The Journal of Animal & Plant Sciences, 23(5): 2013, Page: 1431-1435
ISSN: 1018-7081

THE EFFECT OF DIFFERENT APPLICATIONS ON FRUIT YIELD CHARACTERISTICS OF STRAWBERRIES CULTIVATED UNDER VAN ECOLOGICAL CONDITION

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ABSTRACT

The present study was conducted to determine the effect of different applications on fruit yield, fruit number, fruit index and soluble solid content of strawberries grown in Van ecological conditions during the years 2009-2010. In the study, low plastic tunnel and open field conditions were tested in a field experiment using Aromas, Camarosa, and Sweet Charlie strawberry cultivars. Statistical analysis of the quantitative traits such as fruit yield, fruit number, fruit index and soluble solid content was performed using two-way ANOVA (Factorial design) with three replications in order to determine the influence of the cultivar (C), application (A), and cultivar by application (CxA) interaction on these four yield traits examined. Coefficients of determination (R^2%) for fruit yield, fruit number, fruit index and soluble solid content were found as 38.23 (%), 54.73 (%), 81.63(%) and 52.38 (%), respectively. Application factor significantly influenced only fruit yield ($P<0.05$), but it did not affect other traits. Significant effect of cultivar on fruit index ($P<0.01$) and soluble solid content ($P<0.05$) was observed. Application by cultivar interaction effect statistically influenced only fruit index ($P<0.01$). Low plastic tunnel gave higher value in fruit yield as compared with open field conditions in the study, but there was no significant difference in the rest of the traits with the exception of fruit yield between both applications. In fruit index, Camarosa had the highest value statistically for open field conditions compared to other cultivars, which was statistically similar to each other, but for low plastic tunnel, there were not significant differences among these three cultivars. Sweet Charlie cultivar (8.25%) producing the highest soluble solid content (SSC) amount was different from the SSC amount of Aromas cultivar, which was similar in SSC amount to Camarosa cultivar. It was concluded in the present study that, low plastic tunnel application (475.03 g/plant) positively affected fruit yield compared to open field application (405.64 g/plant) under Van ecological condition, located in the Eastern Anatolia Region of Turkey.

Key words: Fruit yield, Low plastic tunnel,Strawberry, Van Condition.

INTRODUCTION

In strawberry, fruit quality and quantity are dependent on cultivar, ecological conditions during the growth period, and particularly, cultural practices such as irrigation, fertilization, and weed control. In strawberry production, determination of the most suitable cultivar and application for any region has a great importance in terms of attaining desirable productivity in high yield and quality (Gulsoy & Yilmaz, 2004). Previously, several authors have reported that protected cultivation applications could positively affect earliness, yield, and fruit quality traits in the strawberry production (Gecer, 2009). Additionally, Yilmaz *et al*. (2003 & 2006) mentioned that these applications in cold regions would increase productivity. Low plastic tunnel, which is one of the most preferred applications in the production, produced better results in these traits in comparison with the production in open field conditions (Gulsoy & Yilmaz, 2004). However, although these above mentioned applications were significant topics in the context of cultivation and adaptation, there have been few studies in recent years on the effect of protected cultivation on strawberry fruit yield traits in Turkey. Hence, the aim of the present study was to determine the effect of different applications (low plastic tunnel vs. open field) on the quantitative traits such as fruit yield, fruit number, fruit index and soluble solid content of the strawberries cultivated under Van ecological conditions.

MATERIALS AND METHODS

Thirty tons of farm fertilizer per ha was used to enrich soil organic matter of the field experiment. In Autumn and Spring, the soil tillage was performed in 17th May of 2009. Drip irrigation system with black plastic mulch was applied on planting bag in 27th May of the year 2009. Runner plants for each cultivar and application were planted.

Frigo runner plants from Aromas, Camarosa, Sweet Charlie strawberry cultivars in previous year were planted in June1st of the year 2009. In addition, cultural

practices were performed until following year up to the harvest fruits of these strawberry cultivars.

The field experiment was conducted on the basis of 35 x 35 cm cross planting. In the experiment, low plastic tunnel and open field conditions were tested on these three strawberry cultivars. First and final harvest were between 21st May and 12th July period, respectively of the year 2010. Quantitative traits such as fruit yield (g/plant) , fruit number, fruit index and soluble solid content were investigated for each cultivar.

Statistical analysis: In the experiment with three replications, descriptive statistics for all the quantitative traits such as fruit yield, fruit number, fruit index and soluble solid content were expressed as mean ± SE. Each replication was from 20 strawberry plants. The obtained data were analyzed using two-way ANOVA (Factorial design) with three replications via General Linear Model (GLM) of SPSS statistical package program. Significant differences for each trait were determined by Duncan's Multiple Range Test. In the current study, a significance level of 0.05 was considered. The following linear model was adopted for the study.

Y_{ijk}: $\mu+\alpha_i+\beta_j+(\alpha\beta)_{ij}+e_{ijk}$ (for fruit yield, fruit number, fruit index and soluble solid content)

Where:

Y_{ijk} : Amount of k. replication exposed to j. application in i. cultivar

μ: General mean (for each quantitative trait)

α_i: i. cultivar effect

β_j: j. application effect

$(\alpha\beta)_{ij}$: cultivar by application interaction effect

e_{ijk}: Random error.

RESULTS AND DISCUSSION

Table 1 presents ANOVA with F, determination coefficient (R^2%) and coefficient of variation (CV%) values of pomological traits from Strawberry cultivars. Determination coefficients for fruit yield, fruit number, fruit index and soluble solid content were 38.23 (%), 54.73 (%), 81.63(%) and 52.38 (%) respectively, with a range of 38.23 to 81.63 (R^2%). In the present paper, fruit index produced the highest R^2 (81.63%) value, but fruit yield was the trait with the lowest R^2 among the examined traits. For example, 81.63 (%) of total variation in fruit index was explained by application, cultivar and application by cultivar interaction effects in general linear model.

In the current study, CV (%) values for fruit yield, fruit number, fruit index and soluble solid content traits were 15.18 (%), 22.60 (%). 11.72 (%) and 4.66 (%), respectively. Application factor significantly affected only fruit yield ($P<0.05$), but it did not affect other traits, statistically. Significant effect of cultivar on fruit index ($P<0.01$) and soluble solid content ($P<0.05$) was found. Application by cultivar interaction influenced only fruit index ($P<0.01$), statistically.

Table 1. ANOVA table for the pomological traits of Strawberry.

Source of Variation	Fruit Yield (g/plant)	Fruit Number (number/plant)	Fruit Index (g/fruit)	SSC (%)
Application (A)	4.85*	3.81	4.57	3.60
Cultivar (C)	0.16	2.72	15.76**	3.90*
A*C interaction	1.13	2.62	8.62**	0.90
R^2 (%)	38.23	54.73	81.63	52.38
CV (%)	15.18	22.60	11.72	4.66

*: $P<0.05$, **: $P<0.01$

Fruit yield: Table 2 presents results of descriptive statistics and Duncan test for fruit yield in the Strawberry. There was a statistically significant difference in fruit yield between open field and low plastic tunnel (405.64 vs. 475.03 g/plant) ($P<0.05$) as seen in Table 2. This shows that low plastic tunnel gave higher value in fruit yield compared to open field. No significant differences were detected in fruit yield between Strawberry cultivars, which was statistically similar to each other. Numerically, Aromas cultivar produced higher fruit yield, compared with Camarosa and Sweet Charlie cultivars. In the open field, Aromas cultivar yielded numerically the highest fruit yield in comparison with other cultivars, whereas Camarosa was the Strawberry cultivar that provided the lowest value (366.33 g/plant). In the low plastic tunnel, the highest fruit yield was obtained from Camarosa cultivar with 500.64 g/plant, but the lowest fruit yield was from Sweet Charlie with a value of 459.81 g/plant. An average of 434.41 g/plant fruit yield of Sweet Charlie cultivar in the present study (Table 2) was found in agreement with the average (435.27g/plant) reported for this cultivar by Gecer, (2009) under Van Ecological conditions. In the present study, fruit yield average (433.48 g/plant), who obtained for Camarosa cultivar was determined to be much lower than the average reported by Turemis (2002), who obtained the highest fruit yield average with 799.46 (g/plant) from Camarosa cultivar. For open field, Gecer (2009) reported the highest fruit

yield average of 352.05 g/plant, which was lower than the general average with 405.64 g/plant , and mentioned the fruit yield average of 286.34 g/plant for low plastic tunnel was much lower than the average with 475.03 g/plant (Table 2). The present results were in disagreement with Gecer (2009), who found that the fruit yield average from open field was lower than the average from low plastic tunnel. In other words, the positive effect of low plastic tunnel on flower bud formation in Strawbery in comparison with harsh environmental conditions was found in the present study compared to Gecer (2009). Previously, Yilmaz (1997), Gulsoy (2003), and Yilmaz *et al*. (2003) addressed significance of applications of protected cultivation (low plastic tunnel and high plastic tunnel, etc) in the Strawberry. Under Ordu ecological conditions, Islam *et al.* (2003) declared Camarosa (360 g/plant) and Sweet Charlie (333 g/plant) cultivars, which were much lower than the fruit yield values recorded for the present study (Table 2). Under Tekirdag ecological condition at Trakia region of Turkey, Gul (2011) attained much lower fruit yield values in low plastic tunnel (44.347 g/plant) and open field (59.527 g/plant) for Camarosa cultivar compared to the present results (Table 2). For open field, Gunduz (2010) acquired the fruit yield averages of 505.8 and 470.0 (g/plant) for Sweet Charlie and Camarosa cultivars under Hatay condition, of the Mediterranean region of Turkey. These previous averages were observed higher than those (434.41 vs 433.48 g/plant) recorded for the present study. Gunduz (2010) also stated that, averages of fruit yield in Camarosa cultivar were recorded (424.7 g/plant) for first year and (607.9 g/plant) for second year, respectively and corresponding values for Sweet Charlie Cultivar were 503.3 (g/plant) and 626.1 (g/plant) respectively for both years. The results of these two cultivars were higher than those of the Camarosa and Sweet Charlie cultivars (433.48 & 434.41 g/plant) for second year in the present paper. Ozdemir (2003), with a fruit yield average of 734 (g/plant) for Camarosa cultivar, had a higher value as compared to Camarosa cultivar average (433.48 g/plant) observed in the present study.

Table 2. Results of descriptive statistics and Duncan test for fruit yield (g/plant).

Cultivar	Open Field	Low Plastic Tunnel	Average
Aromas	441.60 ± 33.08	464.65 ± 37.73	453.12 ± 23.11
Camarosa	366.33 ± 33.00	500.64 ± 27.57	433.48 ± 35.66
Sweet Charlie	409.00 ± 47.15	459.81 ± 48.28	434.41 ± 32.25
Average	405.64 ± 22.08 B	475.03 ± 20.44A	

* A,B: Difference between means with different capital letter in the last row of the table was significant (comparison of two applications)

Fruit Number: Table 3 depicts descriptive statistics for fruit number in the Strawberry cultivars studied. The influences of cultivar, application, and cultivar by application interaction on fruit number were insignificant. However, when Table 3 was assessed numerically,

i. Low plastic tunnel was the application that caused higher fruit number compared to open field.
ii. For open field application, Aromas and Sweet Charlie cultivars in fruit number which were almost similar results were found higher than Camarosa cultivar.
iii. For low plastic tunnel application, three cultivars had almost the same fruit number, statistically and numerically.

Gecer (2009) also found fruit number averages of 15.68 and 17.52 number/ plant for open field and low plastic tunnel used in strawberry cultivation. These results were lower than those reported in the present study with 26.24 number/ plant for open field and 32.33 number/ plant for low plastic tunnel, respectively. The difference may be attributed to longer harvest period in the study. The author stated the fruit number averages of 19.49 and 20.10 number/plant for Aromas and Sweet Charlie cultivars. In another study, under Van conditions, Gulsoy (2003) reported more fruit number from Fern (8.553 number/plant) and Sweet Charlie (8.737 number/plant) cultivars, which were determined to be statistically similar in fruit number trait. In the present study, fruit number averages of Camarosa cultivar for open field (16.07 number/plant) and low plastic tunnel (32.27 number/plant) applications were much greater the averages (4.98 and 3.957 number/plant) reported by Gul (2011), working on Tekirdag condition.

Table 3. Descriptive statistics for fruit number (number/plant) in the Strawberry

Cultivar	Open Field	Low Plastic Tunnel	Average
Aromas	30.99 ± 2.08	31.72 ± 4.21	31.36 ± 2.11
Camarosa	16.07 ± 1.52	32.27 ± 4.02	24.17 ± 4.10
Sweet Charlie	31.67 ± 5.49	33.01 ± 4.13	32.34 ± 3.09
Average	26.24 ± 3.09	32.33 ± 2.07	

Fruit Index: Results of the descriptive statistics and Duncan test for fruit index are summarized in Table 4. Fruit index were significantly influenced by cultivar (P<0.01) and cultivar by application (P<0.01). When the interaction of Cultivar by Application was taken into consideration, Duncan results noticeably revealed that, for open field application, the highest fruit index was recorded in Camarosa cultivar, which was different from other cultivars, but for other application, three cultivars was statistically observed to be similar to each other. In a previous study by Gecer (2009), Camarosa cultivar had higher fruit index (12.49 g/fruit) compared to Aromas (11.99g/fruit), Sweet Charlie (11.58g/fruit), and Selva (11.29g/fruit) cultivars as also reported by Gunduz (2010) with the highest average from Camarosa Cultivar. These results were found lower than the present results on fruit index of the Strawberry (Table 4). Gul (2011), who conducted on Tekirdag, Trakia region of Turkey, reported that, fruit index averages from Camarosa cultivar were 11.860 (g/fruit) and 11.477 (g/fruit), respectively for open field and low plastic tunnel applications. These previous values were also lower than the corresponding present values (22.82 & 15.80 g/fruit) for both applications applied for Camarosa cultivar in the present study (Table 4).

Table 4. Results of descriptive statistics and Duncan's test for fruit index (g/fruit)

Cultivar	Open Field	Low Plastic Tunnel	Average
Aromas	14.32 ± 1.08b	14.97 ± 1.41a	14.65 ± 0.81 B
Camarosa	22.82 ± 0.49a	15.80 ± 1.14a	19.31 ± 1.67 A
Sweet Charlie	13.29 ± 1.15b	14.04 ± 0.94a	13.67 ± 0.69 B
Average	16.81 ± 1.58	14.94 ± 0.64	

a,b, Difference between two cultivar means with different letter for each application was significant (comparison of cultivars in an application) at P<0.05 level.

A,B: Difference between two cultivar means with different capital letter in the last column of the table was significant (comparison of cultivars) at P<0.05 level

Soluble Solids Content: Results of the descriptive statistics and Duncan test for soluble solids content are illustrated in Table 5. Only cultivar as a main factor had a statistically impact on soluble solids content (P<0.05). When Duncan result was examined, soluble solid content of Sweet Charlie cultivar was significantly higher than the content of Aromas cultivar (P<0.05). However, Camarosa cultivar was not significantly different from other two cultivars. In low plastic tunnel, Gecer (2009) reported a SSC amount of 7.71 (%), which was almost similar to the SSC amount with 8.17 (%) found in the present study (Table 5). Under Ordu Conditions, averages of SSC amount for Camarosa and Sweet Charlie cultivars among eight strawberry cultivars were reported as 7.6 and 8.3(%) by Islam *et al.* (2003). Gunduz (2010) observed to be the highest SSC/acid ratio from Sweet Charlie cultivar, which was exposed to high plastic tunnel application.

In conclusion, the different results in terms of the investigated characteristics may be ascribed to ecological conditions, different cultivation applications, and especially, genotype by environment interactions.

Table 5. Results of descriptive statistics and Duncan test for soluble solids content (%)

Cultivar	Open Field	Low Plastic Tunnel	Average
Aromas	7.33 ± 0.17	8.00 ± 0.29	7.67 ± 0.21 B
Camarosa	8.00 ± 0.29	8.17 ± 0.17	8.08 ± 0.15 AB
Sweet Charlie	8.17 ± 0.17	8.33 ± 0.17	8.25 ± 0.11 A
Average	7.83 ± 0.17	8.17 ± 0.12	

A,B: Difference between two cultivar means with different capital letter in the last column of the table was significant (comparison of cultivars) at P<0.05 level.

Conclusion: Low plastic tunnel application positively affected on fruit yield compared to open field application. Protected cultivation applications must be used easily for obtaining better earliness, yield, and fruit quality traits in the strawberry production.

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