Innovation Technology of Botanical Insecticides for Controlling Cochineal Scale *(Dactylopiusopuntiae)*Insect on Cactus *(Dactylcompoundsopiusopuntiae)* Plant at Southern Tigray, Ethiopia

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 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 camaraandPepper treeand 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.*

Key words; Cactus, Cochineal scale, *leave extract* and Mortality rate

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 (Medina, Rodríguez, & Romero, 2007).

Stintzing and Carle (2005) 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 (Snyman 2006). 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, EthiopiaNefzaoui et al (2010).

In the Tigray region, cactus pear has become a prevalent plant species, covering a significant portion of the land. According to sources such as SAERT (1994) and Nefzaoui et al (2010), 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 (Haile et al 2002) and (Barbera, 1995).

However, Cochineal (Dactylopiusopuntiae), 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 Dactylopidae in the order hemiptera reared for the purpose of carminic acid production (Rodriguez and Niemeyer 1999 Roderuez et al 2001). 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 (Baranyovits 1978, Einser and Nowicki 1980). 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 (Dalvie et al 2003).

Manybotanical 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 (Isman 2006). Arifa et al (2013) 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. Material 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 1730meter 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 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 were collected from the surrounding areas. Specifically, mature leaves of a certain plant species, referred to as “candidate (extracted from plant leaves)” were collected from Alamata (Grakahsu), 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 treeand liquid soap)	200g per Knapsack (20L) (neem: 20%, Lantana camara: 25%, Kondeberber: 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	5000ml per hectare
5	Control (Unsprayed)	No spray

2.3.Insect data

2.3.1. **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; Moussa et al., 2017 as follows:

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

scale	Percent infestation
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 7days after spraying. A total of two times of spray application was done with the interval of seven days. Incidence and cochineal scale insectpopulations 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. Result and Discussion

3.1.Effect of botanical insecticide inseverity 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 treeand 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 by Ramdani, et al., (2021) 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 Finti, et al., (2022) who reported that botanical insecticides like that Beet extract (Beta vulgaris subsp.) could be a promising for controlling of cochineal scale insect.

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 (NLKaLS)	0b	0.00b	0
Control (no spray)	5.51a	2.613a	>50%
Liqud 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; NLKaLS: Neem Lantana camaraPepper treeand liquid soap

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 treeand 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% atone, three and seven days of post-treatment, respectively.This 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. Thisindicates 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 treeand liquid soap)100% mortality rate at the initialobservation 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 findingsIbrahim, et al. (2016), Vigueras et al (2009), Vázquez-García et al (2011) and Adriana Pérez-Ramirez et al (2014) 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.

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

	First spray			Second spray		
Treatment	**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
Liqud Soap	30.89b	32.97c	36.35b	7.57b	19.9bc	31.13b
Salt*liqud 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;NLKaLS: Neem Lantana camaraPepper treeand liquid soap

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 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 leave extracted (combination of Neem, Lantana camara,Pepper treeand 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 in increasing the number of cochineal insects with values of +9.9%, suggesting that without any treatment intervention, the insect population continued to thrive and reproducing (table 5). The result supported by Ibrahim et al. (2016) 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.

Table 5. Efficacy of botanical insecticides for controllingcochineal 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
Liqud Soap	135	43.9bc	67.48abc
Salt*liqud 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; NLKaLS:Neem Lantana camaraPepper treeand liquid soap

a) Before spraying

b) After spraying of Candidate

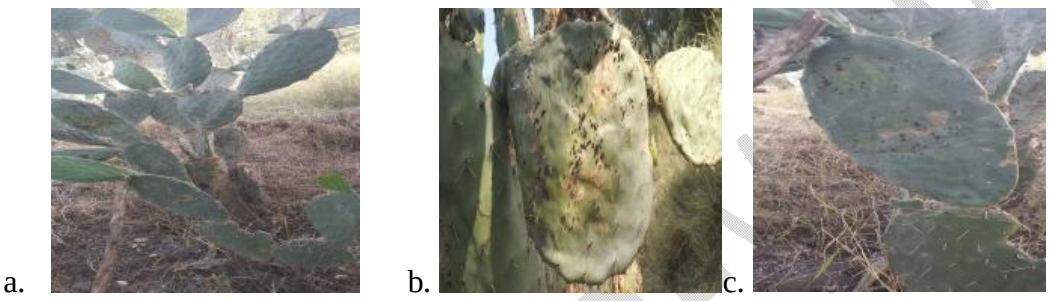

Fig 1. Efficacy of leave extract on the cochineal scale insect on cladode of cactusa) before spray and b) after spray

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 insectcan 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 insecticideextracted from leaves (combination of Neem, Lantana camara,Pepper treeand 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.

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