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The effect of phosphorus fertilizer changes on *Thymus vulgaris L.* yield and essence in different irrigation levels

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Abstract

Thyme essence is rich in phenol compounds with antifungal and antibacterial properties and it is also used as flavoring in the food industry. Periodic irrigation and fertilization are important factors that influence on the quantity and quality for aromatic plants. In this study, qualitative and quantitative changes in the essence of thymus have been studied under different levels of irrigation and phosphorus level. This experiment was conducted in agricultural year of 2011-2012 in research farm in Saveh Islamic Azad university as randomly complete blocks design as factorial in four duplications and two phosphorous factors (in four levels of 150,200,250 and 300 kg/ha) and irrigation period (at four levels 5, 10, 15 and 20 days). The traits were analyzed and all traits decreased with increasing irrigation considerably. Irrigation level of 5 days produced highest fresh and dry substance yield, essence and thyme and highest essence percentage in irrigation level of three while phosphorus had significant effect on dry and caroacrol yield in level three.

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Introduction

Thyme (*Thymus vulgaris* L.) is fragrant and perennial plant from the family Lamiaceae (Lamiaceae). Phenolic essence of thyme is in rank of 10 major essences with antibacterial, antifungal, antioxidant and food preservative and mammalian aging delaying properties (Letchamo *et al*, 1995).Thyme has gained important position in world trading expansion resulted from increase tendency toward cultivating of this plant and also consumption of natural by products (Bagaliyan Kambiz *et al*, 2000).

An appropriate management plan in cultivating could play an important role in competition among the farmers. Since thyme produces good yield in temperate and Mediterranean climate so it can be considered as an industrial agricultural product in Iran with surplus income. Although the growth, quality and quantity of dry ingredients such as herbs and essence biosynthesis are controlled primarily by genetic coding processes but environmental factors also have an important role in this regard. What is important is that thyme oil can be grown in different areas with different color, flavor, viscosity and chemical composition (Morton *et al*, 1977) and of course, irrigation different periods have a significant effect on the yield and composition of the oil(Shariyati and Gazi Shahani zadeh,1997,Shahidi and Frozan,1997).The agronomic factors also impact on the yield and quality of thyme (irrigation period is the main factor) and essence yield and dry matter per unit area(Shafiq Malik *et al*, 1987). Fertilizer need level depends on history of previous crops and soil nutrient on the farm.

Some fertilizers contain only the macronutrients or micronutrients. Others include both categories. Relationship between micronutrients and macronutrients in plant growth environment will not only increase productivity, but also increase their resistance to pests and diseases. Phosphate fertilizers are the main food supplier for growth and development of plants. Phosphorus is required in all periods of plant growth. The main effect of phosphorus fertilizers is on shoot induction, shoot regeneration and plant germination and generally vegetative growth speeds. Research has shown that phosphorus deficiency reduces plant growth. If the deficiency is severe the plant will stop growing. In the case of phosphorus deficiency, the lower leaves of the plant, lime or orange to be burned and they gradually dry and the color is changed to light brown (Omidbeigi, 2005). Phosphorus is main component of protein, so it is needed to grow of plants. Phosphorus is a nutrient that its deficiency is seen in the arid and semiarid regions. For this reason, the organic matter as the major source of phosphorus is negligible in these areas (Malekuti, 1988). Soil substances are also important factors for medicinal plants.

Among the factors related to soil, nutrients play more important role, since these factors can be changed easily and they lead to significant changes in the quantity and quality of the medicinal plants. According to development of extraction and measurement techniques of effective substances numerous researches have been carried out on the effect of external factors, water and fertilizer levels on production of organs used in medicinal plants and secondary metabolites. The quality of the ingredients of medicinal plants can be compared to other plant organs and the amount of heavy metals such as cadmium, lead, zinc and other elements (Omidbeigi, 2005). The research on valerian shows that medium amount of phosphorus increases essence in the root and in this case, vegetative growth of the plant is also desirable. Although considerable amount of phosphorus increases vegetative and root growth but it does not affect on essence level (Omidbeigi, 2005).Overall response to phosphorus depends on the soil conditions, plant species and amount of food (Omidbeigi, 2005). The experiments carried out on the response of thyme to different phosphorus level show that plant biomass responds to all phosphorous amounts but this respond does not increase seed. Due to less utilization of nutrients in the seed the limited use of fertilizers and nutrient uptake of inorganic or organic is enough (Shalz, 1998). However, to achieve higher qualitative and quantitative yield it should be

attempted to conduct research in each area. In this regard, this experiment was conducted for measure the qualitative and quantitative changes of thyme dry matter and essence in different irrigation intervals and changes in the amount of P fertilizer.

Materials and methods

Material

this research was carried out with two factors: phosphorus fertilizers (at levels 150, 200, 250 and 300 kg per ha) and irrigation (at levels 5, 10, 15 and 20 days).

Method

The research was conducted as split-plot experiment in randomized complete block design with 4 replications. The length of each plot was five meters contains five rows spacing 15 cm and the distance between was 2 meters in order to construct irrigation brooks and sewage. The plants were transferred into the shadow after harvest and their weight were measured and they were distributed in order to dry. In order to uniformity of drying, the position of the plants was changed at the appropriate time .Samples were transported to the laboratory after drying to determine the water content and essence. For extraction of thyme, 100 grams of dried leaf powder was weighed exactly by water distillation and essence was extracted and measured. The moisture content of the samples was measured with Dean Stark system. Thyme and caroacrol content of the samples was measured using the GC with Area Normalization apparatus method. The data were analyzed by software SAS and the graphs were drawn by EXCEL and the data were typed by Word and DUNCAN test was employed for comparison of mean in confidence level of %1 and 5.

Results

the phosphorus level had significant effect on leaf fresh and dry weight and also caroacrol yield and fresh and dry yield but its effect was not statistically significant on number of plants, length and number of lateral stem, fresh and dry weight of stem, essence percentage , essence yield thyme and caroacrol percentage (Table 1). Given that P has no active role in vegetative growth the above result seems reasonable. It is obvious that P has no role in germination. Also in different periods of irrigation with less moisture plants growth was increased (Table 2). The comparison of plant height, stem dry weight and essence and thymol percentage and different levels of phosphorus intake were not significantly different (Table 2). However, the different irrigation caused significant differences in the most measured parameters. The different periods of irrigation did not significantly impact on plant height and shoot dry weight but its impact on other measured parameters was statistically significant (Table 1). Five days irrigation level produced the highest number of lateral stems and leaf dry weight, thyme and essence (table 2)Although the highest lateral stem, leaf dry weight was obtained during the 10 day irrigation but there were not statistically significant difference (Table 2). The interaction between phosphorus intake and different irrigation levels on number of lateral stems and dry weight of stems and caroacrol yield was significant but its effect on other measured parameters was not significant (Table 1).

Table 1 a. Analysis of variance of the studied traits.

S.O.V	df	Number of plants	length	Lateral stem	Fresh stem weight	Dry stem weight	Leaf fresh weight	Leaf dry weight	Fresh yield
Duplication	3	310.39 ns	65.61 ns	2.71 ns	0.07 ns	0.008 ns	0.02 ns	0.004 ns	0.14 ns
Irrigation	3	140.42 ns	73.59 ns	19.4 **	0.71 **	0.05 ns	2.66 **	0.54 **	6.1 **
p	3	5.38 ns	3.29 ns	4.48 ns	0.47 ns	0.03 ns	0.39 **	0.08 **	1.65 **
p×Irrigation	9	10.91 ns	1.71 ns	18.47 **	0.001 **	0.001 ns	0.02 ns	0.005 ns	0.02 ns
Error	45	311.48	65.5	0.85	0.009	0.01	0.04	0.008	0.05
cv	-	18.69	13.28	15.07	4.3	19.67	13.3	13.3	6.04

Table 1 b. Analysis of variance of the studied traits.

S.O.V	df	Dry yield	Essence (%)	Essence yield	Thymol (%)	Thymol yield	Caroacroal (%)	Caroacrol yield
Duplication	3	0.008 ns	0.15 ns	0.37 ns	51.88 ns	1.008 ns	0.0004 ns	0.00001 ns
Irrigation	3	0.94 **	0.65 **	7.48 **	256.45 **	31.68 **	0.024 **	0.0028 **
p	3	0.2 **	0.01 ns	1.06 ns	41.1 ns	4.57 ns	0.001 ns	0.0003 **
p×Irrigation	9	0.07 ns	0.02 ns	0.06 ns	2.21 ns	0.27 ns	0.006 **	0.0001 **
Duplication	45	0.02	0.03	0.14	13.26	0.73	0.0002	0.00002
cv	-	10.97	9.47	14.65	10.13	17.35	4.81	11.2

Table 2 a. Mean comparison of the interaction of irrigation and phosphorus level effect of measured traits.

Irrigation	p	Number of plant	Length	Lateral stem	Stem fresh weight	Stem dry weight	Leaf fresh weight	Leaf dry weight	Fresh yield
5	150	95.04ab	64.08 a	3.27 d	2.37 ab	0.68 ab	1.90 b	0.85 ab	4.27 b
5	200	96.05 a	62.91 ab	4.36 c	2.37 ab	0.68 ab	1.80 b	0.81 ab	4.87 a
5	250	96.82 a	62.91 ab	4.36 c	2.56 a	0.74 a	2.19 a	0.98 a	4.75 a
5	300	97.06 a	64.54 a	6.54 b	2.76 a	0.79 a	2.15 a	0.97 a	4.92 a
10	150	94.53 ab	60.99 b	6.98 b	2.25 b	0.65 ab	1.43 bc	0.64 c	3.68 c
10	200	96.31 a	61.48 b	6.10 bc	2.25 b	0.65 ab	1.36 c	0.61 c	3.61 c
10	250	96.83 a	62.64 ab	7.63 ab	2.43 a	0.70 a	1.86 b	0.84 ab	4.30 b
10	300	96.05 a	61.68 b	3.27 d	1.62 ab	0.75 a	1.66 bc	0.75 b	4.29 b
15	150	94.24 ab	58.56 c	7.63 ab	2.11 bc	0.61 b	1.34 c	0.60 c	3.46 c
15	200	95.53 ab	59.46 c	7.63 ab	2.11 bc	0.62 b	1.28 c	0.57 c	3.39 c
15	250	96.07 a	58.77 c	4.36 c	2.29 b	0.61 b	1.45 bc	0.65 c	3.74 c
15	300	97.06 a	60.14 ab	7.63 ab	2.46 a	0.71 a	1.56 bc	0.70 b	4.03 b
20	150	91.23 b	59.14 c	5.45 c	1.90 c	0.55 c	0.96 d	0.43 d	2.86 d
20	200	93.02 b	58.92 c	4.36 c	1.90 c	0.55 c	0.91 d	0.41 d	2.81 d
20	250	87.96 c	58.50 c	8.72 ab	2.06 c	0.59 bc	1.06 cd	0.47 cd	3.12 c
20	300	87.97 c	60.05 b	9.81 a	22.2 b	0.64 ab	1.18 cd	0.53 c	3.41 c

Table 2 b. Mean comparison of the interaction of irrigation and phosphorus level effect of measured traits.

irrigation	p	Dry yield	Essence (%)	Essence yield	Thymol (%)	Thymol yield	Caroacroal (%)	Caroacrol yield
5	150	1.54 b	1.95 bc	3.03 ab	4.21 ab	5.88 b	0.44 a	0.068 a
5	200	1.49 b	2.04 a	3.06 ab	4.44 a	6.06 b	0.41 a	0.061 a
5	250	1.72 a	2.06 a	3.57 a	4.60 a	7.28 a	0.40 ab	0.069 a
5	300	1.77 a	2.09 a	3.71 a	4.53 a	7.33 a	0.31 a	0.057 b
10	300	1.51 b	1.98 c	3.008 ab	4.19 ab	5.76 bc	0.40 ab	0.06 ab
15	150	1.21 c	1.92 c	2.34 cd	3.60 b	3.99 cd	0.29 c	0.036 c
15	200	1.25 c	2.02 b	2.50 cd	3.69 b	4.30 c	0.30 c	0.038 c
15	250	1.31 bc	2.16 ab	2.58 c	3.76 b	4.51 c	0.33 b	0.044 b
15	300	1.42 b	2.10 ab	2.97 c	3.77 b	4.90 c	0.36 b	0.051 b
20	150	0.98 d	1.73 d	1.69 d	3.34 c	2.99 d	0.27 d	0.027 c
20	200	0.96 d	1.57 d	1.51 d	3.37 c	2.96 d	0.30 c	0.029 c
20	250	1.07 cd	1.59 d	1.71 d	3.43 c	3.35 c	0.32 bc	0.034 c
20	300	1.17 a	1.62 d	1.90 c	3.67 b	3.95 bc	0.33 b	0.039 c

Discussion

According to this fact that the highest yield per plant and essence, thyme and caroacrol yield were obtained in two amounts of the 250 and 300 kg, so it can be

concluded that the most appropriate level of phosphorus fertilizer is 250 kg which is economical and environmental pollution is also reduced. The results of this study indicate that different levels of phosphorus supply and irrigation have a significant effect on yield and quality of thyme essence. As you can see in the table 2, the maximum fresh and dry weight in unit area was obtained in irrigation level one that it produced highest essence, thyme and caroacrol yield. The reason is that irrigation is done under different climates and the length irrigation affects on plant growth .Irrigation periods play an important role in change and production of effective substances. By emphasis on external factors (rainfall) it can be considered as a determining factor in the production of active ingredient in the plant (Shariati and Gazi Shhani zadeh, 1997 and Shahidi and Frozan,1997). According to temperature of the early flowering, irrigation period is also important and it has been reported to reduce yield by delay in irrigation in most studies(Mehra ,1986 and Raul ,1989) .The delay in irrigation period reduces the number of established plants. The effect of irrigation periods on quantitative and qualitative yields of fennel cultivar Shorak Shari influences on the growth and also quantity and quality of fennel effective substances (Omidbeigi *et al* ,2005). The maximum quantitative and qualitative yield of essence obtained in irrigation of 5 days. According to the results it can be concluded that phosphorus level and irrigation short period influence significantly on thyme essence quantitative and qualitative yield and they increase thyme essence quantitative and qualitative yield

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