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# The Effects of Organic and Conventional Growing Techniques on Tomato

# Organik ve Geleneksel Yetiştirme Tekniklerinin Domatese Etkileri

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## THE EFFECTS OF ORGANIC AND CONVENTIONAL GROWING TECHNIQUES ON TOMATO


### ABSTRACT:

This study aims to determine the changes in the yield and physiological parameters of the organic and conventionally grown tomatoes (*Solanum Lycopersicum* cv. Şencan 9). In the study carried out according to randomized block experiment design, tomato fruits were grown organic and conventional in two different greenhouses. In the light of the results obtained, significantly higher chlorophyll content (37.09 CCI) and average fruit weight (165.82 g) were obtained from the tomatoes grown conventionally than those grown organically. Leaf stoma conductivity, fruit shape index, and yield in terms of organic and conventional cultivation were different from each other. As a result of the study, significant increases on yield could be achieved by increasing the variety of organic fertilizers and applying organic farming following its technique.


***Keywords:*** *Chlorophyll content, Stoma conductivity, Solanum lycopersicum*

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## ORGANİK VE GELENEKSEL YETİŞTİRME TEKNİKLERİNİN DOMATESE ETKİLERİ


### ÖZ:

Bu çalışmada, organik ve geleneksel olarak yetiştirilen domateslerin (Solanum lycopersicum cv. Şencan 9) verim ve fizyolojik parametrelerindeki değişimlerin belirlenmesi amaçlanmıştır. Tesadüf blokları deneme desenine göre yürütülen çalışmada, domates meyveleri organik ve konvansiyonel olmak üzere iki farklı serada yetiştirilmiştir. Elde edilen sonuçlar ışığında, organik olarak yetiştirilenlere göre geleneksel olarak yetiştirilen domateslerden önemli ölçüde daha yüksek klorofil içeriği (37.09 CCI) ve ortalama meyve ağırlığı (165.82 g) elde edilmiştir. Organik ve konvansiyonel yetiştiricilik açısından yaprak stoma iletkenliği, meyve şekli indeksi ve verimi birbirinden farklı bulunmuştur. Çalışma sonucunda organik gübre çeşitliliğinin artırılması ve tekniğine uygun organik tarım uygulanması ile verimde önemli artışlar sağlanabileceği görülmüştür.


***Anahtar Kelimeler:*** *Klorofil içeriği, Stoma iletkenliği, Solanum lycopersicum*

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## 1. INTRODUCTION

Content of carbohydrates, organic acids, amino acids, vitamins, pigments, various mineral substances, phenolic compounds, and high antioxidant activity, which are essential for human nutrition, tomatoes make a significant contribution to the strengthening of the immune system (George et al. 2011; Sönmez and Ellialtıoğlu, 2014). Tomato cultivation can be done both organically and conventionally. Significant increases have been detected in many bioactive compounds beneficial in human nutrition when grown organically (Öztürk and Özer, 2019).

Increasing soil vitality is one of the most important issues for organic vegetable growing. With the initiation of microorganism activities in the soil, events such as mineralization of nutrients that are important for plant growth, nitrogen fixation, phosphorus solubility, production of plant hormones, and prevention of harmful microorganisms occur (Altın and Bora, 2005; Alagöz et al. 2020).

Monoculture applications, excessive fertilization, insufficient soil cultivation, not leaving fallow, and lack of green manuring threaten soil vitality. The most suitable way to improve the soil structure is to enrich the soil with organic matter (Tüzel et al., 2011; Zhang et al., 2012). Although it requires extra knowledge and skills with organic path plant nutrition, the physical and chemical structure of the soil with green manure recovered and increased efficiency are provided (Beşirli et al., 2009; Nesmeyanova et al., 2013; Patil et al., 2014; Ragozo et al., 2014; XieFeng et al., 2014). The most effective method in green fertilization is to plant various leguminous plants in the soil in autumn and winter and mix them with the soil during full bloom. It is stated that, nematode populations, which are the leading soil-borne pests, and some disease factors decrease with the use of green manure plants, and soil structure strengthens against these diseases and pests (Beşirli et al., 2001; Larkin, 2013; Thakur, 2013; Azimzadeh et al., 2014).

High relative humidity and weed control are one of the most important problems in organic vegetable cultivation in a greenhouse. Many of the organisms that cause disease live in high humidity conditions. In organic greenhouse farming, where conservation comes to the fore, every stage of plant cultivation is kept under control, and optimal environmental conditions are provided. Shade and mulch are used to prevent the plant from becoming stressed throughout the growing season. (Stephens, 2003; Özer, 2017). Different mulching applications in vegetable crops provide advantages in disease and pest control and yield (Radics et al., 2004; Ünlü et al. , 2006; Özer, 2017). The relative humidity in the greenhouse soil not covered up by evapotranspiration causes the rigging. Ascending from the lower leaves of the plant, relative humidity increases the spread of fungal diseases (Ekinci and Dursun, 2006; 2009; Jodaugiene et al., 2014). In farming, the preservation of soil

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moisture, reduction of the product cost, protection and development of soil structure, weed control, temperature changes, and control of diseases and pests can be achieved by mulching (Ünlü et al., 2006; Ekinci and Dursun, 2009; Jordán et al., 2010).

When it comes to organic vegetable production, the first year is crucial due to the loss of yield casued by the use of intensive same chemical fertilizers. Growing organic vegetables requires a process. First and foremost, the organic matter and vitality of the soil should be raised in the organic farming process. This study aims to determine the effects of some physiological parameters and yield elements of tomatoes grown by organic and conventional methods in greenhouses where organic vegetable cultivation has been carried out for 17 years.

## 2. Materyal ve Yöntem

### *2.1 Plant materials*

The field research were carried out in greenhouses created at the Research and Implement Center of the Agricultural Faculty of Ondokuz Mayıs University in Samsun, Turkey (41°37' N, 36°21' E, and 137 m altitude), in 2018. Şencan 9 (*Solanum Lycopersicum* L.) tomato cultivar, which is produced according to organic cultivation procedures, was used as plant material. Broad bean (*Vicia faba* L. cv. Gölyaka) was grown for green manuring.

### *2.2 Greenhouse process*

Two greenhouses with a width of 6 m, and a length of 20 m, and a side height of 3 m were chosen for the study. They have been used for organic production for 17 years. In one greenhouse, organic cultivation was used, whereas in the other, conventional cultivation was used.

The green manure was used as a bottom fertilizer in the greenhouse where organic cultivation is done. Therefore, broad bean seeds were planted on November 15, 2017. When the broad bean plants were in full bloom (April 15, 2018), they were crushed with the hoeing machine (12.6 kg wet broad bean per $m^2$) and mixed into the soil at a depth of 25 cm.

Organic fertilization (from commercial or natural sources) was made in the greenhouse where organic farming was carried out after the findings of the soil analysis were determined. (Kacar and İnal 2008) (Table 1). While creating the fertilization program, the amount of nutrients removed by the tomato from the soil (20-30 kg $da^{-1}$ N, 3-8 kg $da^{-1}$ $P_2O_5$, 30-60 $K_2O$, 3-6 kg $da^{-1}$ MgO and 10-20 kg $da^{-1}$

CaO) was taken into account (Şalk et al., 2008). The 2.5 mg $L^{-1}$ doses of liquid commercial organic fertilizer (NPK, bio-organic fertilizer) were applied to the plants by drip irrigation method 10 days interval from the planting of the seedling. In the greenhouse, only Helicoverpa armigera pests were seen. For this reason, an insecticide, which has an organic active ingredient (Laser, Dow AgroSciences; approval for in organic agriculture), was used twice.

**Table 1.** Some physical and chemical characteristics of the soil.

**Çizelge 1.** Toprağın bazı fiziksel ve kimyasal özellikleri.

| | | pH | EC (dS m-1) | OM (%) | N (%) | K (ppm) | Ca (ppm) | Mg (ppm) | Na (ppm) | Mn (ppm) | Zn (ppm) | Cu (ppm) | Fe (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | Conventional | 7.36 a | 0.95 a | 1.54 b | 0.12 a | 72.71 | 93.33 | 167.20 a | 504.45 | 15.59 b | 10.00a | 3.06 | 11.94 b |
| | Organic | 6.52 b | 0.81 b | 3.15 a | 0.09 b | 890.60 | 1038.67 | 134.40 b | 495.28 | 17.72a | 8.87 b | 3.05 | 17.43 a |
| Analysis Time | Planting | 6.69 b | 0.87 b | 2.19 b | 0.10 | 1049.1 a | 1118.0 a | 190.80 a | 565.25 a | 20.04 | 10.13 a | 3.35 | 15.21 a |
| | First flowering | 6.89 b | 0.87 b | 2.51 a | 0.12 | 716.55 b | 890.0 b | 110.40 c | 408.78 c | 19.22 | 9.23 ab | 2.94 | 13.45 b |
| | Last harvest | 7.25 a | 0.92 a | 2.34 b | 0.11 | 879.31 b | 1040.0 ab | 151.20 b | 525.57 b | 10.72 | 8.95 b | 2.87 | 15.40 a |
| **Main affect** | | | | | | | | | | | | | |
| Significance (interaction) | Treatments | * | * | * | * | ns | ns | * | ns | * | * | ns | * |
| | Analysis Time | * | * | * | ns | * | * | * | * | ns | * | ns | * |

**: P<0.05, ns: non-significant. The differences among the means shown with the same lowercase letter in the same column were not significant*

The di ammonium phosphate (18% N and 46% $P_2O_5$) was applied to 2.3 kg per 120 $m^2$ one month before the planting of the seedling as bottom fertilization in the greenhouse, where conventional cultivation was made. 17.000 mg $L^{-1}$ urea fertilizer (46% N) was applied to the plants by drip irrigation method 15 days interval from the planting of the seedling., 13.500 mg $L^{-1}$ triple superphosphate (42% $P_2O_5$) from the first fruit set was given with a 20-day interval., Total herbicide (Roundup) was used in weed control in the greenhouse where conventional production was made. Eforia 247 (Sygenta) was used as an insecticide against Helicoverpa armigera pest. In addition, Antracol WP70 (Bayer) was used as a precaution against fungal diseases in the greenhouse.

The irrigation of the plants was provided by drip irrigation at regular intervals in both greenhouses. Tomato seedlings were planted on May 3, 2018, with a row spacing of 45 cm, a row of 50 cm, and a wide row of 90 cm. The air temperature, soil temperature, and relative humidity values in the greenhouse were measured regularly (30 da $day^{-1}$) from planting to the end of harvest with data loggers (KT100, Kimo, France) (Table 2). The axillary buds and yellowed or diseased leaves in tomatoes were pruned in the growing period. The leaves under the harvested clusters were also removed completely.

**Table 2.** Greenhouse climatic date.

**Çizelge 2.** Sera iklim değerleri.

| | Greenhouse air temperature (°C) | | | Soil temperature (°C) | | | Greenhouse air humidity (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Highest | Lowest | Mean | Highest | Lowest | Mean | Highest | Lowest |
| Organic | 24.82 a | 29.41 a | 16.01 a* | 25.61 | 29.15 a | 18.56 a | 68.45 b | 81.02 b | 54.64 b |
| Conventional | 24.42 b | 29.28 b | 15.46 b | 25.06 | 28.68 b | 17.15 b | 72.23 a | 90.30 a | 57.13 a |

*The differences among the means shown with the same lowercase letter in the same column were not significant (*: P<0.05)*

### *2.3 Statistical*

The research was conducted using a three-replication randomized block trial design, with nine measurements taken in observation plants in each repetition. SPSS 15.0 statistical analysis program was used to evaluate the data obtained as a result of the study. The differences between the averages obtained were determined by t-test analysis.

## 3. Results and Discussion

### *3.1 Some physical and chemical characteristics of the soil*

Significant statistical differences were determined between the biochemical properties of soil samples taken at different stages of cultivation (planting, first flowering, and last harvest) from conventional and organic greenhouses (P<0.05).

According to the results, the highest pH (7.36), EC (0.95dS $m^{-1}$), N (0.12%), Mg (167.20 ppm) and Zn (10 ppm) were measured in the greenhouse where conventional cultivation was carried out. In the greenhouse where organic cultivation was carried out, the highest organic matter (OM; 3.15%), Mn (17.72 ppm) and Fe (17.43 ppm) values were obtained, while the significant effects of K, Ca, Na and Cu values on the applications were not determined (Table 1).

It is reported that organic fertilizer applications have a regulating effect on soil pH (Demirtaş et al., 2012). In our study, the pH values in the greenhouse where organic cultivation is carried out decreased from 7.36 to 6.52 (Table 1). It is known that the most important application that leads to salinity increases in the soil in greenhouse cultivation is fertilization. It is also an important parameter for monitoring the mineralization of organic matter (DeNeve et al., 2000). With a similar study, mushroom compost waste was applied to the parcels where tomato cultivation was carried out, and soil samples were taken from each parcel at the end of the production season and analyzed. According to the findings, there was an increase in the amount of organic matter, Mg, K, P, and salt in the parcels where mushroom compost was spread, as well as a decrease in the pH values. (Demirtaş et al., 2007). In our study, the slow mineralization of organic fertilizers does not increase the EC value much, while the rapid increase in EC value with the use of chemical fertilizers is thought to be caused by rapid mineralization.

The way to increase soil vitality is to enrich the soil with organic matter. It can be significantly boosted, especially with the addition of organic matter derived from green manure soil organic C and microbial biomass content. . In parallel with this increase, significant increases in yield occur (Alagöz and Özer, 2018). Green manure has been shown to increase the productivity of crop plants by improving the soil physical and chemical properties, in addition to increasing the organic substances imparted to the microorganism activity to soil(Bong et al. 2014; Sensing, 2014; Kröbel et al. 2014; Patil et al. 2014; Xiefeng et al . 2014; Pintoa et al.2017). Similar results are obtained by providing improved results of the study showed that the yield increase of the soil with conventional composting similar values were obtained.

### *3.2 Greenhouse climatic date*

When the temperature within the greenhouse and the average values were compared statistically, there were significant differences between the greatest and lowest temperature values of the therapy (P0.05). According to the results, the temperature in the greenhouse where organic cultivation took place was 16.01 degrees Celsius, whereas the temperature in the greenhouse where conventional cultivation took place was 15.46 degrees Celsius.

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When we examined the soil temperature values in the greenhouses where both cultivation was done, a statistically significant difference was found between the average, highest and lowest temperature values ($P<0.05$). The highest average (26.31°C) and the lowest (18.56°C) soil temperature values were measured in the organic farming greenhouse (Table 1). These values may have resulted from the use of mulch in the greenhouse where organic cultivation is carried out. It is reported that the soil temperature increases significantly with the use of mulch, but the soil temperature values are less affected by the outdoor conditions, providing a stable temperature for the plants (Özer, 2017). The average temperatures were higher in our study in which similar results were obtained, while the highest (29.15°C) and the lowest (17.15°C) soil temperature values were obtained since mulch was not used in the greenhouse where conventional cultivation was performed.

When the relative humidity value in the greenhouse was examined, the highest relative humidity value (average; 71.23, the highest; 90.30, the lowest; 57.13) was measured in the greenhouse with conventional cultivation ($P<0.05$). Our findings are assumed to be attributable to the absence of mulch in the greenhouse where conventional cultivation was carried out. Since the whole soil surface was covered with mulch in the greenhouse where organic farming was practiced, evaporation of water on the soil surface was prevented (Table 2). Mulch has been shown in studies to have impacts such as conserving soil moisture, weed management, and moderating rapid temperature swings, in addition to controlling diseases and pests. (Carter and Johnson, 1988; Abak et al., 1991; Ünlü et al, 2006; Ekinci and Dursun, 2009; Jordán et al., 2010; Mu et al., 2014). Similarly, in our study, no disease was discovered during the cultivation period in the greenhouse where organic cultivation was carried out. The main reason for this is because the usage of mulch in the greenhouse reduces relative humidity levels. It has been observed that the risk of disease is low, especially due to the decrease in relative humidity in the greenhouse.

### *3.3 Properties of some nutrient elements of tomato fruits*

When the nutritional values of organic and conventionally grown fruits were examined, it was significantly affected by the macro and micro nutrient cultivation technique ($P<0.01$). In the study, the highest N (3.91g / 100g), K (5.04g / 100g) Ca (249.76 mg / 100g), Fe (1.53 mg / 100g) and C (0.14 mg / 100g) values was obtained from conventional production systems, the high P (329.69 mg / 100g), Mg (192.82 mg / 100g) and Zn (0.45mg / 100g) values were measured in organically grown tomato fruits (Table 3).

**Table 3.** Properties of some nutrient elements of tomato fruits.

**Çizelge 3.** Domates meyvelerinin bazı besin elementlerinin özellikleri.

| | N g/100g | K g/100g | P mg/100g | Ca mg/100g | Mg mg/100g | Fe mg/100g | Cu mg/100g | Zn mg/100g |
|---|---|---|---|---|---|---|---|---|
| Organic | 3.5±0.05**b** | 4.6±0.12**b** | 329.7±0.11**a** | 189.8±0.09**b** | 192.8±0.03**a** | 1.30±0.02**b** | 0.12±0.01**b** | 0.45±0.01**a*** |
| Conventional | 3.9±0.06**a** | 5.0±0.09**a** | 279.7±0.13**b** | 249.7±0.11**a** | 172.8±0.04**b** | 1.53±0.01**a** | 0.14±0.01**a** | 0.43±0.01**b** |

**: The differences among the means shown with the same lowercase letter in the same column were not significant (P<0.01)*

Gözükara and Kaplan, (2018) N (2.13-2.27%), P (0.20-0.24%), K (3.87-4.15%), Ca (0.18-0.23%), Mg (0.11-0.12%) determined the values of Fe (27.40-32.59 mg / kg), Cu (4.32-5.56 mg / kg) and Zn (15.83-18.55 mg / kg) in tomatoes of different genotypes, they Similarly, Roe et al. (2013) in tomatoes N (0.71 g / 100g), K (1257 mg / 100g), P (94 mg / 100g), Ca (45 mg / 100g), Mg (57 mg / 100g), Fe (1.45 mg / 100g), Cu (0.41 mg / 100g) and Zn (0.56 mg / 100g) contents were determined. In both cultivation methods, except for Cu and Zn values, the mineral contents of the fruits were determined by Roe et al. (2013) was found to be higher than the values determined. In the studies using organic fertilizers, it is reported that the mineralization of organic nutrients is significantly slower (Toor et al. 2006). In our study, it is thought that the nutritional element values in fruits are lower compared to conventional cultivation due to the slow mineralization of green fertilization applied to the soil.

### *3.4 Properties of yield and some physiological parameters of tomato*

Organic and conventional growing plants of leaf chlorophyll content, leaf stomatal conductance, average fruit weight, and fruit shape index and yield values were determined (Table 4). Among these parameters, only the effect of cultivation type on leaf chlorophyll content and average fruit weight was found to be significant (P<0.05). Conventionally grown from plants had a significantly higher chlorophyll content as compared to those grown organically (37.09 CCI) and average fruit weight (165.82g) was obtained. Although there was no significant difference, in the organically grown plants had a higher values in terms of leaf stomatal conductance (365.69 mmol $m^{-2}s^{-1}$), fruit shape index (1.19) and yield (4.26 kg $plant^{-1}$) compared to conventional grown plants.

**Table 4.** Properties of yield and some physiological parameters of tomato.

**Çizelge 4.** Domatesin verim özellikleri ve bazı fizyolojik parametreleri.

| Treatments | Leaf chlorophyll content (CCI) | Stomatal conductivity (mmol $m^{-2}$ $s^{-1}$) | Average fruit weight (g) | Fruit shape index | Yield (kg $plant^{-1}$) |
|---|---|---|---|---|---|
| Organic | 31.72±1.75 b | 359.11±11.25 | 138.83±14.76 b | 1.14±0.07 | 4.03±0.13 |
| Conventional | 37.09±2.04 a | 365.69±11.84 | 165.82±05.79 a | 1.19±0.02 | 4.26±0.28 |

**: The differences among the means shown with the same lowercase letter in the same column were not significant (P<0.05)*

There are many factors affecting the yield in plant cultivation. It is reported that there is a positive and significant relationship between stomatal conductance, which is one of the most important, and yield. It has been reported that stomatal conductivity and yield values are associated with higher soil organic matter and soil microorganism activity (Alagöz and Özer, 2018). In addition, it has been reported that green fertilization application increases the the organic matter of the soil and improves the physical and chemical properties of the soil, thus increasing the productivity of plants (Duyar, 2014; Kröbel et al., 2014; Patil et al., 2014; Xie-Feng et al., 2014; Pintoa et al., 2017). The residence time in soil of nitrogen provided from synthetic fertilizers is much shorter in all conditions. The continuous presence of nitrogen released by slow mineralization in the root zone ensures that the plant continues its development uninterruptedly (Özdemir and Sezer, 2013). It is stated that the nutrients obtained from organic fertilizers have lower availability and mineralization rates (Toor et al., 2006). However, the C / N ratio of the organic waste to be used affects the mineralization time. Especially if the C / N ratio is higher than 25/1, mineralization slows down (Özeker and Ulutürk, 2006). In our study, lower but similar leaf stomata conductivity and yield values were obtained in conventionally grown plants using broad bean as green fertilizer in the greenhouse where organic cultivation was carried out. It is thought that the low yield values of organically grown plants are due to the slow mineralization of organic substances. Especially, the quick nitrogen mineralization may be the reason of the high content of leaf chlorophyll in conventional cultivation.

## 4. CONCLUSION

With the work we have carried out, it has been observed that significant increases in yield and quality can be achieved by performing organic farming in accordance with its technique. The fact that tomatoes, which are crucial in human nutrition, have lower plant nutrient levels as compared to the conventional cultivation technique of organic cultivation, and it is thought to be due to intensive chemical fertilization. The slow mineralization of organic matter explains why this effect is limited in organic farming. This view is especially, supported by the fact that organic and conventional cultivation have no significant effect on leaf stomatal conductivity and yield values, because conventional cultivation does not have a protective claim such as protecting the plant against diseases and pests. In conventional cultivation, pesticide is definitely applied considering the damage they will cause. In organic farming, protection is more prominent, considering these damages. Soil vitality is generally not important in conventional farming because fertilizers given dissolve quickly and respond to your needs. In organic farming, microorganisms perform the mineralization of nutrients. Therefore, considerable decreases in yield in organic farming have occurred as a result of this issue not being taken into account in the application of these two cultivation techniques in previous studies. . In our study, the increase in yield provided by organic farming techniques applied in the greenhouse where organic farming has been carried out for 17 years has been found remarkable.

As a result, in tomato cultivation, which has an important place in human nutrition, in terms of plant nutrients, fruits have lower values in organic cultivation compared to conventional cultivation. It is thought that this effect is due to the use of intensive chemical fertilizers in conventional farming. In organic farming, this effect is more limited due to the slow mineralization of organic matter.

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