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DIFFERENT GROWING CONDITIONS AFFECT NUTRIENT CONTENT, FRUIT YIELD AND GROWTH IN STRAWBERRY

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Abstract

This study aimed to determine the effects of organic and conventional growing on contents of some nutrient elements, nitrogen (N), phosphorous (P), potassium (K), iron (Fe), and manganese (Mn), yield and some growth parameters such as leaf area, petiole length, petiole diameter, crown number, crown diameter, leaf, root dry weight in 'Sweet Charlie' and 'Camarosa' strawberry cultivars. This study consisted of two strawberry cultivars ('Camarosa' and 'Sweet Charlie'), two growing systems (organic and conventional growing) and two different mulches (black and floating sheet). There was significant difference among treatments in terms of P, K, and Mn content in root and Fe content in leaf and yield and some growth parameters. The best treatment in terms of yield and growth parameters was conventional growing with black plastic in 'Camarosa' while the best treatments were organic growing with floating sheet and black plastic in 'Sweet Charlie' in terms of P, K in root and organic growing with floating sheet in 'Sweet Charlie' in terms of Fe in leaf.

Introduction

Organic agriculture is an alternative production system that decreases negative ecological balance. The system recommends organic and green manure, crop rotation, and soil protection to utilize on-site parasite and predators for biological control and to enhance biodiversity. In addition, organic agriculture aims not only to increase yield but also crop quality (Aksoy & Altindisli, 1998; Anon, 2007; Hammad *et al*., 2011). In recent years, the organic cultivation techniques for berries have been developed and the cultivation technique of strawberry grown in organic systems have been reported in many papers (Gliesman *et al.,* 1996; Pranckietene & Pranckietis, 2000; Duagaard, 2001; Leskinen *et al.,* 2002; Forcella *et al.,* 2003; Prokkola *et al.,* 2003; Gurena & Born, 2007; Balci & Demirsoy, 2008).

Prerequisites for a successful strawberry growing are climate, cultivars and soil (Albregts & Howard, 1980; Almaliotis *et al.,* 2002; Daugaard, 2001). Specific nutrient management practices are required for individual cultivars grown under widely different environmental conditions to ensure high yields and quality in fruits (May & Pritts, 1990). Fertilizers used in organic growing are applied at moderate levels and usually mixed into the soil. Strawberries require moderate applications of nitrogen and that the plant uses slight amounts of nitrogen during its growing period (Daugaard, 2001). However, macro and micro mineral elements such as N, P, K, Fe and Mn have a great importance in strawberry growing (May & Pritts, 1990; Kessel, 2003; Ersoy & Demirsoy, 2006).

There are few reports indicating low yield in organic agriculture (Enke, 1988; Glissman *et al*., 1996; Pranckietiene & Pranckietis, 2000). Yield of strawberry plants are closely related to vegetative growing parameters such as leaf area, petiole length, petiole diameter, crown number, crown diameter, leaf dry weight, crown dry weight and root dry weight. For this reasons, growing parameters should be investigated in organic and conventional growing.

The study aimed to compare organic and conventional strawberry growing systems in terms of contents of mineral elements such as N, P, K, Fe, Mn in strawberry plants and yield, and some growth parameters in Sweet Charlie and Camarosa strawberry cultivars.

Materials and Methods

This study was carried out in experimental area of 19 Mayıs University in Samsun, Turkey in 2003-2004. Samsun province is located coastal zone in Black Sea Region at north of Turkey. The climatic data such as maximum, minimum and average temperatures, humidity and rain during experiment were recorded (Fig. 1).

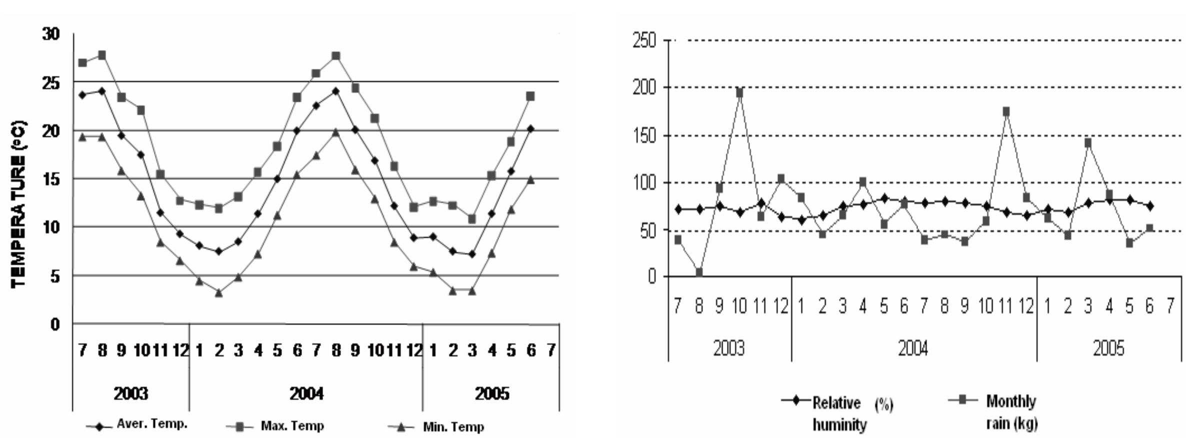

Fig. 1. Variations in temperature, relative humidity and rain fall in experimental area.

Frigo plants of 'Sweet Charlie' and 'Camarosa' strawberry cultivars were planted in double-row with a 32x32 cm and 40x40 cm spacing in a triangle planting system on classical and organic plots, respectively, on 15 July 2003. Frigo plants were soaked into 0.1% Benlate (methyl l-(butylcarbamoyl)-2-benzimidazole carbamate) solution for fungal diseases before planting in classic growing system, but the plants in organic system were not soaked. All plots were mulched with black plastic (0.06 mm thickness) and floating sheet (with a high fiber content and 100% propylene) on 26 December 2003. In classic and organic plots the pH, organic matter, $CaCO_3$ and total salt were 7.62, 5.99%, 4.18% and 0.075%, respectively. As cultivation practice, ammonium sulfate (3g per plant) was applied to plants on classic plots on 19 September 2003 and 27 April 2004. In organic plots, 0.125% Progen Fort organic fertilizer (40 ml per plant, a commercial product containing 10% N, 15% $K0_2$, 0.2% Mn, 0.6% Fe, 0.3% Zn, and 0.2% MgO) was applied to plants on organic plots on 27 April 2004. In addition, 0.1% Delta Plus +15 (humic acid) was applied to plant leaves in organic plots on 23 March 2004. The plants were watered by dripping system.

The 8 treatments in the experiment were: 1. Conventional system mulched with a black plastic using 'Sweet Charlie' (SC-CL-BP), 2. 'Sweet Charlie' using conventional system mulched with a floating sheet (SC-CL-FS), 3. 'Sweet Charlie' using organic system mulched with a black plastic (SC-Or-BP), 4. 'Sweet Charlie' using organic system mulched with a floating sheet (SC-Or-FS), 5. ‘Camarosa’ using conventional system mulched with a black plastic (CAM-CL-BP), 6. ‘Camarosa’ using conventional mulched with a floating sheet (CAM-CL-FS), 7. ‘Camarosa’ using organic system mulched with a black plastic (CAM-Or-BP), 8. ‘Camaros’ using organic system mulched with a floating sheet (CAM-Or- FS). Three plants were pulled up from each treatment on 2nd July, 2004. Yield (g/plant), leaf area (cm^2) according to Demirsoy *et al.,* (2005), petiole length (cm), petiole diameter and crown diameter (mm) using a digital compass, crown number (number/plant), leaf, crown and root dry weight (g) drying at 70°C were determined.

Nutrient contents of plants were analyzed from three plants pulled up from each treatment on 15th July, 2004 (John *et al.*, 1975). The plants were separated in to roots, crowns and leave with petioles and washed. These parts of plant were oven-dried at 70°C. Total nitrogen was determined by Kjeldahl method. Dried and ground plant materials were wet digested with HN03:HCI04 (4:1, v/v). Phosphorus concentration in the solutions was determined by ammonium heptamolybdate- ammonium vanadate in nitric acid method with a Spectrophotometer (Consort P903). K, Fe, and Mn contents of plant materials were determined after the wet-digestion using an Atomic Absorption Spectrometer (Perkin Elmer 2280) with flame (Rowell, 1996). The experiment was arranged in a randomized complete block design with total eight treatments and four blocks, four plots per block and 15 plants per plot. A total of 1920 plants were used. The data was analyzed by analysis of variance (ANOVA) using SPSS 12.0 and Duncan Multiple Range Test to compare means.

Results and Discussion

In terms of nitrogen contents in leaf, crown and root of plants, there was no signifıcant difference among treatments (Table 1). N content in leaves varied from 1.54 to 1.19%. May & Pritts (1990) stated that foliar N levels between 2.0 to 2.8% were considered suffıcient for strawberries. N content in crown varied from 1.14 to 0.82%. Stanislavljeviç *et al*., (1997) reported that crown N was 0.92% in strawberry. Root N content varied from 1.01 to 0.62%. In the experiment, especially leaves N were slightly lower than optimum level for good growth and fruit production. This may result from taking out plants after harvest. Demirsoy *et al.*, (2010) observed that N content in all parts (leaf, crown and root) decreased during harvest due to the demand of the fruits. The other reports also indicated that N content in different parts of the plant decreased from the beginning of fruiting period to the end of harvest (Albregts & Howard, 1980; Human & Kotze, 1990; Archbold & MacKown, 1995).

There was no significant difference among treatments in terms of foliage and crown P content (Table 1). Foliar P varied from 0.36 to 0.34%. May & Pritts (1990) found that foliar P was between 0.40 to 0.25% in strawberry. P content in crown varied from 0.34 to 0.25%. Ferree & Stang (1988) reported that crown P varied from 0.40 to 0.25% at the end of harvest in Earliglow strawberry. Stanislavljeviç *et al*., (1997) reported that crown P was 0.14% in strawberry. In terms of P content in root, there were significant differences among treatments (Table 1). P content in root varied from 0.29 to 0.19%. Root P was the highest at the plants in SC-OR-FS. High root P after harvest may be explained with low yield at this treatment (Table 2). So, Lieten & Misotten (1993) reported that a high amount of P concentrated in the fruits at the expense of other plant organs in prior to ripening.

There was no a significant difference between treatments in foliage and crown K content (Table 1). Foliage K varied from 3.01 to 1.88%. May & Pritts (1990) also reported that adequate foliar K varied from 2.5 to 1.5% in strawberry. Crown K varied from 2.99 to 1.98. Demirsoy *et al.*, (2010) determined that crown K content varied from 0.64 to 1.35% for ‘Sweet Charlie’. K content in root varied from 3.04 to 1.59%. These contents were higher than reported by Demirsoy *et al.,* (2010) for ‘Sweet Charlie’ (0.62-1.03%). In terms of K content in root, there was a significant difference between treatments (Table 1). Root K was the highest at the plants in SC-OR-BP. Lieten & Misotten (1993) reported that fruits accumulated most of the K compared to other organs. Then, high root K contents in SC-OR-BP may also have resulted from low yield at this treatment (Table 2).

Table 1. Effect of conventional and organic strawberry growing on some nutrients in leaf, crown and root.

Treatment	N (%)			P (%)			K (%)			Fe (ppm)			Mn (ppm)		
	Leaf	Crown	Root	Leaf	Crown	Root	Leaf	Crown	Root	Leaf	Crown	Root	Leaf	Crown	Root
SC-CL-BP	1,54	1,11	0,76	0,34	0,27	0,25 ab^{Z}	2,67	2,55	1,59 b	59,2 b	230,7	518,1	45,3	80,6	48,6 ab
SC-CL-FS	1,19	0,82	0,92	0,36	0,24	0,25 ab	2,68	2,60	1,80 b	70,3 b	324,5	430,6	52,8	89,5	14,4 ab
SC-OR-BP	1,27	1,06	1,01	0,34	0,34	0,27 ab	2,70	2,44	3,04 a	50,7 b	303,6	540,3	60,6	79,7	15,7 ab
SC-OR-FS	1,50	1,14	0,62	0,34	0,33	0,29 a	1,88	2,76	2,01 b	160,3 a	247,5	400,6	40,9	60,3	74,3 b
CAM-CL-BP	1,31	0,87	0,90	0,35	0,31	0,21 b	2,27	2,99	1,65 b	69,8 b	283,6	525,9	34,3	48,4	48,6 ab
CAM-CL-FS	1,50	1,00	0,66	0,35	0,27	0,19 b	2,89	2,41	1,90 b	44.0 b	325,8	502,6	33,3	53,3	94,8 a
CAM-OR-BP	1,49	0,88	0,75	0,34	0,26	0,25 ab	3,01	2,05	1,78 b	47,0 b	210,1	525,9	30,5	41,5	15,6 ab
CAM-OR-FS	1,35	0,82	0,79	0,36	0,25	0,27 ab	2,99	1,98	1,69 b	56.0 b	235,98	502,6	35,7	36,5	93,4 ab

^{Z}: Means followed by different letters within columns differ significantly (p<0.05)

SC: Sweet Charlie cv., CAM: Camarosa cv., CL: conventional system, OR: organic system, BP: black plastic, FS: floating sheet

Table 2. Effect of conventional and organic strawberry growing on yield and some growth parameters.

Treatments	Yield (g/plant)	Leaf Area (cm^2)	Petiol Length (cm)	Petiole Diameter (mm)	Crown Number (number/plant)	Crown Diameter (mm)	Leaf dry weight (g)	Crown dry Weight (g)	Root Dry weight (g)
SC-CL-BP	198.9 b^{Z}	6291,7 b	21,2	3,06 ab	5,0 ab	45,6 ab	60,7 bc	7,7	14,7 ab
SC-CL-FS	215.5 ab	4658,9 b	20,7	3,00 ab	4,0 ab	36,9 abc	47,0 c	6,7	10,1 bc
SC-OR-BP	131.0 c	5442,6 b	17,4	3,32 a	4,0 ab	35,9 abc	71,2 bc	7,9	12,8 abc
SC-OR-FS	138.3 c	4879,1 b	17,5	3,04 ab	3,3 b	31,8 bc	51,2 c	4,7	7,2 c
CAM-CL-BP	261.5 a	8889,0 a	20,2	3,21 a	6,3 a	47,1 a	98,6 a	9,5	17,7 a
CAM-CL-FS	220.7 ab	5541,1 b	21,3	2,64 b	4,0 ab	39,5 abc	63,9 bc	8,9	12,9 abc
CAM-OR-BP	256.4 ab	5716,8 b	19,3	2,93 ab	4,0 ab	31,2 c	68,4 bc	6,4	9,0 bc
CAM-OR-FS	213.2 ab	6690,3 b	19.8	2,89 ab	4.7 ab	43,1 ab	81,4 bc	9,5	12,8 ab

^{Z}: Means followed by different letters within columns differ significantly (p<0.05)

SC: Sweet Charlie cv., CAM: Camarosa cv., CL: conventional system, OR: organic system, BP: black plastic, FS: floating sheet

In terms of Fe contents in leaf of plants, there was significant difference between treatments (Table 1). Fe content in leaves varied from 160.3 to 44.00 ppm. Foliage Fe was the highest at the plants in SC-OR-FS. May and Pritts (1990) found that foliar Fe levels between 70 to 250 ppm were considered sufficient for strawberries. In terms of Fe contents in crown and root of plants, there were no differences between treatments (Table 1). Fe content in crown varied from 325.8 to 210.1 ppm. May *et al.*, (1994) suggested that crown Fe varied from 1300 to 300 ppm. Fe content in root varied from 540.3 to 400.6 ppm. May *et al.*, (1994) reported that root Fe content varied from 2700 to 300 ppm. Alberts & Howard (1980) stated that Fe accumulates at most at crown and roots. In the experiment, foliage, crown and root Fe contents were generally lower than informed in other studies (May *et al.*, 1994; Ersoy & Demirsoy, 2006; Demirsoy *et al*., 2010).

There were no significant differences between treatments in terms of foliar and crown Mn in the experiment (Table 1). Foliar Mn varied from 60.6 to 30.5 ppm. May & Pritts (1990) reported that adequate foliar Mn varied from 200 to 50 ppm in strawberry. Crown Mn varied from 89.5 to 36.5 ppm. May & Pritts (1990) informed that crown Mn varied from 90 to 40 ppm in strawberry. In terms of Mn content in root, there was a significant difference between treatments (Table 1). Root Mn varied from 194.8 to 74.3 ppm. Root Mn was the highest at the plants in CAM-CL-FS.

There was a significant difference in term of yield between the treatments (Table 2). The highest yield was Camarosa in conventional growing covered with black plastic (CAM-CL-BP), the lowest yield was from Sweet Charlie in organic growing (SC-OR-BP and SC-OR-FS). Yield of 'Sweet Charlie' being an early variety was lower than Camarosa without considering treatments. This case resulted from more damaging of 'Sweet Charlie' being more advanced stage during spring frost occurred on 4 April 2004. There was a significant difference between the treatments in terms of leaf area. The largest leaf area was also obtained from CAM-CL-BP as parallel to yield. There was no significant difference between the treatments in terms of petiole length. Generally, the plants of Camarosa cv. had longer petioles. There was a significant difference between the treatments in terms of petiole diameter. The plants of the SC-OR-BP and CAM-CL-BP treatments had the thickest petioles (Table 2). While crown number was the highest at CAM-CL-BP, it was the lowest at SC-OR-FS. This result was almost parallel to yield. While crown diameter was the highest at CAM-CL-BP, it was the lowest at SC-OR-FS and CAM-OR-BP.

There were significant differences between treatments in terms of leaf and root dry weight and also leaf and root dry weights of the plants in CAM-CL-BP were higher than those of the other treatments (Table 2). Leaf dry weights of the plants in the SC-OR-FS and SC-CL-FS were the lowest and root dry weights of the plants in the SC-OR-FS were also the lowest. Leaf and root dry weights of the plants in the CAM-CL-BP were the highest. There was no difference between the treatments in terms of crown dry weight. Crown dry weight of the plants in CAM-CL-BP was the highest while those of the plants in SC-OR-FS were the lowest. All the results may explain high and low yield in CAM-CL-BP and SC-OR-FS treatments, respectively.

Conclusion

In present study, however nutrition element contents of the plants in organic growing and vegetative growth parameters of the plant in conventional growing were generally higher, in general there was no statistically difference in terms of yield, nutrition elements contents and vegetative growth parameters between organic and classic strawberry growing. This indicates that organic growing being friendly for environment and human health can be successful in strawberries with a good management program.

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