywords: cotton leafworm, *Spodoptera littoralis,* toxicity, saponin, quinoa extracts, biocidal effect efficiency

INTRODUCTION

Quinoa is a crucial crop for both food sovereignty and security (Villacrés et al., 2022). Chemical resistance and insect population outbreaks are just two issues brought on by the extensive usage of chemical substances (Rizk et al., 1990). As a result, the government decided to use fewer chemicals and attempted to implement integrated pest management programs that would include bio-control agents and other alternative control techniques. New plant products for pest control have recently gained popularity and their discovery and benefits need further research (Isman and Grieneisen, 2013). Botanical pesticides are natural chemicals extracted from pesticide plants and are an excellent alternative to chemical pesticides as they can protect crops from the harmful effects of pesticides. Essential oils, flavonoids, alkaloids, glycosides, esters and fatty acids, saponins" are plant-derived pesticides that have a range of chemical properties and modes of action on pests, including repellents, feeding inhibitors, poisons, growth inhibitors and attractants. Therefore, botanical pesticides are superior to chemical pesticides and are accepted by organic crop producers in developed countries (Hikal et al., 2017). Quinoa (*Chenopodium quinoa* Willd.) contains high levels of biologically active phytoecdysteroids, which are involved in plant defense against insects, and have shown a range of beneficial pharmacological effects in mammals (Graf et al., 2014). These compounds shield birds, insects, and harmful bacteria with a range of physiological and ecological roles. Steroid or triterpenoid saponins are a type of secondary plant metabolite with a range of biological actions (Tava and Odoardi, 1996; Vincken et al., 2007 and Goławska et al., 2012). By engaging in these behaviors, plants strengthen their defenses against molluscs, infections, and insects (Dowd et al., 2011 and Lee et al., 2017).

Triterpene saponins, which give quinoa its bitter taste, must be eliminated before consumption, greatly increasing the cost of manufacture. There is virtually little evidence to support the notion that quinoa saponins offer defense against microbiological diseases and herbivores. According to the study, three different nocturnal insect species' larvae were used to test saponin. Antifungal activity against eight species was measured using bran extract mixed with PDA medium. The study's findings indicate that more research is needed to understand species-specific reactions, even while quinoa saponins in bran extracts may offer some defense against particular insects and phytopathogens (McCartney et al., 2019).

Numerous plant families produce a substance called saponin, which has been demonstrated to have defensive properties against insects and to control the growth and development of insects (Güçlü-Ustündağ and Mazza, 2007). There are several benefits to using non-refined extracts for pest management; these include low environmental impact, cheap usage cost, and a decreased likelihood of pesticide resistance because they include a lot of bioactive components (Isman, 2008). However, because of the quick degradation of bioactive chemicals, the drawbacks include unpredictable efficacy, low toxicity, and low persistence to target pests (Pavela, 2016). More than forty quinoa saponin structures have been discovered in the past thirty years, and the resultant molecular entities are "oleanolic and organic acids, hederagenin, 3β,23,30-trihydroxy-olean12-en-28-oic acid, 3β-hydroxy-27-oxo-Olean-12en-28-oic acid, and 3β,23,30 trihydroxy and phytolaccagenic.

Spodoptera littoralis (Boisd.), a cotton leafworm, is regarded as one of the most dangerous pests of many plant families. It consumes the leaves of many different plant species all year round (Taha-Salaime et al., 2020). One of the most damaging pests of cotton, which is regarded as the most valuable crop in Egypt, is *Spodoptera littoralis*. Larvae affect a variety of commercially significant crops in addition to feeding on cotton leaves. Thus, several control strategies have been implemented to deal with this pest (Aydin and Gurkan, 2006).

The current study aims to evaluate the insecticidal activity of quinoa extracts on *Spodoptera littoralis*, under laboratory conditions which are the most destructive in Egypt.

MATERIALS AND METHODS

1. Plant Materials

Quinoa plants (*Chenopodium quinoa*) were cultivated in Ismailia Governorate, Egypt, and plant samples were collected from the experiment free of any insecticide contamination.

2. Extraction Procedures

2.1. Extraction of quinoa plants

Collected plants were taken directly to the laboratory and divided into leaves, stems, roots and grains and left to air dry in a clean, well-ventilated place. Dried plants were ground using an electric mill, sieved and kept for extraction. One hundred grams of the ground plant material were successively extracted with five organic solvents of increasing polarities, petroleum ether (40-60°C), hexane, acetone, ethanol, and hot water. The mixtures (1 powder: 3 solvent) were mechanically shaken for three hours. The extracts were then filtered through anhydrous sodium sulfate and concentrated under vacuum at 40°C. The resulting crude extracts were weighed and kept in a refrigerator

until evaluation. Residual powders were allowed to dry before starting the successive extractions (Ali, 1999).

1.2. Physical extraction of saponins

Each genotype's ten grams of grains underwent a 15-minute scarification procedure using abrasive paper No. 600. The resultant powder, or bran, was then gathered, sieved, and weighed (Ocación et al., 2022).

1.3. Chemical extraction of saponins

Flores et al. (2013) process was modified and used to the extraction using chemical solvents. Each quinoa genotype's 50 g of grains was added to 150 ml of 70% ethanol in an Erlenmeyer flask over 48 hours. After filtering the mixture, the process was carried out once more for a whole day. Subsequently, the extracts were blended and dried in a water bath at 65°C. After dissolving the residue in ten milliliters of distilled water, n-butanol was used for extraction. In a rotary evaporator, the extracts were finally concentrated to dryness till a dry residue was produced.

2. Biological Activity of the Plant Extracts

2.1. Rearing technique of the cotton leafworm, *Spodoptera littoralis*

At the plant protection department, Desert Research Center, Cairo, Egypt, a stock culture of cotton leafworm, *Spodoptera littoralis* was obtained from a laboratory strain, maintained for several generations without any insecticidal or microbial pressure. The provided insects were used in our study. According to El-Defrawi et al. (1964) the maintained insect culture was reared under constant conditions: 26±2°C and 70±5% relative humidity (RH) and 12: 12 L: D photoperiod. Larvae were maintained in glass jars; at the base of each jar an amount of sawdust was placed to absorb excess humidity. As a source of food, larvae were reared on fresh castor bean leaves, *Ricinus communis* provided daily in appropriate quantities. The formed pupae were collected and placed in clean Jars with moist saw dust placed at the base to provide the pupation site. Newly emerged adult moths were confined into oviposition cages and provided with 10% sugar solution. Egg-masses were collected daily and kept in small clean glass cups until hatching. Newly hatched larvae were transferred to glass jars (Sallam, 2008; Sallam, 2017 and Ali and Sallam, 2023)

2.2. Bioassay technique of plant extract of quinoa

Various quinoa plant crude extracts were used to conduct tests for each of the individual treatments. According to Abo El-Ghar et al. (1994) and El-Sheikh et al. (2013), the leaf-dipping technique was used. To find out how harmful crude quinoa extracts were to *Spodoptera littoralis* larvae, freshly molted third-instar larvae (until less than a day old) were fed castor bean leaves that had been treated with each treatment by dipping a leaf into the solution. A thin layer of the plant extract was left behind after the solvent evaporated. For every treatment, a minimum of one hundred larvae were utilized, divided into five replicates, each containing twenty larvae. The larvae

were put into 400 ml transparent glass jars with treated leaves and wrapped with muslin pieces (Abo El-Ghar et al., 2013). Every day, the mortality of the larvae was recorded, and they were deemed dead if they showed no signs of activity. As a control, larvae were fed on leaves that had just been treated with various solvents. Following one, two, three, and four days of treatment, mortality percentages were assessed and adjusted using Abbott's formula (Abbott, 1925). Toxicological tests were performed on crude extracts using the cotton leafworm *Spodoptera littoralis*. The same experiments were performed on the crude extracts that showed encouraging results in these first tests, employing a range of concentrations (100, 80, 60, 40 and 20%). The studied extracts' LC_{50} values were all computed in milligrams per milliliter.

3. Statistical Analysis and Toxicity Lines

3.1. Toxicity lines

To assess the relative effectiveness of extracts as spots as insecticides, all data from various tests were statistically analyzed. Using Abbott's formula (1925), all percent mortalities in the current study were adjusted for natural mortality. Using the Finney (1971) method, mortality curves (LC-P Lines) were sketched on probit logarithmic graph paper and computed using the POLO software.

3.2. Statistical Analysis

The data were statistically analyzed using variance test (ANOVA) of Duncan's Multiple Range test to compare variation between the means (p less than or equal 0.05).

3.3. Concentrations using efficiency (CUE)

The efficiency of using different concentrations of some solvents (hot water, acetone, ethanol and hexane) as well as saponin using different parts of quinoa plant (grains, leaves and roots) was calculated from the following equation, according to Almadini et al. (2019):

$$\text{Concentrations Using Efficiency (CUE)} = \frac{\text{insect death rate (\%)}}{\text{percentage of used concentration}}$$

RESULTS

1. Toxicity of Different Quinoa Extracts Against Cotton Leafworm Larval Stage Under Laboratory Conditions

Five solvents (water, acetone, ethanol, hexane and petroleum ether) were used to extract leaves, stems, grains and roots of quinoa plants. Saponin extracts were also extracted with special technique. Extracts were tested for their toxicity against cotton leafworm, *Spodoptera littoralis.*

2. Toxicity of Quinoa Leaf Extracts Against Cotton Leafworm Larval Stage

As a general conclusion, it could be said that the toxicity against cotton leafworm larval stage increased as exposure time increased. Data in Table (1)

show the corrected mortality percentage of water leaves extract of quinoa plants against *Spodoptera littoralis.* Water and acetone leaf extracts gave 100% corrected mortality percentage followed by ethanol extract with corrected mortality percentage 90% after four days exposure time against cotton leafworm. Hexane and petroleum ether extracts gave the weakest insecticidal effect, that recording (55 and 34%, respectively) corrected mortality percentage after four days exposure time against cotton leafworm

Table (1). Toxicity of quinoa leaf extracts against cotton leafworm larval stage.

Solvent	Corrected mortality (%)				
	After 1 day	After 2 days	After 3 days	After 4 days	Mean (solvent)
Water	60 ^{d}	82.1 ^{bc}	100.0 ^{a}	100.0 ^{a}	**85.53** ^{A}
Acetone	43 ^{e}	58.0 ^{d}	78.0 ^{c}	100.0 ^{a}	**69.75** ^{B}
Ethanol	44 ^{e}	55.0 ^{d}	77.0 ^{c}	90.0 ^{b}	**66.50** ^{B}
Hexane	20 ^{h}	38.0^{ef}	44.0 ^{e}	55.0 ^{d}	**39.25** ^{C}
Petroleum ether	15 ^{h}	23.0 ^{gh}	30.0 ^{fg}	34.0 ^{f}	**25.50** ^{D}
Control	0 ^{i}	0.0 ^{i}	0.8 ^{i}	1.2 ^{i}	**0.50** ^{E}
Mean (day)	**30.33** ^{D}	**42.68**^{C}	**54.97** ^{B}	**63.37** ^{A}	
F test	F (solvent)=1509.5, F (day)= 509.4, F (solvent*day)=29.7				
P value	P (solvent)=0.0001, P (day)=0.000, P (solvent*day)=0.0001				

3. Toxicity of Quinoa Stem Extracts Against Cotton Leafworm Larval Stage

From Table (2), the effect of stem extracts of quinoa plants on mortality of *Spodoptera littoralis* larvae was from moderate to low. Water extract gave moderate mortality with 54% corrected mortality followed by acetone extract with a corrected mortality percentage of 41% against cotton leafworm after four days of exposure time, respectively. A low effect on corrected mortality percentage was observed when *Spodoptera littoralis* larvae were treated with ethanol, hexane and petroleum ether with corrected mortality (32, 21 and 20%, respectively), after 4 days exposure time.

4. Toxicity of Quinoa Grains Extracts Against Cotton Leafworm Larval Stage

Data presented in Table (3) show the toxic effects of the four solvents of grains of quinoa extracts, water, acetone, ethanol, hexane and petroleum ether in addition to saponin extract against cotton leafworm leaf dip method treated with these materials. Saponin extracts were highly effective with corrected mortality (75, 90, 100 and 100%) through 1, 2, 3 and 4 days of exposure time against cotton leaf worm, respectively. The water, acetone and ethanol treatments were the most toxic against cotton leafworm that gave 100% corrected mortality percentage. While hexane treatment was the second one with 90% corrected mortality percentage after four days exposure period.

Whereas petroleum ether extract was the fourth one, its corrected mortality was 75% after four days exposure period.

Table (2). Toxicity of quinoa stem extracts against cotton leafworm larval stage.

Solvent	Corrected mortality (%)				
	After 1 day	After 2 days	After 3 days	After 4 days	Mean (solvent)
Water	25 $^{d-f}$	31.0 ^{cd}	36.0^{bc}	54 ^{a}	**36.50** ^{A}
Acetone	15 $^{g-j}$	21.0 $^{e-g}$	27.0 ^{de}	41 ^{b}	**26.00** ^{B}
Ethanol	12 $^{i-k}$	15.0 $^{g-j}$	19.0 $^{f-i}$	32 ^{cd}	**19.50** ^{C}
Hexane	10 $^{j-l}$	11.0 ^{jk}	13.0 $^{h-j}$	21 $^{e-g}$	**13.75** ^{D}
Petroleum ether	2 ^{m}	5.0 ^{l}	10.$^{0\ j-l}$	20 $^{e-h}$	**9.25** ^{E}
Control	0 ^{mn}	0.2^{mn}	0.6^{mn}	1^{mn}	**0.45** ^{F}
Mean (day)	**10.67** ^{D}	**13.87** ^{C}	**17.60** ^{B}	**28.17** ^{A}	
F test	F (solvent)=348.3, F (day)= 212.0, F (solvent*day)=9.53				
P value	P (solvent)=0.001, P (day)=0.000, P (solvent*day)=0.000				

Table (3). Toxicity of quinoa grains extracts against cotton leafworm larval stage.

Treatment	Corrected mortality (%)				Mean (solvent)
	After 1 day	After 2 days	After 3 days	After 4 days	
Saponin	75.0 ^{c}	90.0 ^{b}	100.0 ^{a}	100.0 ^{a}	**91.25** ^{A}
Water	65.0 ^{d}	90.0 ^{b}	100.0 ^{a}	100.0 ^{a}	**88.75** ^{AB}
Acetone	53.0 ^{e}	90.0 ^{b}	100.0 ^{a}	100.0 ^{a}	**85.75** ^{B}
Ethanol	41.0 ^{fg}	75.0 ^{c}	90.0 ^{b}	100.0 ^{a}	**76.50** ^{C}
Hexane	33.0 ^{g}	44.0 ^{f}	66.0 ^{d}	90.0 ^{b}	**58.25** ^{D}
Petroleum ether	23.0 ^{h}	38.0 ^{fg}	68.0 ^{cd}	75.0 ^{c}	**51.00** ^{E}
Control	0.2 ^{i}	0.4 ^{i}	0.8 ^{i}	1.2 ^{i}	**0.65** ^{F}
Mean (day)	**41.46**^{C}	**61.06** ^{B}	**74.97**^{A}	**80.89**^{A}	
F test	F (solvent)=1502.2, F (day)= 764.5, F (solvent*day)=46.1				
P value	P (solvent)=0.0001, P (day)=0.000, P (solvent*day)=0.000				

5. Toxicity of Quinoa Root Extract Against Cotton Leafworm Larval Stage

Data presented in Table (4) show that water, acetone and ethanol of roots quinoa extracts were the most toxic against cotton leafworm with 100% mortality as compared with hexane and petroleum ether tested extracts which achieved 90-80% mortality.

Table (4). Toxicity of quinoa roots extracts against cotton leafworm larval stage.

Solvent	Corrected mortality (%)				Mean (solvent)
	After 1 day	After 2 days	After 3 days	After 4 days	
Water	71.0 ^{d}	100.0 ^{a}	100.0 ^{a}	100 ^{a}	**92.75** ^{A}
Acetone	58.0 ^{e}	91.0 ^{b}	100.0 ^{a}	100 ^{a}	**87.25** ^{B}
Ethanol	42.0 ^{f}	86.0 ^{bc}	90.0 ^{b}	100 ^{a}	**79.50** ^{C}
Hexane	21.0 ^{hi}	36.0 ^{fg}	52.0 ^{b}	90 ^{b}	**49.75** ^{D}
Petroleum ether	17.0 ^{i}	28.0 ^{gh}	41.0 ^{f}	80 ^{cd}	**41.50** ^{E}
Control	0.4 ^{j}	0.4 ^{j}	0.8 ^{j}	1 ^{j}	**0.65** ^{F}
Mean (day)	**34.90**^{D}	**56.90**^{C}	**63.97**^{B}	**78.50**^{A}	
F test	F (solvent)=1816.5, F (day)= 773.4, F (solvent*day)=68.8				
P value	P (solvent)=0.0001, P (day)=0.0001, P (solvent*day)=0.000				

From the previous results (Tables 2, 3, 4 and 5), it is concluded that water and acetone extracts of quinoa leaf, followed by saponin extract, water, acetone and ethanol extracts of quinoa grains and roots were very active especially against cotton leafworm after four days of exposure periods with 100% corrected mortalities percentage. Ethanol extract of quinoa leaves, hexane extract of quinoa grains and roots showed 90% corrected mortalities against cotton leafworm after four days of exposure periods. Stems extracts with different solvents (water, acetone, ethanol, hexane and petroleum ether), hexane and petroleum ether of quinoa leaf extracts were the least toxic effect against cotton leafworm after four days of exposure periods which gave corrected mortalities between 55 to 20%, but petroleum ether of quinoa roots and grains gave 80 and 75% corrected mortalities, respectively against cotton leafworm after four days of exposure periods.

According to these results, water, acetone and ethanol extracts of quinoa leaves, saponin, water, acetone and ethanol extracts of quinoa grains and roots extracts, and hexane extract of quinoa grains and roots were chosen for more detailed studies.

6. Toxicity Lines and LC_{50} Values for the Most Toxic Treatments of Quinoa Extracts

From the previous data, it is clear that water, acetone and ethanol extracts of quinoa leaves, saponin, water, acetone and ethanol extracts of quinoa grains and roots extracts, hexane extract of quinoa grains and roots plants gave the most toxic effect against cotton leafworm insects. So, a series of concentrations of above mentioned extracts were tested cotton leafworm insects to calculate LC_{50} levels.

7. Toxicity Lines and LC_{50} Values for Quinoa Leaf Extracts

Data in Table (5) prove that the extraction of water quinoa leaves after 4 days of exposure was more effective than the other treatments acetone and

Ethanol extractions against cotton leafworm. After four days of exposure, the calculated concentrations of water quinoa leaves were 29.3 mg/ml at the LC_{50} levels. Concerning the acetone and ethanol extractions, the values were 34.7 and 48.2 mg/ml for LC_{50} after 4 days exposure period, respectively.

Table (5). Cumulative LC_{50} values (mg/ml) of some quinoa leaf extracts on cotton leafworm insect.

Solvent	Corrected mortality (%)							
	After 1 day		After 2 day		After 3 day		After 4 day	
	LC_{50}	P	LC_{50}	P	LC_{50}	P	LC_{50}	P
Water	66.5	2.1	48.3	2.3	34.3	4.7	29.3	4.2
Acetone	117.3	1.7	68.3	1.7	47.0	2.4	34.7	4.7
Ethanol	168.4	1.2	100.7	1.6	60.3	2.1	48.2	3.0

LC_{50} = lethal concentration that caused the death of 50% of the population.

8. Toxicity Lines and LC_{50} Values for Quinoa Grains Extracts

Results of biopesticides against larvae of cotton leafworm are presented in Table (6). The results show the toxicity of five quinoa extractions (water, acetone, ethanol, hexane and saponin) against the larval instar of the cotton leafworm, at different exposure times. Among the tested quinoa crude extracts, saponin was the most effective compound followed by water, acetone and ethanol extractions while hexane extraction was the least effective one after four days, of exposure time. The results indicated that there was a negative relationship between the time post treatment and LC_{50} values of all the tested treatments. The LC_{50} values were 16.9, 32.3, 33.8, 34.1 and 48.2 mg/l for saponin, water, acetone and ethanol extractions, respectively after four days of exposure.

Table (6). Cumulative LC_{50} values (mg/ml) of some quinoa grains extract cotton leafworm insect.

Treatment	Corrected mortality (%)							
	After 1 day		After 2 day		After 3 day		After 4 day	
	LC_{50}	P	LC_{50}	P	LC_{50}	P	LC_{50}	P
Saponin	38.2	1.7	24.6	1.9	20.0	3.4	16.9	3.2
Water	66.2	1.9	43.7	3.2	36.1	4.8	32.3	4.5
Acetone	109.5	1.3	47.3	3.2	39.9	4.2	33.8	4.1
Ethanol	229.9	0.9	53.1	2.2	40.5	2.7	34.1	3.9
Hexane	351.7	0.9	107.1	1.6	66.3	2.4	48.2	3.3

LC_{50} = lethal concentration that caused the death of 50% of the population.

9. Toxicity Lines and LC_{50} Values for Quinoa Roots Extracts

Results in Table (7) show that LC_{50} values of all tested extracts were 23.0, 33.8, 42.9 and 50.8 mg/ml for water, acetone, ethanol and hexane,

respectively after four days, of exposure. As the period of exposure increased from one day to four days, the LC_{50} values decreased.

Table (7). Cumulative LC_{50} values (mg/ml) of some quinoa roots extract on cotton leafworm insect.

Solvent	Corrected mortality (%)							
	After 1 day		After 2 day		After 3 day		After 4 day	
	LC_{50}	P	LC_{50}	P	LC_{50}	P	LC_{50}	P
Water	43.7	1.8	32.2	3.6	26.2	3.8	23.0	3.7
Acetone	80.4	1.6	46.1	3.1	39.6	4.2	33.8	4.6
Ethanol	165.6	1.2	57.9	2.6	48.6	3.1	42.9	4.1
Hexane	361.9	1.4	168.9	1.6	90.8	2.0	50.8	3.9

LC_{50} = lethal concentration that caused the death of 50% of the population.

10. Concentrations Using Efficiency (CUE)

Results in Table (8) show that the highest efficiency rate was recorded when using saponin extracted from quinoa grains at a concentration of 20, 40% (3.440 and 1.888, respectively). Concerning leaves, the efficiency of using different concentrations ranged from 0.6 with hexane to 1.4 when using hot water as a solvent. The results of root extracts agreed with the results of leaf extracts, which recorded the highest efficiency when using a concentration of 20% of hot water (2.35), while the lowest efficiency rate was recorded with hexane at 20% (0.435).

DISCUSSION

Plant extracts are therefore thought to be suitable substitutes because it has been demonstrated that many plants produce chemicals that protect against insect pest attacks. Quinoa contains numerous nutrients that help protect it from insect pest infestations. However, it appears that a large number of plant species have pesticide constituents that are easily convertible into novel products (Isman, 2017). According to Lin et al. (2019), Quinoa is rich in secondary metabolites, including steroids, nitrogen-containing chemicals, flavonoids, terpenoids, and phenolic acids.

From the previous results, it is concluded that saponin extract, water and acetone extracts of quinoa leaves, followed by water, acetone and ethanol extracts of quinoa grains and roots were very active especially against cotton leafworm after four days of exposure periods with 100% corrected mortalities percentage. Ethanol extract of quinoa leaves, hexane extract of quinoa grains and roots showed 90% corrected mortalities against cotton leafworm after four days of exposure periods. These results agree with Badenes-Perez et al. (2014) that saponins had strong efficiency against target pest insects. Hostettmann and Marston (1995) also reported that several high saponin plant sections from different families exhibit insect resistance. Numerous recent studies, including those on aphids, beetles, caterpillars, and flies, have extensively examined the

structural activity of concentrated or pure saponin fractions against insects (Geyter et al., 2007 and Purkayastha et al., 2016). As a result, saponins showed a high level of effectiveness in controlling pest insects, mainly focusing on their midgut epithelium.

Because any damage to the midgut epithelial cells would result in malnutrition, which will cause the insect to die slowly, the midgut of insects is therefore a valuable target. Saponins are generally described as having the potential to defend host plants and prevent phytophagous insects based on their activities in the body of the exposed organism, such as decreased food consumption, blockages, and other toxins (Wittstock and Gershenzon, 2002 and Mithöfer and Maffei, 2016). Although it is unknown exactly how saponins operate, studies have indicated that they damage cell walls, which is why they're primarily known for their capacity to deter insects from becoming pests (Sparg et al., 2004).

The results indicated that there was an opposite relationship between the time post- treatment and LC_{50} values of all the tested treatments. As the period of exposure increased from one day to four days, the LC_{50} values decreased. This hypothesis agrees with findings reported by Juneja et al. (2012). Bolivia has effectively developed quinoa saponins as a bioinsecticide (Jiang et al., 2018). The surface-active properties of saponins make them suitable for use as detergents and emulsifiers as well. Notably, 20-hydroxyecdysone (Bhakuni et al., 2017 and El Hazzam et al., 2020), which is mostly found in bran, has the capacity to turn into an insect moulting hormone. Quinoa grains were found to contain eleven C27-steroids. Of them, ecdysteroids are the primary steroids that act as hormones for insect moulting and shield plants from nematodes and insects that are not acclimated to their environment. The primary source of ecdysteroids in bran is 20-hydroxyecdysone, which has an A/B-cis ring fusion (5β-H) and a 14α-hydroxy-7-en-6-one chromophore (Dinan, 2001).

The results of the present study suggest that all extractions associated with, promote the death of cotton leafworm, and represent insecticidal activity, and with respect to the biocontrol potential of the extracts, the other extractions, which showed insecticidal activity, might be need further future work and identification. Considering the results of the efficiency of using different concentrations of some solvents as well as saponin using different parts of quinoa plant (grains, leaves and roots), it can be indicated that using grains is better than using both leaves and roots. On the other hand, the results indicate the advantage of using both saponins followed by hot water. On the other hand, it is not possible to rely on hexane as a solvent due to the low efficiency of its use compared to other solvents such as ethanol and acetone. These results agree with the general trend in terms of the importance of measuring the efficiency of use as an important criterion in distinguishing

between the transactions or items used in research experiments, which was confirmed by Almadini et al. (2019) and Badran et al. (2020).

Subsequent research ought to delve into toxicity tests conducted on diverse creatures, the capacity of quinoa extracts for large-scale manufacturing, formulation analyses, and ultimately, the practical effectiveness of quinoa extracts.

Table (8). Efficiency of using different concentrations of different parts of quinoa plant after 4 days from treatments.

Concentration (%)	Grains		Leaves		Roots	
		CUE* (%/%)		CUE* (%/%)		CUE* (%/%)
100		1.000		1.000		1.000
80		1.250		1.250		1.250
60	Water	1.365	Water	1.333	Water	1.450
40		1.303		1.175		1.700
20		1.595		1.400		2.350
100		1.000		1.000		1.000
80		1.250		1.163		1.250
60	Acetone	1.223	Acetone	1.283	Acetone	1.217
40		1.143		1.150		1.325
20		1.225		1.300		1.150
100		0.894		1.000		1.000
80		0.998		1.150		0.975
60	Ethanol	0.692	Ethanol	1.167	Ethanol	1.033
40		0.718		1.200		0.700
20		1.250		1.350		1.000
100		1.000		0.890		0.900
80		1.250		0.925		1.038
60	Saponin	1.578	Hexane	0.817	Hexane	0.833
40		1.888		0.925		0.550
20		3.440		0.600		0.435
Mean		**1.319**		**1.109**		**1.113**

CUE *; Concentrations Using Efficiency

CONCLUSION

As a general conclusion, it could be said that water and acetone extracts of quinoa leaves, saponin water, acetone and ethanol extracts of quinoa grains and roots, are suitable for controlling the larval stage of cotton leafworm and could be used as alternatives to conventional insecticides. The previous crude extracts can be used in integrated pest management.

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التأثير الإبادي لبعض مستخلصات الكينوا ضد حشرة دودة ورق القطن

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أجريت تجارب حقلية لتقييم النشاط البيولوجي لمستخلصات نبات الكينوا باستخدام أجزاء نباتية ومذيبات مختلفة ضد دودة ورق القطن *Spodoptera littoralis* تحت الظروف المعملية. حيث توصلت النتائج إلى أن مستخلص السابونين والمستخلص المائي والأسيتوني من حبوب الكينوا، يليه المستخلص المائي والأسيتوني والإيثانولي لأوراق وجذور نباتات الكينوا كانت فعالة جدًا ضد دودة ورق القطن، خاصة بعد فترات التعرض لمدة أربعة أيام وبنسبة موت مصححة ١٠٠٪. أظهر المستخلص الإيثانولي من حبوب الكينوا ومستخلص الهكسان من أوراق الكينوا وكذلك الجذور نسبة موت مصححة٩٠٪ ضد دودة ورق القطن، وذلك بعد أربعة أيام من فترات التعرض. ومع ذلك، أظهرت جميع مستخلصات الساق ومستخلصات الأوراق باستخدام الهكسان والإيثر البترولي أقل سمية ضد دودة ورق القطن مع نسبة موت مصححة تتراوح بين ٥٤ إلى ٢٠٠٪. بينما أظهر المستخلص الإيثيري لجذور وحبوب الكينوا نسبة موت مصحح ٨٠ و٧٥٪ على التوالي بعد أربعة أيام من التعرض وكانت قيم الجرعة القاتلة ل ٥٠٪ من الأفراد (LC_{50}) في علاقة عكسية مع وقت ما بعد المعاملة وذلك لجميع المعاملات التي تم إختبارها، بعد ١، ٣،٢ و٤ أيام من المعاملة. أظهرت نتائج كفاءة استخدام التركيزات (CUE) أنه تم تسجيل أعلى معدل كفاءة عند استخدام الصابونين والحبوب والأوراق والجذور المستخلصة من نبات الكينوا بتركيز ٢٠ و٤٠٪. تشير النتائج إلى أن جميع المستخلصات مرتبطة بموت دودة ورق القطن ولها نشاط كمبيد حشري. قد تكون هناك حاجة إلى مزيد من الدراسات لتطوير مستخلصات الكينوا لإدراجها في برامج الإدارة المتكاملة لـدودة ورق القطن.