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Effect of mineral nutrient solutions on secondary metabolites of German chamomile in Hydroponics system

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An experiment was conducted at a research field in Khorramabad-Lorestan, Iran, in 2018-2019 to evaluate the effect of nutrient solutions on volatile components of German chamomile in a hydroponics system. The greenhouse experiment was conducted out as a complete block randomized with four replications using a factorial design. Four feeding solutions (Hogland, Shnider, Cooper, and a researcher-suggested solution) were investigated, and hydroponic volumes of Cooocoopit, sand+ Perlit, Coocoopit+ Perlit, and Coocoopit+ sand+ perlit. Nutritional solution and hydroponic volume had a substantial impact on secondary metabolites, according to the findings. The maximum Chamazulene percentage was obtained with 3.62 percent from L2F2, while the lowest percentage was obtained with 2.73 percent from L2F1. L1F4 had the most significant -Bisabolol concentration of 9.55 percent, while L3F1 had the lowest -Bisabolol concentration of 6.21 percent.

Keywords: German Chamomile, hydroponics, nutrition solution, Chamazulene

INTRODUCTION

Chamomile is a mixed family plant that is one of the earliest medicinal plants identified by humans. Among the Babylonian species, chamomile has a significant therapeutic significance (Gholamin and Khayatnezhad 2020, Huang, Wang et al. 2021, Sun, Lin et al. 2021). Because of their anti-inflammatory qualities, Chamazulene, Bisabolol, Pharenesene, and its oxides are considered the essential chemicals among chamomile essence components (Azizi 2007). Essential oils with high levels of Bisabolol and chamazulene are considered highly qualified (Huang, Wang et al. 2021, Zhang, Khayatnezhad et al. 2021, Zhu, Saadati et al. 2021). Medicinal plant cultivation is one of the essential disciplines of agriculture research that can be used to extract and manufacture ingredients for medicine production (Ghiasvand, Nasseri et al. 2011, Ma, Ji et al. 2021, Ma, Khayatnezhad et al. 2021). Advances in chemical science and detection of complex systems in organic synthesis resulted in development in the medicinal sector and the replacement of Chemotherapy at the turn of the century. Many incurable and fatal diseases have been healed in this way by modern medicine (Radmanesh 2021, Rodríguez 2021).

When the volume of chamomile is raised, the essence percentage increases (Shams-Ardakani, Ghannadi et al. 2006). Nitrogen application keeps chamomile in its most youthful physiological stage, resulting in increased essence and bisabolol content (Ren and Khayatnezhad 2021, Tao, Cui et al. 2021). Also, boosting nitrogen and phosphate fertilizer increases essence while increasing potassium fertilizer decreases it. Nitrogen is helpful in the biosynthesis of the essence and the quality and amount of essence (Kabir, Arefin et al. 2021). Because secondary metabolites are produced as a function of plant photosynthesis, the production of secondary metabolites increases as photosynthesis and chlorophyll levels rise, increasing essence production. Environmental conditions have a complex effect on the synthesis of effective materials in medicinal plants. The quality and quantity of effective materials vary depending on the stage of plant growth. Although the quality and quantity of chamomile essence are genetically controlled, the number of functional materials will vary due to the plant's mutual reaction to the environment (Huma, Lin et al. 2021). This study aimed to see how different nutrition solutions affected chamomile plants in hydroponic systems and which nutrition solution produced the highest percentage of the essence.

MATERIALS AND METHODS

From 2018-2019, this test was carried out in the "neginsabz greenhouse" in the Daraei village of Khorramabad-Lorestan, Iran. A blocked randomized field experiment with four replications was conducted. Seed from modified German chamomile was used in this study. The variables were four types of hydroponic media (1.cockpit, 1.cockpit, 1.cockpit, 1.cockpit 2. perlit+sand 3. perlit+cocopit four solution nutrition (cocopit+ sand+ perlit) and four cocopit+ sand+ perlit) (Hogland, Eshnider, Cooper, My solution).

Table1: Table of the elements in the nutrient solution used by the researcher

Calcium nitrate	28 ppm
Potassium nitrate	14 ppm
Potassium mono phosphate	7.734 ppm
Magnesium sulfate	9 ppm
Manganese sulfate	0.3 ppm
Copper sulfate	0.05 ppm
Zinc sulfate	0.2 ppm
Boric acid	0.15 ppm
Fe	0.9 ppm
PH	6.5-7
Temperature	12-25 ºC

The seeds were sowed in February. Flowerpots were filled with different hydroponic media and kept close to each other according to the test design. The florets were spread after the seeds had sprouted, and four florets were retained in each flowerpot. According to the test design, a nutrition solution was administered to the flowerpot. Flowers were sampled 65 days after they were planted. Plant parts such as flowers, leaves, and stems were dried in the dark, then broken and stored in a laboratory environment away from light. The UA-HS-SPME method was used to extract essential chemicals from PDMS fiber. Professor Ghiasvand and a colleague used ideal conditions for sampling analysis (Table2). (Si, Gao et al. 2020, Khayatnezhad and Gholamin 2021).

Table 2: Optimality temperature program for GC in UA-HS-SPME method

Step	Rate (ºC/min)	Temp. (ºC)	Hold Time (min)
1	-	40	0
2	4	180	1
3	10	250	3

After identifying the extracted volatile compounds from cultivated chamomile in a hydroponic system using compounds mass spectra and comparing them to a standard spectrum (NIST) on a GC/Ms machine. Existing compounds were accumulated using the line temperature program (LTPRI)2 and line alkenes C8-C20 for more precise identification and measurement of compounds quantity. The laboratory stages were carried out at Lorestan University's chemistry faculty and the Lorestan University's medicinal plants research center. The data was analyzed using the Mstatc statistical tool, and the means were compared using the Duncan test.

RESULTS AND DISCUSSION

According to the variance analysis, the hydroponic volume and nutrition solution had a substantial effect on Chamazulene, -bisabolol, Farenzen, and Germacrene-D (table 3). The researcher's nutrition solution obtained the highest Chamazulene and bisabolol percents (with 3.33 percent and 9.21 percent, respectively). In comparison, the lowest Chamazulen was obtained (with 2.90 percent) from Cooper's nutrition solution, and the lowest bisabolol percent was obtained (with 7.19 percent) from Hogland's nutrition solution (table 4). The nutrition solution of Shnider produced the highest Farenzen percent (84.73%), whereas the nutrition solution of Hogland produced the lowest Farenzen percent (81.45%). (table 4). Also, the highest Germacrene percent (3.45%) was acquired from Cooper's nutrition solution, while the lowest Germacrene percent (2.89%) was obtained from Shnider's nutrition solution (table 4).

Table3: variance analysis of hydroponic volume and nutrition solution on matricaria chamomile

		Means of squares			
Variation source	df	β-Bisabolol (%)	Chamazulene (%)	Germacrene-D (%)	Pharenzen (%)
year	1	0.242ns	0.003^{ns}	0.014^{ns}	5.975^{ns}
Error	6	------	------	------	-----
hydroponic volume	3	6.654**	0.184^{**}	0.219^{**}	59.133^{**}
hydroponic volume + year	3	1.205**	0.029^{*}	0.046^{*}	12.321^{**}
nutrition solution	3	28.829**	1.327^{**}	1.917^{**}	80.495^{*}
nutrition solution + year	3	0.016^{ns}	0.001^{ns}	0.002^{ns}	0.258^{ns}
hydroponic volume + nutrition solution	9	1.225**	0.567^{**}	0.209^{**}	19.578^{**}
hydroponic volume + nutrition solution + year	9	0.152^{ns}	0.063^{**}	0.042^{**}	3.1^{**}
Error	42	-----	-----	-----	-----
Coefficient of variation (%)		3.55	2.37	3.46	1.06

Table 4: Means comparison of hydroponic volume and nutrition solution on matricaria chamomile

Treatments	means comparison			
	β-Bisabolenol	***Chamazulene***	***Germacrene-D***	**Pharenzen**
Year				
Year 1	8.00^{a}	3.12^{b}	3.09^{a}	83.61^{a}
Year 2	7.92^{a}	3.41^{a}	3.31^{a}	84.04^{a}
Hydroponic Volume				
Cocopit(L1)	8.217^{a}	3.14^{a}	3.00^{c}	82.63^{b}
Sand+Perlit(L2)	8.327^{a}	3.18^{a}	3.09^{b}	82.67^{b}
Cocopit+Perlit(L3)	7.31^{c}	3.01^{b}	3.18^{a}	85.07^{a}
Cocopit+Sand+Perlit(L4)	7.987^{b}	3.15^{a}	3.15^{a}	84.93^{a}
Nutrition Solution				
Hogland(F1)	7.19^{c}	3.00^{c}	3.10^{b}	81.45^{b}
Eshnider(F2)	7.25^{c}	3.22^{b}	2.89^{d}	84.73^{a}
Cooper(F3)	8.18^{b}	2.90^{d}	3.45^{a}	84.6^{a}
My Solution(F4)	9.21^{a}	3.35^{a}	2.98^{c}	84.52^{a}
Hydroponic Volume × Nutrition Solution				
Cocopit× Hogland	7.10^{g}	3.41^{b}	2.89^{ef}	79.42^{g}
Cocopit× Eshnider	7.40^{f}	2.96^{de}	2.76^{g}	85.66^{ab}
Cocopit× Cooper	8.82^{c}	2.93^{de}	3.30^{b}	83.36^{d}
Cocopit× My Solution	9.55^{a}	3.28^{c}	3.04^{cd}	82.06^{e}
Sand+Perlit× Hogland	8.00^{de}	2.73^{g}	3.15^{c}	81.31^{ef}
Sand+Perlit× Eshnider	8.04^{de}	3.62^{a}	2.83^{fg}	80.91^{f}
Sand+Perlit× Cooper	7.97^{de}	2.88^{ef}	3.42^{b}	84.84^{bc}
Sand+Perlit× My Solution	9.30^{ab}	3.47^{b}	2.94^{def}	83.62^{d}
Cocopit+Perlit× Hogland	6.21^{h}	2.97^{de}	3.39^{b}	83.48^{d}
Cocopit+Perlit× Eshnider	6.48^{h}	2.88^{ef}	2.86^{efg}	86.42^{a}
Cocopit+Perlit× Cooper	7.77^{e}	2.99^{d}	3.65^{a}	84.21^{cd}
Cocopit+Perlit× My Solution	8.78^{c}	3.19^{c}	2.84^{fg}	86.17^{a}
Cocopit+Sand+Perlit× Hogland	7.46^{f}	2.89^{def}	2.97^{de}	81.59^{ef}
Cocopit+Sand+Perlit× Eshnider	7.10^{g}	3.41^{b}	3.10^{c}	85.92^{a}
Cocopit+Sand+Perlit× Cooper	8.17^{d}	2.82^{fg}	3.42^{b}	85.99^{a}
Cocopit+Sand+Perlit× My Solution	9.22^{b}	3.47^{b}	3.10^{c}	86.24^{a}

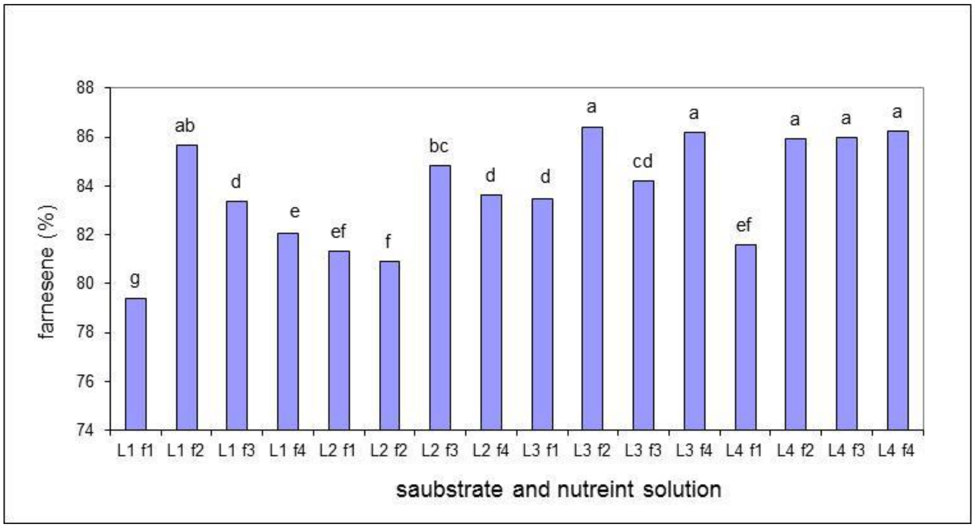

Figure1: The interaction effect of substrates and nutrient solutions on Farnesene

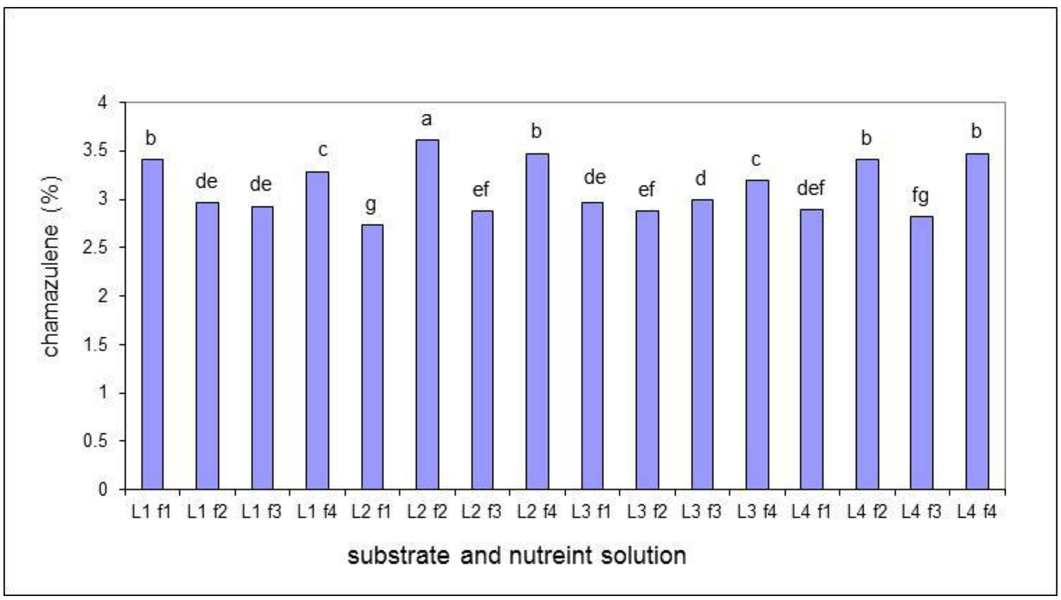

Figure 2: The interaction effect of substrates and nutrient solutions on Chamazulene

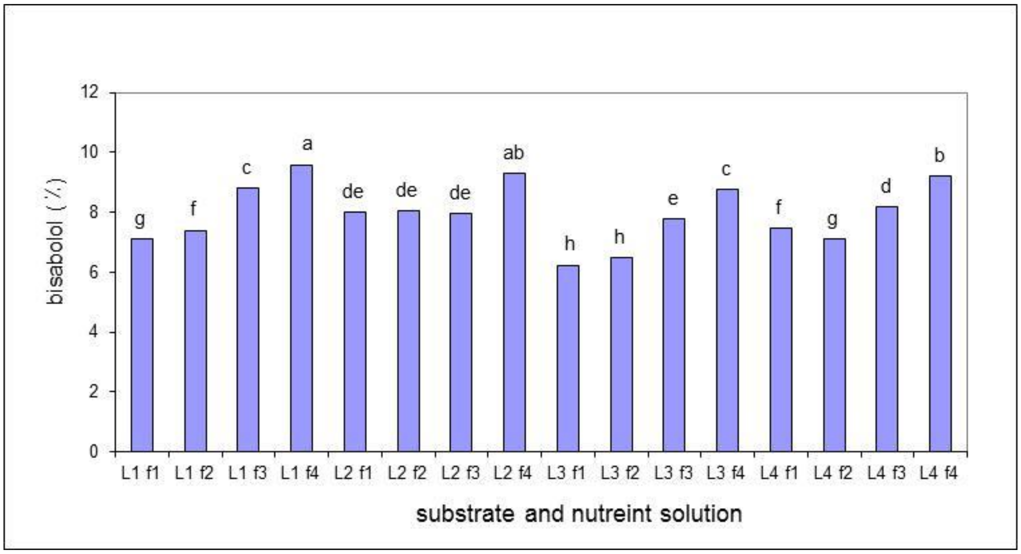

Figure 3 : The interaction effect of substrates and nutrient solutions on Bisabolol

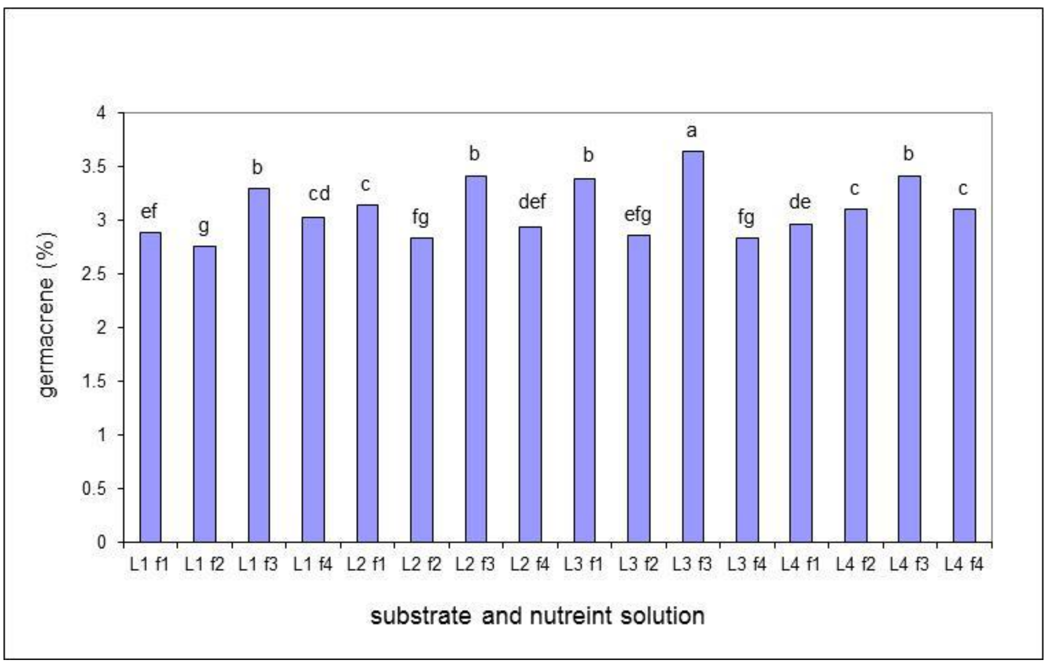

Figure 4: The interaction effect of substrates and nutrient solutions on Germacrene

The interaction impact of nutrient solution and substrate on the percent of Farnesene was significant at the percent 1 level, according to the variance analysis results in table 2.4. The substrate and nutrient solution had the highest percentage of Farnesene (L3F2=86.42%). In the substrate and nutrient solution, the lowest proportion of Farnesene was found (L1F1=79.42%). (See Figure 1) The interaction impact of nutrient solution and substrate on the percent of Chamazulene was significant at the percent 1 level, according to the variance analysis results in table 2.4. The substrate and nutrient solution had the highest percentage of Chamazulene (L2F2=3.62%). In addition, the substrate and nutritional solution contained the smallest amount of Chamazulene (L2F1=2.73%). (See Figure 2) The interaction impact of nutritional solution and substrate on the percent of Bisabolol was significant at the percent 1 level, according to the variance analysis results in table 2.4. The substrate and nutrient solution had the highest percentage of Bisabolol (L1F4=9.55 percent). In addition, the substrate and nutrient solution had the smallest amount of Bisabolol (L3F1=6.21%). (See Figure 3)

CONCLUSION

The findings revealed that the kind of hydroponic volume and nutrition solution substantially impacted the quality and quantity yield of chamomile plants. With proper environmental management, high yields can be achieved. According to the findings, the effect of the year had the most negligible impact on chamomile crop yield, and no significant differences were observed in treatments except for chamazulene percent, indicating that the environmental conditions, hydroponic volume, and nutrition solution remained constant over two years. The results showed that the chamomile plant responded differently to different hydroponic volumes, with the best yields of Farenzen and Germacrene-D in coocoopit+Perlit and the highest yields of Chamazulene and -bisabolol in Sand+Perlit. In addition, the maximum yield of Farenzene was achieved in the Eshnider nutrition solution, while the highest yield of -bisabolol was obtained in the researcher's solution. The nutrition solution delivered to the plant is one of the most critical aspects of hydroponic volume. In this study, four nutrition formulae were employed, with the F4 nutrition formula (created by the researcher) having the highest yield on Farenzene, Chamazulene, and -bisabolol, among the others.

The findings of the comparison of the mean revealed that L3F3 and L4F3 had the highest yield of volume interaction and nutrition solution, indicating that they had the best volume and nutrition solution among the other treatments.

In a comparison of means, the interaction of L3F2 produced the most significant yield of Farenzene, whereas L3F3 produced the highest Germacrene-D. As a result of the findings, a volume of Coocoopit+Perlitin cooper nutrition solution may be optimal for Chamomile planting in a greenhouse. One of the critical reasons for the high efficiency of the manufacturing is the capacity to keep water and nutrition solution in Coocopit volume and more nutrition in Cooper solution. The weather plays a significant impact on chamomile development and creation. When chamomile grows in salty, unfertilized soil, it produces a short plant (about 5 cm tall). Research conducted in Iran and other countries revealed a significant difference in the quality and quantity of beneficial components in different species of chamomile that grow in various climate conditions.

Some species' essences contain a large amount of Chamazulen, whereas others do not. The amount of flower essence varies depending on the climate of the growing area and ranges from 0.4 to 1.5 percent. Chamazulen makes up 12 to 20% of the essence and has a vital role in edema treatment (Ghiasvand, Nasseri et al. 2011, Xu, Ouyang et al. 2021). The amount of effective chemicals is affected by environmental conditions and pressures (Jia, Khayatnezhad et al. 2020, Cheng, Hong et al. 2021, Hou, Li et al. 2021, Wang, Shang et al. 2021, Zheng, Zhao et al. 2021, Zhu, Liu et al. 2021). With the application of nitrogen fertilizer and essence, the physiological stage of Chamomile remains younger, and the amount of Bisabolol is enhanced (Hewitt 2021). Franz also believed that increasing nitrogen and phosphate fertilizer increases essence, while potassium fertilizer application decreases it. From a quantitative (flower dry weight per unit area) and qualitative (flower essence amount and effective material percent of essence) standpoint, the presence of nutrition elements such as phosphorus, which play a vital role in the plant reproductive process, can increase the yield of German chamomile plants (Karasakal, Khayatnezhad et al. 2020, Guo, She et al. 2021). It has been estimated that the amount of -bisabolol and its oxide is 78 percent, and the amount of Chamazulen is 1-15 percent (Li, Mu et al. 2021, Sun and Khayatnezhad 2021). This study found the highest concentrations of -bisabolol and Chamazulen from hydroponic volumes of Coocoopit and private nutrition solution and hydroponic volumes of sand+perlit and Eshnider nutrition solution (with 9.4 percent and 3.7 percent, respectively). -bisabolol oxide A and -bisabolol oxide B is the most abundant compounds in chamomile extract (Barth 2021, Yin, Khayatnezhad et al. 2021). As shown in the diagram, the minimum and greatest amounts of -bisabolol reported in studies were 6.3 percent and 9.4 percent, respectively. In terms of -bisabolol quantity, sand+ Perlit and private nutrition solution treatments had identical results. Because these treatments produce the most output, we recommend them as the best nutrition solution and hydroponic volume. Another element that influences the accumulation of flavones in tissues is the climate throughout time. Environmental factors and light intensity both help to increase the number of flavones in the body. The amount of flavones was affected by the hydroponic volume and nutrition solution, with some volumes and nutrition solutions showing an increase in the amount of these compounds.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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This paper was from my own master thesis.

AUTHOR CONTRIBUTIONS

Sina Mohammadzadeh conducted, planned, Analyzed the data, wrote manuscript and interpreted the results and involved in manuscript preparation. All authors read and approved the final version.

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