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Original Article

Influence of fertilization on growth, yield and chemical constituents of *Lallemantia iberica* plant

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ABSTRACT

This investigation was carried out to study the influence of fertilizers on growth, yield and chemical constituents of *Lallemantia iberica* (Bieb.). The field experiments were carried out during two successive seasons, 2010/2011 and 2011l2012 at Sekem farm (50km from Cairo North East Governorate, Egypt) on *Lallemantia iberica*(Bieb.) to study the effect of mineral nitrogen fertilizer (140 and 200kg N ha^{-1}) or compost as organic fertilizer (12 and 18 tons ha^{-1}) alone or in combination with bio fertilizer (rhizobacterin). Growth characters, nutrients content, total carbohydrate (%), mucilage (%) fixed and essential oil were determined. The data revealed that various fertilizer levels, in general, improved the different growth characteristics as well as the amount of studied chemical constituent's content. The highest values regarding plant height, number of branches, total fresh and dry weights, nutrients content, as well as total carbohydrates and mucilage were recorded as a result of application of combined fertilizer of compost at 7.5 Ton + 90 Kg N / Fed. and rhizobacterin. The accumulation of fixed and essential oils were also promoted by the various fertilizer treatments.

Keywords: *Lallemantia iberica***,** Nitrogen, compost, biofertilizer, rhizobacterin, vegetative growth and yield, essential oil, fixed oil, mucilage, carbohydrates, fatty acids.

INTRODUCTION

Lallemantia iberica, commonly known as dragon's head, is a species of flowering plants in lamiaceae family and speared in south western Asia and Europe. It grown well in arid zones and requires a light well and drained soil [1]. *Lallemantia iberica* as a valuable species, that plant parts can be economically used [2]. It is mainly cultivated for its seeds that content edible oil known as *Lallemantia* oil, and reached 30% to 38%. [3]. The oil in used as substitute for linseed in the production of varnish polish, ink, soap and linoleum [1]**.** Moreover, the seeds are used traditionally as stimulant, diuretic and expectorant [4]. Seeds mucilage used in treatments of various disorders such as nervous, hepatic and diseases and also used as general tonic, aphrodisiac and expectorant remedies (**[5]**, **[6]** and **[7]**.

Composting is a biological process in which organic biodegradable wastes are converted into hygienic, hums rich product (compost) for use as a soil conditioner and an organic fertilizer **[8]**. These are also used to provide biological control against various plant pathogens **[9]**. Many researcher gained good yield production with applied compost manure for several medicinal and aromatic plants such as *Hyosyamus muticus* **[10]**, *Sidriti smontana* **[11]**, *Vetiver iazizaniodides* L. **[12]** and *Mentha piperita* **[13]**.Biofertilizers are microbial inoculants, used for application to either seeds or soil for increasing soil fertility with objective of increasing the number of such microorganisms and to accelerate certain microbial processes. Nitrogen fixing bacteria such as *Azotobacter chrococcus* and *Azospirillum bipoferum* could increased growth and yield of medicinal plants such as fennel (**[14]** and **[15]**), sweet flag (**[16]**., and davana (**[17].**

This study was carried out to determine the optimum levels of different fertilizers including compost, mineral nitrogen and bio-fertilization to produce the highest growth, essential and fixed oils yield as well as chemical composition and active

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constituents of *Lallemantia iberica* under Egyptian conditions.

MATERIALS AND METHODS

This experiment was conduct at Sekem Farm located on 50km from North East of Cairo, Sharkia Governorate, Egypt, during 2010/2011 and 2011/2012 seasons. The seeds of dragon's head (*Lallemantia iberica*) were imported from the Botanical Garden of the University of Vienna, Austria.

The experimental plant area was $4m^2$ consisting of 2 rows with distance between rows of 50cm. The seeds were sown directly in the field on 17^{th} October during the two seasons. The seedlings were thinned twice leaving one plant in each pit. The compost manure was obtained from Sekem Company and was added before sowing at two levels of 5 and 7.5t/fed. The chemical characters of the used compost were determined as shown in Table (1). For the mineral fertilizer, the plants received a basic close from nitrogen in from of ammonium nitrate (33.5%N) at two rates of 60 kg N/fed and dose 90 kg N/fed., divided into equal portions, and applied after 4^{th} and 6^{th} weeks from transplanting in both seasons. Calcium super phosphate (15% P_2o_5) was applied during soil preparation at rate of 300kg/fed., while potassium sulphate (48%K_20) at rate of 100 kg/fed., divided into two equal doses, which were added after 4^{th} and 6^{th} week from planting date. The suspension of bio-fertilizer (rhizobacterin, obtained from laboratories of Sekem Co., Cairo Egypt) was received to plants twice. i.e. after 4^{th} and 6^{th} weeks from planting seeds which added to the soil at the rate of 1L/fed. with irrigation. The experiment consists of eleven treatments with 3 replicates, each replicate contained nine plants. The layout of the experiment was completely randomized design.

The growth characters data were obtained at one stage at 75% of full flowering stage (in March and April) in both seasons. The growth and yield characters were determined included:

1- Plant height (cm).
2- Number of branches/plant
3- Fresh weight of herb (g/plant)
4- Dry weight of herb (g/plant)
5- Weight of 1000 seed (g)
6- Yield of seed (g/plant)
7- Yield of seed kg/fed.

The chemical analysis was carried out on dried herb of *Lallemantia iberica* plants. Total nitrogen was determinated using the modified micro kjeldal methods **[18]**, phosphorus and potassium% according to Murphy and Riley **[19]** and Isaac and Kerber **[20]** respectively. The total carbohydrates% was determined using spectopholometercally according to Dubois *et.al.* **[21]**The essential oil was determined in the fresh herbage of each treatment. Samples were separately subjected to water distillation for 3h according to Guenther **[22]**. The samples presented in three replications and the given average was presented in ml oil/100g herb. The obtained essential oil was analyzed by using Dschrom 6200 series gas liquid chromatography (GLC), according to British Pharmacopoeia **[23]**.

The chromatograph apparatus was fitted with capillary column BPX-5 and 5% phenyl (equiv.) polysillphenylene-siloxan 30m× 0.25mm ID×0.25µm film. Temperature program ramp increased with a rate of 10ºC/min from 70 to 190ºC. Flow rates of gases were nitrogen at 1ml/min, hydrogen at 30ml/min and 330ml/min for air. Detector and injector temperature were 300ºC and 250ºC, respectively. The obtained chromatogram and report of GC analysis for each sample were analyzed to calculate the percentage of main components of volatile oil. The identification of these compounds was achieved by matching their retention times with those of authentic samples injected with the same conditions. Fixed oil was extracted from seeds by petroleum ether for a period of 24h in a soxhelt apparatus. The solvent was evaporated by rotary evaporator and the residue was dried to a constant weight at 95oC according to AOAC **[24].** Fatty acids appropriately liberated by using HCl conc. Fatty acids were transesterified into methyl ester (FAME) using N-trimthylsulfoniumhydroxide (Macherey-Nagel, Duern, Germany) according to the procedure described by Arens *et.al.* **[25].** FAME was identified on a Shimadzu gas chromatography (GC)-14A equipped with flame ionization detector (FID) and C-R4AX chromatopac integrator (Kyoto, Japan). The flow rate of the carrier gas helium was 0.6ml/min and the split value with a ratio of 1:40. A sample of 1µl was injected into a 30m× 0.25 mm× 0.2 µm film thickness, Supelco SPTM -2380 (Bellefonte, PA, USA) capillary column. The injector and FID temperatures were set at 250oC/min the initial column temperature was 100oC, programmed by 5oC/min to 175oC and kept for 10 min at 175oC, then by 8oC/min to 220oC and kept for 10 min at 220oC. A comparison of the retention times of the samples with those of authentic standard mixture (Sigma, St. Louis, MO, USA; 99% purity specific for GLC), run on the same column under the same conditions, was made to facilitate the identification.

Statistical analyses: The obtained data of both seasons were statistically analyzed with analysis of variance (ANOVA) as described by Snedecor and

Cochran **[26]**, using the MSTAT-C statistical software **[27]**package based on Duncan's Multiple Range Test to determine the statistical significance of differences in means between treatments as outlined by Waller and Duncan **[28]**. The probability level of P ≤ 0.05 was considered significant.

RESULTS AND DISCUSSION

Growth characters: The growth characters of *Lallemantia iberica* plants as affected by different fertilizer treatments during two successive seasons (2010/2011 and 2011/2012) are shown in Table (2). It is clear to notice that, in general, all fertilizer levels had capacity to increase significantly various growth characters. Thus the two nitrogen levels (60kg/fed and 90kg/fed) increased significantly the plant height, number of branches, fresh weight and dry weight of herb comparing with control. However, applied two compost levels (5t/fed and 7.5t/fed) resulted in significant increment for various vegetative growth characters i.e. plant height, number of branches, fresh and dry weight of herb. The highest level of compost gave the maximum significant increment that is true for the two successive seasons. The combined treatments between the two compost levels and the two nitrogen rates caused more promotion in vegetative growth characters than applied any of these fertilizers alone. At the meantime, the interaction between compost levels (5t/fed or 7.5t/fed), with rhizobacterin resulted in increment vegetative growth characters (plant height, number of branches, fresh and dry weight of herb) compared with those treated with compost levels alone. In addition the combined treatment between compost at 7.5t/fed + Rhizobacterin caused more promotion for the same characters comparing with the combined treatment between low compost level 5t/fed+Rhizo. Finally, from these results of applied various fertilizer treatments, it can be recorded that the maximum plant height (52.66cm and 66.78cm) number of branches (19.44 and 20.56) fresh weight (165,11 and 186.92g/plant) dry weight (33.02g and 37.38g/plant) during the first and the second seasons, respectively, were resulted due to applied compost at 7.5t combined with 90kgN/fed.

The favorable effects of the combination between compost fertilizer and nitrogen mineral on vegetative growth may be explained that the beneficial effects of both of them on improvement of physical and biological soil properties, which effect on availability of nutrient elements to be observe by plants root, and that effect on the physiological processes which increased cell elongation and cell diversion. The pronounced effect of compost on vegetative growth were reported by several authors, on *Verbascum thopisus***[29]**, on *Hyoscymus muticus***[10]** and on *Sideritis Montana***[11]**. In addition, Priyadarshani *et.al.* **[12]** found that higher biomass production of *Vetiveriaziz aniodes* were obtained with applied fertilizer mixture of compost: inorganic (3:1). On the other hand, the promotion growth caused by bacteria due to fix the atmospheric nitrogen, dissolve the phosphorus and potassium in the soil and control the pathogen via production plant growth regulator **[30]**.

Yield characters: The data illustrated in Table (3) showed that the various fertilizer treatments had significant effect, in most cases, on seed yield (g/plant and kg/fed) and seed index (weight of 1000seeds), during both seasons (2010/2011 and 2011/2012). The highest level of nitrogen (90kgN/fed) combined with compost (7.5t/fed) caused more stimulated effect on seed yield (g/plant and kg/plant) comparing with lower level, for the two successive seasons. Similar trend was noticed with seed index treated with various nitrogen level while an opposite trend was recorded with compost levels. Meanwhile, the different interaction treatments including compost + nitrogen or compost + rhizobactrien, caused more increment in seeds yield (g/plant and kg/plant) when comparison with single treatments of compost or nitrogen. The seed index showed similar trend in most cases. However, the maximum mean values of seed yield (g/plant, kg/plant) and seed index were recorded with applied compost7.5t + 90kgN which produced seed yield of 11.47, 11.69g/plant and 332.20, 342.10 kg/plant, while the seed index recorded 5.47 and 5,67g for first and second seasons, respectively. The favorable effect of nitrogen fertilization on seed yield may be due to that nitrogen is the most essential elements for the plant growth, this leads to increase the production of protein, which allows the leaves to grow larger and hence having larger surface available for synthesis (**[31]**, on common bean). Positive effect of compost fertilizer as organic waste on soil structure, aggregate stability and water holding capacity were reported in several studies (**[32]**, **[33]**, **[34]**on wheat plant. Moreover, compost has a high nutritional value with high concentration of nitrogen, phosphorus and potassium, while the concentration of heavy metals and other toxic substance were very low (**[35]** on radish plants.

Chemical Constituants:

Nutriments Content (%) : The data in Table (4) indicated the effect of two levels of nitrogen fertilization (60 and 90kg/fed), two compost levels (5t and 7.5t/fed) and bio fertilizer treatment (Rhizobactrien) on nitrogen, phosphorus and potassium content of *Lallemantia iberica* plant during the growing season 2011/2012. It was clear to notice that all fertilizer treatments increased the macro nutrient content (N,P and K), compared with control plants. The higher level of nitrogen (90kgN/fed) or compost (7.5t/fed) produced higher percentage of applied nitrogen (3.05 and 2.79%) and phosphorus (0.27 and 0.24%) comparing with lower level. For potassium percentage, applied the higher nitrogen level, also, caused higher potassium percentage (5.43%), while the reverse trend was noticed with compost, that low level of compost (5t/fed) produced higher value percentage of P (5.28%). The interaction treatments between various levels of compost + nitrogen or compost + rhizo, showed significant stimulation in the accumulation of their macro-nutrients, in most cases, comparing with applied nitrogen or compost singly. However, the maximum values of macro nutrients content (%) were obtained with applied compost 7.5t/fed + 90kgN/fed) which given 3.79%, 0.42% and 6.15% for nitrogen, phosphorus and potassium percentage, respectively. The pronounced effect of organic fertilizer (compost) and inorganic fertilizer may be attributed to the provision of favorable soil condition improve soil PH, electrical conductivity and organic matter content) and supply of proper nutrient for better growth and yield. (**[12]**on *Vetiveriaziz aniordes* L). However, compost has already been established as a suitable fertilizer for improving the productivity and chemical contents of several medicinal and aromatic plants, such as *Dracocephalum moldavica* (**[36]**, *Anethum graveolens* L. (**[37]**, *Tagetes erecta* (**[38]2.**

Total carbohydrate percentage: The data obtained in Table (4) illustrated that fertilizer treatments produced significant increment in total carbohydrate percentage as compared with control. However, the two nitrogen levels (60 and 90kgN/fed) caused more carbohydrate accumulation (27.33 and 28.33%) than the two compost levels (5 and 7.5t/fed) which recorded (21.33 and 22.67%), respectively. Moreover, the interaction between various compost levels with different nitrogen levels caused more stimulative effects on carbohydrate percentage than the applied these fertilizer alone. The maximum percentage value of total carbohydrate was recorded with applied 7.5t/fed compost + 90kgN/fed that given (32.0%). On other hand, the two compost levels (5 and 7.5t/fed) compared with rhizo lead to insignificant increased in total carbohydrate percentage (24.0 and 25.33%) comparing with control treatments, (20.0%). These results are accordance with these obtained by Abbasi *et.al.* **[39]**on *Amaranthus hyeochondriacus* plants treated with nitrogen fertilizer. On the other hand, the total carbohydrate increased significantly with increasing N rate of compost fertilizer from 100 to 240kgN/fed **[40]**. Bio fertilizer play an important role in carbohydrate synthesis by supplying growing plants with the required nutrients elements **[41]**. In addition compost and bio fertilizer could be effect on enzyme, total leaf area of plant which reflected on production and caused more carbohydrate through photosynthesis.

Mucilage percentage: The mucilage percentage of *Lallemantia iberica* plants treated with different levels of nitrogen, compost and rhizo or their interaction were shown in Table (4). It is clear that various fertilizer treatments affect significantly on mucilage percentage as compared with control (unfertilized). The highest value of mucilage percentage (17.7%) was obtained from the plants received compost at 7.5t + 90kgN/fed. In contrast, the lowest mean value of mucilage percentage (10.2%) was obtained from control plants. The promotion in mucilage accumulation by applied chemical and organic fertilizer may due to the increase in available nutrition for plant roots which improve the photosynthesis process of Isabgol plants **[42]**, and **[43]**.

Essential oil percentage and yield (ml/plant and L/fed.): Data on essential oil percentage and yield (ml/plant and L/fed) as affected by different fertilizer treatments are shown in Table (5). Applied various fertilizers levels increased significantly the essential oil percentage and oil yield (ml/plant and L/fed) in both seasons compared with control plants. The highest oil percentage (0.267% and 0.297% for 1st and 2nd season) were recorded with applied compost at 7.5t/fed + 90kgN/fed). Similarly, the same treatment also caused maximum accumulation in oil yield (0.88, 0.11ml/plant and 2.35, 2.94L/fed for 1st and 2nd season, respectively). On the other hand, the lowest value of mucilage for three traits was obtained with applied compost at 5t/fed at first season and 7.5t/fed compost at second one (with one exception for oil percentage). The difference in essential oil content between two seasons may be attributed to the differences in the environmental factors. From the forgoing results, it could be recorded that the promotion effect of the combination of bio-fertilizers with organic fertilizer on essential oil yield was confirmed the pervious works of on celery plant **[44]**, on *Rosmarinus officinalis* **[45]**and on *Anethum graveolens* L**[36]**.

Essential oil composition: The main constituents of essential oil of *Lallemantia iberica* treated by various fertilizers treatments are shown in Table (6). The GC analysis identified the main compound as germacrene in most treatments which ranged from 23.28 to 34.23%, followed becaryophyllene, in most cases, and ranged from 20.21 to 32% of the total identified constituents, Sabinene was identified as the third main constituents for all different treatments (7.51 to 16.2%).

The two mains compound germacrene and caryophyllene were increased with various fertilizers treatments, and the highest increased was obtained with applied 7.5t/fed + 90kgN/fed. The third main component, namely sabinen, decreased with various fertilizer treatments and the interaction between 7.5t compost + 60kgN/fed gave the lowest of sabinen values. Fertilizer might enhance the essential oil biofertilizer processes through its direct or indirect role in plant metabolism such as photosynthesis, enzymatic system resulting in more plant metabolism. The promotion effect of different fertilizer treatments on essential oil constituents were also reported on some medicinal and aromatic plants. The application of biological fertilizer was led to increase in carvone content of dill essential oil which leading to higher quality of dill essential oil **[46]**. Using vermicpmpost on basil (*Ocimum bacilicum*) was led to increase in limonene and methyl chavecol content which improve the quality of essential oil **[47]**. Moreover, on dill stated that the application of organic and biofertilizer lead to higher essential oil yield and also carvone content in comparison with separate application of them**[36]**.

Fixed oil percentage and yield (ml/plant and L/fed.): Data in Table (7) indicated that different fertilizer treatments increased all fixed oil traits during 2010/2011 and 2011/2012 season. The two nitrogen levels were effective than the two compost level in increased the fixed oil accumulation during the two season. Furthermore, the interaction treatments between two compost levels with nitrogen or rhizo gave significant increase in fixed oil yield (ml/plant and L/fed) compared with control. Compost at 7.5t/fed + 90kgN/fed gave the highest and significant value of essential oil percentage (28.0%and 30.0%) and fixed oil yield ml/plant (3.48ml and 3.86ml/plant) as well as fixed oil kg/fed (92.79L/fed, 102.70L/fed) for 1st and 2nd season, respectively. The simulative effective of higher proportion of compost and NPK fertilizer on enhancing the biomass production might be attributed to higher oil yield. Similar resulted had been reported by Gorttappeh *et.al.* **[48]**and Saeed *et. al.* **[49]**

The Relative Percentages of Fatty Acids: Fats are classified into saturated and unsaturated fats. Saturated fats tend to increase blood cholestrol levels, while unsaturated ones show the reverse direction; they are mostly from plant sources. The most common saturated fatty acids found in plant lipids that contain 16 or 18 carbon atoms. Low content of saturated fatty acids is desirable for edible uses **[50]**. Eight fatty acids [accounting for 99.93 % to 99.99% of total fatty acids (Table8) were identified in fixed oil extracted from the seeds produced from the plants fertilized and control treatments for *Lallemantiaiberica* plants. Three saturated fatty acids and five unsaturated ones were markedly identified and grouped into three classes , i.e. , major fatty acids (more than 10%), minor fatty acids (less than 10%) and traces one (less than 1%) were identified. It can be noticed that , the relative percentage of saturated fatty acids ranged from 8.85 to 9.75% while, unsaturated fatty acids ranged from 90.21 to 91.11 %. The main fatty acids in fixed oil were α-linolenic acid (60.47 – 64.92%), linoleic acid (2.55 – 14.85%) and oleic acid (11.78 – 13.74%). The maximum mean value for α-linolenic acid (64.92%) was obtained from plants fertilized with compost at 5t + 60kg N /Fed, while the minimum value (60.47%) was obtained from plants fertilized by compost at 7.5t + 60 kg N /Fed. The minimum mean value for linoleic acid (12.55%) was obtained from plants treated with compost at 7.5ton + Rizobium , while the highest value (14.85%) was obtained from plants fertilized with compost at 7.5t/Fed . In addition, the highest mean value for oleic acid (13.74%) was obtained from plants fertilized by compost at 5 t / Fed., while the lowest means value (11.78%) was obtained from plants treated by compost at 7.5t + N60kg/Fed. In this respect, Ahmed and Abdin **[51]** stated that, nitrogen probably promotes elongation of the carbon chain of rape seed oil; however, fatty acid composition changes by nitrogen. Nitrogen (N) is the most recognized in plant for its presence in the structure of the protein molecule. Accordingly, N plays an important role in synthesis of the plant constituents through the action of different enzymes (**[52]**and **[53]**).

Table1. Chemical analysis of the used compost during 2010/2011 and 2011/2012 seasons.

Character	2010/2011	2011/2012
pH	7.6 2	7.54
E.C. (dSm^{-1})	9.65	9.50
Organic matter %	42.41	44.63
Organic carbon %	24.63	27.34
Total nitrogen %	1.35	1.43
C/N ratio	1:18	1:20
Total phosphorus %	1.30	1.60
Total potassium %	2.31	2.35
Ash (%)	60.00	54.43

Table 2: Effect of fertilization on some growth characters of *Lallemantiaiberica* plant during 2010/2011 and 2011/2012 seasons.

Treatments	Plant height (cm)		Branches number /plant		Fresh weight g/plant		Dry weight g/plant	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Control	35.22^{g}	44.00^{f}	12.22^{f}	13.11^{f}	111.91^{g}	112.32^{f}	22.38^{g}	22.46^{f}
N60kg/fed	37.44^{f}	51.22^{cde}	15.22^{d}	15.33^{de}	149.20^{cdef}	152.40^{cde}	29.84^{cdef}	30.49^{cde}
N90 kg/fed	41.00^{e}	54.00^{bcd}	17.56^{c}	17.89^{c}	156.22^{abcd}	159.20^{bcd}	31.24^{abcd}	31.84^{bcd}
Compost 5t/fed	35.67^{g}	46.89^{ef}	13.22^{e}	14.56^{ef}	142.61^{f}	143.92^{e}	28.51^{f}	28.78^{e}
Compost 7.5t/fed	35.89^{g}	49.78^{def}	13.78^{e}	14.67^{ef}	144.33^{ef}	146.31^{de}	28.68^{ef}	29.26^{de}
Compost 5t+ N60kg/fed	42.89^{d}	57.11^{bc}	18.11^{bc}	18.44^{bc}	158.41^{abc}	160.40^{bc}	31.69^{abc}	32.09^{bc}
Compost 5t+ N90 kg/fed	49.22^{b}	59.57^{b}	18.67^{ab}	20.00^{ab}	160.40^{ab}	166.61^{b}	32.09^{ab}	33.31^{b}
Compost 5t+ Rhizo.	36.66^{fg}	50.00^{def}	14.22^{e}	15.78^{de}	147.84^{def}	150.70^{cde}	29.56^{def}	30.13^{cde}
Compost 7.5t+ N60kg/fed	47.00^{c}	58.00^{bc}	18.56^{abc}	19.89^{ab}	159.82^{ab}	163.82^{bc}	31.95^{ab}	32.76^{bc}
Compost 7.5t+ N90kg/fed	52.66^{a}	66.78^{a}	19.44^{a}	20.56^{a}	165.11^{a}	186.92^{a}	33.02^{a}	37.38^{a}
Compost 7.5t+ Rhizo.	39.78^{e}	53.00^{bcde}	16.00^{d}	16.89^{cd}	152.60^{bcde}	156.70^{bcde}	30.51^{bcde}	31.33^{bcde}

Means followed by similar letter(s) within the same column are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.

Table 3: Effect of fertilization on seeds yield of *Lallemantia iberica* plant during two 2010/2011 and 2011/2012seasons.

Treatments	Seeds yield (g/plant)		Seeds yield (kg/plant)		Seed index (g)	
	First season	**Second season**	**First season**	**Second season**	**First season**	**Second season**
Control	7.27^{d}	7.73^{c}	193.61^{d}	205.93^{c}	3.00^{d}	3.07^{e}
N60kg/fed	8.12^{cd}	8.36^{c}	216.20^{cd}	222.63^{c}	4.23^{c}	4.37^{d}
N90 kg/fed	8.97^{bcd}	9.12^{c}	238.92^{bcd}	242.90^{c}	4.33^{c}	4.40^{d}
Compost 5t/fed	7.63^{d}	7.89^{c}	203.40^{c}	210.10^{c}	5.03^{abc}	5.27^{ab}
Compost 7.5t/fed	8.53^{cd}	8.78^{c}	227.30^{cd}	234.00^{c}	4.93^{abc}	5.10^{abc}
Compost 5t+ N60kg/fed	10.57^{abc}	11.03^{b}	281.60^{abc}	293.83^{b}	4.57^{bc}	4.83^{bcd}
Compost 5t+ N90 kg/fed	11.37^{ab}	12.07^{ab}	302.82^{ab}	321.50^{ab}	4.50^{bc}	4.70^{bcd}
Compost 5t+ Rhizo.	11.38^{ab}	11.93^{ab}	303.13^{ab}	317.91^{ab}	4.80^{abc}	5.03^{bc}
Compost 7.5t+ N60kg/fed	11.47^{ab}	11.69^{ab}	305.50^{ab}	311.42^{ab}	5.17^{ab}	5.20^{ab}
Compost 7.5t+ N90kg/fed	12.47^{a}	12.84^{a}	332.20^{a}	342.10^{a}	5.47^{a}	^{a}
Compost 7.5t+ Rhizo.	11.59^{ab}	12.10^{ab}	308.70^{ab}	322.40^{ab}	4.23^{c}	4.53^{cd}

Means followed by similar letter(s) within the same column are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.

Table 4. Effect of fertilization on chemical constituents (%) of *Lallemantia iberica* plant during 2011/2012 season.

Treatments	Herb total macro-nutrients			Total carbohydrates %	Seeds mucilage%
	N%	P%	K %		
Control	2.23^{e}	0.16^{e}	4.92^{g}	20.00^{f}	10.20^{d}
N60kg/fed	2.87^{d}	0.27^{c}	5.32^{ef}	27.33^{abcde}	14.67^{b}
N90 kg/fed	3.05^{cd}	0.28^{c}	5.43^{def}	28.33^{abcd}	15.67^{ab}
Compost 5t/fed	2.39^{e}	0.20^{de}	5.28^{ef}	21.33^{ef}	12.87^{c}
Compost 7.5t/fed	2.79^{d}	0.24^{cd}	5.20^{fg}	22.67^{def}	12.80^{c}
Compost 5t+ N60kg/fed	3.19^{bc}	0.28^{c}	5.38^{ef}	29.67^{abc}	16.47^{a}
Compost 5t+ N90 kg/fed	2.93^{cd}	0.36^{b}	5.71^{bcd}	31.33^{ab}	17.00^{a}
Compost 5t+ Rhizo.	2.95^{cd}	0.34^{b}	5.81^{bc}	24.00^{cdef}	14.67^{b}
Compost 7.5t+ N60kg/fed	3.41^{b}	0.28^{c}	5.99^{ab}	29.67^{abc}	16.53^{a}
Compost 7.5t+ N90kg/fed	3.79^{a}	0.42^{a}	6.15^{a}	32.00^{a}	17.07^{a}
Compost 7.5t+ Rhizo.	2.99^{cd}	0.28^{c}	5.58^{cde}	25.33^{bcdef}	15.40^{ab}

Means followed by similar letter(s) within the same column are not significantly different at P≤ 0.05 according to Duncan's Multiple Range Test.

Table 5.Effect of fertilization on essential oil% and yield (ml/plant and L/feddan) of *Lallemantia iberica* plant during 2010/2011 and 2011/2012 seasons.

Treatments	first season			second season		
	%	ml/plant	L/feddan	%	ml/plant	L/feddan
Control	0.097[e]	0.022[f]	0.58[f]	0.107[d]	0.024[f]	0.64[f]
N60kg/fed	0.195[b]	0.058[b]	1.55[b]	0.183[bc]	0.062[cd]	1.65[c]
N90 kg/fed	0.182[bc]	0.057[b]	1.51[b]	0.168[c]	0.059[d]	1.58[cd]
Compost 5t/fed	0.133[d]	0.038[e]	1.01[e]	0.203[b]	0.053[e]	1.41[de]
Compost 7.5t/fed	0.167[c]	0.048[cd]	1.28[cd]	0.187[bc]	0.049[e]	1.31[e]
Compost 5t+ N60kg/fed	0.136[d]	0.043[de]	1.15[de]	0.162[c]	0.052[e]	1.39[de]
Compost 5t+ N90 kg/fed	0.188[bc]	0.060[b]	1.61[b]	0.215[b]	0.071[b]	1.91[b]
Compost 5t+ Rhizo.	0.181[bc]	0.054[bc]	1.43[bc]	0.213[b]	0.064[cd]	1.71[bc]
Compost 7.5t+ N60kg/fed	0.183[bc]	0.058[b]	1.55[b]	0.202[b]	0.066[bc]	1.76[bc]
Compost 7.5t+ N90kg/fed	0.267[a]	0.088[a]	2.35[a]	0.297[a]	0.110[a]	2.94[a]
Compost 7.5t+ Rhizo.	0.175[bc]	0.053[bc]	1.42[bc]	0.158[c]	0.050[e]	1.32[e]

Means followed by similar letter(s) within the same column are not significantly different at P≤ 0.05 according to Duncan's Multiple Range Test.

Table 6: Effect of fertilization on essential oil constituents of *Lallemantia iberica*plant during 2011/2012 season.

Essential oil constituents (%)	Control	N60/fed	N90/fed	Compost 5t	Compost 7.5t	Compost 5t+N 60	Compost 5t + N90	Compost 5t+Rhizo	Compost 7.5t+N 60	Compost 7.5t+N 90	Compost 7.5t+Rhizo
α- pinene	0.86	3.12	2.05	1.89	0.18	2.30	2.39	1.54	1.18	1.94	0.23
β-pinene	5.79	10.13	7.30	7.71	2.12	9.22	10.25	5.47	5.25	8.68	3.73
Sabinene	16.28	12.03	9.13	11.86	7.51	10.11	11.44	8.40	9.45	9.88	13.17
Furan 2-pentyl	---	---	---	---	---	---	---	---	---	0.47	---
Myrcene	0.62	---	0.65	0.67	---	---	1.84	---	---	1.45	---
Limonene	3.39	2.50	1.59	1.46	9.43	0.79	1.76	2.26	8.25	1.61	9.39
Geraniol	---	---	---	---	---	0.12	0.41	0.43	0.8	---	2.15
Fenchon	---	---	---	---	---	1.90	---	---	1.74	---	2.26
geranyl acetate	2.85	2.46	1.54	1.29	0.66	1.72	0.36	1.35	1.3	0.27	0.43
α-copaene	---	0.38	---	---		---	---	---	0.58	---	---
Trans-b-damascenane	---	0.41	0.23	---	1.70	---	---	---	---	---	---
α-terpeninaciton	3.95	6.30	5.12	4.87	5.18	5.63	5.47	6.22	6.80	6.10	5.74
Caryophylline	24.21	26.12	25.85	23.11	23.94	25.22	22.85	25.81	22.21	32.00	22.46
β- farnesene	---	---	---	---	---	---	---	---	---	---	---
Germacrene	23.41	30.3	31.31	31.48	26.15	27.46	28.28	28.9	23.28	34.23	27.30
Eremoligenol	---	---	---	---	1.35	---	---	---	---	---	---
Bicyclogermacrene	---	---	---	---	---	1.39	---	---	---	---	---
δ- cadinene	10.87	---	13.05	12.86	13.16	11.02	12.28	18.08	14.31	---	10.19
Dodecen-4-yne(z)	---	---	---	---	1.47	---	---	---	---	---	---
Aromadendrene	3.74	3.70	1.21	1.16	1.68	1.00	1.16	0.54	1.92	1.61	1.27
α-cadinol	1.34	1.70	0.63	0.33	0.87	1.13	---	---	0.64	---	1.59
Patchoulene	1.67	---	---	1.02	1.60	---	---	---	1.5	---	---
β-oplopenone	---	---	---	---	---	---	---	---	---	---	---
Total identified	98.98	99.15	99.66	99.71	97.00	99.01	98.49	99.00	99.21	98.24	99.91
Total oxygenated	8.14	9.17	7.52	6.49	11.23	10.5	6.24	6.00	11.28	6.84	12.17
Total unoxygenated	90.84	89.98	92.14	93.22	85.77	88.51	92.25	93.00	87.93	91.40	87.74

Table 7: Effect of fertilization on fixed oil% and yield (ml/plant and L/feddan) of *Lallemantia iberica* plant during 2010/2011 and 2011/2012seasons.

Treatments	first season			seconed season		
	%	ml/plant	L/feddan	%	ml/plant	L/feddan
Control	20.67[b]	1.51[e]	40.21[e]	21.33[d]	1.66[e]	44.16[e]
N60kg/fed	25.67[ab]	2.07[cde]	55.19[cde]	27.00[abc]	2.26[de]	60.18[de]
N90 kg/fed	26.67[a]	2.42[bcd]	64.52[bcd]	27.66[abc]	2.54[cd]	67.73[cd]
Compost 5t/fed	23.33[ab]	1.76[de]	46.90[de]	24.00[cd]	1.89[e]	50.34[e]
Compost 7.5t/fed	24.67[ab]	2.10[cde]	56.05[cde]	25.33[bcd]	2.22[de]	59.12[de]
Compost 5t+ N60kg/fed	25.33[ab]	2.69[abc]	71.18[abc]	26.33[abc]	2.90[bc]	77.24[bc]
Compost 5t+ N90 kg/fed	27.00[a]	3.07[ab]	81.70[ab]	29.00[ab]	3.47[ab]	92.48[ab]
Compost 5t+ Rhizo.	23.67[ab]	2.67[abc]	71.74[abc]	25.00[bcd]	2.99[bc]	79.53[bc]
Compost 7.5t+ N60kg/fed	26.67[a]	3.08[ab]	82.08[ab]	28.33[abc]	3.34[ab]	88.91[ab]
Compost 7.5t+ N90kg/fed	28.00[a]	3.48[a]	92.79[a]	30.00[a]	3.86[a]	102.70[a]
Compost 7.5t+ Rhizo.	22.67[ab]	2.62[abcd]	69.90[abcd]	25.67[abcd]	3.11[bc]	82.88[bc]

Means followed by similar letter(s) within the same column are not significantly different at P≤ 0.05 according to Duncan's Multiple Range Test.

Table 8: Effect of fertilization on fatty acids content of *Lallemantia iberica* plant during 2011/2012 season

Essential oil constituents (%)	Control	N60/fed	N90/fed	Compost 5t	Compost 7.5t	Compost 5t+N 60	Compost 5t + N90	Compost 5t+Rhizo	Compost 7.5t+N 60	Compost 7.5t+N 90	Compost 7.5t+Rhizo
Palmitic acid $C_{16:0}$	6.60	6.62	6.70	6.71	6.71	6.65	7.03	6.66	6.43	7.32	6.59
Palmitoleic acid $C_{16:1}$	0.26	0.23	0.29	0.27	0.54	0.23	0.24	0.26	0.54	0.26	0.25
Stearic acid $C_{18:0}$	2.19	2.22	2.20	2.36	2.19	2.16	2.30	2.16	2.18	2.24	2.03
Oleic acid $C_{18:1}$	12.67	12.66	12.56	13.74	12.88	12.21	12.41	12.39	11.78	12.31	12.43
Linoleic acid $C_{18:2}$	13.64	13.39	13.49	14.1	14.85	12.58	13.19	13.41	13.12	13.15	12.55
α-linolenic acid $C_{18:3}$	63.03	63.62	63.44	61.25	61.22	64.92	63.5	63.94	60.47	63.55	64.84
Arachidicacid $C_{20:0}$	0.40	0.20	0.25	0.33	0.43	0.27	0.27	0.16	0.24	0.19	0.24
Arcachidonic acid $C_{20:4}$	1.17	0.99	1.02	1.19	1.12	0.94	1.02	0.98	1.19	0.97	1.02
Total identified	99.96	99.93	99.95	99.95	99.94	99.96	99.96	99.96	95.95	99.99	99.95
Total saturated acids	9.19	9.04	9.15	9.40	9.33	9.08	9.60	8.98	8.85	9.75	8.86
Total unsaturated acids	90.77	90.89	90.80	90.55	90.61	90.88	90.36	90.98	91.11	90.21	91.10

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