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Influence of Mulch Types on Yield and Quality of Organically Grown Strawberry Cultivars

Sevinç ŞENER[1*] Nurgül Fethiye TÜREMİŞ[2]

[1]Department of Organic Agriculture, Vocational School of Technical Sciences, Akdeniz University, Antalya
[2]Department of Horticulture, Faculty of Agriculture, Çukurova University, Adana
*Corresponding author: ssener@akdeniz.edu.tr

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Abstract: The present studywas carried out during 2011-2013 under open-field cultivation conditions to find out the effect of black plastic, agro-textile and sawdust mulch types on yield and quality of organically grown strawberries (*Fragaria x ananassa* Duch.) cv. 'Monterey', 'Albion', 'Aromas', 'Camarosa' and 'Sweet Charlie'. The yield per plant, fruit weight and diameter, firmness, total soluble solids, titratable acidity, pH and fruit skin color were measured. At the end of the study, it was determined that the plant yield and fruit quality were affectedby the genotypes and mulch types . The highest values were obtained from the 'Monterey' in terms of yield per plant (696.90 g / plant), fruit weight (18.40 g / fruit) and fruit diameter (37.05 mm). Among different types of mulches, textile mulch was found to be superior in terms of yield per plant (486.11 g / plant) and fruit diameter (31.92 mm). The effect of genotype and mulch type on the average values of acidity, pH and fruit firmness were statistically significant. While the fruit skin color L, chroma and hue values were found significantly different for the genotypes, it was determined that the difference of mulch type significantly affected only the hue angle.

Key words: Strawberry, quality, mulch, agro-textile mulch, sawdust mulch, genotype.

Organik Yetiştirilen Çilek Çeşitlerinde Malç Tiplerinin Verim ve Kaliteye Olan Etkisi

Özet: Bu çalışma organik olarak yetiştirilen (Fragaria x ananassa Duch.) cv. 'Monterey, Albion, Aromas, Camarosa ve Sweet Charlie' çilek çeşitlerinde siyah plastik, tekstil ve talaş malç tiplerinin bitki verimi ve meyve kalitesi üzerine olan etkilerini belirlemek amacıyla 2011-2013 yılları arasında açık tarla koşullarında yürütülmüştür. Çalışmada farklı çeşit ve uygulamalarda bitki başına verim, meyve ağırlığı, meyve eni, meyve sertliği, SÇKM, titre edilebilir asitlik, pH, meyve dış rengi değerleri ölçülmüştür. Bitki başına verim (696.90 g/bitki), meyve ağırlığı (18.40 g/meyve) ve meyve eni (37.05 mm) gibi verim kriterleri bakımından en yüksek değerler 'Monterey' çeşidinden elde edilmiştir. Farklı malç tipleri arasında, tekstil malç bitki başına verim (486.11 g/bitki) ve meyve eni (31.92 mm) bakımından daha üstün bulunmuştur. Meyve kalite kriterlerinden asitlik, pH ve meyve sertliği ortalama değerleri üzerine çeşit ve malç tipi farklılığı istatistiksel olarak önemli düzeyde etki etmiştir. Meyve dış rengi L, chroma ve hue değerleri çeşitlere göre önemli düzeyde farklı bulunurken, malç tipi farklılığının yalnızca Hue değerini önemli düzeyde etkilediği belirlenmiştir.

Anahtar kelimeler: Çilek, kalite, malç, agro-tekstil malç, saman malç, genotip.

Introduction

Strawberry (*Fragaria x ananassa* Duch.) is an important berry plant, widely grown and demanded all over the World (Garriga et al., 2015; Guerrero-Chavez *et al.*, 2015). It is reported that from 2004 to 2014, world strawberry production has reached 8.1 million tons from 5.5 million tons. In the same period, it is reported that the production of Turkey increased by more than twice, reaching 376,070 tons from 155,000 tons. of Organic strawberry production is 3,280 tons in Turkey (FAOSTAT, 2017).

Strawberries can be consumed fresh or processed such as; used in jams and preserves, juices and sweets (Casierra-Posada et al., 2011). World production of strawberry has increased continuously and strawberry cultivation allows the use of family labor on small rural areas (Ponce et al., 2010). Commercial value of fruits is associated with the outward appearance. These characteristics can be listed as follows: dark color, fruit size and shape, defective fruit and other parameters like firmness, sweetness and acidity (Azodanlou et al., 2003). In addition to this consumers pay much more attention to food quality traits (Correia et al., 2011). Strawberry yield and quality is affected by some factors such as; temperature, fruit ripeness, maturity, genotypes, irrigation regime, mulching, fertilization, planting date (Khanizadeh 1994; Kivijärvi et al., 2002; Anttonen et al., 2006; Kumar and Dey, 2012; Akhtar and Rab, 2015). In strawberry cultivation use of mulch is common because of it positively effect on fruit quality and yield. These positive effects can be listed as follows; such as providing clean fruits conserves soil moisture, increasing soil temperature, increasing yields, preventing the emergence of weeds, improving the physical properties of soil, and preventing disease and pests (Gupta and Acharya, 1993; Birkeland et al., 2002; Plekhanova & Petrova 2002). Many materials can be used as mulches such as; hay, grass clippings, cardboard, paper, newspaper, wood chips, bark chips, peat moss, compost, polypropylene and polyethylene, biodegrable polyester fibers or living plants. Compared to other fruit species, strawberries can not compete with weeds for solar radiations, water, root system (Shoemaker, 1975). Using plastic mulch is a common practice in cultivation of strawberry (Anttonen et al., 2006, Shiukhy et al., 2015). Black mulch's thermal and radiation properties increased the soil temperature so it enhanced plant growth (Casierra-Posada et al., 2011). In addition to all these limited number of studies research the effect of alternative mulch materials such as; sawdust and agro-textiles usage in organic strawberry cultivation. Therefore, the question arises as to whether these changes in strawberry yield and quality as caused by the mulch type and cultivar. In Turkey, strawberry cultivation is depend on usually ecological conditions, in addition upland open-field cultivation used neutral cultivars (Adak and Gübbük, 2015). This experiment was carried out to demonstrate the effects of different mulch types on the yield and quality traits of three day-neutral ('Monterey', 'Albion' and 'Aromas') and two short-day strawberry cultivars ('Camarosa' and 'Sweet Charlie') under central Anatolia conditions for summer growing season.

Materials and Methods

Plant material and growth conditions

The investigation was undertaken in Nevşehir (Turkey) and was conducted under open-field conditions 1150 m above sea level. The treatments consisted of 5 strawberry cultivars and 3 mulch types. The cultivars assessed were as follows: three neutral 'Monterey, Albion, Aromas' and two short-day strawberries 'Camarosa, Sweet Charlie' cultivars. Black plastic mulch (PM), agro-textile mulch (TM) and sawdust mulch (SM) are used as mulching materials. Seedlings planted in a 30x30 cm spacing arrangement into 100 cm beds. Through the trial irrigation was made by sprinkling water and drip irrigation. Seedlings were transplanted on 19 May 2012. Organic agriculture certificated products were used along the trial for fertilization and plant production.

Experimental design and treatments

The experiment was established a randomized block design (RBD) with factorial treatment using 5 cultivar x 3 mulch type x 4 repetitions x 30 plants per parcel. PM and TM were applied before seedling process and SM was applied 15 days after the seedling as 10 cm's denseness.

Measurement of physical–chemical parameters

The ripe fruits obtained from each treatment were harvested during the experiment. Fruits were transported to the laboratory under refrigeration. They were graded for size and skin color and damaged fruits were eliminated. Post-harvest

evaluations assessed 10 randomly selected marketable fruits per repetitions. Yield criteria's were measured every harvest period to determine the plant yield, fruit weight and fruit diameter. Total soluble solids (TSS), total titratable acidity (TTA), TSS/TTA ratio, pH, firmness and external color determined at ten days intervals.

The fruit diameter was measured by digital caliper. Fruit firmness measurements were conducted using a penetrometer with 5/16ıı (0,79 cm) (Fruit pressure tester FT 327, Italy) plunger and the results expressed in kilogram (kg). TSS content was measured (in Brix) by a hand-held refractometer. TTA, expressed in citric acid percentage, was determined by titrating 1 mL of juice in 50 mL distilled water with 0.1 N NaOH solution to pH 8.1.

Skin color values L*, a* and b* were measured (opposite sides) by Minolta Chroma Meter CR-300. Fruit color was expressed as Chroma (C*) and Hue angle (H^0). The C* and H^0 values were calculated by the formulas (1) and (2) given below (McGuire, 1992).:

$$(H° = \arctan [b*/a*]) \quad (1)$$

$$(C* = [a*2 + b*2]½) \quad (2)$$

Statistical analysis

Data obtained from research results were analyzed in randomized complete block design in according to factorial order. Statistical analyses were performed with use of 23.0 SPSS software (SPSS Inc., Chicago, Illinois). Mean values of application were compared with Duncan's test after variance analysis. Differences between means at 5% ($p<0.05$) level were considered as significant.

Results and Discussion

Many researchers have reported that there are several factors affect the product yield and genetic variation (Karhu et al., 2007; Fan et al., 2012; Özdemir et al., 2013). In the present study effects of the cultivar on yield per plant, fruit weight and fruit diameter were statistically significant and also as it can be seen from the Table 1, yield per plant and fruit diameter were affected by the mulch types.

Highest yield criterias' such as; yield per plant (696.90 g/plant), fruit weight (18.40 g/fruit) and fruit diameter (37.05 mm) values were observed in 'Monterey' cultivar, whereas lowest values were found in 'Camarosa' and 'Sweet Charlie'. It is known that the difference of genotype affects fruit size (Hortyński et al., 1991; Cordenunsi et al., 2002; Atkinson et al., 2006). The difference in yield per plant among the cultivars is due to the genetic characteristics of the cultivars. It is thought that the photoperiodic types affected the amount of yield. In fact, day-neutral cultivars had greater amount of yield, compared to short-day cultivars. The critical day length among short day cultivars varies between 8 - 11 h (Hancock et al., 2008). Day-neutral cultivars better adapted to climate conditions in Central Anatolia were found more efficient than short day cultivars.

Agro-textile mulch was found to be more advantageous in comparison to black plastic and sawdust mulch in terms of yield per plant and fruit diameter. Moreover, total yields of 486.11 g/plant and fruit diameter of 31.92 mm were obtained by the use of agro-textile mulch. Some studies report that the types of mulch influences the fruit yield (Kasperbauer 2000; Singh et al., 2007; Casierra-Posada 2011; Kumar and Dey 2012) and quality (Kere et al., 2003; Singh et al., 2007; Kumar and Dey, 2012). In this study, while there was not a statistically significant effect of the different mulch types on the fruit weight but a significant effect on the fruit diameter. However the results obtained from the present study are not in accordance with the results obtained from the other studies conducted in this subject (Singh et al., 2007). Which was reported that the type of mulch affected the yield of per plant. In the present study, the effect of agro textile mulch on yield per plant was higher than that of the other mulches. This result can be attributed to air and water permeability of this mulch. According to the results obtained from this study it can be said that mulch type affected the plant productivity.

Table 1. Yield per plant, fruit weight and fruit diameter of strawberry cultivars grown by using different mulch types.

Çizelge 1. Farklı malç tipleri kullanılarak yetiştirilen çilek çeşitlerinin bitki başına verim, meyve ağırlığı ve meyve çapı değerleri

Cultivar *Çeşit*	Yield (g/plant) *Verim (g/bitki)*	Fruit weight (g) *Meyve ağırlığı (g)*	Fruit diameter (mm) *Meyve çapı (mm)*
Monterey	696.90 a	18.40 a	37.05 a
Abion	645.80 b	18.03 b	34.35 b
Aromas	611.79 c	14.86 c	28.84 c
Camarosa	169.69 e	11.99 d	29.14 c
Sweet Charlie	231.05 d	12.02 d	26.07 d
Mulch type *Malç tipi*			
Black plastic *Siyah plastik*	458.80 b	15.16	30.67 b
Agro-textile *Agro-tekstil*	486.11 a	15.10	31.92 a
Sawdust *Saman*	468.23 b	14.91	30.68 b
Mulch *Malç*	*	NS	*
Cultivar *Çeşit*	*	*	*
M x G *M x Ç*	NS	NS	NS

* Values in the same column significantly different at P=0.05. NS: Values in the same column are not significant at P=0.05.

**Aynı sütunda yer alan değerler istatistiksel olarak farklıdır (P=0.05). NS: Aynı sütunda gösterilen değerler istatistiksel olarak önemli değildir (P=0.05).*

Effects of cultivars and mulch type on the TSS, TA, pH, firmness and TSS/TA ratio values of fruits were presented in Table 2. Different significance patterns were observed for cultivar, mulch type and cultivar x mulch type interactions (Table 2). Among the quality parameters, TA and pH were found significantly different across cultivar x mulch type interaction. As seen in Table 2, the effects of cultivar and mulch type on all fruit criteria were found statistically significant whereas the effect of mulch types on TSS was not consistent.

The fruits of 'Monterey' cultivar were firmer (0.79 kg); had lower TSS/TA (6.33%) and pH (3.59%), than those of the other cultivars. 'Albion' had higher values of TSS (9.05%) and TA (1.40%) than those of the other cultivars.

The TSS values were different among the genotypes, but it was not affected by the mulch type. However, Karhu et al. (2007) reported that the TSS ratio was affected by the type of mulch. There were not a statistically significant difference in TSS content of the cultivars among the mulch types which may be due to the use of different mulch materials from other studies (Karhu et al., 2007; Singh et al., 2007; Kumar and Dey, 2012).

The fruit firmness was influenced significantly from the sawdust mulch (0.76 kg) compared to black plastic and agro-textile mulch. Firmness was maintained better with the sawdust mulch treatments than the others. Agro-textile mulch treated fruits were significantly had higher TSS/TA (7.50%) and lower acidity (1.21%) than those of the fruits treated with black plastic and sawdust mulch.

Table 2. TSS, TA, pH, firmness and TSS/TA of the strawberry cultivars grown by using different mulch types.

Çizelge 2. Farklı malç tipleri kullanılarak yetiştirilen çilek çeşitlerinin SÇKM, TA, pH, sertlik ve SÇKM/TA değerleri

Cultivar *Çeşit*	TSS *SÇKM* (%)	TA *TA* (%)	pH *pH* (%)	Firmness *Sertlik* (kg)	TSS/TA *SÇKM/TA* (%)
Monterey	8.34 c	1.37 b	3.59 d	0.79 a	6.33 d
Abion	9.05 a	1.40 a	3.65 c	0.79 ab	6.65 cd
Aromas	8.09 d	1.20 c	3.68 bc	0.76 b	6.96 c
Camarosa	8.55 b	1.19 c	3.83 a	0.69 c	7.57 b
Sweet Charlie	8.41 c	1.12 d	3.69 b	0.62 d	8.13 a
Mulch type *Malç tipi*					
Black plastic *Siyah plastik*	8.50	1.29 a	3.72 a	0.70 b	6.90 b
Agro-textile *Agro-tekstil*	8.52	1.21 c	3.70 a	0.72 b	7.50 a
Sawdust *Saman*	8.45	1.26 b	3.64 b	0.76 a	6.98 b
Mulch *Malç*	NS	*	*	*	*
Cultivar *Çeşit*	*	*	*	*	*
M x G *M x Ç*	NS	*	*	NS	NS

Table 3. Fruit color values of L*, C* and H^0 of the strawberry cultivars grown by using different mulch types.

Çizelge 3. Farklı malç tipleri kullanılarak yetiştirilen çilek çeşitlerinin meyve dış rengi L, C ve H^0 değerleri*

Cultivar *Çeşit*	L* *L**	C* *C**	H^0 H^0
Monterey	30.45 ab	71.91 b	30.72 a
Abion	29.42 cb	72.74 a	28.82 c
Aromas	30.45 ab	72.83 a	27.91 d
Camarosa	31.10 a	72.70 a	29.93 b
Sweet Charlie	28.57 c	72.58 a	30.46 ab
Mulch Type *Malç Tipi*			
Black plastic	29.86	72.30	29.83 a
Agro-textile *Agro-tekstil*	30.37	72.57	29.35 b
Sawdust *Saman*	29.77	72.79	29.53 ab
Mulch *Malç*	NS	NS	*
Cultivar *Çeşit*	*	*	*
M x G *M x Ç*	NS	NS	*

* Values in the same column significantly different at P=0.05. NS: Values in the same column are not significant at P=0.05.

**Aynı sütunda yer alan değerler istatistiksel olarak farklıdır (P=0.05). NS: Aynı sütunda gösterilen değerler istatistiksel olarak önemli değildir (P=0.05).*

Effect of cultivar on fruit color was found statistically significant, whereas different mulch types affected significantly only hue value (Table 3). 'Camarosa' had high L* value (31.10) than those of the other cultivars, whereas 'Sweet Charlie' (28.57) had lower values (Table 3). The highest hue value was obtained from the 'Monterey' cultivar. Different mulch treatments had no significant effect on the fruit color values of L*and Chroma values, ($P \leq 0.05$) (Table 3). On the other hand black plastic mulch treated fruits had higher hue values (29.83). As a result, it can be said that the fruit color of the genotypes were significantly different ($P < 0.05$). But the different mulch types had no significant effect on the fruit color except for hue angle similarly with Karhu et al., (2007).

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