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CURRENT TREND IN LAMIACEAE AS A RESPONDING TO NATURAL ELICITORS SPRAYING: FOCUSING ON NATURAL PRODUCTS AND PLANT STRESS. A MINI NARRATIVE REVIEW

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Abstract:

Lamiaceae is the largest family in the order Lamiales, with 236 genera and over 7,000 flowering plant species. Known as the mint family, it is important for its aromatic leaves and medicinal properties. Stresses affect plant physiology, prompting the production of secondary metabolites. Elicitors accelerate secondary metabolite formation in plants. By the present review, Web of Science, Scopus, Google Scholar, PubMed and Science Direct databases were referred to collect information about natural elicitors (amino acids, polyamines, yeast, seaweeds and plant extracts). This present work reviewed the literature from 2015 to march 2024. The aim of this work is to highlight the recent in the impact of natural elicitors on secondary metabolite accumulation and plant stress in Lamiaceae. Foliar spraying of natural elicitors induced changes in plants, such as increased volatiles accumulation and alterations in essential oil composition, phenolic contents, and total flavonoids, as well as antioxidant enzymes. Variations in growth, oil composition, and yield were observed in different plant species in response to drought and salinity stress. The plants adapted by changing their physiological activities to produce secondary metabolites. Spraying Natural elicitors effectively reduces the damage of oxidative stress and mitigates the negative effects of salinity, water deficit, and heavy metals on secondary metabolites in plants of the Lamiaceae family, leading to plants of this family adapting to conditions of various environmental stresses. Review showed that focusing on *Ocimum* genus; importance of studying various biological extracts especially on plant extracts on Lamiaceae genus, including diverse species like Chia (*Salvia hispanica* L.).

Keywords: *Lamiaceae*, Natural- Elicitors, Foliar spraying, Secondary Metabolites, Plant Stress.

2. Introduction:

Lamiaceae, previously called the mint or family Labiatae, is a significant plant family with volatile oil. With over 7,000 species, it is one of the largest plant families consisting of 236 genera

(Marzouk et al., 2018; Hamed et al., 2021). The plant taxa being a part of to the family are well known as spices and vegetables, as source of valuable oils, in cosmetics, and for pharmaceutical purposes (Tamokou et al., 2017; Tchatchouang et al., 2017).

Several plant species of *Lamiaceae* have been used since antiquity as herbs and spices helping for food flavoring, acting as food preservatives as well as for nutritional and healthy properties (Nieto, 2017; El-Gharbaoui., 2017). Furthermore, common plants of the family such as oregano (*Origanum vulgare* L.), mint (genus *Mentha*), culinary sage (*Salvia officinalis* L.), rosemary (*genus Lavandula*), common thyme (*Thymus vulgaris* L.), among others, have an extensive history of use as spices and herbal remedies for multiple purposes (Ulewicz-Magulska and Wesolowski., 2023; Babotă et al., 2023).

The major effects of metabolites, including application in health, importance for nutrition and economical added values of plant material are attributed, mainly, to secondary metabolites (Sanchez and Demain, 2011). Natural products are compounds derived from living organisms, either as primary or secondary metabolites. Secondary metabolites are chemicals with diverse structures, synthesized by certain plants and strains of microorganisms and not crucial for growth, unlike primary metabolites (Omokhefe Bruce, 2022).

During their growth cycle, plants create Secondary Metabolites (SMs) to assist in cellular functions and survival during stress. Secondary metabolites of plants consist of phenolic compounds (flavonoids and phenylpropanoids), nitrogen-containing compounds (cyanogenic glycosides, alkaloids, and glucosinolates), and terpenes (isoprenoids) (Jamwal et al., 2018; Sanchez and Demain, 2011). Terpenoids, phenolic compounds and alkaloids are the main classes of SMs. Moreover, Saponins, Glycosides and tannins are included as SMs for their specific structure. Biosynthetic pathways of SMs in plants include Malonic-acid pathway, Shikimic- acid pathway, MEP (methylerythritol-phosphate) pathway and Mevalonic-acid pathway (Figure 1).

Secondary metabolites have several functions and roles for plants to sustain their life. Moreover, SMs are involved in defense system and in interactions between plants and their surrounding environment (Chen et al., 2022). Also, SMs contribute to specific fragrances, plant color, flavors, and it induces plant's responses to various plant stresses and pathogens (Reshi., et al., 2023). They play an essential role in helping plants cope with different stress conditions. The composition and amount of their secondary metabolites are impacted by Environmental factors such as the thermal stress, osmotic stress, drought stress, salinity, and (Assaf et al., 2022). Environmental stressors can affect metabolite production, resulting in reactive oxygen species formation (Aftab, 2019).

The amount and quality of these compounds are influenced by environmental conditions and stress levels. SMs are crucial for plant adjustment to difficult environments and are valuable sources of active ingredients. These compounds aid plants in adapting to their surroundings and have been studied for their importance in plant physiology and human health since the 19th century. Over 200,000 bioactive phytochemicals, known as plant secondary metabolites, have been found globally, derived from more than 391,000 identified plant species (Yeshi et al., 2022).

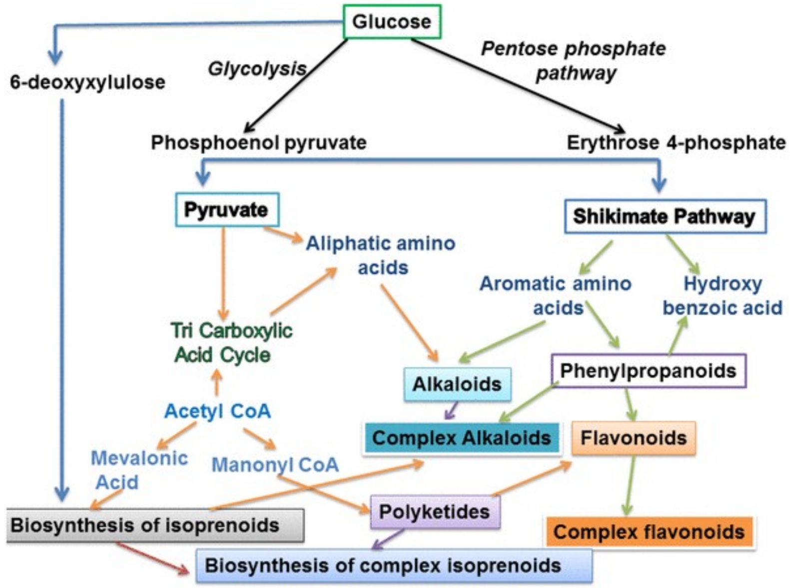

Fig.1. Biosynthesis pathway of secondary metabolites in plant (Isah., 2018).

Plants respond to environmental stresses by creating compounds that aid in stress management and boost plant resilience and productivity. Biostimulants with active ingredients are believed to enhance plant quality, but their complete impact on plants is yet to be fully comprehended, necessitating additional research (Teklić et al., 2021).

Environmental stresses, whether abiotic or biotic, have a detrimental impact on plant development and output. Abiotic stressors like drought, salinity, and soil pH cause over half of crop loss by inducing physiological and biochemical changes in plants (Salam et al., 2023). Genetic variability in plants results in differences in bioactive content, which can be impacted by environmental factors like climate change, pathogens, and herbivore attacks (Yeshi et al., 2022).

Secondary metabolites in plants are crucial for ecosystem functioning, defense, and communication, helping to minimize damage from environmental stress and combatting various abiotic stressors. Environmental stresses greatly impede plant growth globally, impacting important metabolic processes such as water uptake, mineral assimilation, germination, root growth, photosynthesis, respiration and protein synthesis, as a result of high levels of harmful reactive oxygen species (Alnusaire et al., 2022). Plants adapt to stress by altering membranes, maintaining cell structure, and producing antioxidants and secondary substances. Biostimulants for plants can enhance growth, metabolism, and metabolite production (Nia et al., 2016). Organic compounds are mainly carbon-based compounds with covalent bonds to elements like hydrogen, oxygen, or nitrogen (Noller et al., 2023).

Chemical compounds known as elicitors can trigger stress responses in plants, causing increased production of secondary metabolites or the creation of new ones. Various factors like type, dose, and treatment schedule of elicitors play a key role in determining their impact on secondary metabolite production. Furthermore, achieving successful accumulation of biomass and secondary metabolites depends on crucial parameters including elicitor concentrations, cell line, exposure duration, culture age and nutrient composition (Naik & Al-Khayri, 2016).

Environmental factors and stress influence secondary metabolites (SMs) in plants, contributing to their adaptation and survival. Biosynthesis is controlled by elicitors through different metabolic pathways, with abiotic and biotic factors influencing elicitation, ultimately enhancing SMs production for the pharmaceutical industry. Abiotic elicitors such as temperature, light, salinity, drought, and ozone, as well as biotic elicitors like fungi, bacteria, phytohormones, rhizobacteria, and polysaccharides are essential. Improving strategies for SM production is crucial for various applications and product advancement (Humbal & Pathak, 2023).

Foliar nutrients are proven to boost crop yield and improve resistance to pests, diseases, and drought. This technique is especially useful for improving the growth of aromatic and medicinal plants in sustainable farming and horticulture (Shahrajabian et al., 2022). Additionally, foliar fertilization is more beneficial than soil fertilization when the plant's need for nutrients is greater than what the root system can provide, or when nutrient absorption is hindered, particularly in challenging environmental conditions that could impact the crop yield (Fernández et al., 2013). Leaves can take in nutrients via water-based solutions and foliar treatments, enabling nutrients to be directly sent to other parts of the plant. Additionally, foliar applications can aid in managing harsh conditions like heat, cold, frost, drought, and saltiness through the use of growth regulators, stimulants, or biostimulants (Gao et al. 2018; Godoy et al., 2021). It is crucial to adapt the timing and concentration of nutrient application to suit different growth stages (Niu et al. 2021).

2. Effect of Natural Elicitors as Spraying Application on Secondary Metabolites and Plant Stress

Elicitors are a group of molecules/compounds that enhance several defense mechanisms in plants (Jamiołkowska., 2020). They, as stimuli, can be originated from different sources including living organisms, nonliving components, and environmental sources that accelerate the production of secondary metabolites in plants (Bharti et al., 2023). In plants, many elicitors play a vital role in stress tolerance mechanism generating numerous numbers of SMs, enhancing, therefore tolerance to abiotic and biotic stresses (Rani et al., 2023).

2.1. Spraying of Amino Acids and Poly amines

Amino acids are the basic building blocks of proteins, and they serve as the nitrogenous backbones for compounds like neurotransmitters and hormones. In chemistry, an amino acid is an organic compound that contains both an amino ($-NH_2$) and carboxylic acid (-COOH) functional group, hence the name amino acid (LaPelusa & Kaushik, 2022).

Polyamines are organic compounds contain two or more amino groups ($–NH^{+3}$) found in all cells (eukaryotic and prokaryotic), synthesized from various amino acids. They are vital for cell functions like growth, gene regulation, division, and survival, as well as DNA and protein synthesis, apoptosis, stress response, angiogenesis, and communication among cells., Spermidine spermine, and putrescine are common polyamines in the all organisms (Lenis et al., 2017; Bae et al., 2018; Cui et al., 2020). They are essential for the growth and development of prokaryotic and eukaryotic organisms. They are widespread in all living organs of plants and play a crucial role in protein synthesis transcription and cellular enzyme activity balance. Polyamines also impact plant physiological functions, including growth, cell differentiation, and response to stress, flower development, organogenesis, and breaking the dormancy of tubers. Their concentration increases in proliferating cells (Takahashi & Kakehi, 2010).

Melatonin (MEL) serves as a pivotal regulator in plants and is present in a wide range of organisms, such as plants, bacteria, algae, invertebrates, and vertebrates. Discovered in plants in 1995, MEL plays a significant role in plant defense against oxidation, regulation of growth, and stimulation in challenging environmental conditions. Its quantity increases in stress environments, influencing plant growth and development. Plant species abundant in MEL display enhanced stress resistance and are involved in stress-related changes like flowering, fruiting, and aging. Plants possess an enzymatic system for MEL production and can take in MEL from the surroundings (Kołodziejczyk & Posmyk, 2016; Kilic et al., 2021; Sharma et al., 2023).

The impact of amino acid solutions on various secondary metabolites' quantity and quality varied depending on the mint cultivar *Mentha piperita* (Granada), *Mentha spicata* (Crispa), and *Mentha piperita* (Swiss). Phenylalanine spraying at a concentration of 100 mg L^{-1} enhanced essential oil percentage by 0.53 units in *Mentha piperita* 'Granada' plants. For *Mentha spicata* 'Crispa', foliar application of tyrosine solutions at 100 mg L^{-1} concentration had the most significant effect on the essential oil's odor profile. *Mentha piperita* 'Swiss' showed the highest total flavonoid content when sprayed with tyrosine at 100 mg L^{-1} concentration. Flavonoid levels were influenced by the mint variety, amino acids, and their concentrations (Velička et al., 2022).

Al-Fraihat et al. (2023) examined the influence of various amino acid types (L-tryptophan acid at 100 ppm, glutamine acid at 200 ppm, and L-tryptophan acid + glutamine acid) on the growth of rosemary (*Rosemarinus officinalis* L.) plants, looking at salt resistance, plant height, chlorophyll, dry herb weight and proline content, volatile oil percentage, and constituents. They discovered that rising soil salinity had negative effects on plant height, dry weight, salt resistance, and chlorophyll but increased proline content in leaves. Amino acids improved growth, chlorophyll content, and salt resistance, with the SRI exceeding 100% under certain salinity levels. GC/MS analysis identified camphor, D-verbenone, and α-pinene as major volatile oil components.

Basil (*Ocimum basilicum* L.) leaves sprayed with; glycine betaine and proline were improved in their content of total phenols under salinity conditions when comparing with controls. All proline and glycine betaine treatments enhanced the content of flavonoids in leaves under conditions of salinity comparing with the control (Safwat & Abdel Salam, 2022).

Foliar spraying of proline on *Satureja hortensis* L. (summer savory) increased total phenol to 9.8%, flavonoids to 18%, and essential oil yield to 15.8%, while 24-epibrassinolide spraying significantly increased phenolic compounds to 32.15% (Abbasifar et al., 2020).

L-phenylalanine spraying significantly increased the essential oil content in *Melissa officinalis*, potentially promoting secondary metabolite biosynthesis. The highest yields were observed from the foliar spray of L-phenylalanine (1000 mg L). The six major compounds of *M. officinalis* essential oil were Neral, Z-Citral, E-Citral, Geranial, Citronellal, and β-Caryophyllene, with the highest content of Neral and citronellal at 1000 mg/L L-phenylalanine (Baharlou et al., 2019).

Ghazal (2015) examined the effect of phenylalanine and tryptophan, along with ascorbic acid, on the yield and essential oil of *Thymus vulgaris* plants. Phenylalanine at 150 mg/l had the most positive impact on yield and essential oil, with thymol, p-cymene, and linalool being the key components of the oil. He suggested using phenylalanine to promote high production and oil yield in thyme plants.

Under different water stress, essential oil percentage of thyme decreased, while glycol peroxidase and proline increased. Foliar application of amino acids positively impacted these traits, with commercial and proline amino acid foliar application yielding the highest essential oil yield. Consuming proline under stress conditions can help plants withstand drought stress (Kazempour et al., 2023).

Tarasevičienė et al., (2021) investigated the impact of foliar application with L-tryptophan, L-tyrosine, L-phenylalanine at two concentrations (100 mg L^{-1} and 200 mg L^{-1}) on the phenols content of mints, specifically *Mentha piperita* "Swiss". The study found that foliar application of amino acids boosted the total phenol content by 1.22 to 3.51 times, depending on the treatment and mint variety. Tryptophan has the most significant impact on total phenolic acids, with the most significant effect on total phenolic acids. The results indicated that biophenol content varies based on foliar spray and variety, and each mint variety has its own response to various amino acid applications.

All Putrescine (butane-1,4-diamine) concentrations show significant increase in total soluble phenols concentrations of *Thymus vulgaris* plants comparing with the control. Foliar application of putrescine reduce the harmful effect of drought stress by changing accumulation of phenolic compounds and activities some related enzymes. Spraying at 0.2 mM has the ability to enhance oil yield hence allowing thyme plants to grow better under water stress condition (Abd Elbar et al., 2019).

Mohammadi-Cheraghabadi et al., (2023) studied the effect of putrescine on the essential oil (EO) content, yield, and profile of *Salvia officinalis* (sage) harvested in spring and summer. They found that all treatments improved EO quality and quantity, with nearly 30% available soil water depletion and better quality in summer the highest content of essential oil was predicted under 3.04 mM of putrescine. GC/MS analyses identified 25 monoterpene compounds in sage's EO, with α-thujone, camphor, pinocarvone, β-thujone, and 1, 8-cineole being the most abundant.

A study on *Salvia officinalis* found that putrescine significantly impacted the amount of total phenolic compounds, flavonoids, and antioxidant activity. The best concentration for improving the essential oil yield of sage was 1000 mg L^{-1}. The key essential oil compounds of different putrescine treated sage were cis-thujone, camphor, trans-thujone, 1,8-cineole, α-humulene, viridiflorol, camphene, α-pinene, β-pinene, and limonene (Zeynali et al., 2023).

Kabiri et al., (2018) showed that 100 µM melatonin-treated Moldavian balm plants (*Dracocephalum moldavica*) displayed the best leaf surface area, flower length, lateral branching, and antioxidant enzyme activities. Application of 100 µM melatonin did not significantly impact catalase activity compared to the control or other melatonin concentrations under various drought stress levels. The lowest H_2O_2 and lipid peroxidation levels were observed at 100 µM melatonin under severe drought stress. This concentration also enhanced chlorophyll content and relative water content, but had no significant impact on proline content or leaf length in comparison to the control. The results imply that 100 µM melatonin applications is more effective in mitigating moderate and severe drought stress compared to 50 or 150 µM concentrations.

A study was conducted to analyze the impact of Melatonin's foliar application on the secretion products in leaf trichomes of lemon balm (*Melissa officinalis* L.) without external stress factors. Monoterpenoids, essential for the quality of lemon balm's oils, showed variations due to Melatonin effects (Kilic et al., 2021).

Melatonin significantly improved basil plant resistance to drought through the activation of antioxidant enzymes (phenylalanine ammonia-lyase, catalase, polyphenol oxidase and ascorbate peroxidase) and secondary metabolites (flavonoid, total phenol, and anthocyanin in levels). Additionally, melatonin treatment boosted relative water content and photosynthetic pigments, and decreased lipid peroxidation leading to enhancements in plant dry matter. It was determined that applying melatonin through foliar spraying triggered pre-adaptive reactions to drought stress before controlling antioxidant defense mechanisms (Naghizadeh et al., 2024)

Applying 50 µM Melatonin (MEL) may help herbs withstand Arsenic (As) stress by strengthening antioxidant machinery and osmoregulation capacity (Farouk & Al-Amri, 2019). Application of various melatonin concentrations on *Agastache foeniculum* enhanced the content of total phenol, flavonoids content as well as essential oil %, and methyl chavicol especially at 100 µM (Mohammadi et al., 2022).

The review highlighted the utilization of various biological elicitors including Phenylalanine, proline, L-tryptophan, glutamine, glycine, L-tyrosine, Putrescine (butane-1,4-diamine), melatonin. Foliar spraying with these elicitors has enhanced the essential oil content, flavonoid, total phenol, and anthocyanin of *Lamiaceae* genera, with notable impacts on specific oil components like Neral and citronellal in *Melissa officinalis*, thymol, p-cymene, and linalool in *Thymus officinalis*. Biological elicitors also enhanced the content of total phenols and flavonoidcontent. The review recommends the use of natural stimulants to improve the production of active substances in plants of the Lamiaceae family, in addition to increasing the plants' ability to toleration the environmental stresses.

2.2. Spraying Bio-Extract (Yeast, Seaweeds and Plant extracts)

Yeast extract is typically described as the extract that is soluble in water, made from yeast waste streams like baker's yeast, brewer's yeast, Candida utilis, Candida tropicalis, and Kluyveromyces marxianus (Demirgül et al., 2022). It is a complex product consisting mainly of cell wall material and cell contents, with a high level of free amino acids and B group vitamins. The primary free amino acids found in yeast extracts are glutamic acid, glycine, alanine, and valine (Vieira et al., 2016).

Seaweeds provide fertilizers and plant growth regulators with abundant nutrients, including carbohydrates, proteins, minerals, polysaccharides, and polyphenols, phlorotannins, and plant hormones. Algal extracts may contain additional substances like urea, humic acids, and growth hormones, impacting plant growth, soil fertility, and microorganisms. Exploring other seaweeds and extraction methods is recommended due to their potential benefits (Górka et al., 2018).

Growth characters of two basil varieties (*Othimum basilicum* var. basilicum and *Othimum basilicum* var. Genovese) significantly enhanced with 3 ml/L algal extract treatments. Essential oil composition, yield, and proline content also saw significant increases. All varieties showed differences in growth, oil composition, and yield, possibly due to salinity stress variations. The essential oils of basil plants had 30 components, with linalool, Estragole, and Eucalyptol being the main ones. Algal extract were crucial in improving basil plant growth and quality under salt stress, potentially aiding in sustainable medicinal plant production (El Gohary et al., 2023).

Taha et al. (2020) found that applying 1g/L of palm pollen grains extract on water-stressed sweet basil (*Ocimum basilicum* L.) plants significantly increased their essential oil content compared to control plants with no treatment, which produced 0.6% volatile oil.

Whene sweet basil (*Ocimum basilicum* L.) plants sprayed with 4 g yeast extract/L yielded 0.65% essential oil. Geranial, linalool, and neral are the primary components. Linalool accounted for 32.69% of the volatile oil in control plants and 35.36% in plants treated with 4 g yeast extract /L (Nassar et al., 2015).

Application of *Moringa oleifera* leaves extract enhances the medicinal properties of *Ocimum basilicum* oil by boosting bioactive compounds like linalool, estragole, and eucalyptol in plants grown under 1000 ppm salt stress. Of the MLE concentrations tested, 5 mg/L showed the greatest improvement in key bioactive compound levels (Alkuwayti et al., 2020).

Mohamed et al. (2022) found that the application of yeast extract at 5 g/l. or 10 g/l significantly enhanced the growth of essential oil % in basil plants compared to the control.

Either yeast extract alone or combined with 75% mineral N (225 kg/acre) promoted essential oil % compared to 75% mineral N (225 kg/acre). Foliar spraying of moringa leaf extract (MLE) at 5 g/l, or at 10 g/l, significantly enhanced the essential oil % basil (*Ocimum basilicum* L.) plants either alone or combined with 75% mineral N (225 kg/acre) compared to control and 75% mineral N (225 kg/acre) only (Mohamed et al., 2022).

Foliar application of yeast extract significantly improved the quality of *Mentha x piperita* (peppermint) essential oil, increasing the production of menthone, neomenthol, piperitone, γ-terpinene, and isomenthol acetate by 42%, 60%, 39%, 59%, and 34%, respectively (Motiee & Abdoli, 2021).

Chia (*Salvia hispanica* L.) was treated with microalgae strains of *Arthrospira platensis*, *Chlorella vulgaris*, *Nostoc muscorum*, and *Anabaena azollae* in two application methods, foliar spray and soil drench. Microalgae applications significantly enhanced seed oil yields, as well as an increase in linolenic and linoleic fatty acids, with a reduction in saturated fatty acids, namely, palmitic and lauric acid (Youssef et al., 2022).

El-Gohary et al., (2020) found that plants sprayed with banana peel extract (BPW) and algae extract (ALS) in clary sage (*Salvia sclarea* L.) had the highest accumulation of total flavonoids. The major constituents were gallic and chlorogenic acids, which varied with ALS, BPW, and ALS + BPW levels. The highest values of major compounds were produced from plants treated with BPW without ALS, while plants treated with ALS × BPW had higher chemical constituents. Aloe leaf extract foliar application on *Salvia officinalis* especially at highest concentration (40 ml/L) significantly increased essential oil percentage.

The recommended producing higher essential oil percentage grown in sandy soil was at using Aloe leaf extract (Abbas et al., 2016).

Spraying *Monarda citriodora* with pomegranate peel extract at 3 g/l resulted in the highest essential oil %, total phenolic compounds, and flavonoid values. Thymol was the most abundant essential oil component, followed by p-cymene and carvacrol. The highest thymol percentage was from moringa leaves at 2 g/l, while p-cymene was highest in pomegranate peel extract at 3 g/l. Carvacrol reached its peak at 14.57% with pomegranate peel extract at 2 g/l. Moringa leaves extract was more effective than pomegranate peel extract in enhancing chemical constituents (Monoterpene hydrocarbon compounds) at all concentrations tested (Wahba et al., 2022).

Spraying Lemon Bee balm (*Monarda ciriodora* L.) plants with moringa leaves extract (MLE) at all concentrations increased essential oil % comparing to unsprayed. All doses of MLE enhanced the phenol content compared to the control plants. Foliar spraying of MLE significantly increased the total flavonoids compared with control treatment in both cuts during the two seasons (Sarhan et al., 2022).

Sage plants (*Salvia officinalis* L.) were sprayed with aloe leaf extract in sandy soil. It found that Aloe leaf extract considerably raised the amount of essential oil, notably at the maximum concentration (40 ml/L). The results collected led to the recommendation to use Aloe leaf extract to produce a larger proportion of essential oil when cultivated in sandy soil (Abbas et al., 2016).

Spraying of active dry yeast, *Allium sativum* and garlic extracts on marjoram growth characteristics increased essential oil percentage, and chemical constituents (Massoud et al., 2017).

The review highlighted the utilization of various biological extracts including moringa leaves, *Aloe vera* leaves, pomegranate and banana peels, as well as yeast extract, macroalgae, and microalgae strains. Foliar spraying with these extracts has enhanced the essential oil content of *Lamiaceae* treated plants, with notable impacts on specific oil components like β-caryophyllene, linalool, geranial, neral, and in basil and thymol peppermint. Yeast was the most focused on extract, followed by moringa and *Aloe* leaves. *Ocimum* genus has received the most attention in studies, indicating a need for broader research on various biological extracts to better understand their effects on Lamiaceae family, including diverse species like Chia (*Salvia hispanica* L.).

Conclusion and future aspects

Abiotic factors were found to influence both SMs production and stress resistance in plants of this family. Several studies have explored the impact of external elicitors on secondary metabolites (SMs) and stress resistance in *Lamiaceae* plants. The review focused on how elicitors affect SM production and stress tolerance in *Lamiaceae* taxa, with a range of biological and natural elicitors being investigated in papers published from 2015 to March 2024. The articles were reviewed contained the impact of amino acids, Polyamines, algae extract, yeast extract and plant extract on *Lamiaceae* taxa, covering essential oil (EO), stress responses and tolerence, flavonoid, and phenolic compounds. Elicitors can induce changes in secondary metabolite accumulation directly or indirectly through other physiological processes. Foliar spraying with elicitors induced various changes in plants, mostly enhancing volatile accumulation, changes in EO composition and concentration of phenolic compounds and flavonoids. It is important to consider factors such as plant development stage, environmental conditions, treatment timing, type and concentration of elicitor when interpreting the results. Studies focused on the impact of chitosan on several *Lamiaceae* plants, specifically *Mentha* and *Ocimum*, with limited coverage. *Lavandula* and *Hyssopus*, among other genera, were not investigated. The main focus of studies has been on yeast extract, moringa leaves extract and Aloe leaves extract coming next. Articles had concentrated mostly on the *Ocimum* genus, highlighting the necessity for more extensive studies on different biological extracts to comprehend their impact on the *Lamiaceae* family, which includes diverse species such as Chia (*Salvia hispanica L.*). All elicitors effectively reduced oxidative stress damage and boosted total phenolics, flavonoid content, and antioxidant enzymes. Foliar spraying with bio-elicitors or with natural elicitors is a popular method in cleaning farming that involves spraying nutrients directly on leaves to correct soil deficiencies. This technique helps overcome limitations like leaching and antagonism between nutrients. It effectively saturates plant tissue with deficient nutrients, overcoming soil fertilization limitations like leaching. Foliar nutrition is the fastest way to cure nutrient deficiencies and improve plant performance.

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