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Gibberellic Acid Foliar Application Influences Growth, Volatile Oil and Some Physiological Characteristics of Lavender (*Lavandula officinalis* Chaix.)

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Abstract

A greenhouse pot experiment was conducted to evaluate the effects of GA_3 foliar application based on RCBD with four replications on growth characteristics, essential oil content and yield and some macronutrients content of French lavender (Lavandula officinalis Chaix.). The following treatments were included: control (foliar spray with distilled water), GA_3 foliar application at 100, 200 and 300 mgl^{-1} plus foliar spray with formulated GA_3 tablet prepared at 100 mgl^{-1} concentration. Inflorescence essential oil was extracted by hydrodistillation method. Volatile oil yield per square meter was evaluated based on dry weight of plant material. The results showed that the highest amounts for volatile oil content and yield belonged to 300 mgl^{-1} GA_3 treatment. Chlorophyll content as well as leaves fresh and dry weight attained their greatest quantities under 300 mgl^{-1} GA_3 applications as well. Fresh and dry weight of inflorescence showed significant differences between treatments with control, 200 and 300 mgl^{-1} GA_3 had the greatest sum of data. Tissue nitrogen and phosphorous content were affected by treatments with their highest concentrations possessed by 300 and 100 mgl^{-1} GA_3 applications respectively. Potassium content was not affected by the treatments. Considering the promoting effects of 300 mgl^{-1} GA_3 foliar application upon most of the studied traits it seems that this and likely > than 300 mgl^{-1} GA_3 concentrations would be the preferable foliar application levels for promoting the growth characteristics and essential oil production of this value-added multidisciplinary aromatic plant.

Keywords: *Lavandula officinalis* Chaix., GA_3, Foliar application, Growth, Essential oil, N content

Introduction

During human life, medicinal and aromatic plants have been played an irreversible role in healthcare systems both for treatment and prevention of diseases and/or disorders as well as from nutritional point of view. Furthermore, in the last three decades, interest in natural derived biomaterials has been dramatically increased owing to great side effects of their synthetic counterparts [1].

Lavender (*Lavandula officinalis* Chaix.), an important multidisciplinary aromatic plant with great use in pharmaceutical, fragrance and food industries and for aromatic garden design belongs to Nepetoideae subfamily of Lamiaceae. *Lavandulla* genus divides into two sections as *Stoechas* and *Spica*. *Lavandula officinalis* Chaix. or French lavender has been categorized in *Spica* section of this plant taxa [2]. This plant is native of South Europe [3]. In Iranian flora, lavender is predominantly distributed in northern parts of the country [4].

Pharmaceutically, this plant and its preparations have long been used as sedative, digestive, anti-convulscent, diuretic, perspiration stimulant, and in cold and flu treatment as well as for treatment of sadness and anxiety [5,6].

Several intrinsic and extrinsic factors affect growth, development and secondary metabolites biosynthesis and accumulation of medicinal and aromatic plants [7,8].

Phytohormones and plant growth regulators (PGR_S) have been defined as one of the main factors influence plants growth and their primary and secondary metabolites pool. Gibberellins are PGR_S with stimulating effects on the majority of plants internal and visible responses with many detectable demonstrations such as increased shoot length due to accelerated cell division and enlargement and their unique effects on flowering behavior of plants [9-12]. Pablo Morales-Payan [13] reported that GA_3 application significantly affected leaves fresh and dry weight of *Coleus amboinicus* Lour.. At the same time, Gul *et al* [14] noted that GA_3 foliar spray enhanced the height and ornamental wealth of *Araucaria heterophylla* plants. Same results for the positive effects of GA_3 on plant growth and development have been reported by Santos *et al* [15] in *Ocimum* spp. Furthermore, EL-Naggar *et al* [16] in their work on carnation cv. "Red sim" demonstrated that gibberellic acid foliar application surprisingly affected plant growth and its subsequent flower production potential.

In the present investigation we tried to study the effects of GA_3 foliar applications on growth, essential oil productivity and some physiological traits of French lavender plant aiming to the future rational cultural management of this high-valued multidisciplinary aromatic plant.

Material and Methods

This study was carried out in the Research Greenhouse of Horticultural Sciences Department of Maragheh University in Northwest Iran during spring and summer of 2010.

Plant material and treatments: Homogenous rooted herbaceous cuttings of French lavender plant supplied by Maragheh Municipality Greenhouse were employed as plant material. Cuttings were planted in 5 liter pots containing medium-sized perlite. Irrigation and nutrition of plants were according to our previous work on *Tanacetum balsamita* L. [7,8]. This experiment was conducted in a polyethylene covered greenhouse with temperature range, light intensity and relative humidity relevance of 20-35^{0C}, ~500 µmolm^{-2}s^{-1} and 40-50% respectively. Treatments were included: control (spray with distilled water), GA_3 (Merck, Germany) foliar application at 100, 200 and 300 mgl^{-1} levels plus foliar spray with 100 mgl^{-1} GA_3 solution prepared from formulated GA_3 tablet (Berelex, Valent Biosciences Corporations) commercially in use in vineyards. The experiment was arranged as randomized complete block design with three replications. Each experimental unit consisted of three pots anyone containing one rooted cutting. Pots were spaced 20, 40 and 70 cm between pots, within block and between blocks respectively. Treatments i.e. foliar spray of solutions were twice applied on plants first time; 40 days after planting of rooted cuttings and sequentially 30 days after first application.

Measurements: The studied traits were consisted of: leaves chlorophyll index, leaves and inflorescences fresh and dry weight, inflorescence essential oil content and yield as well as leaves N, P and K concentrations. Leaves chlorophyll content was evaluated by chlorophyll meter (SPAD, 502, Minolta, Japan) during late season from 30 individual leaves in each experimental unit (the mean of 30 measurements was considered as final data) related to each replication or block for statistical analysis. Dry weight of leaves and inflorescences were determined beyond their fresh weight measurement and drying of materials in an air-forced oven 70^{0C} for 72 hours. Those tissues yields per m^2 were evaluated according to the area coverage of each plant i.e. pot area. Inflorescence essential oil content (v/w) was extracted by Clevenger type apparatus *via* hydrodistillation based on the method described in European pharmacopoeia during 120 minutes [7,8]. For this, inflorescences were air-dried in greenhouse under ambient temperature and air flow conditions for 3 days. Essential oil yield was evaluated based on the oil content in related dry weight of inflorescences in ml per square meter [7,8]. For nitrogen, phosphorous and potassium content in leaves, Kjeldahl, Colorimetric method (Vanadate-molybdate) and Phlame-Photometric (Corning, series 410, France) methods were employed respectively. Due to the low quantity of inflorescence dry weight, the plant materials from three replicates were integrated and for this reason essential oil content and yield of flowers were not imported in statistical analysis procedures. For the rest of data statistical analysis was carried out by SAS 9.2 software. Mean comparisons were accomplished by Duncan's multiple range test at $P \leq 0.01$, $P \leq 0.05$ and $P \leq 0.1$.

Results and Discussion

GA_3 foliar application affected growth characteristics (figure 1 and table 1), N and P content (figure 2) and inflorescence essential oil content and yield (table 2) of lavender plant. Leaves fresh weight ($P \leq 0.05$) and dry weight ($P \leq 0.01$) were influenced by GA_3 treatments. The highest and the lowest data for these traits were recorded in 300 mgl^{-1} GA_3 and GA_3 tablet treatments respectively. Any increase in GA_3 concentration resulted in significant raise in leaves fresh and dry weight (table 1). GA_3 as growth regulator has documented promoting effects on cell division and enlargement and consequently on some growth parameters such as leaves number and area. Such an increase in leaf related traits especially leaf area correlates with agglomerated dry weight and biomass. These finding are in accordance with the results of Akter *et al* in mustard [12]. There is evidence that leaves fresh and dry weight increment is due to the accumulation of some biomolecules mainly responsible for cell division and subsequent enlargement and this leads to the thickened and larger leaves [16]. Like with leaves, 300 mgl^{-1} GA_3 application possessed the first level for inflorescence fresh and dry weight. It has been reported that gibberellic acid with its stimulating effects on most morphological, physiological and biochemical aspects of plant growth has additive impacts on overall growth and development of plants. These promoting effects hasten the transition of plants towards flowering growth stage i.e. reproductive stage of growth. Above mentioned expanding growth effects of GA_3 goes to increased number of flower bearing plants and ultimately elevated fresh and dry biomass of reproductive organs. Furthermore, high quantitative data for control treatment fresh and dry weight of inflorescence is compensated by the higher amounts of leaves biomass in GA_3 treatments especially 300 mgl^{-1} GA_3 application. EL-Naggar *et al* [16] wrote that GA_3 foliar implementation had stimulating effects on flower induction of *Dianthus caryophyllus* L. and hence led to the increased inflorescence biomass and essential oil production.

Table 1. Effects of GA_3 foliar application on leaves and inflorescence fresh and dry weight of lavender (*Lavandula officinalis* Chaix.).

Treatments (mgL^{-1})	Leaves FWt (g)	Leaves DWt (g)	Inflorescence FWt (g)	Inflorescence DWt (g)
Control	126.90bc	43.32bc	4.50b	2.07b
GA_{100}	129.80bc	44.12bc	3.56b	1.60b
GA_{200}	137.13b	46.75b	2.34c	1.11c
GA_{300}	146.58a	54.50a	5.33a	2.60a
Tablet	115.15c	39.32c	2.20c	1.21c
Probability	$P<0.05$	$P<0.01$	$P<0.10$	$P<0.05$

Different letters in columns show significant different between treatments based on Duncan's multiple range test.
Tablet: Formulated GA_3 tablet prepared equal to 100 mgl^{-1}

Table 2. Effects of GA_3 foliar application on inflorescence essential oil content and yield of lavender (*Lavandula officinalis* Chaix.)

Treatments (mgL^{-1})	Essential oil content (%DWt)	Essential oil yield (ml/m^2)
Control	3.84	9.09
GA_{100}	1.56	2.27
GA_{200}	4.50	4.54
GA_{300}	6.03	11.36
Tablet	1.03	1.13

Tablet: Formulated GA_3 tablet prepared equal to 100 mgl^{-1}

Several factors influence secondary metabolites quantity and quality of medicinal and aromatic plants [7,8]. PGR_S have crucial impact on primary and secondary metabolism of plants. Essential oil production and accumulation of volatile oil bearing plants positively responds to these molecules especially their synthetic ones at external applications. Among PGR_S there is strong evidence that, GA_3 had constant effects on plants growth and development, and consequently their active principles content and yield. It seems that, GA_3 application on lavender plants increased the light efficiency and assimilation potential of plants leading to intensified secondary metabolites production and increased volatile oil biosynthesis and storage. Moreover, it is likely that elevated leaves fresh and dry weight of plants under 300 mgl^{-1} GA_3 application and concomitant increase in assimilation potential led to the suitable interactions of primary and secondary metabolism in favor of essential oil production [8,17]. The highest amounts for essential oil content and yield beyond GA_3 application at 300 mgl^{-1} are in total agreement with above mentioned growth and biochemical evidence.

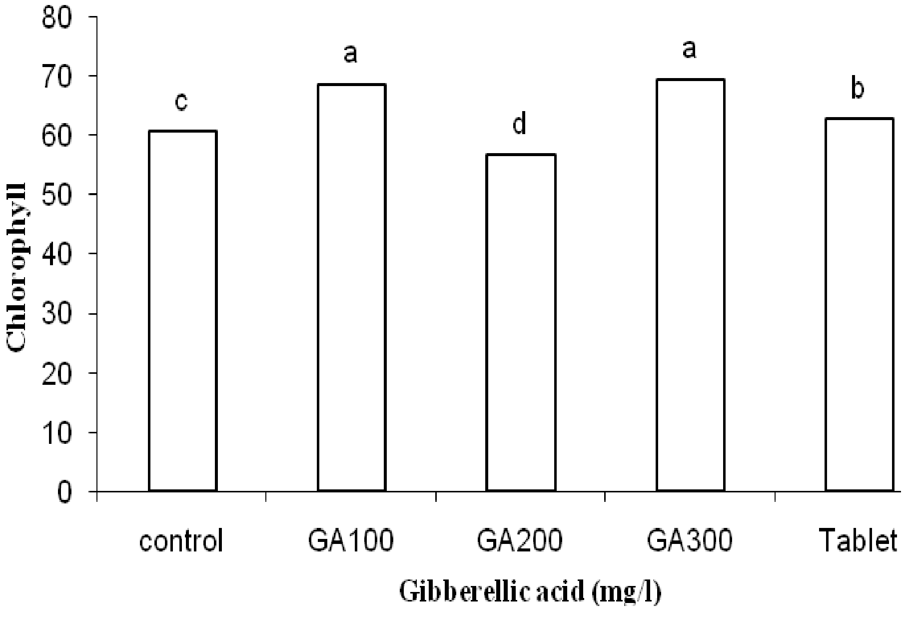

Figure 1. Leaf chlorophyll content of lavender (*Lavandula officinalis* Chaix.) as affected by foliar application of gibberellic acid.
Tablet: Formulated GA_3 tablet prepared equal to 100 mgl^{-1}
Different letters on bars show significant different between treatments based on Duncan's multiple range test at $P<0.01$

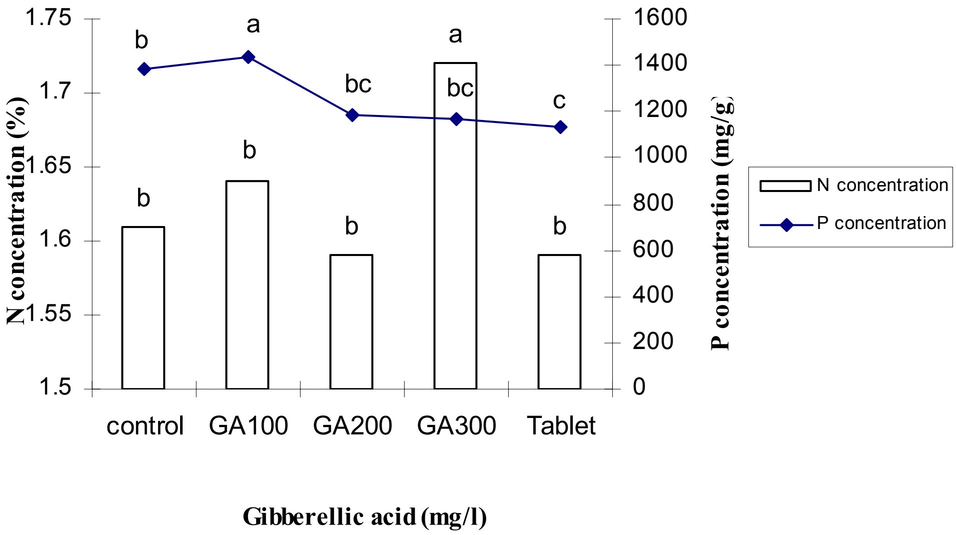

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Figure 2. N and P concentration of lavender (*Lavandula officinalis* Chaix.) plant as affected by GA_3 foliar application.
Tablet: Formulated GA_3 tablet prepared equal to 100 mgl^{-1}
Different letters show significant different between treatments based on Duncan's multiple range test at P<0.05 for phosphorous and P<0.1 for nitrogen.

GA_3 foliar application meaningfully ($P \leq 0.1$) affected nitrogen content of plants. Similar with other traits, the greatest N content of leaf tissue belonged to 300 mgl^{-1} GA_3. There were no significant differences between treatments regarding tissue potassium content. Phosphorous content of plants was influenced ($P \leq 0.05$) by the treatments and the highlighted data for this trait owned by 100 mgl^{-1} GA_3 application. Eid *et al* [18] in their study on croton reported that GA_3 treatment increased the absorption and tissue accumulation of N, P, K and micronutrients. Furthermore, Shah *et al* noted that in *Nigella sativa* L. the main reason for elevated growth parameters of plants beyond GA_3 treatment was raised absorption potential and assimilation of mineral nutrients during vegetative growth stage [19]. It is possible that GA_3 had the potential to accelerate the nutrients partitioning towards cells and active growth sites and concomitantly increases those nutrients absorption *via* increased root potential, and finally intensifies minerals and their related bio-molecules accumulation in shoots especially new leaves and apical shoots passing active growth and development. Leaves chlorophyll content was influenced by GA_3 treatments. Like with many of the studied traits, 300 mgl^{-1} GA_3 treatment had the maximal amounts for chlorophyll index. Our findings are in well conformity with the results of Reda *et al* [20]. Those scientist reported similar results on chlorophyll content of *Thymus vulgaris* L. plants in response to some PGR_S. It is probable that GA_3 links with chlorophyll biosynthesis in leaves and hence had visible effects on plants green factory content.

Conclusion

The results obtained from the present experiment showed that French lavender positively responded to GA_3 application. 300 mgl^{-1} GA_3 foliar spray had increasing effect on almost majority of the traits. In spite of non-significant and negligible effects of formulated tablet GA_3 treatment, it seems that higher concentrations of this cheap GA_3 source might be worthy of consideration for future applications regarding growth promotion and essential oil production. In addition, the increasing trend for many of traits with elevated GA_3 levels makes it possible that higher levels (>300 mgl^{-1}) of GA_3 as foliar application might be another research avenue on this high-valued crop. However, this claim needs to be investigated.

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