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Soilless Culture Production of Alecost [*Chrysanthemum balsamita* (L.) Baill.]: A Preliminary Study

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Abstract

Two separate experiments were conducted in order to evaluate the soilless culture production of Chrysanthemum balsamita plants. In the first experiment eight treatment combinations of N (100, 200, 300 and 400 mgl^{-1}) and K (100 and 200 mgl^{-1}) were applied on plants. In the second experiment four concentrations of the modified Hoagland's nutrient solution (0.25X, 0.5X, 1X and 2X) were employed as treatments. The results showed that treatment combinations of N and K had significant effects on all studied traits. For leaves fresh and dry weight as well as leaf area the best treatment was $N_{200}K_{200}$, The highest data for essential oil content and yield belonged to $N_{200}K_{200}$ treatment combination as well. $N_{200}K_{200}$ and $N_{400}K_{100}$ had the greatest output for tissue potassium and nitrogen content, respectively. Different concentrations of nutrient solution had significant effect on leaves fresh and dry weight as well as on leaf area. For all traits 1X treatment was the best. In contrast with growth parameters, the superior essential oil content and yield was recorded in 0.25X treatment. Unlike to essential oil related traits, 2X treatment had the highest data for tissue potassium and phosphorus content. In total, C. balsamita plant positively responded to soilless culture production.

Keywords: Soilless culture, *Chrysanthemum balsamita*, Essential oil, Nitrogen, Potassium, Nutrient solution concentration

Introduction

Alecost [*Chrysanthemum balsamita* (L.) Baill.] is a herbaceous, perennial, and rhizome bearing herb belonging to the Asteraceae or Compositae family [1,2]. The genus *Chrysanthemum* has 26 species in Iran [1]. The *balsamita* species is locally named 'Shahesparam' in Azerbaijan provinces of Iran [1,3]. Alecost is a hardy plant naturalized and adapted in Northwest of Iran and in most regions of the world such as: Italy, Spain, Lithuania, Romania and Turkey [2,4,5,6].

Medicinal characteristics of alecost are due to the presence of essential oil synthesized and accumulated in glandular trichoma located on the abaxial surface of the leaves [4]. Alecost and its essential oil derived preparations have been used as sedative, laxative, cardiotonic, appetizer and flatulent [4,6,7]. Dried leaves of alecost have been used as herbal tea, spice, condiment as well as in confectionary [4,6,7]. Alecost volatile oil is the most important secondary metabolite of this plant and the majority of healing, medicinal and culinary properties of this plant is devoted to volatile oil [3,4,6,7,8]. Furthermore, in recent years alecost have been used as a rich source of a high valued monoterpene i.e. carvone [9,10].

Hydroponic production of medicinal and aromatic herbs is a new insight towards the mass production of these plants leading to high secondary metabolites yields and qualities

[9,10,11]. Soilless culture production of plants especially medicinal herbs has many valuable advantages such as: high yields, cleaner production, year-long cultivation, and production of drugs with minimum herbicide and pesticide residues [12,13]. Suitable and adequate supply of water, air, and nutrient elements, thereafter increase in absorptive and metabolic potential of roots and subsequently higher production of aerial and underground parts are the main advantages of this production systems compared with field grown counterparts [3,12,14,15]. In a series of experiments on the assessment of growth and cultural requirements of alecost, we tried to evaluate the basic nutritional needs of alecost in hydroponic system. To the best of our knowledge there is no previous report on the soilless culture production of alecost.

The aim of the present report was to evaluate for the first time the effects of different levels of N & K and different concentrations of nutrient solution on the growth and essential oil content and yield of alecost.

Material and Methods

This experiment was carried out at Research Greenhouse of Horticultural Sciences Department at the University of Tabriz, Iran. Propagation materials were rhizome cuttings supplied from an established alecost field near Tabriz in Northwest Iran.

Growing conditions

The greenhouse used in these experiments was an one-layer polyethylene covered greenhouse with ambient temperature, light and relative humidity of 15-30^{0}C, ~400µmolm^{-2}s^{-1} and 40-50% respectively. Rhizome cuttings (10cm length×1cm width) were prepared, rinsed with tap water, disinfected with Benomyl and immediately planted in pots containing medium sized perlite and vermiculite (8:2 volume: volume).

First experiment

In this experiment four concentrations of N (100, 200, 300 and 400 mgL^{-1}) and two concentrations of K (100 and 200 mgL^{-1}) based on the modified Hoagland's nutrient solution were applied on plants. Experimental design was factorial, based on RCBD with three replications and 8 treatment combinations.

Second experiment

In this experiment four concentrations of the modified Hoagland's nutrient solution (0.25X, 0.5X, 1X and 2X) were used as treatments. Experimental design was randomized complete block with 6 replications.

Measurements

Leaf area: Leaf area (cm^2) of plants were measured at the end of the growing season, i.e. button stage of flowers in last week of September, by leaf area meter (Li-Cor, Model Li-1300, USA) and also the fresh weight of leaves was recorded. Dry weight of leaves was evaluated after drying of leaves in an air-forced oven at 70^{0}C for 72 hrs until constant weight.

Essential oil content and yield: Volatile oil content of plants was measured through 120 min hydro-distillation of 50 grams of air-dried aerial parts of plants by Clevenger-type apparatus, according to the European pharmacopoeia. Essential oil yield was evaluated by the multiplication of essential oil content to the related dry weight of plants and reported as mlm^{-2}.

Nutrients content: Nitrogen content (mgg^{-1}) of plants was measured according to the Kjeldahl method. Phosphorus and potassium content were assessed by colorimetric (Vanadate-Molybdate) and flame photometric (CORNING, Series 410, France) methods respectively.

Data analysis

All data were subjected to variance analysis by SAS 8.02 software. Mean comparisons were carried out by Duncan's multiple range test at P<0.05 and P<0.01 levels.

Results and Discussion

Treatment combinations of N and K statistically ($P<0.05$) influenced leaves fresh and dry weight of alecost (Table 1).

Table 1. Effects of treatment combinations of nitrogen and potassium on leaf area and leaf fresh and dry weight of alecost.

Treatment combinations	Leaf area (cm^2)	Leaf fresh weight (g)	Leaf dry weight (g)
$N_{100}K_{100}$	14597 a	598.5 ab	90.7 ab
$N_{200}K_{100}$	14324 ab	577.8 abc	85.6 abc
$N_{300}K_{100}$	11903 c	516.8 cd	79.3 bc
$N_{400}K_{100}$	11580 c	470.3 d	72.0 c
$N_{100}K_{200}$	12198 c	503.0 cd	76.3 c
$N_{200}K_{200}$	14437 a	635.1 a	97.6 a
$N_{300}K_{200}$	13190 abc	557.7 abc	84.0 bc
$N_{400}K_{200}$	12499 bc	531.9 bcd	84.3 bc

Different letters within columns show significant difference between treatments based on Duncan's multiple range test at $P<0.05$

The highest data for these traits belonged to $N_{200}K_{200}$ treatment combination. Jeliazkova *et al* [16] reported that N and K fertilization increased seed and whole plant yield of fennel. Singh *et al* [17] noted that NPK fertilization positively influenced leaves fresh and dry weight of ocimum plants. It seems that balanced applications of nutrient elements, especially macronutrients like N and K, improves harmonized above and underground development of plants parts, which in turn leads to the increased production of medicinally important organs, i.e. leaves. Furthermore, Dorais *et al* [13] reported the promoting effects of controlled and balanced application of N and K on gentian, valerian, dandelion and wormwood plants. Leaf area of plants was significantly ($P<0.05$) influenced by N and K treatment combinations and $N_{200}K_{200}$ treatment resulted in the highest leaf area. It is likely that optimum ratios of N and K increases the distribution of photo-assimilates toward the above ground parts of plants and the result of this phenomenon would be an increased above ground parts biomass as well as leaf area.

Treatment combinations of N and K influenced nitrogen and potassium content of plants (Figure 1).

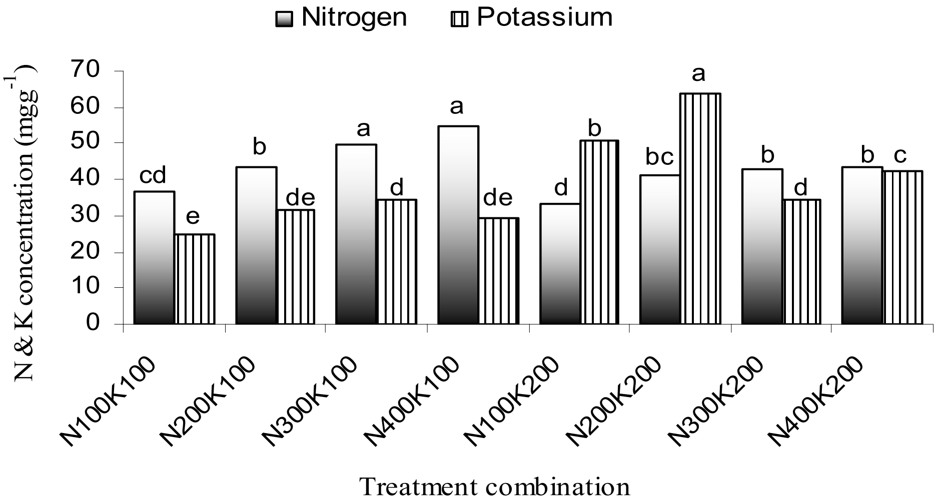

Figure 1. Effects of treatment combinations of nitrogen and potassium on N & K content of alecost.
Different letters on bars show significant difference between treatments based on Duncan's multiple range test at $P<0.05$.

In contrast with growth characteristics, the highest tissue N content belonged to $N_{300}K_{100}$ and $N_{400}K_{100}$ treatments. This inconsistency between growth characteristics and tissue N content shows that the increased growth in $N_{200}K_{200}$ treatment caused the nitrogen dilution in plant tissues and thereafter reduced tissue N content [18]. Similar results have been reported by Singh and Singh [19]. For potassium content of plant tissue, the best treatment was $N_{200}K_{200}$. This trend shows that along with growth characteristics, maximum absorption and assimilation of K within plant needs the equal and balanced ratios of N and K.

Different concentrations of nutrient solution had significant effects on fresh and dry weight of leaves (P<0.01) and leaf area (P<0.05) (Table 2). In all three traits, the highest data were recorded in 1X treatment; the 2X treatment or treatments with the highest concentration of nutrient solution had the lowest data for all traits.

Table 2. Effects of different concentrations of nutrient solution on leaf fresh and dry weight and leaf area of alecost.

Treatments	Leaf fresh weight (g)	Leaf dry weight (g)	Leaf area (cm^2)
0.25X	365.1b	58.5b	9582 a
0.5X	410.0a	59.2ab	9767 a
1X	421.6a	61.3a	10235 a
2X	378.8b	55.2c	8707 b
ANOVA	**	**	*

Mean separation within columns based on Duncan's multiple range test.
* and ** Significant at P<0.05 and P<0.01 respectively.

It seems that standard or 1X concentration of nutrient solution increases the growth characteristics of plants by balanced availability and allotment of nutrient elements in the growing media and hence increased absorptive ability of plant root system and subsequently promoted the plant growth.

Different concentrations of nutrient solution statistically (P<0.01) influenced N, P and K content of plants (Figure 2).

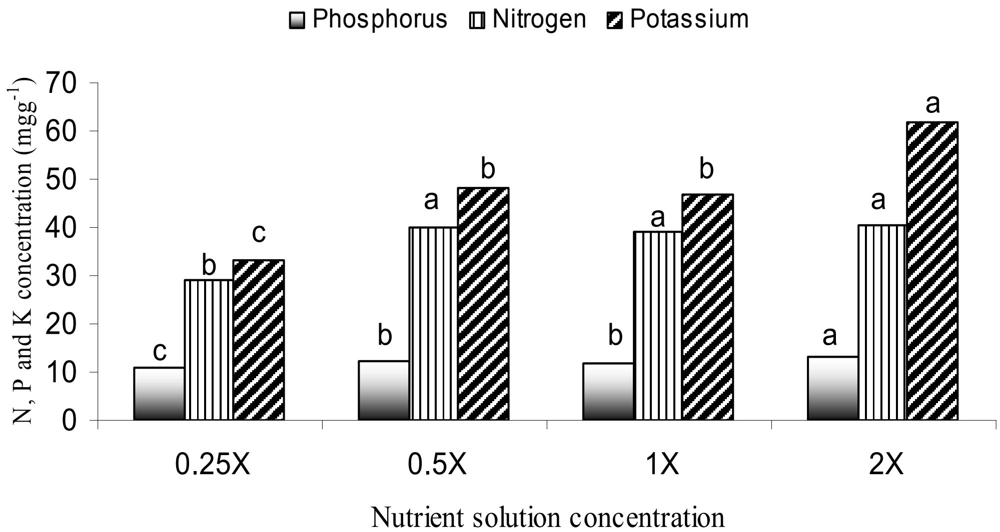

Figure 2. Effects of different concentrations of nutrient solution on N, K and P content of alecost.
Different letters on bars show significant difference between treatments based on Duncan's multiple range test at P<0.05

The highest tissue N content belonged to the 0.5X, 1X and 2X concentrations. This trend indicates that increase of N content in the nutrient solution is not invariably accompanied by a corresponding tissue N content. 2X treatment had the highest tissue P and

K content. Increase in tissue P and K content with promoting of nutrient solution concentration is completely reasonable. Udagawa [15] reported that increase in nutrient solution concentration accompanied increase in K and P content of dill and thyme plants. It is noteworthy that for both P and K, the lowest concentration of nutrient solution i.e. 0.25X had these nutrients sufficiency and no deficiency symptoms were observed.

N and K treatment combinations affected essential oil content and yield of costmary (Figure 3).

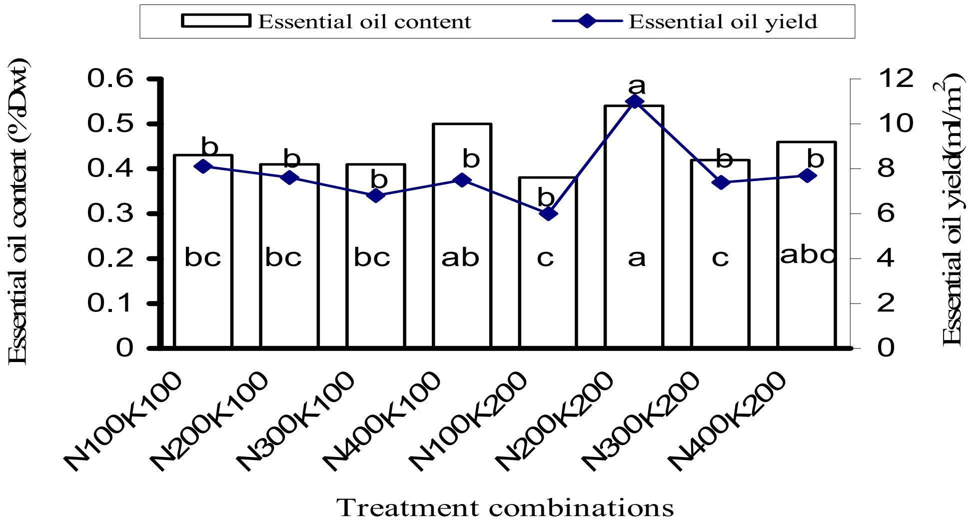

Figure 3. Effects of treatment combinations of nitrogen and potassium on essential oil content and yield of alecost. Different letters show significant difference between treatments based on Duncan's multiple range test at P<0.05

The highest data for these traits belonged to the $N_{200}K_{200}$. This result shows that for enhancing of volatile oil production in alecost, precise and balanced application of these macronutrients is essential. Munsi [20] reported similar nutrient balance for N and P in Japanese mint production. Abdallah *et al* [21] reported that N and K fertilization increased seed yield and essential oil content and yield of fennel. As mentioned earlier (Table 1), $N_{200}K_{200}$ treatment had the highest leaf dry weight and area. Therefore, it seems that optimum concentrations of N and K affect essential oil content and yield by promoting leaf biomass and area as well as increasing of plant ability for utilization of nutrient solutions in hydroponics systems.

Different concentration of nutrient solution meaningfully ($P<0.05$) influenced alecost essential oil content and yield. The highest essential oil content belonged to 0.25X treatment (Figure 4).

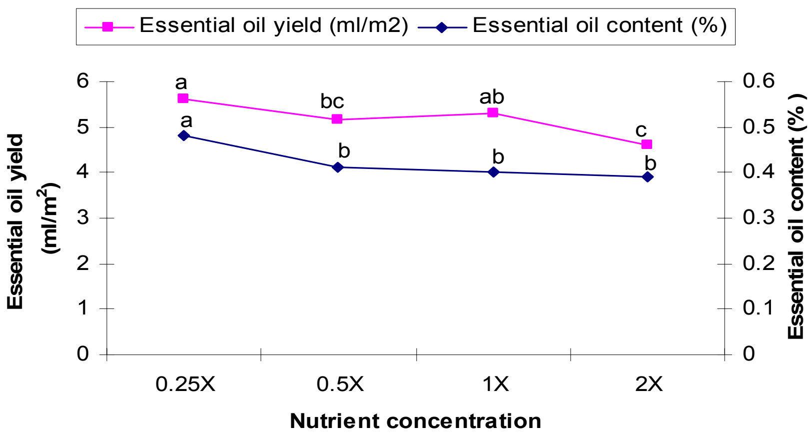

Figure 4. Effects of different concentrations of nutrient solution on essential oil content and yield of alecost Different letters show significant difference between treatments based on Duncan's multiple range test at P<0.05.

There was no significant difference between other treatments. The highest essential oil yield was recorded in 0.25X and 1X treatments. Along with growth parameters, 2X treatment had the lowest essential oil content and yield as well. The results related to the essential oil content and yield implies that alecost has the potential capability of essential oil biosynthesis and accumulation under low nutrient solutions concentrations. Suh *et al* [14] reported that the highest essential oil content and yield of different ocimum varieties related to the low concentrations of nutrient solution. Udagawa [15] noted that the lowest concentration of nutrient solution had the elevated essential oil content in dill plants. It seems that under low nutrient solution concentrations, increased absorptive capacity of roots leads to the intensified metabolic and biochemical activities of plant and resulted in an increase of essential oil production.

Conclusion

In general, the results obtained from the present experiment showed that accurate and balanced ratios of N and K as well as appropriate concentrations of nutrient solution had encouraging effects on growth parameters and essential oil content and yield of alecost. Finally, it seems that successful hydroponics production of this high-value medicinal plant could be a promising message for pharmaceutical and food industries on meeting their high demands for alecost raw material.

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