

Full Length Research Paper

Evaluation changing of essential oil of balm (*Melissa officinalis* L.) under water deficit stress conditions

Hossein Aliabadi Farahani^{1*}, Sayed Alireza Valadabadi¹, Jahanfar Daneshian¹ and Mohammad Ali Khalvati²

¹Islamic Azad University of Takestan branch, Iran.

²Department of Plant-Microbe Interaction, German Research Centre for Environment and Health Munich (Helmholtz Zentrum Muenchen), Ingolstaedter 1 Neuherberg, Germany.

Accepted 18 July, 2025

An experiment was carried out using a randomized complete block design with 4 replications to study the effect of water deficit stress on essential oil of balm. The factors studied included 5 levels of water deficit stress that were T₁ (100% field capacity), T₂ (80% field capacity), T₃ (60% field capacity), T₄ (40% field capacity) and T₅ (20% field capacity) respectively. The results showed that water deficit stress significantly affected biological yield, essential oil yield, essential oil %, leaf yield, height of plant, tiller number, stem diameter, stem yield and internode length in P < 0.01. Highest biological yield and height of plant were achieved under T₁, highest essential oil yield was achieved under T₃ and highest stem diameter and essential oil % were achieved under T₅. The results of this experiment showed that essential oil yield was reduced under water deficit stress but essential oil % increased under this condition.

Key words: Water deficit stress, essential oil, balm.

INTRODUCTION

Balm, *Melissa officinalis* L., a perennial herb native to southern climates of Europe and North America, is presently found in both wild and cultivated states. Several other species of *Melissa* have been reported from the Mediterranean and central Asian areas, but only *M. officinalis* L. is cultivated. The plant grows erect and reaches a height of 0.5 to 1 m. The highest levels of essential oil have been extracted in late summer from the lower parts of the plants (Kennedy et al., 2005). The essential oil contains geraniol, citronellol, cintronellal, linalool, eugenol acetate and nerol. The essential oil is often adulterated with mixtures of lemongrass, citronella or lemon oil. Oil of balm has also been shown to have antiviral, antibacterial and antispasmodic activity. Balm has been reported to be an insect repellent. As a medicinal plant, lemon balm has traditionally been employed against catarrh, fever (Kabala-Dzik et al, 1993), flatulence (Weizman et al., 1993) and headaches (Wake et al., 2000). Water deficit occurs when water potentials in the rhizosphere are sufficiently negative to reduce water

availability to sub-optimal levels for plant growth and development (Aliabadi et al., 2008a). Drought stress is especially important in countries where crop agriculture is essentially rain-fed (Boyer, 1982; Ludlow and Muchow, 1990). Drought stress causes an increase in solute concentration in the environment, leading to an osmotic flow of water out of plant cells. This in turn causes the solute concentration inside plant cells to increase, thus lowering water potential and disrupting membranes along with essential processes like photosynthesis. These drought-stressed plants consequently exhibit poor growth and yield. In worst case scenarios, the plants completely die. Certain plants have devised mechanisms to survive under low water conditions. These mechanisms have been classified as tolerance, avoidance or escape (Kramer and Boyer, 1995; Neumann, 1995). Drought stress reduced dry matters of coriander by reduction in the area of the leaf, height of plant and lateral stem number (Aliabadi et al., 2008c). Droughted *M. officinalis* plants showed a significant decrease in the endogenous levels of photosynthetic pigments, the antioxidant function of α -tocopherol and the dissipation of excess excitation energy by the xanthophyll cycle may help to avoid irreversible damage to the photosynthetic apparatus that

*Corresponding author. E-mail: farahani_1362@yahoo.com.

Table 1. Mean squares of some characteristics of balm.

Mean squares										Value Sources
Essential oil yield	Essential oil %	Stem yield	Leaf yield	Biological yield	Internode length	Stem diameter	Tiller number	Height of plant	df	
26.049	0.034	187357.18	3453762.1	11531168.779	2.352	0.851	56.191	197.831	4	Replication
2.158**	0.001**	38846.414**	323859.218**	137129.613**	0.186**	0.027**	0.149 **	7.97 **	3	Water deficit stress
0.842	0.001	10781.464	49149.644	18496.304	0.114	0.015	5.28	6.439	12	Error
10.65	9.13	4.74	7.56	2.68	7.38	3.32	4.85	4.43		CV (%)

** and * : Significant at 1 and 5% levels respectively.

decreased biological yield of balm (Munne-Bosch and Alegre, 1999). The results of a study showed that drought stress reduced flowering shoot yield, essential oil yield and internode length and increased essential oil % of coriander (Aliabadi Farahani et al., 2008b). Drought stress is the most important environmental factor that decreases plants yield but in some medicinal plants increases essential oil. Therefore, this experiment was performed to study the effect of water deficit stress on essential oil of balm.

MATERIAL AND METHODS

This experiment was carried out using a randomized complete block design with 4 replications. The factors studied included 5 levels of water deficit stress that were T₁ (100% field capacity), T₂ (80% field capacity), T₃ (60% field capacity), T₄ (40% field capacity) and T₅ (20% field capacity) respectively. The field was prepared in an 8 m² area (4m × 2 m). In order to determine the soil moisture rate of 100% field capacity, 24 h after irrigation we selected 5 field soil samples by sampling drill, then samples were weighed by electrical scale and placed under 105°C in electrical oven for 48 h. Soil moisture rate of 100% field capacity was determined by the following formula.

$$\theta_w = \frac{\text{Moist soil weight} - \text{Dry soil weight}}{\text{Dry soil weight}}$$

We selected field soil samples for determination of soil moisture rate daily, then determined 80% field capacity, 60% field capacity, 40% field capacity and 20% field capacity respectively. At the end of flowering stage, we selected 100 g flowering shoot from each plot for determination of essential oil % by Clevenger. Finally, essential oil yield determined by the following formula.

Essential oil yield = Essential oil percentage × Flowering shoot yield

At the end of growth stage for determination of some characteristics of balm, we selected 10 plants from each plot and then determined biological yield, stem yield, height of plant, tiller number, leaf yield, stem diameter and internode length. Data were subjected to analysis of variance (ANOVA) using statistical analysis system and followed by Duncan's multiple range tests and terms were considered significant at P < 0.05 by MSTAT-C software.

RESULTS

The results showed that water deficit stress significantly affected biological yield, essential oil yield, essential oil %, leaf yield, height of plant, tiller number, stem diameter, stem yield and internode length in P < 0.01 (Table 1). Highest biological yield (6469 kg/ha), internode length (5.31 cm), leaf yield (3736 kg/ha), height of plant (65.32

cm) and stem yield (2733 kg/ha) were achieved under T₁, highest essential oil yield (12.97 kg/ha) was achieved under T₃ and highest essential oil % (0.3013%) and stem diameter (4.37 mm) were achieved under T₅ (Table 2) (Figures 1, 2 and 3).

DISCUSSION

As it was shown in the results of this study, drought stress had a negative effect on most of the morphological characteristics under study, but in terms of the essential oil %, it was completely different. This shows that in order to resist drought stress, the plant uses different ways. Great reduction in the length and width of the leaf and accordingly reduction in the area of the leaf, reduction in the height of plant and tiller number, all contribute to the reduction of plant's evapotranspiration area and consequently reduction in the produced dry matter is the final result of the reduction in the plant's photosynthesis which in turn, is the result of drought stress. Under drought stress, stomata become blocked or half-blocked and this leads to a decrease in absorbing CO₂ and on the other hand, the plants consume a lot of energy to absorb water, these cause a reduction in producing photosynthetic matters.

Drought stress increased the amount of the %,

Table 2. Means comparison of some characteristics of balm.

Essential oil yield (kg/ha)	Essential oil (%)	Biological yield (kg/ha)	Stem yield (kg/ha)	Leaf yield (kg/ha)	Internode length (cm)	Stem diameter (mm)	Tiller number (n/plant)	Height of plant(cm)	Treatments
6.73 b	0.1041 c	6469 a	2733 a	3736 a	5.31 a	3.25 d	49.26 a	65.32 a	T ₁
7.68 b	0.1274 c	6047 b	2600 b	3447 b	5.17 a	3.45 cd	50.38 a	61.51 ab	T ₂
12.97 a	0.1456 b	5978 b	2537 b	3441 b	3.92 b	3.57 c	48.25 a	58.32 bc	T ₃
8.71 ab	0.2813 ab	3094 c	2014 c	2583 c	3.85 b	4.05 b	48.35 a	54.63 c	T ₄
3.97 c	0.3013 a	2319 d	1068 d	1464 d	3.57 b	4.37 a	40.91 b	45.92 d	T ₅

Means within the same column and factors, followed by the same letter are not significantly difference ($P < 0.05$) using Duncan's multiple range test.

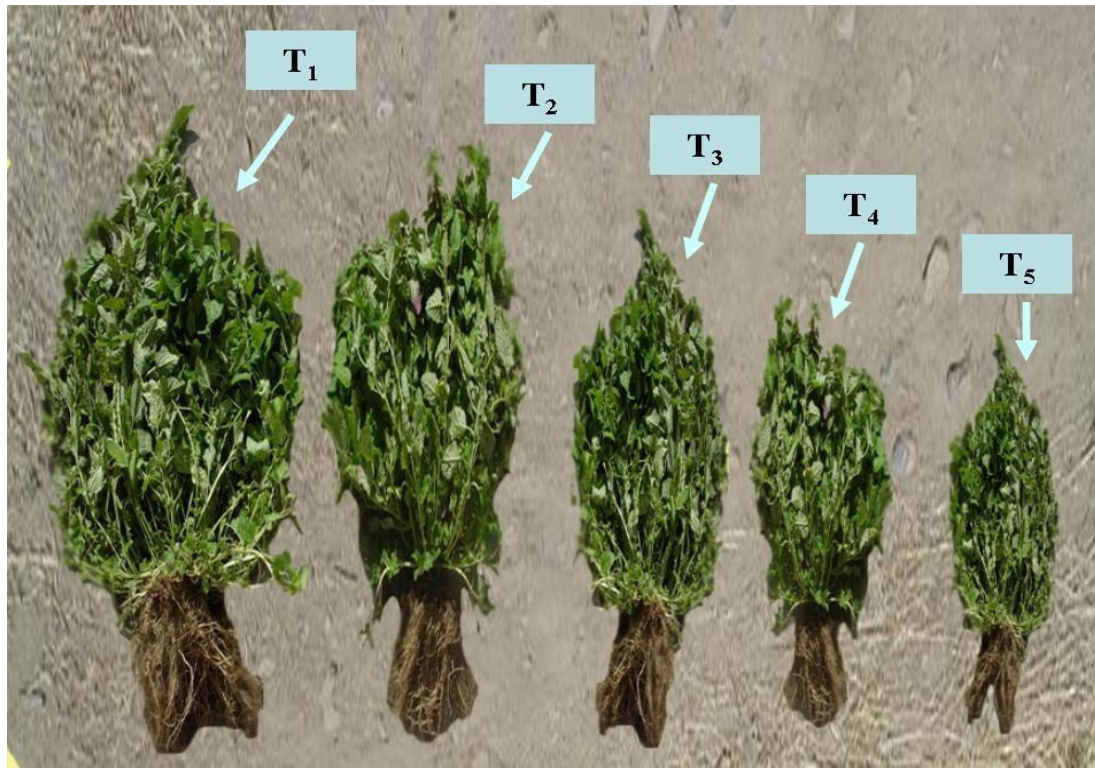


Figure 1. Height of plants under different levels of water deficit stress.

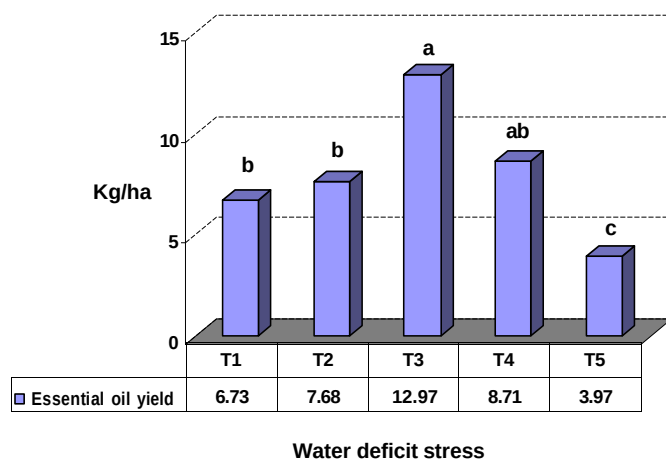


Figure 2. Essential oil yield under different levels of water deficit stress.

essential oil because in case of stress, more metabolites are produced in the plants and substances prevent from oxidization in the cells. It was also seen that as the increase of drought stress, its height of plant, stem diameter and stem yield decreased. Shoot reduction could be due to the reduction in the area of photosynthesis, drop in producing chlorophyll, the rise of the energy consumed by the plant in order to take in water and to increase the density of the protoplasm and to change respiratory paths and the activation of the path of phosphate pentose or the reduction of the root deploy, etc. Examining the amount of essential oil % indicated that with exerting mild drought stress T2 and T3, the amount of essential oil % didn't change so much. But exerting the fairly large drought stress T4 resulted in the great increase of essential oil % and as drought stress T5 became more, it was reduced, but regarding the essential oil percentage, no significant difference was observed between treatments T4 and T5. This fact indicates that exerting mild drought stress T3 and fairly large drought stress T4, is proper to gain more essential oil %, for as drought stress rise, the flowering shoot yield decreased of balm, the interaction between the amount of the essential oil % flowering shoot yield is considered important as 2 components of the essential oil yield. As it can be seen in Table 2, by exerting stress, essential oil yield goes up first and then by the rise in drought stress, the amount of the essential oil drops. Our results were similar to the findings of Aliabadi Farahani et al. (2008b) and Munne-Bosch and Alegre (1999).

Conclusion

The investigation showed that essential oil yield of balm was reduced under water deficit stress. This condition can be the most important environmental factor for the increase of essential oil rate by control of irrigation.

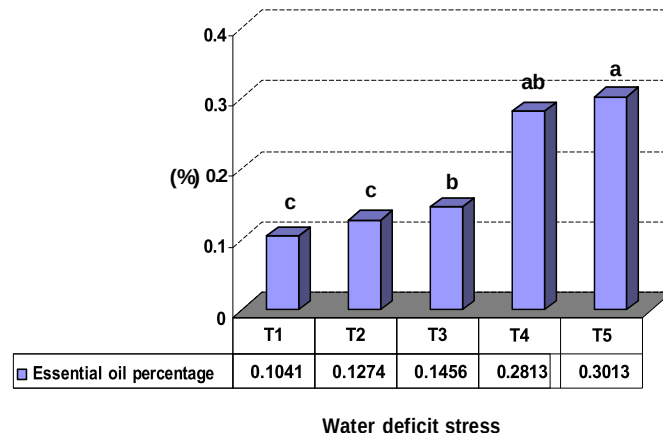


Figure 3. Essential oil percentage under different levels of water deficit stress.

ACKNOWLEDGEMENTS

The authors are indebted to Dr. Sharifi-Ashoorabadi, Dr. Lebaschi and Dr. Sefidkon for providing financial assistance and continuous encouragement to carry out in the investigation.

REFERENCES

- Aliabadi FH, Lebaschi MH, Hamidi A (2008b). Effects of Arbuscular Mycorrhizal Fungi, phosphorus and water stress on quantity and quality characteristics of Coriander. J. Adv iNat Appl. Sci. 2(2): 55-59.
- Aliabadi FH, Lebaschi MH, Shiranirad AH, Valadabadi AR, Daneshian J (2008a). Effects of arbuscular mycorrhizal fungi, different levels of phosphorus and drought stress on water use efficiency, relative water content and proline accumulation rate of Coriander (*Coriandrum sativum* L.). J. Med. Plants Res. 2 (6):125-131.
- Aliabadi FH, Lebaschi MH, Shiranirad AH, Valadabadi AR, Hamidi A, Daneshian J (2008c). Effects of arbuscular mycorrhizal fungi (*Glomus hoi*), different levels of phosphorus and drought stress on physiological growth indices of Coriander (*Coriandrum sativum* L.). Abstracts Book of 5th International Crop Science Congress & Exhibition. p. 231.
- Baher Z, Mirza M, Ghorbanali M, Rezaii MB (2002). The influence of water stress on plant height, herbal and essential oil yield and composition in *Satureja hortensis* L. Flavour Fragrance J. 17(4): 275-277.
- Boyer JS (1982). Plant productivity and environment. Sci. 218: 443-448.
- Fatima S, Farooqi AHA, Sangwan RS (2005). Water stress mediated modulation in essential oil, proline and polypeptide profile in palmarosa and citronella java. Physiol. Mol. Biol. Plants. 11(1): 153-156.
- Kabala-Dzik A, Stojko R, Szaflarska-Stojko E, Wroblewska-Adamek I, Stojko A, Stojko J, Stawiarska-Pieta B (2004). Influence of honey- balm on the rate of scare formation during experimental burn wound healing in PIGS. Bull Vet Inst Pulawy. 48: 311-316.
- Kennedy D, Little OW, Haskell CF, Scholey AB (2006). Anxiolytic effects of combination of *Melissa officinalis* and *Valeriana officinalis* during laboratory induced stress. Phytother Res. 20(2): 96-102.
- Khalid KHA (2006). Influence of water stress on growth, essential oil, and chemical composition of herbs (*Ocimum* sp.). Int. agrophysics. 20(4): 289-296.
- Kramer PJ, Boyer JS (1995). Water Relations of Plants and Soils. Academic press. San Diego, USA. pp 1-495.
- Ludlow MM, Muchow RC (1990). A critical evaluation of the traits for improving crop yield in water limited environments. Adv. Agron. 43:107-153.

- Munne-Bosch S, Alegre L (1999). Role of dew on the recovery of water-stressed *Melissa officinalis* plants. J. Plant Physiol. 154(5): 759-766.
- Neumann PM (1995). The role of cell wall adjustment in plant resistance to water deficits (Review and Interpretation). Crop Sci. 35:1258-1266.
- Wake G, Court J, Pickering A, Lewis R, Wilkins R, Perry E (1999). CNS acetylcholine receptor activity in European medicinal plants traditionally used to improve failing memory. J. Ethnopharmacol. 69(2): 105-114.
- Weiman Z, Alkrinawi S, Golfarb D, Bitran C (1993). Efficacy of herbal tea preparation in infantile colic. The J. Pediatr. 122(4): 650-652.