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# Physiological Response of Lavender (*Lavandula* sp. L.) to Phenylalanine and Crest for Medical Applications

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**Abstract** Grown throughout Europe, the Middle East, and Asia, lavender (*Lavandula* spp.) is a herbaceous perennial plant of to the Lamiaceae family. The primary source of secondary metabolites, which are utilized in food, medicine, cosmetics, and other products, is these plants. Phenols, flavonoids, and carotenoids are the most valuable secondary metabolites found in lavender. To modify or improve bioactive metabolites in greenhouse production, a number of strategies have been employed, including the application of fertilizer, metabolism-inducing substances, and biological factor control. Two lavender species—*Lavandula angustifolia* and *Lavandula* x intermedia—are compared in this study. In 2021 and 2022, a greenhouse experiment was conducted. Four levels of phenylalanine treatment (0, 50, 100, or 150 mg/L) and three levels of Crest® (kinetin 0.010%; Indole Butyric Acid 0.005%; Gibberellic Acid 0.005%; Fine Americas, Inc., Walnut Creek, CA) (0, 25, or 50 mg/L) were applied before flowering in this factorial randomized complete block design. The majority of development features were shown to be positively impacted by phenylalanine levels. The results showed that applying phenylalanine and Crest® exogenously to lavender plants significantly boosted both kinds' plant growth. Compared to other treatments, phenylalanine at 50 mg/l and Crest® at 50 mg/l enhanced plant height, branch count, leaf area, flower count, fresh weight, and dry weight. Overall, we believe that the best way to improve lavender vegetative growth in greenhouse agriculture systems was to spray lavender plants with 50 mg/l phenylalanine and 50 mg/l Crest®. Crest® and phenylalanine may be a viable method for boosting the development of medicinal plants and may be crucial to the process. Crest® and phenylalanine may be a good way to boost the yield of therapeutic plants and may be crucial for the synthesis of phytochemicals in plants like lavender. Before farmers may employ phenylalanine and Crest® to maximize lavender yield, more research is required to assess growth dynamics and comprehend how these substances impact plants.

**Key Words** Phenylalanine, Crest®, Lavender, Growth Parameters, Statistic

## INTRODUCTION

The genus *Lavandula* is an important member of the family Lamiaceae, consisting of about 30 species and 100 varieties. Lavender is a perennial shrub and an evergreen bushy semi-shrub [1]. The area of origin for the *Lavandula* species is southern Europe, most specifically the western Mediterranean basin, extending from East to the Dalmatian Coast and Greece [2]. Lavender flowers are used as a medicine. Lavender is also used to treat some skin conditions, such as burns, wounds, minor scratches, and psoriasis. However, lavender essential oils are used to treat anxiety and insomnia [3]. Moreover, *Lavandula* contain essential oils and phenolic compounds known for their general antioxidant abilities. Scientists have investigated its chemical composition, biological activities, and potential therapeutic uses [4]. In several phytopharmaceuticals, lavender is utilized as a cholagogue, carminative, stomachic, diuretic, and spasmolytic. Essential oils, flavonoids, phenolic acids, anthocyanin, and numerous other valuable phenolic compounds are among the many natural antioxidants found in flowers, which are typically a major part of plants. Lavender's many physiologically active components, primarily essential oils and phenolic and aromatic compounds, are thought to have antioxidant, antifungal, and anti-carcinogenic properties [5,6]. There have been numerous animal and human studies evaluating the medicinal properties of lavender using modern scientific methods. These studies have demonstrated the potential for

reviving lavender's therapeutic efficacy in neurological disorders based on evidence-based medicine [1,7].

The different varieties of this plant range in height from 9 inches to 3 feet. Lavender is divided into four main categories: Among these categories under study is English lavender, known as *Lavandula angustifolia*, which is a frost-resistant species, characterised by its beautiful varieties and bright flower colors; and *Lavandula intermedia*, a hybrid between *Lavandula latifolia* and *Lavandula angustifolia*. The different types of lavender are similar in their ethnobotanical characteristics and main chemical components [5]. Plants also create a variety of amino acids and proteins that support their defensive systems. Primary and secondary metabolic pathways are the main uses for the amino acid phenylalanine (PA) [8,9]. Additionally, it acts as a precursor for numerous phenolic chemicals that are crucial for plant defence against unfavourable environmental circumstances, including flavonoids, lignin, condensed tannins, benzenoids, and volatile phenylpropanoids [10]. Some research on the growth of soybeans (Glycine max) has demonstrated the benefits of foliar phenylalanine spraying. [11], Salvia officinalis, or common sage [12]. One plant hormone that significantly speeds up plant growth and development is gibberellic acid (GA3). Because GA may regulate a range of growth and development phenomena in different crops, it is regarded as a plant growth regulator. GA3 enhances dry weight and yield [14], stimulates stem elongation, and encourages plant growth [15,16]. Lavender productivity can be greatly impacted by growing site, climate, propagation technique, and morphological traits. [17]. Additionally, the efficient production of lavender is facilitated by the use of environmentally friendly and adaptable growing techniques, such as plant growth regulators (PGRs), which enhance the genetic potential of plants. According to Wilkinson *et al.* [18] and Lymperopoulos *et al.* [9], the application of PGRs can boost yields and enhance the quality of farmed goods. Additionally, PGR treatment improves photosynthesis, respiration, and nutrition by boosting cell activity in the plant body through biochemical processes. [12]. Because of their therapeutic and medical use, medicinal plants have contributed to the global economic cycle and are now widely consumed, especially in wealthy nations [7]. Additionally, because they can adapt to soil and climate conditions, herbs are compatible with organic agricultural approaches [20]. Additionally, the variety of nutrients is crucial because it affects plant vegetative growth [21], which in turn affects crop quality and production as well as essential oil [22,23]. Organic and biological fertiliser applications include [24]. The equilibrium between water and nutrient uptake in the root zone, as well as the advantageous effects of these fertilizers on essential hormones and enzymes and their stimulating effects on plant growth, may be responsible for this increase. Some of these stimulants help plants respond to their surroundings, while others have an impact on both quantitative and qualitative plant performance [25]. Amino acids, like phenylalanine, are among these substances that either directly or indirectly affect physiological activities related to plant growth and development. One of the most significant amino acids, phenylalanine contributes to the synthesis of aromatic compounds and antioxidants [26]. Achieving the highest amount of biologically active chemicals and therapeutic in medicinal and aromatic plants requires careful consideration of the ideal fertilizer level based on environmental circumstances. The phytohormone controls almost every aspect of plant growth and development, including germination, cell division, stem and root growth, seed growth, and flowering time [27].

The present study was carried out to investigate the effect of different levels of Crest® PGR (Fine Americas, Walnut Grove, CA) and concentrations of phenylalanine acids on vegetative growth under greenhouse conditions of two species of lavender. (*L. angustifulia,* and *L. intermedia).*

## METHODS

### Experimental Design and Treatments

*Lavandula* × *intermedia* 'Provence' and *L. angustifolia* 'Hidcote' were used in this study. Plants were grown in Mississippi State 106 University's Department of Plant and Soil Sciences greenhouses (latitude 27-33 ° N; longitude 88-47 ° W) (Figure 1) with the temperature set points at 24/20° C Day/Night.

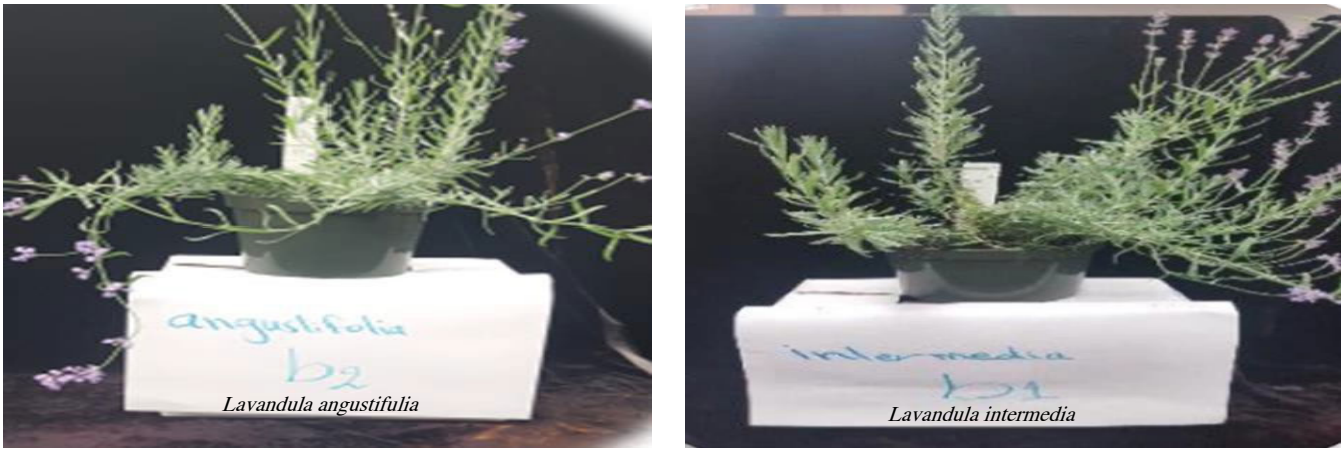



Figure 1: *Lavandula* species which used of this study (*L. angustifulia*, and *L. intermedia*)

Table 1: Chemical and Physical properties of the potting soil of experimental/ Mississippi State University (Soil Testing Laboratory) (AL-Garallaa)

| Characteristics | Units | Values |
|---|---|---|
| Soil pH | ----- | 6.3 |
| Phosphorus | lbs./acre | 905 |
| Potassium | lbs./acre | 3956 |
| Magnesium | lbs./acre | 2924 |
| Zinc | lbs./acre | 36.0 |
| Calcium | lbs./acre | 8000 |
| Total soluble salts | | 0.4 (Low) |
| Soil texture | ----- | Peat moss |

pH of soil is slightly acid. No lime recommended for this crop

**Treatment Details**

Five replications of the experiment were conducted using a Randomised Complete Block Design (RCBD). For eight months (2021–2022), plants were cultivated. The plants and flowers were taken at the soil line when half of the plants were in flower. Crest® (kinetin 0.010%; Indole Butyric Acid 0.005%; Gibberellic Acid 0.005%; 0, 25, or 50 mg/L) and four fertiliser treatment levels (0, 50, 100, or 150 mg/L phenylalanine) were applied. Plant samples were rotated every day while the plants were air-dried at 20°C for a month.

**Measurements**

Growth metrics (plant height, number of branches, leaf area, number of flowers, fresh weight, and dried weight) were measured. The dry weight (Dw-g) of all plants (buds, flowers, leaves, and stems) was calculated by weighing dry samples, and at the conclusion of the growing season, vegetative growth was noted for every plant. The soil was also subjected to chemical and physical analyses (Table 1).

**Statistical Analysis**

SAS (Version 9.4) was used to finish the experiment's data analysis. The means of the treatments was compared using the LSD test at a 5% probability level.

## RESULTS

The experiment elements and their interaction significantly impact the plant height of the experiment, according to the results of the two-way analysis of variance in Table 2. Using (verities ×Crest 25), a notable improvement in intermediate growth was observed (plant height of 41.33 cm). The reason may be attributed to the increased plant height due to GA3 treatment as gibberellin has a role in cell division and increases cell absorption of water, which is reflected in the increase in their protoplasmic volume and the increase in the surface area of the plant, its tissues, and its size [27]. While application (veritiesx Crest 50) achieved (No, branches24.25, No. flowers 15.25, leaf area 17.08, fresh weight 20.87g), respectively, followed by the *angustifolia* (verities ×Crest 50) with heights of dry weight 9.26g (Table 2) compare to control treatment from spraying only distilled water. It was also found in Table 2 that spraying phenylalanine with a concentration of 50mg/L (veritiesx Ph 50mg/L) led to a significant increase in (No. branches 26.22, No. flower 12.89, leave area 18.53, fresh weight 27.11, dry weight 9.62) compared to Ph 100 g /L, while spraying phenylalanine with a concentration of 100mg/L led to a significant increase in plant height which reached 41.22 cm. The three-way results showed (Table 3) that the interaction between Crest and phenylalanine resulted in more branches for the interaction between ($Cr_{25}$× $ph_{50}$) and *angustifolia*, where the branch number reached 23.33 and ($Cr_{50}$ × $Ph_{50}$) and *angustifolia,* where plant height reached 40.83 and fresh weight 19.51. The lowest mean dry weight was in the interaction of ($Cr_{25}$×$Ph_{100}$g / L and *angustifolia,* which gave 5.03g. The presence of a significant interaction of Crest50ml /L× Ph100× *angustifolia,* which reached 14.33 flowers/plant and 9.51 dry weight, respectively. [28] indicated that a significant increase in plant height by different levels of GA3 was observed in the number of flowers/plant. However, a significant interaction between 50ml/L Crest /L× Ph150× *angustifolia* produced the greatest leaf area, reaching 17.43 per plant. Moreover, the results of the three-way interaction show in Table 3 the presence of a significant interaction of Crest50ml /L× Ph50× *intermedia,* which reached 19.70 leave area /plant, 17.33 No. flowers, 29.15 fresh weight, and 11.12 dry weight, respectively. Well as the interaction between different concentrations of Crest25x Ph100 x *intermedia* had significantly statistically influenced the plant height. Plant height was the highest (51.33 cm). The application of different concentrations of Crest 0 × Ph50× *intermedia* had significantly influenced the number of branches /plant was found highest number of breaches/plant (31.00) compare with the control. Results showed that the interaction effects of bio-fertilizers. Phenylalanine increases plant nutrient uptake, which helps increase photosynthesis and morphological growth [28]. In terms of morphological and physiological measures, phenylalanine and Crest were significant across all treatments (Table 2, 3). In actuality, this can be the result of the many nutrients given to the plants, which enhance their growth. Applying biofertilizers may improve photosynthesis, which would boost plant development [21].

Shows that treatments have a substantial impact on plant height (cm), dry and fresh weight (g), and dry and fresh weight. Plant growth indices, such as plant height, number of branches, number of flowers, leaf area, and fresh and dry weight, exhibited the greatest increase when compared to control, phenylalanine treatments, and Crest, according to an analysis of plant growth features (Table 2, 3). Plant hormones and other growth factors are derived from amino

Table 2: The One-Way Effect and Two-Way Interactions for Varieties, Foliar Applications of Crest and Phenylalanine on Some Growth Parameters of Lavender, on Plant Height (Cm), No. Branches, Leaf Area, No. Flowers, Fresh Weight, and Dry Weight. Theirs Differences of Parameters at a Significance Level pf $p \leq 0.05$

| Treatment | Plant Height (cm) | No. Branches (branch plant$^{-1}$) | Leaf Area (cm$^2$) | No. Flowers (flower plant$^{-1}$) | Fresh Weight (g plant$^{-1}$) | Dry Weight (g plant$^{-1}$) |
|---|---|---|---|---|---|---|
| Ang. × Cr$^{0}$ | 31.96 | 15.83 | 12.81 | 7.75 | 13.81 | 7.32 |
| Ang. × Cr$^{25}$ | 26.21 | 17.58 | 13.00 | 9.42 | 15.56 | 7.22 |
| Ang. × r$^{50}$ | 33.79 | 18.75 | 16.52 | 12.33 | 17.82 | 9.26 |
| Int. × Cr$^{0}$ | 31.17 | 23.25 | 15.43 | 9.33 | 18.66 | 6.96 |
| Int. × Cr$^{25}$ | 41.33 | 17.50 | 17.08 | 8.75 | 17.50 | 8.08 |
| Int. × Cr$^{50}$ | 37.17 | 24.25 | 16.68 | 15.25 | 20.87 | 9.24 |
| LSD (0.05) | 2.75 | 0.96 | 2.06 | 1.89 | 1.87 | 1.22 |
| Varieties × Phenylalanine (g. L$^{-1}$) | | | | | | |
| Ang. × Ph$^{0}$ | 31.89 | 16.22 | 10.87 | 8.33 | 13.70 | 7.01 |
| Ang. × h$^{50}$ | 34.44 | 21.89 | 15.99 | 12.67 | 17.15 | 9.43 |
| Ang. × h$^{100}$ | 25.72 | 17.33 | 14.66 | 8.44 | 15.62 | 7.50 |
| Ang. × h$^{150}$ | 30.56 | 14.11 | 14.91 | 9.89 | 16.46 | 7.77 |
| Int. × Ph$^{0}$ | 32.00 | 19.11 | 17.69 | 9.22 | 15.68 | 7.69 |
| Int. × Ph$^{50}$ | 40.22 | 26.22 | 18.53 | 12.89 | 27.11 | 9.62 |
| Int. × Ph$^{100}$ | 41.22 | 19.44 | 15.26 | 10.89 | 15.04 | 7.60 |
| Int. × Ph$^{150}$ | 32.78 | 21.89 | 14.12 | 11.44 | 18.21 | 7.45 |
| LSD (0.05) | 4.19 | 1.42 | 1.92 | 1.15 | 2.01 | 0.91 |

Table 3: Effects of Three-Way Interactions for Varieties, Foliar Applications of Crest and Phenylalanine on Some Growth Parameters of Lavender, on Plant Height (Cm), No. Branches, Leaf Area, No. Flowers, Fresh Weight, and Dry Weight. Theirs Differences of Parameters at a Significance Level of $p \leq 0.05$

| Treatment | Plant Height (cm) | No. Branches (Branch. Plant$^{-1}$) | Leaf Area (cm$^2$) | No. Flowers (Flower. Plant$^{-1}$) | Fresh Weight (g. Plant$^{-1}$) | Dry Weight (g. Plant$^{-1}$) |
|---|---|---|---|---|---|---|
| verities × Crest (mg. L$^{-1}$) × Phenylalanine (g.L$^{-1}$) | | | | | | |
| Ang.×Cr$^{0}$×Ph$^{0}$ | 30.67 | 13.00 | 8.45 | 4.00 | 11.43 | 5.42 |
| Ang.×Cr$^{0}$×Ph$^{50}$ | 38.50 | 22.00 | 14.62 | 12.67 | 15.12 | 9.45 |
| Ang.×Cr$^{0}$×Ph$^{100}$ | 24.67 | 16.00 | 14.34 | 7.00 | 14.19 | 7.97 |
| Ang.×Cr$^{0}$×Ph$^{150}$ | 34.00 | 12.33 | 13.81 | 7.33 | 14.52 | 6.42 |
| Ang.×Cr$^{25}$×Ph$^{0}$ | 31.00 | 17.33 | 9.64 | 9.33 | 14.53 | 6.85 |
| Ang.×Cr$^{25}$×Ph$^{50}$ | 24.00 | 23.33 | 16.04 | 14.00 | 16.81 | 9.35 |
| Ang.×Cr$^{25}$×Ph$^{100}$ | 25.50 | 17.00 | 12.84 | 4.00 | 14.32 | 5.03 |
| Ang.×Cr$^{25}$×Ph$^{150}$ | 24.33 | 12.67 | 13.49 | 10.33 | 16.59 | 7.64 |
| Ang.×Cr$^{50}$×Ph$^{0}$ | 34.00 | 18.33 | 14.53 | 11.67 | 15.14 | 8.77 |
| Ang.×Cr$^{50}$×Ph$^{50}$ | 40.83 | 20.33 | 17.30 | 11.33 | 19.51 | 9.49 |
| Ang.×Cr$^{50}$×Ph$^{100}$ | 27.00 | 19.00 | 16.81 | 14.33 | 18.34 | 9.51 |
| Ang.×Cr$^{50}$×Ph$^{150}$ | 33.33 | 17.33 | 17.43 | 12.00 | 18.26 | 9.27 |
| Int.×Cr$^{0}$×Ph$^{0}$ | 22.67 | 18.33 | 16.37 | 8.00 | 15.25 | 7.16 |
| Int.×Cr$^{0}$×Ph$^{50}$ | 44.00 | 31.00 | 17.96 | 11.00 | 26.21 | 7.91 |
| Int.×Cr$^{0}$×Ph$^{100}$ | 35.67 | 21.67 | 14.67 | 9.00 | 16.94 | 6.41 |
| Int.×Cr$^{0}$×Ph$^{150}$ | 22.33 | 22.00 | 12.71 | 9.33 | 16.24 | 6.36 |
| Int.×Cr$^{25}$×Ph$^{0}$ | 35.67 | 15.00 | 18.59 | 7.33 | 16.87 | 7.61 |
| Int.×Cr$^{25}$×Ph$^{50}$ | 37.00 | 20.67 | 17.92 | 10.33 | 25.96 | 9.82 |
| Int.×Cr$^{25}$×Ph$^{100}$ | 51.33 | 15.00 | 16.61 | 9.33 | 12.15 | 7.77 |
| Int.×Cr$^{25}$×Ph$^{150}$ | 41.33 | 19.33 | 15.21 | 8.00 | 15.01 | 7.12 |
| Int.×Cr$^{50}$×Ph$^{0}$ | 37.67 | 24.00 | 18.09 | 12.33 | 14.92 | 8.31 |
| Int.×Cr$^{50}$×Ph$^{50}$ | 39.36 | 27.00 | 19.70 | 17.33 | 29.15 | 11.12 |
| Int.×Cr$^{50}$×Ph$^{100}$ | 36.67 | 21.67 | 14.49 | 14.33 | 16.02 | 8.64 |
| Int.×Cr$^{50}$×Ph$^{150}$ | 34.67 | 24.33 | 14.43 | 17.00 | 23.39 | 8.88 |
| LSD (0.05) | 7.15 | 2.57 | 3.13 | 2.55 | 3.24 | 1.75 |

acids. [29,30,31]. The role of amino acids in boosting photosynthesis and protein synthesis, boosting plant metabolic productivity, boosting plant tolerance to biostresses, and boosting quality characteristics can all be linked to increased plant growth [32]. When compared to the control, all foliar treatments significantly increased plant growth. When comparing the plant's appearance to its root uptake, the effects of foliar treatment are immediately ascertained [33]. However, compared to the control in thyme, Hakimi, [4] found that the amino acid treatment of phenylalanine and tryptophan at various concentrations significantly increased the plant height. (Thymus vulgaris L.). Furthermore, phenylalanine is essential for the synthesis of phenylpropanoid molecules. Increased leaf area, chlorophyll content, and photosynthetic rate result from phenylalanine's rapid elimination of plant shortages, which also has the potential to boost the product's amount and quality [34]. This was seen in daisy flowers (Bellis perennis L.) [35]. As foliar concentration rises, leaf uptake efficiency falls and may even negatively impact leaf metabolism and photosynthesis.

## DISCUSSION

*Lavandula* dry weight was enhanced by organic treatments (Crest and Phenylalanine). Additionally, by aiding in the rooting process of plants, Crest and Phenylalanine have boosted the attraction of elements like nitrogen and phosphorus, which are important for the synthesis of chlorophyll. Improved nitrogen uptake by plants through the use of Crest and phenylalanine is another factor encouraging *Lavandula* growth. This has also resulted in higher cell division, increased water content of plant tissues, and increased weight gain of the shoots [36]. Plants need amino acids like phenylalanine to absorb more nutrients and minerals like phosphorus and nitrogen [37]. The enzyme phenylalanine ammonia lyase, which is essential to the metabolic signal transduction pathway, contains phenylalanine. When L-phenylalanine is applied to leaves, it can increase the uptake of nutrients like nitrogen and phosphorus, which will immediately and favourably impact plant growth [38,39]. Other researchers have also reported that phenylalanine application improves the productivity and secondary metabolites of mint (*Mentha spp.*) [23]. On the other hand, the interaction of biofertilizers between Crest and L-phenylalanine can help plants improve their growth and vegetative growth. Begum *et al.* [40] indicated that the moisture of vegetative bodies of medicinal plants should be equal to 80% to obtain dry weight of appropriate quantity and quality. There is a relationship between some factors such as light quality, seasonal and climatic variations, nutritional relationships, plant growth regulators, some abiotic stresses, and leaf length in plants [18]. Research also indicates that amino acids (phenylalanine) act as beneficial stimulants for plant growth, both quantitatively and qualitatively [41,42]. Amino acids play an important role in plant metabolism and hormonal processes [ 41,37]. As a result, their application may play a significant role in raising the yield of medicinal plants both quantitatively and qualitatively. According to Miller (1961) [43], it is clear from the initial biological effect found that kinetin should not be viewed as merely another auxin. Both kinetin and indoleacetic acid were necessary for cell division in tobacco callus tissue, and the cells continued to divide and expand in the absence of the other. The functions of kinetin may interfere with those of other plant hormones, and may be the result of their interaction [44]. In our study, Crest and phenylalanine stimulated the concentration, uptake, and accumulation of nutrients, leading to increased plant growth of two species of *Lavandula* [45].

## CONCLUSION

Plant height, number of branches, leaf area, number of flowers, fresh weight, and dry weight were all raised by 50 mg/l of phenylalanine and 50 mg/l of Crest®.The majority of growth features were positively impacted by phenylalanine levels. The results showed that applying Crest® and phenylalanine exogenously to lavender plants significantly boosted both species' growth. For improving lavender vegetative growth in greenhouse agriculture systems, 50 mg/l Crest® was the ideal concentration. One of the biggest difficulties for the coming decades may be the development of medicinal plants in an environmentally sound and sustainable manner. Our findings show that Crest and L-phenylalanine foliar spray. have positive impacts on growth metrics, stimulation, and the synthesis of therapeutic essential oils like lavender. The most significant component of lavender's phytochemicals is its essential oil. It is a volatile combination primarily made up of sesquiterpene and monoterpene components. In general, we discovered that the possible application of L-phenylalanine and Crest of the lavender seedlings to enhance the quality of *Lavandula* essential oil satisfies ISO 3515 (2002) in accordance with International Slandered Lavender Oil for Pharmaceutical Purposes.

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