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Original article

Assessment of morpho-physiological and quantitative and qualitative yield of Peppermint (*Mentha piperita* L.) under different irrigation regimes and application of different nitrogen fertilizer

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Extended abstract

Introduction

Water and nitrogen fertilizer are major determinants of the level of agricultural production in the world, in addition to the quantity and quality of Medicinal plants are also effective. Iran's climate is mainly dry and semi-arid, in such a situation, where abnormal environmental stresses occur for plants. Improving crop yields in these stress conditions require good management of inputs (such as water and nutrients), their amount and type, and knowledge of physiological processes and plant defense mechanisms is essential. Water stress can significantly alter the metabolism of plants and reduce growth and photosynthesis and ultimately yield of plants. In this situation, effective management of water consumption in agriculture is an urgent necessity. In this regard, the use of agronomic techniques such as application of organic fertilizers or enhancement of soil biological conditions may be effective in reducing the effects of water stress and less use of chemical fertilizers for sustainable agriculture and human nutritional health. Also, intensive agriculture with the widespread use of chemical fertilizers, especially nitrogen can cause an increase in costs and environmental pollution. A key component of sustainable agriculture is use of organic fertilizers such as vermicompost and azocompost.

Materials and methods

In order to investigate the effects of water deficit stress and different nitrogen fertilizers on morphological, physiological traits, biological yield and essential oil percentage of peppermint, a experiment was conducted in a factorial arrangement in a randomized complete block de sign with three replications were carried out in 2018 at the field research station of the Agricultural Research Center of Tarbiat Modares University in Karaj (51 10’E, 33 44’ N, 1305.2 m above sea level). Experimental treatments consisted of three irrigation regimes (irrigation up to field capacity and after unloading 25, 40 and 55% water use in root zone, respectively) as the major factor and six fertilizer treatments based on nitrogen requirement respectively (100% chemical fertilizer, no fertilizer, 50% chemical + 50% azocompost, 100% vermicompost, 100% azocompost and 50% chemical fertilizer + 50% vermicompost) were as sub-factors. After field preparations, this area was divided into 54 experimental plots each of which were 2 m long with six rows, 0.2 m apart. Between all the main plots, a 3 m alley

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was kept to eliminate the influence of lateral water movement. Plant to plant distance in each row was 0.2 cm.

Results

Analysis of variance showed that the effect of all the experimental treatments and their interaction on all measured traits was significant. The results showed that mild and severe drought stress decreased plant height (18.2 and 42.92%) and biological yield (15.11 and 51.98%, respectively), while pigment, carotenoid, anthocyanin, proline and essential oil percentage increased. Nitrogen fertilizer application increased all measured traits. In most of the traits measured in this experiment, 50% chemical fertilizer and 50% vermicompost fertilizer were evaluated even better under severe water deficit conditions than other treatments.

Conclusion

The results also showed that if the aim of planting peppermint is to improve the quality (essential oil percentage) of the plant by applying high water deficit stress, it can save more than 50% water consumption by producing the highest essential oil percentage. And vermicompost fertilizer can also be substituted for nitrogen chemical fertilizer to promote safe and sustainable.

Keywords**:** Water deficit stress; Vermicompost; Urea; Azocompost; Essential oil content

Table 1. Physico-chemical properties of the soil of the experimental field and vermicompost and azocompost use in experimental site

	Soil texture	EC	pH	Organic carbon	Total N	C.N	P_{Avail}	K_{Avail}	Fe	Zn
		dS m^{-1}		------------ % ------------			----------------- mg kg^{-1} -----------------			
Soil	Sandy loam	1.43	7.4	1.4	0.14	0.099	27.6	520	8.40	1.14
Vermicompost	-	2.25	7.97	-	1.393	22.304	16450	14650	7445	164
Azocompost	-	3.1	5.7	21.45	1.54	13.93	5700	23700	8920	34.5
Water	-	0.74	8.29	-	-	-	-	-	-	-

Table 2. Analysis of variance for agronomical, morphological and physiological characteristics of peppermint effect of irrigation regime and N fertilizer treatments

S.O.V	df	Height	Chl a	Chl b	Total Chl	Carteniode
Block (B)	2	22.8	1.31	0.0374	0.72	0.0482
Irrigation regime **(I)**	2	398.5**	8.51*	0.5748**	13.35**	1.1799**
B×I	4	10.63	0.48	0.0172	0.052	0.0283
Fertilizer (F)	5	25.05*	3.67**	0.3634**	6.34**	0.2230*
F×I	10	17.62*	2.67**	0.1903**	4.23**	0.1593*
Sub error	10	7.91	0.27	0.0619	0.21	0.0640
C.V. (%)	-	*14.01*	*9.2*	*15.5*	*6.37*	*12.2*

Table 2. Continued

S.O.V	df	Anthocyanin	Proline	Biological yield	Essential oil perecntage
Block (B)	2	0.00044	0.17	254853.1	0.0011
Irrigation regime **(I)**	2	0.0011*	94.06**	5223914.9**	0.5270**
B×I	4	0.00009	0.98	144795	0.0252
Fertilizer (F)	5	0.00071**	33.92**	1105551.4**	0.3499**
F×I	10	0.00024**	11.64**	749458.5**	0.1823**
Sub error	10	0.00007	0.53	48786.98	0.0098
C.V. (%)	-	*12.3*	*10.01*	*11.6*	*4.3*

I: Irrigation regime, F: Fertilizer. * Significant at 5% and 1% probability level, respectively

Table 3. Mean comparison of irrigation regime × nitrogen fertilizer interaction on for agronomical, morphological and physiological characteristics of peppermint

Irrigatio	Fertilizer	Height	Chl a	Chl b	Total Chl	Car
		cm	--------------------------------mg/g f.w--------------------------			
I_1	F_1	24.66^{abc}	4.070^{fg}	1.195^{gf}	5.26^{gh}	1.715^{ef}
	F_2	21.60^{b-f}	5.923^{cd}	1.58^{b-f}	7.50^{d}	1.940^{cde}
	F_3	25.66^{ab}	4.776^{ef}	1.379^{efg}	6.15^{ef}	1.812^{def}
	F_4	27.66^{a}	5.223^{de}	1.494^{def}	6.71^{e}	1.882^{de}
	F_5	22.66^{bcd}	3.756^{g}	1.028^{g}	4.78^{h}	1.424^{f}
	F_6	28.60^{a}	6.586^{abc}	1.858^{a-d}	8.44^{bc}	2.117^{a-e}
I_2	F_1	19.66^{d-h}	6.643^{abc}	1.910^{abc}	8.55^{abc}	2.319^{abc}
	F_2	17.66^{e-i}	4.773^{ef}	1.512^{c-f}	6.28^{ef}	1.910^{cde}
	F_3	21.66^{b-f}	4.69^{ef}	1.300^{efg}	5.99^{efg}	1.905^{cde}
	F_4	18.33^{d-i}	5.03^{e}	1.410^{efg}	6.44^{e}	1.974^{b-e}
	F_5	22.00^{b-e}	5.00^{e}	1.454^{def}	6.45^{e}	1.816^{def}
	F_6	15.66^{g-j}	6.41^{abc}	2.020^{a}	8.43b^{c}	2.524^{a}
I_3	F_1	16.33^{g-j}	6.61^{abc}	1.842^{a-d}	8.45^{bc}	2.200^{a-d}
	F_2	12.33^{j}	4.363^{efg}	1.258^{gf}	5.62^{fg}	1.951^{cde}
	F_3	17.00^{f-j}	6.95^{ab}	1.947^{ab}	8.89^{ab}	2.388^{ab}
	F_4	20.00^{c-g}	6.816^{ab}	1.925^{abc}	8.74^{abc}	2.506^{a}
	F_5	14.66^{ij}	6.33b^{c}	1.699^{a-e}	8.02^{dc}	2.511^{a}
	F_6	15.00^{hij}	7.25^{a}	2.007^{a}	9.26^{a}	2.407^{a}

Table 3. Continued

Irrigatio	Fertilizer	Anth	Pro	Bio. yield	Essen. Oil
		------------- µmol/gf.w------------		$kg.ha^{-1}$	%
I_1	F_1	0.060^{de}	5.820^{i}	3158.33^{a}	2.346^{def}
	F_2	0.060^{de}	2.413^{k}	2316.70^{cde}	2.046^{ghi}
	F_3	0.073^{bcd}	7.560^{cde}	2641.70^{bc}	2.246^{f}
	F_4	0.053^{e}	6.073^{ghi}	2841.66^{ab}	2.293^{ef}
	F_5	0.066^{cde}	$6.190^{f\text{-}i}$	2108.33^{de}	2.206^{fg}
	F_6	0.076^{bc}	4.550^{j}	2016.70^{de}	1.913^{ij}
I_2	F_1	0.053^{e}	5.896^{hi}	2033.33^{de}	2.193^{fgh}
	F_2	0.060^{de}	5.670^{ij}	1966.66^{e}	2.030^{hi}
	F_3	0.060^{de}	8.263^{cd}	1095.83^{g}	2.533^{bc}
	F_4	0.073^{bcd}	6.023^{ghi}	2158.33^{de}	2.346^{def}
	F_5	0.073^{bcd}	$6.600^{e\text{-}i}$	2341.66^{cd}	1.853^{j}
	F_6	0.083^{ab}	$7.166^{d\text{-}g}$	1116.60^{g}	2.666^{b}
I_3	F_1	0.073^{bcd}	$7.073^{d\text{-}h}$	979.20^{g}	2.883^{a}
	F_2	0.073^{bcd}	$6.633^{e\text{-}i}$	1112.50^{g}	2.043^{ghi}
	F_3	0.096^{a}	15.373^{a}	1595.83^{f}	2.426^{cde}
	F_4	0.073^{bcd}	$7.403^{c\text{-}f}$	2375.00^{cd}	2.91^{a}
	F_5	0.063^{cde}	8.44^{6c}	1166.66^{g}	2.270^{ef}
	F_6	0.096^{a}	14.150^{b}	1060.40^{g}	2.506^{bcd}

I1, I2 and I3: Irrigation after depleting (25, 40 and 55%) ASW, respectively. F1, F2, F3, F4, F5, F6: 100% Chemical, No fertilizer, 50% Chemical + 50% Azocompost, 100% Vermicompost, 100% Azocompost,
50% Chemical + 50% Vermicompost, respectively.
Means in each column followed by similar letter (s) are not significantly different at 5% probability level using LSD Test.