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Effect of Organic Fertilizer Containing Mint and Thyme Oil Extract on Tomato Seedling Growing

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ABSTRACT
Success in vegetable cultivation begins with using plant materials that growth healthy and strong. Seedling growth and development has an important role in greenhouse vegetable production. In the present study, effects of organic fertilizer were obtained from mint and thyme oil extract on tomato seedlings were investigated. Local Çanak tomato cultivar, which is provided from Nevşehir region, and Toprak F_1 cultivar, was used in the study. Organic and commercially fertilizer applications were held on both species and root length (cm), shoot length (cm), stem diameter (mm), root fresh weight (g), shoot fresh weight (g), leaf width (cm), leaf length (cm), dry matter content (%), moisture content (%), nutritional value and chlorophyll index values of the seedlings were determined. Results show that organic fertilizer dosage was high and seedlings' growth and development was affected negatively. On the other hand, the dry matter content and some plant nutrient values of the seedlings in organic fertilizer applications were higher than commercial fertilizers. Therefore the organic fertilizer is promising for organic seedling production. It is resulted that, application dosage experiments should be conducted to use organic fertilizer in an effective way.
Keywords - Mint, organic fertilizer, thyme, tomato, seedling

I. INTRODUCTION

Organic agriculture is a sustainable production for human health and environment protecting. Use of synthetic chemicals in agriculture has increased and spread since the "Green Revolution" took place in agriculture since 1970's. Thus, environmental pollution and disorders in human health have taken place since. Organic agriculture has been considered as a solution for these problems and reached at a commercial level, as a result of consumers' spreading demand [1]. Techniques such as crop alternation, green fertilizer, compost application and biological contention have been used in organic agriculture method to control the pests and sustain soil fertility [2]. Tomatoes (*Lycopersicon esculentum* L.), which play an important role in human consumption, is a vitamin and mineral rich vegetable [3]. According to results from some studies, it is known that tomatoes are considered to be the most consumed organic food [4]. In recent years, tomatoes' share of market continuously increases as a result of being produced in green houses and fields in both our country and worldwide. Examining the data of tomatoes' production, it is seen that, tomatoes are cultivated as 163.434 millions of tons worldwide [5] and 12.615 millions of tons in Turkey. 3.399.100 tons of this total production is held as greenhouse cultivation [6]. Seedlings are used 100% in greenhouse cultivation. But, the rate is reported as 55% in field cultivation. 2.486.030.382 seedlings are produced in Turkey in 2014. Among the species to be produced as seedlings, tomatoes are on the top with a 51% (602.547.244 seedlings) share [7, 8].

An important point on tomatoes cultivation is healthy seedling cultivation and efficient-balanced fertilization [9].

Synthetic chemicals are used for fertilization period and 82 kg/da fertilizer is reported to be used in average. Use of synthetic chemical fertilizer, especially in Mediterranean and Aegean regions [10], leads to various human health and environmental problems. Extracts obtained from aromatic plants and various organic fertilizers are reported to be considered as an alternative for synthetic chemicals [11, 12]. However, there are not many studies on medical plants and aromatic plants having the potential to be used as organic fertilizer [13].

In the study, effects of mint-thymus extract in seedling cultivation which has an important place in organic agriculture, on seedlings development and nutrient uptake.

II. MATERIAL AND METHOD

The study was conducted in Akdeniz University Technical Sciences Vocational School's research and application green house, in 2014-2015. In the experiment, 'Toprak F_1' (Gento) seeds and seeds of a local tomatoes cultivar named "Çanak" collected

from Nevşehir city. The design was a 2 × 2 factorial experiment in a randomized complete block design with two cultivars, 'Çanak' and 'Toprak F_1'. There were three replications of two fertilizer treatments and tomato cultivars.

In this study, the organic fertilizer materials were obtained from mint and thymus plants. These plants' essential oils are obtained by being hydro-distillated in Clevenger apparatus. Materials belong to grinded plants have been extracted for 3 hours (v w-1%). Essential oils were preserved in +4 ºC until the analysis [14]. Max foli is a commercial fertilizer and (powder form) used in conventional parcels. In the trial, 250ml/l dosage of the organic fertilizer was used on the plants for 3 times by spraying on the leaves for 15 days periods. For the conventional parcels, Max foli (20-20-20+ME) fertilizer application was held on the plant as 15 g in 15 lt water, as spraying on the leaves for 3 times at 15 days period just as for herbal extract.

At the end of the trial, measurements and observation was held to measure root and stem length, stem width, root and stem fresh weight, leaf width and length and finally chlorophyll index. As an addition, dry matter (%), moisture content (%) and finally, macro and micro nutrient element measurements were held to specify the effects of fertilizers and seedlings on nutrient intake.

Data analyzes were performed using SAS 9.1. Mean values of application were compared with LSD and Duncan test after variance analysis. Differences between means at 5% ($P < 0.05$) level were considered significant.

III. RESULTS AND DISCUSSIONS

Table 1. , Macro and micro elements efficiency border levels for tomatoes seedlings [15].

N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)
3.50-5.00	0.30-0.65	3.50-4.50	1.00-3.00	0.35-1.00	50-300	25-200	18-80

Macro and micro nutrient element analysis were held on seedlings to define the effectiveness of organic and chemical fertilizers, obtained from mint and thymus extracts and efficiency frontier values by Campbell [15] in Table 1 were used as reference for result analysis.

Table 2. Effect on N amount of cultivars and fertilizer types

Cultivar	Fertilizer type		Cultivar Mean
	Conventional	Organic	
Toprak F_1	5.06 A	2.56 B	3.81
Çanak	5.22 A	2.52 B	3.87
Fertilizer type Mean	5.14 a	2.54 b	
$LSD_{\%5}$Cultivar: N.S. LSD%5CultivarxFertilizer type: 0.238 $LSD_{\%5}$Fertilizer type: 0.1683			

N.S.: Not significant

N content amount of 'Toprak F_1' and 'Çanak' tomatoes cultivar was given in Table 2. As seen in Table 2, N contents of cultivars x fertilization interaction and fertilatiazer type were statistically significant. Beside, between the averages of cultivars were not determined an important differences.

N content was not considered statistically significant. Maximum N content in terms of cultivar x fertilizer type was found in 'Toprak F_1' and 'Çanak' cultivars conventional fertilizer type and the minimum N content was found in the same cultivars' organic fertilizer type. Maximum N content according to cultivar x fertilizer type interaction was found in conventional fertilizer type as 5.14% and minimum N content according to fertilizer type was found in organic fertilizer type as 2.54%.

Examining effects of fertilizer type on N content, there was not seen any significant difference and N content ranged between 3.81% and 3.87%. N content of organic seedlings were found inefficient.

Table 3. Effect on P amount of cultivars and fertilizer types

Cultivar	Fertilizer type		Cultivar Mean
	Conventional	Organic	
Toprak F_1	0.81A	0.34C	0.58a
Çanak	0.48B	0.20D	0.34b
Fertilizer type Mean	0.64a	0.27b	
$LSD_{\%5}$Cultivar:0.0329 $LSD_{\%5}$CultivarxFertilizer type: 0.0465 $LSD_{\%}$5Fertilizer type: 0.0329			

P content of seedlings was given in Table 3. P content was found statistically significant in terms of both cultivar and fertilizer type. Maximum P content in terms of cultivar x fertilizer type interaction was found in 'Toprak F_1' cultivar, being applied

chemical fertilizer, as 0.81% and was found minimum in 'Çanak' cultivar being applied organic fertilizer, as 0.20%. As same as N content results, P content of organic seedlings was found between frontier efficiency levels.

Table 4. Effect on K amount of cultivars and fertilizer types

Cultivar	Fertilizer type		Cultivar Mean
	Conventional	Organic	
Toprak F_1	4.16B	4.38A	4.27a
Çanak	4.31A	3.98C	4.15b
Fertilizer type Mean	4.23	4.18	
$LSD_{\%5}$Cultivar: 0.1021 $LSD_{\%5}$CultivarxFertilizer type: 0.1444 $LSD_{\%5}$Fertilizer type: N.S.			

K amount of seedlings were applied organic and chemical application was given in Table 4. K content was not considered statistically significant in terms of fertilizer type. Maximum K content in terms of cultivar x fertilizer type interaction was obtained from 'Toprak F_1' cultivar in organic fertilizer application and all values were ranged in between efficiency levels.

Table 5. Effect on Ca amount of cultivars and fertilizer types

Cultivar	Fertilizer type		Cultivar Mean
	Conventional	Organic	
Toprak F_1	2.73A	1.71C	2.22b
Çanak	2.69A	2.30B	2.50a
Fertilizer type Mean	2.71a	2.01b	
$LSD_{\%5}$Cultivar: 0.0995 $LSD_{\%5}$CultivarxFertilizer type: 0.1407 $LSD_{\%5}$Fertilizer type: 0.0995			

Ca amount of seedlings were treated organic and chemical fertilizer was given in Table 5. Ca content was considered statistically significant in terms of fertilizer type and cultivar. Maximum Ca content in terms of cultivar x fertilizer type interaction was obtained from 'Toprak F_1' (2.73%) cultivar was fertilized with chemical fertilizer. All values were determined between efficiency levels.

Table 6. Effect on Mg amount of cultivars and fertilizer types

Cultivar	Fertilizer type		Cultivar Mean
	Conventional	Organic	
Toprak F_1	0.55A	0.34B	0.44b
Çanak	0.59A	0.55A	0.57a
Fertilizer type Mean	0.57a	0.44b	
$LSD_{\%5}$Cultivar:0.0343 $LSD_{\%5}$CultivarxFertilizer type:0.0485 $LSD_{\%}$5Fertilizer type: 0.0343			

Mg content of 'Toprak F_1' and 'Çanak' cultivars was given in Table 6. As seen in Table 6, Mg content was statistically affected by cultivar x fertilizer type interaction, fertilizer type and cultivar. Maximum Mg content in terms of cultivar x fertilizer type interaction was found in 'Çanak' cultivar (0.55%) of organic fertilizer type and 'Toprak F_1'cultivar of conventional fertilizer type. In the assessment, only the 'Toprak F_1' cultivar's Mg content was found a little less under efficiency level.

In contrast to the results obtained, Demir et. al., [16] have reported that the mineral content of tomatoes grown in open field was found to be higher in organic applications than in conventional applications. In this study, macro nutrient element content of seedlings in organic fertilizer application was found to be lower than the seedlings in conventional fertilizer applications. However, results show that, K, Ca, and Mg content of seedlings in organic fertilizer application is between the efficiency levels. Thus, it can be said that parcels, on which organic fertilizer was applied, are inefficient in terms of N and P. Scheffer et. al., [17]) have reported that organic fertilizer application increases the amount of P in the soil and yet, does not affect C, K, Mg and Ca amounts. These studies show that the differences in the contents of fertilizers have a direct link to the nutrient element uptake of the plants.

Table 7. Effect on Fe amount of cultivars and fertilizer types

Cultivar	Fertilizer type		Cultivar Mean
	Conventional	Organic	
Toprak F_1	202.33D	289.25 A	245.79a
Çanak	232.42B	212.83 C	222.63 b
Fertilizer type Mean	217.38b	251.04 a	
$LSD_{\%5}$Cultivar:5.3618 $LSD_{\%5}$CultivarxFertilizer type:7.5827 $LSD_{\%5}$Fertilizer type:5.3618			

Table 8. Effect on Zn amount of cultivars and fertilizer types

Cultivar	Fertilizer type		Cultivar Mean
	Conventional	Organic	
Toprak F_1	51.25A	37.58B	44.42a
Çanak	34.83C	38.00B	36.42b
Fertilizer type Mean	43.04a	37.79b	
$LSD_{\%5}$ Cultivar: 0.891 $LSD_{\%5}$ CultivarxFertilizer type: 1.2601 $LSD_{\%5}$Fertilizer type: 0.891			

Table 9. Effect on Mn amount of cultivars and fertilizer types

Cultivar	Fertilizer type		Cultivar Mean
	Conventional	Organic	
Toprak F_1	28.75C	41.75A	35.25b
Çanak	38.08B	41.83A	39.96a
Fertilizer type Mean	33.42b	41.79a	
$LSD_{\%5}$Cultivar: 1.0349 $LSD_{\%5}$CultivarxFertilizer type: 1.4635 $LSD_{\%5}$Fertilizer type: 1.0349			

The results of plant micro nutrient element analysis were given in Tables 7, 8 and 9. Examining the values in the Tables, Fn, Zn and Mn content of seedlings are at efficiency levels. Demir et. al., [16], in the study they examine the effect of multiple fertilizer combinations and N,P,K fertilizer on tomatoes' mineral matter content, reported that, there are not any significant differences between application in terms of Fn, Zn and Mn content. Demirtaş et. al., [18], have reported that the combined use of humic acid and NPK fertilizer have increased the macro and micro nutrient element content of tomatoes. In the study, any supportive matter was not added into the fertilizer. This reveals that, the herbal extract used in the study is efficient in terms of analyzed nutrient elements.

Table 10. Average moisture % and dry matter % of root and stem lengths of tomatoes seedlings in organic and chemical fertilizer applications

	Shoot		Root	
	% Moisture	% Dry matter	% Moisture	% Dry matter
Conventional Toprak F_1	90	10	89	11
Conventional Çanak	91	9	87	13
Organic Toprak F_1	86	14	75	25
Organic Çanak	88	12	83	17

Average moisture % and dry matter % of root and shoot of tomatoes seedlings in organic and chemical fertilizer applications were given in Table 10. Examining the data of the study, average moisture % and dry matter % content of seedlings obtained from conventional parcels in chemical fertilizer application is higher than data obtained from organic fertilizer application. Cultivars' average moisture % values are found close to each other. This result reveals that the difference is occurred from applications. On the other hand, examining the roots' and shoots' dry matter % content it is seen that the values obtained from seedlings in organic fertilizer application are higher. Additionally, average dry matter content % of Toprak F_1 cultivars' shoots in conventional fertilizer application is higher than Çanak tomatoes cultivar, however, Toprak F_1 cultivar's content in organic fertilizer application was found higher. Examining the roots' dry matter content % according to cultivars, it is seen that Çanak cultivar is superior in conventional fertilizer application and Toprak F_1 cultivar is superior in organic fertilizer application. Consequently, it is seen that average dry matter content % is highly affected by applications, just as in moisture content %.

Table 11. Growth of tomato seedling cultivars in organic and conventional fertilizers

	Root length	Shoot length	Root fresh weight	Shoot fresh weight	Stem diameter
Conventional Toprak F_1	128.72 a	92.09 a	0.150 a	0.569 a	2.00 b
Conventional Çanak	89.39 b	95.32 a	0.146 a	0.595 a	2.22 a
Organic Toprak F_1	35.10 c	49.15 c	0.010 b	0.063 c	1.22 d
Organic Çanak	82.76 b	67.41 b	0.035 b	0.138 b	1.46 c

Effects of fertilizer application on tomatoes seedlings' root and shoot length, root and shoot fresh weight, stem diameter were given in Table 11. Examining the root length data in Table 11, it is seen that, Toprak F_1 cultivar in conventional fertilizer application statistically have the highest values of root length; Çanak cultivar's root length values in conventional and organic fertilizer application take place in the same group and the lowest values were obtained from Toprak F_1 cultivar in organic fertilizer application. Both cultivars' conventional applications have higher values than organic fertilizer applications and they take place in the same group, in terms of shoot length and fresh weight.

Çanak cultivar has statistically higher values than Toprak F_1 cultivar in organic applications. Chalkos et. al., [19] have reported that, through use of M. spicata L. as an organic fertilizer for tomatoes, the material's effect on shoot length reveals on 40th and 60th days. Conventional applications' values were found to be higher than organic applications in terms of root fresh weight. The highest stem diameter value was found in Çanak cultivar in conventional application and the lowest value was found in Toprak F_1 cultivar in organic application. Demirkıran et. al., [20] have reported that, tomatoes growth and development criteria has higher values in leonardit and inorganic fertilizer application; leonardit application can catch up with 20-20-0 fertilizer type and leonardit application plays a greater role in root development. Similarly, Karanatsidis and Berova [21], in their study, applying organic fertilizer on pepper plants, have had positive results. In this study, seedling development results obtained from organic fertilizer application are thought to be a result of inefficient uptake of N and P.

Table 12. Leaf width, height and leaf chlorophyll index of tomato seedling cultivars in organic and conventional fertilizers

	Leaf width	**Leaf length**	**Chlorophyl index**
Conventional Toprak F_1	10.59 a	18.17 a	116.30 b
Conventional Çanak	8.38 b	18.67 a	212.70 a
Organic Toprak F_1	3.64 c	7.16 b	45.35 d
Organic Çanak	3.22 c	6.96 b	57.60 c

Effects of organic and chemical fertilizer applications on leaf width, leaf length and chlorophyll index were given in Table 12. As for the other criteria, average values for the conventional applications are higher than those for organic applications in the data. In terms of leaf width, Toprak F_1 cultivar in conventional applications is statistically higher than other applications and cultivars. Apart from other criteria, the highest value was found to be in Çanak cultivar in conventional application and the value was considered to be statistically different from other applications and cultivars. Rodrigues et. al., [22] have found in their study that the P value has decreased the leaf area and this resulted in a reduction in photosynthesis rate. In this study, inefficient P values of tomato shoots in organic fertilizer application explain the low rate of leaf development. Additionally, it is reported in many studies that medical and aromatic plants' have allelopathic characteristics [23, 24, 25] These researchers reported that evaporation of some plants such as Thymus and Salvia, as a result of transpiration, have negative effects on development processes of some plants.

Table 13. Effect of fertilizer type on the growth and leaf chlorophyll index of tomato seedlings

	Fertilizer type	
	Organic	**Conventional**
Root length	58.93 b	109.05 a
Shoot length	58.28 b	93.70 a
Root fresh weight	0.02 b	0.148 a
Shoot fresh weight	0.10 b	0.58 a
Stem diameter	1.34 b	2.11 a
Leaf width	3.43 b	9.48 a
Leaf length	7.06 b	18.42 a
Chlorophyll index	51.48 b	164.50 a

Effects of organic and conventional fertilizer applications on root length, shoot length, leaf width, Leaf length and chlorophyll index of seedlings were comparatively given in Table 13. Examining data in the table, it is seen that, measurement values of criteria are higher in conventional application than in organic applications. Thus, organic fertilizer obtained from essential oils obtained from mint and thymus plants have a lower effect on seedling' growth and development, than chemical fertilizer. Effects of essential oils obtained from herbal extracts depend on the oil's components and content, ecological conditions, growing technics and plant species [26]. Additionally, monoterpenes is the main component of various essential oils and as a result of monoterpene increase in the dosage applied, inhibiting effect of essential oils may increase [27]. It is also reported in some studies that, essential oils in small dosages may effect plants' development positively [28]. In a study, the essential oil obtained from rosemary plant applied on tomatoes, lettuce and pepper seeds, and then germination rations were examined, the lowest alleopathic effect was found in tomatoes and the highest was found in lettuce seeds [29]. Önen and Özer [30], have used absinthe plants' dried and grinded leaves and rhisomes. Leaves of absinthe have increased the germination rate of pepper and cress, and rhisomes have increased the germination rate of cress. They resulted in the same study that, low dosage application of absinthe rhisomes have increased the germination rate of pepper seeds, but cucumber and tomatoes seeds were impacted negatively. Önen and Özer [30] have reported that the increased dosage has adverse impact in germination and seedling development. It is thought that the results were obtained from this study was caused of the high dosage of organic fertilizer.

Table 14. Effect of cultivars on the growth and leaf chlorophyll index of tomato seedlings

	Cultivars	
	Toprak F_1	**Çanak**
Root length	81. 91 a	86.08 a
Shoot length	70.62 b	81.37 a
Root fresh weight	0.080 a	0.090 a
Shoot fresh weight	0.32 b	0.37 a
Stem diameter	1.61 b	1.84 a
Leaf width	7.11 a	5.80 b
Leaf length	12.67 a	12.82 a
Chlorophyll index	80.83 b	135.15 a

Statistical examination of root length, shoot length, root fresh weight, shoot fresh weight, stem diameter, leaf width, leaf length and chlorophyll index data of Çanak and Toprak F_1 cultivars' seedlings grown in greenhouse were comparatively given in Table 14. It is seen that, all criteria, except for the leaf width, are higher for Çanak cultivar. Additionally, Çanak cultivar was found statistically superior to Toprak F_1 cultivar in terms of root length root fresh weight, stem diameter and chlorophyll index. Nitrogen has important roles in structure of some organic components such as nucleic acid, chlorophyll, amino acid [31]. In this study, seedlings' content of N was significantly ($P < 0.05$) lower in the organic fertilizer application than the conventional fertilizer application. There are 2 possible reasons for inefficiency of organic fertilizer application on seedling development: i) Inefficient N and P uptake, ii) Essential oils' allelopathic effect due to high application dosage. Essential oils have some biological effects due to their containing of different complex components [32].

Essential oils may inhibit plants' development depending on their components [33, 28, 24]. Mentha spicata L. ve Thymus braspicata L.'s essential oils' bioherbicidal effects [28], and Thymus vulgaris L's essential oils' biotoxic effect [34] have been reported in some studies. Essential oils' effects can be influenced by their active ingredient properties [32]. Chalkos et al., [19] have reported that the compost were obtained from Mentha spicata L. and Salvia fruticosa L. can be used as fertilizer in tomatoes cultivation.

IV. CONCLUSION

This study showed that, organic fertilizer obtained from mint-thymus extract, applied on tomato seedlings is inefficient comparing to chemical fertilizer. Additionally, amounts of average root and stem dry matter content % and some plant nutrient elements are higher or almost at the same efficiency line in organic fertilizer applied seedlings than chemical fertilizer applied seedlings. As a conclusion, the fertilizer used in the study seems to bid fair. The result may be examined by applying mint thymus extract used in the study, combined with another fertilizer which has high N and P content. Additionally, considering allelopathic effect of herbal extracts, it is suggested to set a new trial through different dosages by decreasing the dosage for this organic fertilizer, containing mint thymus extract.

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