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RESEARCH ARTICLE

Antitermitic Activity of Woods Impregnated with Medical Plant Mentha Spicata (Mint) Extract against Subterranean Termite

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Abstract

Subterranean termites destroy wooden structures and feed on cellulose-based products throughout the world, incurring significant economic damage. The investigation is being conducted to determine the effectiveness of medicinal plant Mentha spicata (Mint) extracts against subterranean termites under laboratory and field conditions in order to monitor termite activity. In laboratory bioassays, the anti-termitic and repellent effects of Mentha spicata (Mint) extracts were studied at various concentrations, i.e., 2%, 4%, 6%, 8%, and 10%. After performing a repellency test, it was noted that the medicinal plant M. spicata extract is repellant at higher dosages and non-repellant at lower dosages. The same thing happens in anti-termite tests: the mortality rate is low at lower doses and high at higher doses. Four different types of wood species named A. pindrow, C. deodara, A. arabica and P. euramericana were treated with M. spicata extract and buried in the active nest of termites for three months under suitable conditions. The field trial was held at the Wagha border, 30 kilometers from Lahore. In field trials, choice and no-choice bioassays were performed. After trials, it has been noted that P. euramericana is the maximum wood consumed and C. deodara is the minimum wood consumed in no-choice field trials. In field trials, termites feed on P. euramericana, a more appealing wood, and A. arabica, a less appealing wood. So the result is that M. spicata extract is a non-repellent medicinal plant.

1. Introduction

Mentha spicata, commonly known as spearmint, also known as common mint or garden mint, is native to Europe and southern temperate Asia. It is neutralized in many other temperate parts of the world, including southern and northern Africa, South America, and North America. Spearmint is a perennial herbaceous plant. M. spicata first described scientifically by Carl Linnaeus in 1753. Spearmint (Mentha spicata), one of the best-known mints, is an aromatic plant belonging to the family Lamiaceae. Spearmint is cultivated commercially throughout the world and can freely adapt to grow in numerous types of soil. The plant is known to grow well in moist habitats such as swamps or creeks, where the soil is sand or clay, and in sunny to partly sunny conditions (Chrysargyris etal. 2017). In addition, spearmint has been generally recognized to be safe in regular diets and can be safely consumed (Telci et al.2010). The aromatic oil known as spearmint oil is also used as an additive and sometimes as a scent. Spearmint's essential oils and extracts have been studied for their biological activities, which have been reported as an antioxidant(Rubertoetal.2000), antibacterial and fungicidal (Scherer et al.2013). Another important set of properties of the essential oil of spearmint is its insecticidal and insect-repellent activity (Kumar etal.2011; Ercanetal. 2013), which derives from the presence of compounds with individually strong insecticidal activity as well as their synergistic action (Mahanta and Khanikor, 2017). They are less persistent than conventional pesticides, non-toxic to other organisms when used in a controlled manner,

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and highly effective against resistance (Attiaetal. 2012). Studies have shown that plants of the genus Mentha possess unusual antimicrobial behaviour (Mimica-Dukicet al. 2003), mainly due to the presence of oxygenated monoterpenes in their chemical composition (Hussain et al. 2010; Karamanetal. 2003; Kiticetal. 2002; Sahinet al. 2003). Mints are cherished in the United States for their essential oils. The fresh-ground biomass and dried leaves of the plant are used as seasonings in food. Peppermint is one of the most widely consumed single-ingredient herbal teas. Peppermint tea is brewed from plant leaves. Peppermint tea is used to treat coughs, bronchitis, and irritation of the oral mucosa and throat. Peppermint oil with green tea polyphenols might be valuable as an anti- allergic agent. The essential oil of peppermint is used in conventional medicines. Peppermint has been used in herbal medicine in the past, dating back to ancient Egyptian, Greek, and Romantimes.

Peppermint (M. piperita) oil is one of the most admired and widely used essential oils, primarily because of its main components' menthol and menthone (Derwich et al. 2010). Peppermint oil vapor is used as an inhalant for respiratory congestion. In complex patients with infiltrative pulmonary tuberculosis, essential oils can be used (Shkurupii et al., 2006). Traditionally, the species are used to treat various digestive complaints such as colic in infants, flatulence, diarrhea, indigestion, nausea, vomiting, morning sickness, anorexia, and to reduce gas and cramping. Peppermint is used to treat irritable bowel syndrome (Hoffman, 1996).

In tropical, subtropical and warm temperate regions of the biosphere, termites can be found in nearly all forest ecosystems and they are biologically important insects as well as economically (Su and Scheffrahn 2000; Scholzetal. 2017). Termites are very destructivepolyphagous insect pests that are known to inflict extensive damage to finished and unfinished wooden structures, household goods, plants, and agricultural products such as sugarcane, millet, barley, and rice (Sen-Sarma et al. 1975). Termites are also known to consume a diversity of materials, ranging from paper fabrics to even non-cellulosic materials such as asphalt bitumen, lead, asbestos and metal foils (Bultmanetal.1979). In a multitude of environments, subterranean termites (Isoptera: Rhinotermitidae) play vital roles in nutrient cycling, soil mineralization and cellulose decomposition (Harris, 1966; Wood & Sands, 1978; Black & Okwakol, 1997). Subterranean termites play a critical role in the forest ecosystem, where nutrient cycles are critical. In tropical forest ecosystems, their presence can contribute up to 22% of total nitrogen input (Yamada et al. 2006).

Almost 3000 termite species have been described (Kambhampati and Eggleton 2000), but only 183 species are damaging buildings worldwide; 83 of these species cause major damage (Su and Scheffrahn 2000). The order Isoptera contains seven families containing Rhinotermitidae, Kalotermitidae, Termitidae, Serritermitidae, Mastotermitidae, Termopsidae and Hodotermitidae (Emerson, 1959; Krishna, 1970; and Eggleton, 2001). Due to morphological similarity with early branches of termites, they are now categorized as Blattodea (Klass etal., 2000;Xiao., 2012). In a tropical and subtropical ecosystem, termites are well recognized and have the ability to damage all kinds of finished and unfinished wooden structures (Shanbhag and Sundararaj, 2013). There are about 3000 termite species, but only 53 have been discovered and recognized in Pakistan, and 11 have been reported to cause harm (Iqbal and Saeed, 2013). In a variety of ecosystems, subterranean termites play essential roles in the mineralization of soil, the cycling of nutrients, and the breakdown of cellulose (Harris, 1966; Wood, S 1974; Black and Okwakol, 1997).

In tropical forest ecosystems, nutrient cycles are tremendously important. Subterranean termites play a significant role and contribute up to 22 percent of total nitrogen (Yamada et al., 2006). Termites do significant damage when they attack wood in search of their primary food source, cellulose (Su, 2002).In a tropical and subtropical ecosystem, termites are well recognized and have the ability to damage all kinds of finished and unfinished wooden structures (Shanbhag and Sundararaj, 2013).Foraging behavior and termite activity increased in more humid environment and is revealed by study on Coptotermes gestroi (Kulis etal., 2008) and Coptotermes frenchi (Evans 2003). Termites have a strong similarity to cockroaches as they are eusocial pests (Eggleton, 2001). According to the data from 2010, the destruction caused by subterranean termites was repaired by consuming 80% of the total cost worldwide (Rust and Su 2012). Odontotermes and Microtermes species are severe agricultural pests of fungus-growing termites and are responsible for enormous damage to agriculture in Pakistan. In Punjab' several regions, including Lahore, Qadeerpur, and Gojra, Odontotermes obesus and Microtermes obesi are the species that cause tremendous destruction to the green foliage crops. M. obesi attacked and destroyed the sugarcane fields with ferocity. O. obesus seriously attacked wheat and sunflowers. The Indian white termite, O. obesus (Rambur) is widely distributed throughout Central Asia and causes considerable economic losses, such as damage to fuel wood, railway lines and wooden cabinets (Qureshi et al. 2015). Dry wood termites spend their whole lives in the wood, where they also feed and breed. All types of dry and dead wood, such as furniture, structural timbers and other wooden items, are targeted by them because, with a small humidity content, they can persist in wood (Myles et al. 2007). There are about 3000 termite species, but only 53 have been discovered and recognized in Pakistan, and 11 have been reported to cause harm (Iqbal and Saeed, 2013).Keeping in view the following effect of Mentha spicata crude extract against subterranean termite in the laboratory and field condition is undertaken.

2. Results

Feeding preferences of subterranean termites were evaluated using choice and no choice bioassays. In both choice and no choice bio assay, four different wood species were treated with different concentrations of medicinal plant Mentha spicataextract and then buried in the termite nest for about 3 months to check their feeding preference under different environmental conditions.

2.1 No Choice Field Trials

In no choice field bioassay, four different kinds of wood species were dried at 70 0C temperature and then weighed. The woods were treated with M. spicata extract and then buried in the termite nest to check the anti-termitic activity of wood. Among these species, minimum mass loss was notified in C. deodara (15.5%) and A. arabica (27.0%). Maximum consumption was showed in P. euramericana (72.5%) after 3 months. Current results revealed that, C. deodara is less preferred by termite when treated with Mentha spicata extract and found to be resistant wood. Whereas, was susceptible to termite attack. The mean values noted for the consumption of wood by termites are, P. euramericana at 2%, 4%, 6%, 8% and 10% concentration is (16.4, 15.5 14.5, 13.7 and 12.4g), A. pindrow at 2%, 4%. 6%, 8% and 10% concentration is (11.3, 9.6, 8.4, 7.2 and 6.8g), C. deodara at 2%, 4%, 6%, 8% and 10% concentration is (3.8,3.1, 2.7, 2.4 and 9.1g) and A. arabica at 2%, 4%, 6%, 8% and 10% concentration is (5.4, 4.9, 4.1, 3.8 and 2.9g). Mean followed by same letter show significant difference (Table 4.1).

2.2 No Choice Field Trials

The results of no choice field bioassay presented comparable pattern of mass loss Different Woods offer to termites meaningfully in term of mass loss (g) and percentage mass loss. Highest (72.5%) wood consumption was noted P. euramericana. Least mass losses were observed in C. deodara (15.5%).

2.3 Choice field trials

In these trials the wooden blocks of four different kind of species were dried at temperature 70 0C and then the blocks were tie in a form of group with alternate wood species.

2.3.1 Pindrow vs P. euramericana

These two species of woods were dried at 70 0 C temperature and provided to termites. In a choice of two woods, termites quickly found the appealing wood and feed more on the appealing wood. Table 4.2 shows that in combinations of wooden blocks dried at 70 0 C two species of wood, termites, exhibited maximal feeding on P. euramericana and the minimal feeding on A. pindrow. The volume of wood consumption was considerably different (P=0.000***). Termites consume 6.6% A. pindrow and 17.8% P. euramericana.

2.3.2 Arabica vs C. deodara

In a choice of two woods termites quickly found the palatable wood and fed more on the appealing wood. Table 4.2 shows that among the wooden blocks dried at 70 0 C and provided in combinations of two wood types, termites exhibited remarkable feed on C. deodara and limited feed on A. arabica, and significantly the amount of wood consumed was different (P=0.003**). Termites consume 5.5% A. arabicaand 7.3%C. deodara.

2.3.3 Pindrow vs C. deodara

In a choice of two woods termites quickly found the appealing wood and fed more on the palatable wood. Table 4.2 shows that among the wooden blocks dried at 70 0 C and provided in combinations of two wood types, termites exhibited remarkable feed on A. pindrow and limited feed on C. deodara, So, the amount of wood consumed was significantly different (P=0.001**). Termites consume 7.2 % A. pindrow and 4.0% C. deodara.

2.3.4 Arabica vs P. euramericana

In a choice of two woods termites quickly found the palatable wood and fed more on the appealing wood. Table 4.2 shows that among the wooden blocks dried at 70 0 C and provided in combinations of two wood types, termites exhibited remarkable feed on P. euramericana and limited feed on A. arabica, and significantly different was the amount of wood consumed (P=0.05*). Termites consume 17.5% P. euramericana and 8.5% A. arabica.

2.4 Repellency Test

The repellency of the medicinal plant extract demonstrated the height of the collision between a number of termites detected on the treatment curve and a number of termite death curves. A low proportion of connection between the two curves suggests a high amount of repellency, whereas a large percentage of connection between the two curves shows a low level of repellency (Remmen and Su, 2005). According to this criteria, the Mentha spicata extract treatment is clearly non-repellent after 8 hours. The repellency of medicinal plant extract was proven to be repellent at higher concentrations, such as 8% and 10% Mentha spicata extract, but non-repellent at all other dosages, such as 2%, 4%, and 6% Mentha spicata extract (Table 4.3). These findings demonstrated that Mentha spicata extract is a long-acting, non-repellent medicinal herb, making it appropriate for long-term control programs.

2.5 Anti-termitic Assay

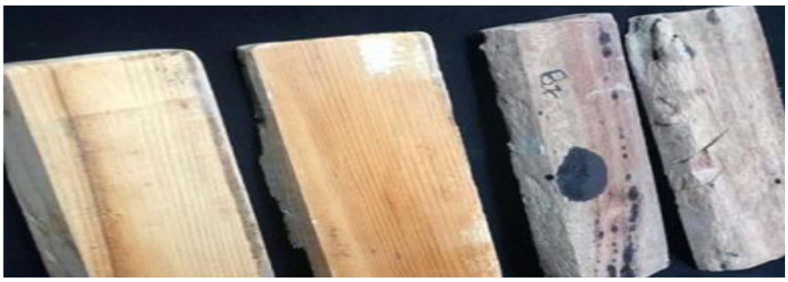
The percentage mortality for subterranean termites when treated with medicinal plant Mentha spicata extract, after 8 hours was 20 in 2.00%, 37 in 4.00%, 60 in 6.00%, 83 in 8.00% and 100 in 10.00% respectively. Minimum percentage mortality was recorded in low concentration 2.00% is 20 and maximum percentage mortality was recorded in high concentration 10.00% is 100. For control, termites are treated only with water and lowest percentage mortality was recorded is 13%.

(a) A. pindrow vs C. deodara

(b) A.arabica vs D.sisso

(c) M. indica vs P. roxburghii

(d) A.pindrow vs A.arabica



(e) C. deodara vs D. sisso

Plate 1. *Figure showing feeding preferences of termite. (a)A. pindrow vs C. deodara (b) A. arabica vs D. sisso (c)M. indica vs P. roxburghii (d) A. pindrow vs A. arabica (e) C. deodara vs D. sisso.Magnification. 100X*

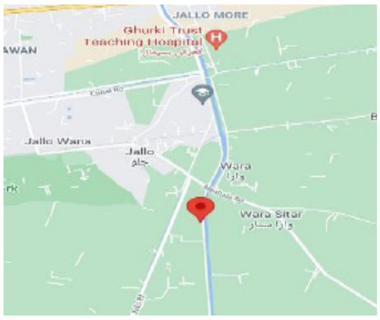
3. Materials and Methods

The chapter deal with the methods used for this analysis, the samples and their characteristics, and the data collection process. In order to get the results of the report, the chapter provides a summary of the original research that was applied in the next chapter.

3.1 Plant Collection

(a). Termites Collection

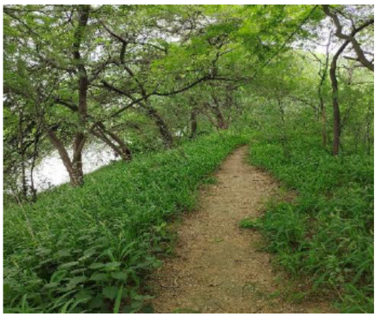
(b). Mentha spicata (Mint)



(c) Map location of area

(d)Rich vegetation

(e) Mound of Termites



(f) Herbs and Shrubs

(g) Plantation

(h) Location

(i) River view pavement

Plate 2. *(a) Termites collection (b)Mentha spicata (Mint) (c)Map location of area (d)Rich vegetation(e)Mound of Termites (f)Herbs and Shrubs(g)Plantation (h) Location(i)River viewpavement. Magnification. 100X*

Leaves of plant Mentha spicata (mint) were collected from different places like, farms/ institutions near in Lahore. Some 1-2kg leaves of Mentha were taken and taxonomically identified by Prof.Dr. Khalid Nasir, a taxonomist at Punjab University herbarium.

3.2 Site Selection

Experiments were conducted in a place near the Wahga border in Lahore, Pakistan. The area was rich with vegetation. There were also different plants, herbs and shrubs that are favorite food sources of termites. Termite colonies are found even on the surface of the ground. Termites have been found to feed on dead plants, herbs and shrubs. Termite colonies are typically found in the shade and near water sources. Due to a lot of plantation sunlight did not directly affect the termites. In summer, the climate is very hot. The highest temperature in June and July, the hottest months, is 40 oCusing a medicinal plant extract on four commercial wood species that had been dried at 70 °C, we examined the feeding preference, resistance, and anti-termitic action of subterranean termites. When all of the wooden blocks were dried at 70 °C, the results of no-choice field trials indicate P. euramericana; A. pindrow; A. arabica; C. deodara. When treated with the extract of the medicinal plant Mentha spicata, the result indicated that C. deodara was resistant and was the wood that was consumed the least, at 15.5%. whereas P. euramericana demonstrates that the maximum amount of wood consumed is 72.5%. In controlled field trials, two kinds of wooden blocks were tied together and fed to subterranean termites. The findings indicate that termites preferred the one palatable wood from each pair. 6.6% of A. pindrow and 17.8% of P. euramericana. There was a considerable difference in the quantity of wood consumption (P = 0.0001). Termites consumed 5.5% A. arabica and 7.3% C. deodara in the pair, with a considerable difference in the quantity of wood consumption (P = 0.003**) between the two species. Termites consume 7.2% of A. pindrow and 4.0% of C. deodara in pairs of (A. pindrow vs. C. deodara). There was a major difference in the amount of wood used (P = 0.001**). Termites consume 17.5% P. euramericana and 8.5% A. arabica in pairs of (A. arabica vs. P. euramericana). The quantity of wood consumption differed considerably (P = 0.05*). In a repellency test, the result indicated that the extract of the medicinal plant Mentha spicata shows repellency at higher concentrations, whereas Mentha spicata extract was non- repellant at lower concentrations. Winter is cold and mean temperature is 13 oC. Average rainfall is 141.7 mm, with maximum rainfall (52%) in the summer monsoon and 30% in winter. Soil is rich in nutrients and organic matter.

3.3 Collection of Termites

Workers of subterranean termites were collected from a place near the Wahga border that is 30 km away from Lahore. The termites were kept alive for at least a week by filling each petri plate with water-soaked filter sheets and 5-gram oven dried soil.

3.4 Wood Species

Commercially important wood species A. pindrow (Palwadar), C. deodara (Diar), A. arabica (Keekar), P. euramericana (Poplar) were selected for trials. There were a great variety of timbers in Pakistan but for performing experiment most of wood species were taken from lumber yard. Selected wood species are as follows. A. pindrow (Palwadar), C. deodara (Diar), A. arabica(Keekar), P. euramericana (Poplar). Each piece of wood was cut into small blocks (L, W, T = 4x5x1 cm). Every day, wooden blocks were dried in the sun. Finally, before being exposed to termites, wooden blocks were oven-dried at 42 degrees Celsius for 72 hours. To maintain the moisture atan adequate level distilled water was used as required during experimentation; however, experiments were applied directly into the nest where naturally adequate moisture is maintained.

3.5 Preparation of Plant Extract

Using a grinder, the medicinal plant leaves were crushed into a thin powder. Twenty grams of leaf powder were extracted in a Soxhlet extractor with 200 ml of ethanol. The dried residues were extracted using a rotary evaporator and refrigerated before being used to make stock solution. For plant extract, a 10% stock solution was created by dissolving 1 gram of dried extract in 10 ml of absolute ethanol, and then 2%, 4%, 6%, 8%, and 10% concentrations were generated from the stock solution.

3.6 Anti Termitic Assay

The tests were carried out in accordance with the protocol outlined by Abbas et al. (2013). Each filter paper was moistened with 0.5 ml of 2%, 4%, 6%, 8% and 10% concentrations. The filter papers were dried at room temperature and put in a separate petri dish. Each petri dish was then populated with five workers and five soldiers of subterranean termites. Observations were collected every 1/2 hour up to 08 hours, and after an interval of 08 hours, data regarding the termites' death rate was recorded.

3.7 Repellency Assay

Filter sheets 9 cm in diameter were divided into two equal halves to estimate repellency. One half of each filter paper was treated with 2%, 4%, 6%, 8%, and 10% concentrations of both extracts, while the other half was served untreated with distilled water only. Ten termites were introduced into the Petri dish & #39;Centre. The repellent effect was measured every 15 minutes by counting the number of termites on treated (T) and untreated (UT) filter paper, and theexperiment lasted 2 hours. For each concentration, three replicates were made. When 21 (a total of three repetitions) of 30 termites were present on an untreated pan in a petri dish, a treatment dose was judged repellant.

3.8 No ChoiceField Trials

Four different species of wood were prepared and dried for 48 hours at 70 degrees Celsius. Blocks of each type of wood species were tied separately and treated at 2%, 4%, 6%, 8% and 10% concentrations of Mentha spicata (mint) extract. For three months, individually tied blocks of wood was suppressed 30 centimeters below the surface in the soil at various nest locations. After 3 months, the experiment was dismantled and wooden blocks were taken out of the nest, washed, dried and reweighed to understand feeding consumption.

3.9 Choice Field Trials

Termites feeding preferences and resistance were compared by conducted choice field trials in A.pindrow vs P. euramericana, A. arabica vs C. deodara, A. pindrow vs C. deodara, and A. arabica vs P. euramericana. These pairs were tied up in a bundle with the help of copper wire. The location of the nest is different, but the methodology of the test is the same. as in no-choice field trials. The wooden blocks of four diverse wood species measuring (4x5x1 cm) were prepared and dried at a suitable 70 °C temperature for 48 hours. After 3 months, the wooden blocks were taken out of the nest, washed, dried and reweighed, and the wood consumption was calculated.

3.10 Statistical Analysis

Using one-way ANOVA at a significant ($P<0.05$) level, the percentage mortality of termites and no choice bioassay were computed. The paired comparison t test was used tostatistically assess the selected bioassays.

(a). No choice trials

(b). Choice trials

(c). Mound of termites

(d). BRB canal flowing

(e). Site of mound for installtion

(f). BRB canal nearby

(g). Mound with woods

(h). Burried Woods in mound

(i). Combs in Mound

(j). Installation in areawith vegetation

Plate 3. *(a)No choice trials(b) Choice trials (c)Mound of termites (d) BRB canal flowing (e)(e) Site of mound for installtion (f) BRB canal nearby(g) Mound with woods (i) Combs in Mound(h) Installation in area withthick vegetation of Wagha border. Magnification. 100X*

4. Discussion

Based on these findings, the Mentha spicata extract treatmentis clearly non-repellent. The agricultural and domestic sectors can be affected considerably by the presence ofpests. Chemical pesticides are still being used, so it' more important than ever to use products made from plants to control them. Repellents made from plants are known to have minimalnegative effects on the environment. They can be used to repel pests by arousing their sensesbefore they can attack (Jimma 2014; Cespedesetal.2014).Using a medicinal plant extract on four commercial wood species that had been dried at 70 °C, we examined the feeding preference, resistance, and anti-termitic action of subterranean termites. When all of the wooden blocks were dried at 70 °C, the results of no-choice field trials indicate P. euramericana; A. pindrow; A. arabica; C. deodara. When treated with the extract of the medicinal plant Mentha spicata, the result indicated that C. deodara was resistant and was the wood that was consumed the least, at 15.5%. whereas P. euramericana demonstrates that the maximum amount of wood consumed is 72.5%. In controlled field trials, two kinds of wooden blocks were tied together and fed to subterranean termites. The findings indicate that termites preferred the one palatable wood from each pair. 6.6% of A. pindrow and 17.8% of P. euramericana. There was a considerable difference in the quantity of wood consumption (P = 0.0001). Termites consumed 5.5% A. arabica and 7.3% C. deodara in the pair, with a considerable difference in the quantity of wood consumption (P = 0.003**) between the two species. Termites consume 7.2% of A. pindrow and 4.0% of C. deodara in pairs of (A. pindrow vs. C. deodara). There was a major difference in the amount of wood used (P = 0.001**). Termites consume 17.5% P. euramericana and 8.5% A. arabica in pairs of (A. arabica vs. P. euramericana). The quantity of wood consumption differed considerably (P = 0.05*). In a repellency test, the result indicated that the extract of the medicinal plant Mentha spicata shows repellency at higher concentrations, whereas Mentha spicata extract was non- repellant at lower concentrations. The products of these investigatedplants, particularly L. camara and R. stricta, can be used to make phytochemicals that can beused to protect non-target creatures from pesticides. Positive findings regarding human and animal health safety have been found in a numberof studies involving plant extracts in agriculture and residential pest management (PascualVillalobos and Robledo, 1999; Scott et al.2004; Pino etal. 2013; Najem et al.2020; Al-Solami 2021). Consequently, the use of bio pesticides in place of synthetic insecticides hasemerged as a method that is generally supported and recognized.Despite the fact that some botanicals are less potent than chemicals, they are stillharmless for the environment. They are also renewable and decomposable. However, thewidespread and extensive use of biochemical pesticides typically results in risks to humans andthe environment from insect resistance and residues (Lamirietal, 2001).Consequently, it is anticipated that botanical insecticides, which are based on natural plantcomponents, will find practical application because they offer products that are selective, effective, and safe from toxicological testing.To suppress termites, the soil is commonly treated with natural/synthetic substances. Insecticides used to create a soil barrier, preventing subterranean termites from tunneling andreaching food sources. The capacity of termites to burrow throughtreated soil and the toxicity of materials (plant extracts) in laboratory studies were used to evaluate potential soil termiticides (Grace et al.1993; Su et al. 1993). For termite-resistant interpretations and anti-termite medicinal plant extracts, the findingspresented here largely confirm by previous findings (Ahmed et al.2017).Numerous studies have demonstrated that plant extracts can be applied to filter paperand/or mixed into soil to calculate mortality (Blaske et al. 2003; Jembereet al. 2005). They came to the assumption that plant extracts could be used to control termitesboth below and above ground.

5. Conclusion

As a result of over-exploitation and habitat degradation, aromatic and medicinal plants are experiencing genetic erosion and must be protected. The current investigation discovered that various medicinal plants had anti-termitic properties. The usage of these medicinal plants should be encouraged as these are readily available, accessible and affordable among local populations. These medicinal plants can be used as an eco-friendly and long lasting insecticide against termites. The extract of medicinal plant M. spicata was particularly efficient against subterranean termite, causing considerable death. In order to achieve results that are both safer and superior, further investigation is necessary to determine the effectiveness of medicinal plant extract against additional species of termites residing in different ecological zone of Pakistan.

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