



Efficacy of Botanical Insecticides for Controlling Cochineal Scale (*Dactylopius opuntiae*) Insect on Cactus (*Dactylcompound sopius opuntiae*) Plant at Southern Tigray, Ethiopia

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AA and TB design the study, perform the statistical analysis and write the protocol first draft of the manuscript. Author AS manages analysis of the study. All authors read and approved the final manuscript.

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ABSTRACT

Cochineal scale insects, scientifically known as *D. opuntiae*, are small insects that feed on the sap of cacti plants. These insects are notorious for their ability to rapidly reproduce and spread, causing significant damage to cactus populations. Tigray region, located in northern Ethiopia, has been

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particularly affected by the relentless attack of cochineal scale insects on its cacti. The aim of this study was to evaluate botanical insecticide to control cochineal scale insect of cacti plant in southern Tigray, Ethiopia. Field experiment was conducted during 2024 in off-season at Raya-azobo district. A total of five treatments; leave extract (Neem, *Lantana camara* and Pepper tree and liquid soap), salt+liquid soup, liquid soup, water and control (no sprayed)) were used in the field experiment. The experiment was laid out randomized complete block design (RCBD) with three replications. The mortality rate of cochineal scale insect had a significant difference at ($p < 0.001$) among the treatments. The highest rate of mortality (free of cochineal scale insect) was calculated from the leave extract (100%) extracted from leaves. However, the increasing number of cochineal scale insect was observed from untreated (control) (+9.9%) followed by cladodes treated with water (45.29%). The current research findings provide strong evidence that botanical insecticide derived from plant leaves could be an effective solution for controlling cochineal scale insect infestations on cacti. These eco-friendly alternatives offer several advantages over synthetic pesticides in terms of reduced toxicity to non-target organisms. Beside; it should be promoted to further demonstration and popularization at farmer level in the coming off-season.

Keywords: Cactus; cochineal scale; leave extract and Mortality rate; insects; plant species.

1. INTRODUCTION

Cactus *Opuntia* is used for various purposes such as food (fruit and fresh or dried cladodes) and forage for animals producing milk. They are also used as a substrate for the creation of the gender cochineal *Dactylopius*, producers of carminic acid [1,2]. Described cactus pear to a “dromedary of the vegetation world,” suggesting that it possesses unique characteristics that enable it to adapt and flourish in dry climates. Therefore, cultivation of the plant may assume greater agricultural importance in dry areas since a larger part of the land is destined to become arid or semi-arid due to climate change [3]. Because of ever increasing human and livestock pressures on the land, a decline in soil productivity, and recurrent drought and famine, there is an increasing reliance on cactus pear to minimize risk and ensure crop and food security. Working with cactus is an effective solution to bring food security in drought-prone areas of Tigray, Ethiopia [4].

In the Tigray region, cactus pear has become a prevalent plant species, covering a significant portion of the land. According to sources such as [4,5] it is estimated that cactus pear occupies over 379,338 hectares of land in the region. This accounts for approximately 7.4% of the total land area of Tigray. Notably, around 56% of this cactus pear population is concentrated in southern Tigray. Cactus pear is a valuable plant with diverse applications ranging from food production to environmental protection. Its cultivation not only benefits farmers by providing food and income but also contributes to

sustainable agricultural practices and ecosystem conservation [6,7].

However, Cochineal (*Dactylopius opuntiae*), scale insects pose a serious threat to cactus plants due to their feeding behavior and potential for causing significant damage. It is primarily sessile parasite native to tropical and subtropical South America and Mexico. It belongs to the family Dactylopiidae in the order hemiptera reared for the purpose of carminic acid production [8,9]. Cochineal scales are coated by white wax filament that can make cacti look unsightly. When the scales are crushed, a red fluid exudes from their bodies. The cochineal insect's host-specific feeding habits on *Opuntia* species have made it a valuable resource for the production of carminic acid, a versatile natural dye with applications across various industries [10,11]. While chemical insecticides have been a go-to solution for pest control among small-scale farmers, their negative impacts on the environment and human health cannot be ignored. It is crucial for farmers to explore alternative pest management strategies that prioritize sustainability and long-term [12].

Many botanical insecticides derived from commonly available plants offer small-scale farmers an affordable, accessible, and environmentally friendly alternative to synthetic pesticides. Botanical insecticides like neem and *Nicotiana* are considered to have low toxicity to mammals [13]. According [14] also reported that extraction of novel herbal pesticides was very effective for the control of adult scale insects. Therefore, due to abundant availability of selected plants in the study area and ample

earlier evidences, the current study was undertaken to assess the impact of botanical insecticides on the cochineal scale insect in cactus plant at Raya-azebo district during 2024 off season.

2. MATERIALS AND METHODS

2.1 Description of Study Area

The experimental was conducted at off-season during 2024 under field condition in Raya-azebo district, southern Tigray. The experimental site is found in the southern administrative zone of Tigray within 12.80N and 39.60E with an altitude ranging from 1730 meter above sea level. The district is characterized by having bimodal type of rainfall pattern with light rains during February to April and heavy rains between Julys to September. The mean annual rainfall is about 724 mm with mean daily maximum and minimum temperatures of 18.3°C and 13.93 °C respectively for the western highlands, and 23.44°C and 19.64°C respectively in the valley. About 90% of the district is described as “midland” and 10% as “lowland”. Cactus has invaded a considerable part of the land in the study area. Mixed crop-livestock farming is the dominant farming system of the district. Pasture is available in communal grazing lands. Crop residue mainly the stalk of maize and sorghum; straw of teff, wheat and barley; chopped cactus are used to feed cattle whenever there is a severe shortage of feed during the dry season.

2.2 Plant Material

A total of five treatments leave extract (neem, lantana camara, pepper tree and Liquid Soap), Salt+Liquid soap, Liquid soap, Water and Control (no sprayed) were used in the field experiment. The experiment was laid out in randomized complete block design (RCBD) with three replications. In the experiment conducted, plant materials (leaves of the plant) were collected from the surrounding areas. Specifically, mature leaves of a certain plant species, referred to as “combined leaves (extracted from plant leaves)” were collected from Alamata (Grakahsu): lantana camara and Raya-azebo (Kara-adushohu): pepper tree and Neem, which is in close to the study site. The Salt and Liquid soap were used and purchased from the market. Then, the leaves of all plant materials were chopped and shade dried (until they are completely dried). The dried materials were put into blender machine to make powder. Two hundred (200) gram of sample

powder was taken and mixed with 15 litter of water for one hour. The mixture was filtered with the help of filtering cloth (material) and it was considered as stock solution by diluting with water. The stock solution was ready for spraying (Table 1).

Tale 1. Total number of treatment used in the experiment

S. No.	Treatment name	Rate of application
1	Leave extract (combination of Neem, Lantana camara, Pepper tree and liquid soap)	200g per Knapsack (20L) (neem: 20%, Lantana camara: 25%, pepper tree: 25% and Liquid soap: 20%)
2	Salt*Liquid Soup	300g salt*75ml Liquid Soup per Knapsack (20L)
3	Liquid Soup	200ml per Knapsack (20L)
4	Water	500 litter per hectare
5	Control (Unsprayed)	No spray

2.3 Insect data

Severity record scale of cochineal: All cactus plants were observed, and examine for the presence of the Cochineal scale insect in the entire visited cladodes cactus. Severity cochineal scale infestation was estimate according Sources; [15] as follows:

Table 2. Severity recording scales for cochineal scale insect of cactus plant

Scale	Percent infestation (severity)
0	No infestation
1	Low infestation less than 25% of the pad surface infected
2	Medium infestation if >25%-50% of the pad surfaces infected
3	High infestation if more than >50% of the pad surface infected

2.4 Data Collection

Data was collected from three randomly sampled cladodes in each plot, before spraying, and 1, 3 and 7 days after spraying. A total of two times of spray application was done with the interval of seven days. Incidence and cochineal scale insect

populations during the period of study were recorded as indicator to the effectiveness of the applied treatments. The attached cochineal adults were counted from the sampled cladode of cactus plant before and after treatment applications and expressed in mortality percentage rates and, then correlated to the damage levels.

2.5 Data Analysis

The total count data were subjected to mortality percentage rate and analyzed using GenStat 18th Edition statistical software. Least Significant Difference (LSD) values were used to separate differences among treatment means at 95% probability level.

3. RESULTS AND DISCUSSION

3.1 Effect of Botanical Insecticide in Severity of Cochineal Scale Insect

The study of cochineal scale insects, particularly in relation to their impact on cactus plants, is crucial for both agricultural practices and ecological balance. Cochineal scale insects (*Dactylopius spp.*) are known pest that can severely affect the health and productivity of cactus plant. There was a significant variation ($P < 0.01$) among the treatments used to control cochineal scale insects on cactus plants. The results indicate that the lowest mean severity percentage (free of cochineal scale) was recorded from the leave extracted (combination of neem, lantana camara, pepper tree and liquid soap) treated cactus cladodes. This suggests that the treatments applied to these cladodes were effective in controlling cochineal scale insect infestations. Conversely, the control which consisted of unsprayed cactus cladodes, exhibited the highest mean severity percentage,

indicating that without any intervention, these plants were more severely affected by cochineal scale. The mean severity percentage was noted to be 2.613%. Following this, the treatment with water yielded a mean severity percentage of 2.517%, while liquid soap treatment resulted in a slightly lower mean severity percentage of 2.473%. Similarly, free of cochineal colony was observed and recorded from the candidate treated. However, maximum number of colony was counted from control (5.51) followed by water only treated (5.1) (Table 3). The result support [16] who stated that application of biodegradable products, black soap at 60 g/l in double application or in combination with *C. annuum* extract at 200 g/l, was effective for the control of *D. opuntiae* as a safe alternative to chemical insecticides. In addition [17] who reported that botanical insecticides like that Beet extract (*Beta vulgaris subsp.*) could be a promising for controlling of cochineal scale insect.

3.2 Mortality Percentage of Cochineal (*Dactylopius coccus Costa*) Scale Insect

In the current study, it was found that there was a significant difference among the treatments in reducing the percentage of cochineal scale insect on both time of spraying. This indicates that the different treatments applied had varying levels of effectiveness in reduction the population of the cochineal scale insects. The highest number of cochineal scale mortality rate was recorded from leave extracted (combination of Neem, Lantana camara, Pepper tree and liquid soap) viz. 73.08%, 92.97% and 96.04% at one, three and seven days of post-treatment, respectively followed by Salt*Liquid soap viz. 36.73%, 41.92% and 58.07% at one, three and seven days of post-treatment, respectively. This

Table 3. Efficacy of botanical insecticide on cochineal scale insect on cactus cladodes

Treatment	Colony after spray	Severity scale (AS)	severity percentage (AS)
Leave extract (NLCaLS)	0b	0.00b	0
Control (no spray)	5.51a	2.613a	>50%
Liquid Soap	4.96a	2.473a	>25-50%
Salt*liquid soap	1.00b	1.00b	1-25%
Water	5.1a	2.517a	>50%
Mean	3.32	1.72	
L.s.d (5%)	2.2	0.88	
CV (%)	35.2	27.3	

Note; AS: After spray; NLCaLS: Neem Lantana camara Pepper tree and liquid soap

suggests that the natural compounds present in the plant leaves extract may have properties that are effective in reduction cochineal scale insect infestations. On the other hand, increasing cochineal scale was observed in the control (remained unsprayed) viz. 1.74%, 2.69% and 4.72% at one, three and seven days after first spray, respectively. This indicates that without any intervention, the cochineal scale population increase time to time. In addition, water spray treatment also exhibited low levels of cochineal scale mortality rate (20.01%, 21.39% and 29.39%) at one, three and seven days after first spray, respectively (Table 4). This implies that water spray alone may not be an effective method for managing cochineal scale infestations.

Similarly, in second spray the highest mortality rate of cochineal scale insect was calculated from leave extract (combination of Neem, Lantana camara, Pepper tree and liquid soap) 100% mortality rate at the initial observation and assessment of treated cactus cladodes. The use of leaf extracts shows great promise in reduction and controlling of cochineal scale insects

effectively. However, increasing the number of cochineal scale insect was observed from control (untreated) viz. 2.37%, 3.52% and 5.18% at one, three and seven days after second spray, respectively followed by water treated cladodes viz. 9.6%, 11.18% and 15.91% at one, three and seven days after second spray, respectively (Table 4).

Many authors have also reported in agreement to our research findings [18,19,20] investigated that plant extracts can produce toxic substance (may be terpenoids) against the Cochineal (*Dactylopius coccus* Costa) scale insects of cactus. These compounds disrupt various metabolic processes or nervous systems in Cochineal scale insects leading to their demise or repulsion due to unpleasant taste or smell for them.

3.3 Efficacy of Botanical Insecticides on Cochineal Scale Insect

The study on cochineal insect count was conducted two times, once before and after the botanical application on the different cactus

Table 4. Mean values of treatments in their cochineal scale mortality percentage after first spray and second spray

Treatment	First spray			Second spray		
	After 1 day	After 3 day	After 7 day	After 1 day	After 3 day	After 7 day
Leave extract (NLKaLS)	73.08a	92.97a	96.04d	100.00a	100.00a	100.00a
Control	+1.74c	+2.69e	+4.72a	+2.37c	+3.52d	+5.18d
Liquid Soap	30.89b	32.97c	36.35b	7.57b	19.9bc	31.13b
Salt*liquid soap	36.73b	41.92b	58.07c	16.42b	23.98b	30.64b
Water	20.17b	21.39d	29.39b	9.65b	11.18c	15.91c
Mean	31.82	36.72	42.02	25.85	29.71	33.7
L.s.d (5%)	11.919	4.781	12.273	5.548	5.561	8.475
CV(%)	19.92	6.9	15.5	11.4	9.9	13.4

Note; NLCaLS: Neem Lantana camara Pepper tree and liquid soap

Table 5. Efficacy of botanical insecticides for controlling cochineal scale insects on cactus

Treatment	Cochineal scale before spray	Cochineal scale after spraying	Efficacy botanical insecticides (%)
Leave extract (NLKaLS)	318.1	0a	100a
Control (no spray)	100.8	110.8d	+9.9d
Liquid Soap	135	43.9bc	67.48abc
Salt*liquid soap	140.4	15.85b	88.71ab
Water	147.8	80.86cd	45.29c
Mean	168.42	50.28	56.51
L.s.d (5%)	Ns	44.51	14.329
CV (%)	66.8	34.66	13.5

Note; AS: After spraying; NLCaLS: Neem Lantana camara Pepper tree and liquid soap



Fig. 1. Efficacy of combination of leaf extract on the cochineal scale insect on cladode of cactus a) before spray and b) after spray

cladode. There was a significant ($P < 0.05$) variation among the treatments (Fig. 1). The highest percent population reduction (100%) of cochineal scale insects was observed in the leaf extract (combination of Neem, Lantana camara, Pepper tree and liquid soap) after application and spraying. This indicates that the plant leaves extract treatment was highly effective in reducing the population of cochineal scale insects to zero. On the other hand, the control group that remained unsprayed recorded an increase in the number of cochineal insects with values of +9.9%, suggesting that without any treatment intervention, the insect population continued to thrive and reproduce (Table 5). The result supported by [18] who reported that botanical pesticides such as tree tobacco (*Nicotiana glauca*) could be a promising candidate to control cochineals and reduce the use of chemical application to minimize its side effects on the environment.

4. CONCLUSION AND RECOMMENDATION

The research findings on cochineal infestation in Tigray highlight the urgent need for proactive

measures to address this agricultural challenge. By leveraging these insights to develop tailored solutions and engage with local farming communities, there is a potential to enhance resilience against cochineal infestations and safeguard agricultural livelihoods in the region. This scale insect can cause significant damage to plants by feeding on their sap, leading to stunted growth and even death of the plant if left unchecked. To effectively combat the cochineal scale insect pest infestation affecting cactus plants in the Tigray region, it is crucial to adopt a multi-faceted approach that prioritizes environmental sustainability and cost-effectiveness. This requires a thorough understanding of the pest's biology, ecology, and potential control strategies. By focusing on sustainable and cost-effective methods, local communities can work together to reverse the damage caused by this devastating pest. The current research findings conducted under field conditions provide strong evidence that botanical insecticide extracted from leaves (combination of Neem, Lantana camara, Pepper tree and liquid soap) is an effective solution for controlling cochineal scale insect infestations on cacti.

These eco-friendly alternatives offer several advantages over synthetic pesticides in terms of reduced toxicity to non-target organisms, minimal impact on the environment, and lower risks for human health. Beside; it should be promoted to further demonstration and popularization at farmer level in collaboration Agricultural and Rural Development, University and NGO in our mandate areas and other cochineal scales infested areas of the region.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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