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Research Article

Evaluation of the Efficiency of Different Biotechnical Techniques for the Control of Varroa Mite in Eastern Amhara

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Abstract

This study was conduct to investigate the efficiency of certain botanical smokes against Varroa mite. In the field, four botanical smokes (Cordia Africana, Terminallia, Tobacco, Barley + Olea leaf smoke) and two control groups (Sticky bottom board only and without sticky bottom board and untreated) were tested as control agents against the parasite mite V. destructor. Throughout the treatment period, each colony received the treatments of each tested substance. Data showed that among all four tested treatments, tobacco leaf smoke followed by Terminallia leaf smokes were effective in controlling Varroa as they had an efficiency of 73.2%, 62.59%, respectively. These compounds also found to be helpful in the reduction of varroa mite load as they showed percentage of reduction of mite infestation were 63.59% and 49.84% respectively. As a result, these smokes could be employed as part of standard beekeeping procedure while working with colonies.

Keywords

Botanical, Sticky Bottom Board, Smoke

1. Introduction

During the past four decades, the invasive ecto-parasit mite, *Varroa destructor* has become the largest threats to apiculture and honeybee health world-wide [11]. No other pathogen has had such a large impact on beekeeping or honeybee research throughout the history of apiculture [11]. Mite infestation of bees is known to cause immune-suppression, weight loss, decreased flight performance, and reduction in lifespan [2, 8, 13]. The mite is also serving as a vector for some honeybee viruses [4]. Moreover, even if the global market demands healthy, safe, good quality & organic products, medication is a must to suppress varroa's damage. It has been very difficult to present hive products to consumers as natural or organic products. Thus, this situation seriously affects the international market accreditation processes [11]

The presence of varroa mite has been confirmed in many African countries including Ethiopia [12, 13, 9, 5, 6]. Varroa

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mites cannot be eliminated from bee colonies, but beekeepers can monitor its presence and still maintain productive bees, and control methods can be used to keep mites at a manageable level [11]. Prevention and control of this mite can be carried out using different methods. These include biotechnical, biological, and chemical methods [10]. Nowadays, different chemicals are available for the treatment of Varroa mite infestation. The problem with treating varroosis is that the mites have evolved resistance to many of the synthetic varroacides that have been employed, and the widespread use of chemical treatments has resulted in drug residue in honey, beeswax, and other honeybee products.

Alternative strategies for varroa control are numerous and exhibit a wide range of efficacy and practicality [1]. Biotechnical methods involve beekeeping management techniques specifically designed to reduce mite levels in a colony. Biotechnical methods are generally not used as a complete means of Varroa control [11]. The aim of this experiment is to determine the efficiency controlling varroa destructor with four different methods. Therefore the Objective of the Study was to evaluate and recommend the best varroa mite control method in the study area.

2. Materials and Methods

2.1. Study Area

The study was been conducted in Jinqaba research apiary sites at sekota zuria districts during the years 2021 and 2022 in Amhara region. Sekota zuria (jinkaba) is districts (Woreda) located in the Amhara Region of Ethiopia, specifically within the Wag-himra Zone [11]. The area was characterized by midlands with rainy season typically occurs from June to September. Farmers in the district cultivate a variety of crops and engage in livestock rearing [13]. Beekeeping is also a significant activity in the districts, with local honeybee races contributing to honey and pollen production. This is an important source of income for many households. Environmental Concerns Soil erosion and deforestation are environmental issues that can affect apiculture productivity [12].

2.2. Colony Management

All colonies were identified as being infested with Varroa mites using the sugar shake method, and treatments were assigned randomly to colonies within Jinkaba apiaries that had comparable varroa mite infestation levels (% infestation = mites/bee x 100). Twenty-four honeybee colonies were divided into six groups of four colonies, with each group receiving treatment with open mesh floors and 5-10 puffs of smoke administered through the hive entrance using a smoker.

1. Group 1: Sticky bottom board + Tobacco leaf smoke,
2. Group 2: Sticky bottom board + Barley bran mixed with *olea europaea* smoke,
3. Group 3: Sticky bottom board + *Cordia africana* leaf smoke
4. Group 4: Sticky bottom board + *Terminalia brownii l*eaf smoke
5. Group 5: Sticky bottom board only
6. Group 6: left untreated or control (without sticky bottom) without receiving any one of the treatments for the control of varroa mite from bee colonies.

2.3. Data Collection

To monitor Varroa populations before and after treatments, a "sticky board" with wire mesh was pushed in all hives' bottom prior to each treatment under the wire/wood frame, where falling mites were trapped and the wire kept bees from removing them. These boards were removed, replaced by new ones daily and the trapped mites were counted. The hive entrances remained open during the experiment and applications were carried out after sunset, when all honeybees had returned to the hives.

The number of mites collected after each application was recorded and the efficiency percentage of each application of these compounds was determined.

$$Effectivness\ in\ controlling\ varroa\ mite = \frac{Final\ of\ fallen\ mites\ in\ treatment - final\ of\ fallen\ mites\ in\ control}{Final\ of\ fallen\ mites\ in\ treatment}\ x100$$

$$\%\ \text{reduction of infestation} = 100 \times 1 - (\text{Ta} \times \text{Cb})/(\text{Tb} \times \text{Ca})$$

Where, T= % infestation of treated mites
C=% infestation of untreated mites
A= after, B= before treatment

2.4. Data Analysis

Data obtained were statistically analyzed using analysis of variance (ANOVA) and means were separated by a tukey test in SAS.

3. Results

The mean number of mites collected from the colonies that received five applications is indicated in (Table 1). Over the entire test, the highest daily mean number of mites on the sticky bottom board traps was caught for the application of tobacco leaf smoke (ranged from 2.75 to 15.25 with a total fallen mites of 48.5 mites/hive) followed by those that have received *Terminalia brownii l*eaf smoke, barley + olea leaf smoke, and Cordia Africana leaf smoke (34.75, 17.75, 16.25

and 13 mites/ hive, respectively). The total number of fallen mites did not differ significantly among the four botanical smokes (*Terminalia*, Tobacco, *Cordia africana*, and barly+ *Olea* smoke), but the total number of fallen mites of all botanical smokes was significantly higher than the sticky bottom board treatment with no botanical smoke (13 mites/hive). Furthermore, when the effectiveness of each botanical smoke in controlling varroa mite was evaluated, tobacco leaf smoke came out on top in terms of suppressing varroa mite, followed by Terminalia leaf smoke, with efficacy of 73.2 and 62.59 %, respectively (Table 1).

Table 1. *Number of fallen varroa mites and efficacy after 5 application of different botanical smoke treatments for controlling of varroa mites.*

Treatments	Pre- trt count	Applications					Total fallen mites	Efficacy (%)
		1st	2nd	3rd	4th	5th		
S B B + BARLEY + OLEA LEAF	8.35	5	2.25	2	2.25	3.25	17.75^{ab}	26.76
S B B +TERMINALIA LEAF	10.3	11	10	4.5	3.75	5.5	34.75^{ab}	62.59
S B B+ CORDIA AFRICANA	2.85	4	4.5	2.75	3.25	1.75	16.25^{ab}	20
S B B + TOBACCO	6.45	15.25	14.75	9.75	6	2.75	48.5^{a}	73.2
S B B	5.15	0.75	1.75	2.75	4.25	3.5	13^{b}	

NB. SBB stands for sticky bottom board

As a result, regular and more frequent smoke treatments during colony inspections throughout the year may be essential and could be an alternative method for keeping mite populations under control. With respect to the comparison between the efficacies of all treatments in the reduction of mite load in the colony, data in (Table 2) showed that using tobacco leaf smoke followed by *Terminalia* leaf smoke was most effective than using other botanical smokes. The percentage of reduction of mite infestation for tobacco leaf smoke and *Terminalia* leaf smoke treatments were 63.59% and 49.84% respectively. The sticky bottom board + tobacco treatment shows the highest efficacy with a 63.59% reduction in mite infestation. The sticky bottom board + terminalia leaf treatment also demonstrates significant effectiveness with a 49.84% reduction. Other botanical treatments show moderate reductions, while the control treatment with only a sticky bottom board and the untreated control show minimal to no reduction. For example, the treatment with sticky bottom board + terminalia leaf had a pre-treatment count of 4.91 mites. Applications:

This section shows the number of mites fallen after each application of the treatments. For instance, the sticky bottom board + tobacco treatment had 15.25 mites fall after the first application, 14.75 after the second, and so on. The sticky bottom board + tobacco treatment had the highest total fallen mites at 48.5.

Efficacy (%) This shows the percentage reduction in mite count due to the treatment. The sticky bottom board + tobacco treatment had the highest efficacy at 73.2%, indicating it was the most effective treatment. The sticky bottom board + tobacco treatment was the most effective, with the highest total fallen mites (48.5) and the highest efficacy (73.2%). The sticky bottom board + terminalia leaf treatment also showed substantial effectiveness, with a total of 34.75 fallen mites and an efficacy of 62.59%. The control treatment (sticky bottom board alone) had the lowest total fallen mites (13) and no calculated efficacy, serving as a baseline for comparison. Other treatments (barley + olea leaf and Cordia Africana) had moderate to low efficacy, indicating less effectiveness in reducing mite counts.

Table 2. *Percentage of mite load reduction after the application of different botanical smoke treatments for controlling of varroa mites.*

Treatment	Pre- treatment Mite load	Post- treatment Mite load	% reduction of infestation
sticky bottom board + barley + olea leaf	4.12 ±0.49	3.18 ±0.82	27.44
sticky bottom board +terminalia leaf	4.91 ±0.83	2.62 ±0.31	49.84
sticky bottom board + Cordia Africana	4.78 ± 1.9	3.81 ±0.34	25.07
sticky bottom board + Tobacco	5.5 ±1.2	2.13 ±0.08	63.59

Treatment	Pre- treatment Mite load	Post- treatment Mite load	% reduction of infestation
sticky bottom board	4.69 ±0.41	4.58 ±1.18	8.20
control	5.02 ±0.76	5.34 ±1.6	

4. Discussion

The effectiveness of botanical smokes in controlling varroa mites is significantly lower than that of chemical treatments such as Oxalic acid, which boasts greater than 95% efficacy [10]. Organic and essential oils like formic acid and thymol have also shown high efficacy rates of 94.7% and 96.9%, respectively [5]. Despite their high effectiveness, the use of pesticides poses drawbacks, including residual effects on bee products and the development of resistance in mites. Therefore, natural components could present new opportunities for the beekeeping industry. The findings of this study align with previous research on the efficacy of natural products. For example, [7] reported that the most effective natural treatment was sumac seed smoke, which resulted in a 64.8% mean reduction in mites, followed by eucalyptus oil (62.7%), mint oil (61.7%), and eucalyptus leaves smoke (28.9%). [6]. also observed that tobacco smoke had a beneficial effect on colonies suffering from Parasitic Mite Syndrome. Colonies treated with tobacco smoke exhibited larger populations and produced more honey compared to control hives. Nicotine in tobacco smoke has an anesthetic effect on insects and potentially a lethal effect on mites, contributing to its beneficial impact [6].

Terminalia trees are known to produce secondary metabolites, such as cyclic triterpenes and their derivatives, flavonoids, tannins, and other aromatic compounds. These substances have been found to possess antifungal, antibacterial, anti-cancer, and hepatoprotective properties [2]. Specifically, a new triterpenoid, glauconitic acid, along with several known compounds including arjunic acid, arjungenin, sericoside, and friedelin, were isolated from the stem bark of Terminalia glaucescens. These compounds exhibited β-glucuronidase inhibitory activity [5].

The results indicate that while botanical smokes like those from tobacco and Terminalia species show some promise in controlling varroa mites, they are less effective than conventional chemical treatments [3]. However, their use could mitigate some of the issues associated with chemical residues and resistance, making them a valuable component in integrated pest management strategies.

5. Conclusion

Varroa mite is considered one of the most important honeybee pests so it must be controlled. Experiments were carried out to evaluate some non-chemical options in controlling this mite. The efficacy of using different botanical smoke application methods on reduction of varroa mite infestation level in honeybee colonies were studied at the apiary of Jinkaba bee research station at SDARC. As a general conclusion, the result obtained from present study showed that application of tobacco leaf smoke followed by *Terminallia* leaf smoke were more effective than applying other botanical smokes tested. As final consideration, these smokes could be used as normal beekeeping practice during manipulating colonies. This action could be considered as the beginning for making integrated pest management program for controlling varroa mite. However, since these might be a short sighted solution. The long-term solution is to select resistant honeybee lines from best stock of the beekeepers.

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Author Contributions

Alemu Tsegaye: Conceptualization, Formal Analysis, Methodology, Software, Writing – original draft

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Data Availability Statement

Data will be making available on request.

Conflicts of Interest

The authors declare no conflicts of interest.

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