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EFFECTS OF SEVERAL CULTIVARS', MULCH AND FERTILIZER APPLICATIONS ON PLANT GROWTH AND DEVELOPMENT CRITERIA AND PLANT'S NUTRITION ELEMENTS UPTAKE IN ORGANIC STRAWBERRY PLANTATION IN NEVŞEHIR CITY

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Abstract

This study was conducted to investigate the effect of different mulch types' (black plastic, textile and sawdust) and fertilizer applications (Ekoflora, Mog, Bio-one, Ferbanat L and Natural Bioplasma) effect in strawberry (*Fragaria vesca* L.) cultivars ('Monterey', 'Albion', 'Aromas', 'Camarosa' and 'Sweet Charlie'). The effects of applications on plant nutrient concentrations (N, P, K, Ca, Mg and Fe) and plant growth and development criteria (plant height, steam diameter, number of leaf and root height) were determined. Fertilizer material and cultivars caused significant differences in the plant growth and development of five strawberry cultivars, while mulch materials' effects found only on number of leaf and root height. Highest values in terms of plant growth and development criteria were found in 'Camarosa' cultivar and black plastic and textile mulch. The most superior cultivar in terms of plant's nutrition elements uptake was 'Camarosa'. Black plastic and textile mulch were found more advantageous compared to sawdust mulch. Differences in the plant growth and development criteria and plant's nutrition elements uptake obtained from fertilizer applications were noted.

1. INTRODUCTION

Organic foods are popular with healthy, delicious and environmentally friendly properties (Nandwani & Sochinwechi, 2016). Organic strawberrys' commercial value has increased worldwide (Hakala *et al.*, 2003). Strawberry (*Fragaria*) is a member of Rosaceae.

Concerning strawberries, Turkey was the third strawberry producer after USA and Mexican with a total production of nearly 353.173 tons and 3.857 tons' of this production was organic (FAO, 2014).

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According to TÜİK (2013) reports, 654 tones strawberries were produced in Nevşehir and 8,80 tons' of this production was organic. Strawberry, which is cultivated and produced in high quality worldwide, has also gain importance in our country, recently. (Macit *et al.,* 2006). Cultivar selection is feature in strawberry production (Nacar, 2012). Adaptation experiments are in progress as long as new cultivars are developed (Kaleci & Günay, 2006).

Deficit plant nutrients and control of the weeds are the main problems in organic agriculture. Mulching may influence the temperature and moisture content of the soil (Acharya *et al.,* 2005). Mulching increased the yield by controlled weeds and gain clean fruits (Kumar & Deyb, 2011; Plekhanova & Petrova, 2002). Black plastic mulch material has been widely used in agricultural practices (Anttonen *et al.,* 2006). Textile, straw, sawdust and paper mulch types are also prefered due to their air and water permeability properties (Pop *et al.,* 2013; Dobbs, 2003; Berglund *et al.,* 2006; Skroch *et al.,* 1992). It is reported that, some organic and inorganic materials could also be used as mulch material in strawberry cultivation (Birkeland *et al.,* 2002; Cabilovski *et al.,* 2014; Demirsoy *et al.,* 2012; Kumar & Deyb, 2011; Bilck *et al.,* 2010; Kuru, 2009).

Fertilizing is the most important factor for yield, quality and plant development in plant production. Organic fertilization is as important as inorganic fertilization for plant growth processes (Cabilovski *et al.,* 2014). Organic fertilizers' harmful effects are not excessively when it applied high dosage cause of their narrow nutrition elements range. Additionally, most of organic fertilizer types contain nutrition elements in more or less levels, therefore they ease keeping the plant nutrient balance (Aktaş, 1991). Several studies reporting that certificated and organic commercial fertilizer have effects on plant development (Aras, 2009; Gülbağ, 2010; Rahman *et al.,* 2014) and nutrition element uptake (Türkoğlu, 2005; Özkan, 2012; Geçer & Yılmaz, 2012).

The aim of this study was to show the efficiency of different mulch types and organic fertilizers which will be used by strawberry growers in central Anatolia. In this regard, the current research was carried out with three neutral 'Monterey, Albion, Aromas' and two short-day strawberry cultivars (Fragaria × ananassa Duch.) 'Camarosa, Sweet Charlie' to study the effect of organic fertilizer application and mulching on growth and development criteria and nutrient uptake of strawberry plants in the open conditions.

2. MATERIAL AND METHOD

2.1. Material

Experiment was carried out in the open conditions in Nevşehir city, which has 1150 m height and located in central Anatolia in 2011-2012 and 2012-2013 seasons. Frigo seedlings of strawberry cultivars were grown under organic conditions. 'Monterey', 'Albion', 'Aromas', 'Camarosa' and 'Sweet Charlie' strawberry cultivars were used as plant material in the present study, while Ekoflora, Mog, Bio-One, Ferbanat L. and Natural Bioplasma used as organic fertilizer products. Also mulch materials were black plastic mulch, textile mulch and sawdust. Black plastic and textile mulch materials were bought from commercial associations and hornbeam sawdust as mulch was provided from a carpenter's shop. 20 microns thick cloths were used for black plastic mulching. Textile mulch material has air permeability.

2.2. Method

The experiment was designed as a Randomized Blocks with 4 replicates in Nevşehir city in 2011-2012 and 2012-2013 seasons. Each replicate which is a parcel contains 30 plants. The experiment continued for two years. Soils were sampled and analyzed from the depth of 30 cm—in April 2011. Through the trial, irrigation, sprinkler irrigation, drop irrigation was held. Seedlings were planted on 19.05.2012. Black plastic mulch was applied before planting process and sawdust mulch was applied 15 days after planting as 10 cm's layer. As an addition, M.O.G and Bio-one, Natural Plasma, and Ferbanat L fertilizer types were applied as liquid fertilizer and Ekoflora

fertilizer was mixed into soil before planting process. The applications dosage and methods of the fertilizers are given in Table 1.

Table 1: Applications dosage and methods of the fertilizers

Fertilizer	Application doses	Application time	Application method
Ekoflora	250 kg/da	Pre-emergence	Soil addition
Mog	0.5-1 l/da	4 applications	Soil addition plus foliar spray
Bio-One	0.3 l/da	1 application	Soil addition
Ferbanat L	0.5-0.7 l/da	4 applications	Foliar spray
Natural Bioplasma	1 l/da	4 applications	Foliar spray

In the trials, the effects of mulch type and fertilizer materials on the plant growth and development criteria (plant length, stem width, number of leaves and root length) and plant nutrient uptake (N, P, K, Ca, Mg, Fe) were observed.

2.3. Statistical analysis

Data were analyzed by SPSS 23 software and comparing averages was done by Duncan's test and a probability value of 5%. Significance levels of application differences according to variance analysis and different group were given in tables.

3. FINDINGS AND DISCUSSION

Some chemical and physical soil properties were determined (Table 2). Soil at the experimental site was found 55% sandy loam with a pH of 5.64. The results show that the trial soil is sandy loam, less acid reactive, unsalined, having very less azote, rich in phosphor and iron; efficient in calcium, zinc, potassium and magnesium, and poor in manganese. Soil's organic matter content was defined as 0.93%.

Table 2: Chemical and physical analysis results of the experimental soils

Analysis	Measurement unit	Values
pH		5.64
Total salt (EC)	(µS/cm)	147
Salt	(%)	0.006
$CaCO_3$	(%)	1.1
Organic matter	(%)	0.93
Texture	(%)	55
N	(%)	0.028
P	(kg/da)	35.1
Ca	(mg/kg)	1225
K	(kg/da)	63
Ma	(mg/kg)	218
Fe	(mg/kg)	71.73
Mn	(mg/kg)	2.53
Zn	(mg/kg)	1.22

3.1. Effects of different mulch and fertilizer applications on strawberry cultivars' growth and development criteria

In Table 3, plant height, stem width, number of leaves and root lengths are given. The effects of the cultivars on plant height, stem width, number of leaves and root lengths of plants were statistically ($P < 0.05$) significant. In all of the plant growth and development criteria, (plant height; 32.63 cm, stem width; 59.63 mm, number of leaves; 95.30 pieces and root length; 20.73 cm) the highest averages were reached in 'Camarosa' cultivar. Similar plant height results were also obtained by some researchers; 'Sweet Charlie' 22.58 cm, 'Camarosa' 28.50 cm (Rahman *et al*., 2014), 'Camarosa' 30.43 cm (Gülbağ, 2010), 'Camarosa' 29.67-32.31 cm (Atasay, 2007).

Stem width of 'Camarosa' cultivar were reported as 41.87-52.00 mm range by Atasay (2007). Rahman *et al*., (2014) have reported average number of leaves as 35.42 pieces/plant for 'Sweet Charlie' and 37.58 pieces/plant for 'Camarosa' cultivar. These values are lower than our results. Yet reported difference might be resulted from different growing conditions. Polat (2005) reported that average number of leaves for 'Camarosa' has ranged between 43.15-52.05 pieces/plant. Atasay (2007) reported that average number of leaves for 'Camarosa' as 90.06-113.37 pieces/plant. Results obtained by Polat (2005) and Atasay (2007) are close to values obtained in our study.

Table 3: Effects of different cultivars on the plant growth and development

Cultivars	Plant height	Stem diameter	Number of leaf	Root height
Monterey	30.61 b	49.91 b	64.28 c	16.53 b
Albion	22.26 c	45.25 c	81.17 b	15.89 c
Aromas	20.39 d	41.28 e	80.05 b	14.87 d
Camarosa	32.63 a	59.63 a	95.30 a	20.73 a
Sweet Charlie	20.47 d	42.44 d	63.87 c	14.24 e

Mean separation rows by Duncan's multiple test at 0.05 level

Effects of mulch types on the growth and development of plants were investigated (Table 4). As shown in Table 4, we observed a significant difference between mulch types in terms of number of leaf and root length. However, plants mulching with black plastic and agro-textile mulches had higher leaf number (agro-textile; 78.47 number/plant, black plastic; 78.03 number/plant) and lengthier roots (black plastic; 16.91 cm, agro-textile; 16.73 cm).

Table 4: Effects of different mulch types on the plant growth and development

Mulches	Plant height	Stem diameter	Number of leaf	Root height
Black plastic mulch	25.96	48.15	78.03 a	16.91 a
Tekstil	25.49	48.37	78.47 a	16.73 a
Talaş	24.37	46.59	74.31 b	15.71 b

Mean separation rows by Duncan's multiple test at 0.05 level

Growth responses of strawberry plants in different fertilizer types are shown in Table 5. Statistical differences found between fertilizer applications in terms of plant growth criteria. Examining effects of applications on plant height, the highest average value was reached in Mog application (25.75 cm). The highest average value of stem width was found in Mog application (48.61 mm) and Bio-one application (48.98); the highest average number of leaves value was found in Natural Bioplasma (78.05 pieces) and the highest root length values were found in Ekoflora (16.57 cm), Bio_one (16.63 cm) and Natural Bioplasma (16.65 cm) applications. In some studies conducted by Gülbağ (2010) and Aras (2009), strawberry cultivars showed similar results; 25.07-26.87 cm average plant height ranges (Gülbağ, 2010), 26.7-29.64 cm plant height values ranges for 'Camarosa' cultivar (Aras, 2009).

Table 5: Effects of different fertilizer materials on the plant growth and development

Fertilizers	Plant height	Stem diameter	Number of leaf	Root height
Ekoflora	25.00 b	46.59 c	76.74 ab	16.57 a
Mog	25.75 a	48.61 a	75.78 b	16.40 ab
Bio-One	25.31 ab	48.98 a	77.33 ab	16.63 a
Ferbanat L.	25.28 ab	47.40 b	76.78 ab	16.00 b
N.Bioplasma	25.01 b	46.93 bc	78.05 a	16.65 a

Mean separation rows by Duncan's multiple test at 0.05 level

3.2. Effects of different mulch and fertilizer applications on plant nutrition element uptake

Macro and micro nutrient content of the different strawberry cultivars are given in Table 5. In the research plant nutrient uptake was statistically influenced by organic fertilizer treatments. The amount of N (2.86%), K (1.71%), Ca (1.64%), Mg (326.61 ppm) and Fe (158.24 ppm) in 'Camarosa' were observed to be higher than other cultivars. In terms of P the highest value was found in 'Albion' cultivar (0.30%). According to previous studies, plant activator (Crop-set and Isr 2000) applications applied on 'Selva' and 'Camarosa' strawberry cultivars have a positive effect on N and Cu content of leaves (Türkoğlu, 2005). N rate was defined as 2.42-2.98% and P rate was defined as 0.45-0.52% on 'Camarosa' cultivar (Adak, 2009). Geçer and Yılmaz (2012) have reported the K content of seedlings similar with this study as 1.04% for 'Aromas', 1.02% for 'Camarosa' and 1.02% for 'Sweet Charlie'.

Table 6: Effects of different cultivars on the plant nutrient uptake

Varieties	N (%)	P (%)	K (%)	Ca (%)	Mg (ppm)	Fe (ppm)
Monterey	2.57 b	0.25 bc	1.51 b	1.59 c	305.67 c	146.90 b
Albion	2.54 b	0.30 a	1.50 b	1.60 c	314.42 b	142.01 c
Aromas	2.55 b	0.24 d	1.47 c	1.57 b	312.25 b	137.35 d
Camarosa	2.86 a	0.26 b	1.71 a	1.64 a	326.61 a	158.24 a
Sweet Charlie	2.57 b	0.24 cd	1.41 d	1.53 d	295. 43 d	110.68 e

Mean separation rows by Duncan's multiple test at 0.05 level

The effects of black plastic, textile and sawdust mulches on strawberry's plant nutrition uptake were given in Table 7. As seen in Table 7, the highest P (0.27%) and Fe (142.22 ppm) uptakes were obtained from black plastic mulch treatment and it was significantly superior to the other mulches. Effects of plastic and sawdust mulches on N uptake were found equal. Agro-textile mulch was found superior by uptakes the Mg elements. Kumar and Deyb (2011) reported that they have found N rate as ranging between 0.33-0.76% for application without mulching, as ranging between 0.42 - 0.88% for sawdust application and as ranging between 0.48 - 1.03% for black plastic mulch application. It is thought that, the results may occur from factors of climate or soil.

Table 7: Effects of different mulch types on the plant nutrient uptake

Mulches	N (%)	P (%)	K (%)	Ca (%)	Mg (ppm)	Fe (ppm)
Black mulch	2.63 a	0.27 a	1.52	1.59	312.28 b	142.22 a
Agro-textile	2.59 b	0.26 ab	1.52	1.59	314.79 a	139.29 b
Talaş	2.63 a	0.25 b	1.53	1.58	305.57 c	135.60 c

Mean separation rows by Duncan's multiple test at 0.05 level

Fertilizer products had significant effects on plants' N, P, K, Ca, Mg and Fe uptake (Table 8). As shown in Table 8, the highest effect on uptakes are; Ekoflora on N (2.70%) and K (1.57%); Bio-One on Ca (1.61%); Ferbanat L on Mg (316.89 ppm) and these form a significant difference depending on applications. Özkan (2012) reported that, effect of fertilizer applications is not significant on Ca uptake of leaves for 'Fern' strawberry cultivar and average value ranges between 7863.4 - 10016.0 ppm. The reason different results were obtained from studies is thought to be different grow up conditions (greenhouse of open field) or ecological factors (day time duration, light intensity, height of location and etc.).

Table 8: Effects of different fertilizer materials on the plant nutrient uptake

Gübreler Fertilizers	N (%)	P (%)	K (%)	Ca (%)	Mg (ppm)	Fe (ppm)
Ekoflora	2.70 a	0.27 a	1.57 a	1.58 b	309.02 b	139.68

Mog	2.64 b	0.24 b	1.53 b	1.59 b	309.83 b	137.77
Bio-One	2.64 b	0.25 ab	1.52 b	1.61 a	309. 43 b	139.29
Ferbanat L.	2.48 c	0.26 a	1.45 c	1.58 b	316.89 a	138.68
Natural Bioplasma	2.63 b	0.26 a	1.54 b	1.58 b	309.21 b	140.18

Mean separation rows by Duncan's multiple test at 0.05 level

4. RESULT

- It is found at the end of the study that, cultivar and fertilizer material differences over strawberries have a significant effect on growth and development criteria such as plant height, stem width, number of leaves and root length, however, mulch differences have an effect only on number of leaves and root length.
- The highest values of growth and development criteria were found in 'Camarosa' cultivar of all and black plastic mulch type of all.
- A statistically positive effect of all fertilizer materials on plants' growth and development criteria was found.
- The most successful cultivar in terms of nutrition element uptake was 'Camarosa' and it was followed by 'Albion'. Additionally, black plastic mulch and textile mulch was considered to be more advantageous compared to sawdust mulch.

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